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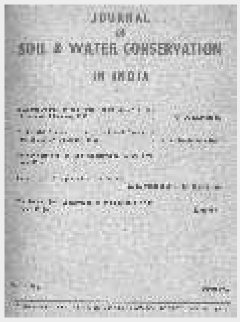

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Contents

Pledge

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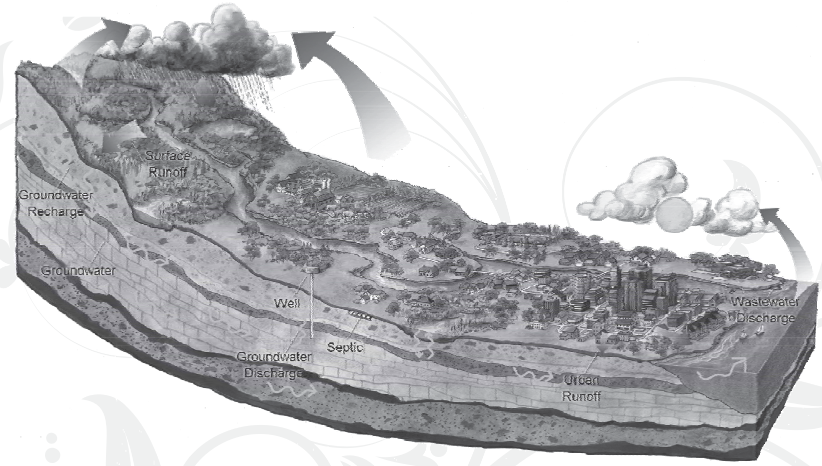

I pledge to conserve Soil,
that sustains me.
I pledge to conserve Water,
that is vital for life.
I care for Plants and Animals and the Wildlife,
which sustain me.
I pledge to work for adaptation to,
and mitigation of Global Warming.
I pledge to remain devoted,
to the management of all Natural Resources,
With harmony between Ecology and Economics.

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Natural resource conservation and its effect on land use planning strategies in Turkey

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ABSTRACT

Natural resource management is one of the most important topics in terms of future land use planning projections due to that human-induced land degradation process accelerated by climate change in arid and semi-arid climates. Soil erosion related to the negative effects on the environment is one of the first issues come to mind when mentioned on land degradation. Land use plan including policies and practices for the protection of the natural resources such as the negative effects of erosion, soil salinity, desertification etc. is extremely important due to that the basis of sustainable resource management is based on appropriate land usage facilities. No doubt, the success of the plan is closely related to protection of soil structure against to the current and potential problems of the land. In this context, to produce the effective and compressive plan for environmental assessments digital data bases occurred from the related natural resources such as soil, climate, topography, land use patterns in local, regional and national scale are urgently need. Because of that soil conservation requires assessing water and wind erosion risks to identify problem areas. The main purpose of this study is to share some important attempts carried out by us to evaluate regional and national soil erosion assessments.

Key words: Planning, arid and semi-arid climate, erosion, salinity, desertification, sustainable, topography, evaluate, assessments.

INTRODUCTION

Planning to natural resource conservation

Soil and vegetation degradation can lead to a significant reduction of the ecosystem functionality with unfavorable effects on biodiversity, desertification, and water resource quality (Dregne and Chou 1992; UNCCD 1994; MEA 2005; Saygýn et al. 2011). According to the ISRIC/UNEP (1991), 20 million ha of the land productivity is quite significantly reduced by erosion and land degradation every year. The main land degradation of 1094 million ha land is by water erosion, and just 548 million ha of land suffers from wind erosion, especially in the arid and semi-arid areas (Oldeman 1991).There is increasingly urgent need for planning so that land resources are limited and finite in addition to conserving fragile ecosystems against from land degradation processes. Demands for different land use types especially in the developing countries are greater than the available land resources and these demands become more pressing on natural resources (FAO 1993). Land-use planning is a systematic and iterative procedure carried out in order to create an enabling environment for sustainable development of land resources which meets people's needs and demands (Fig. 1). The main aim of a land use planning is to assess the physical, socio-economic, institutional and legal potentials and constraints with respect to an optimal and sustainable use of land resources and empowers people to make decisions about how to allocate those resources. At this point the main mission of soil scientists could be describe as to produce effective politics for sustainable resource management from the viewpoint of physical land resources conservation and development.

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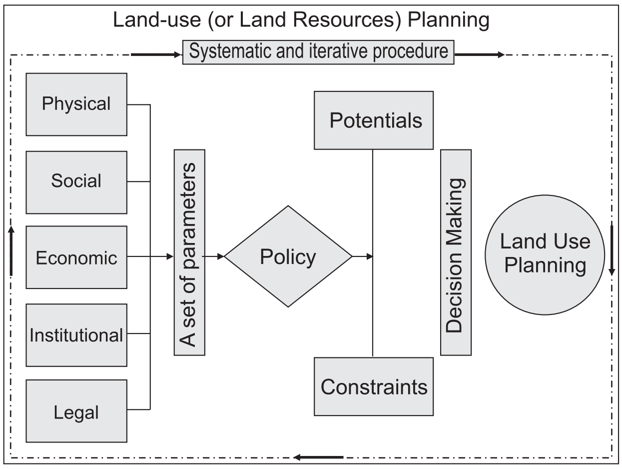

Fig. 1: Systematic and iterative procedure of Land-use Planning

General aspects of soil, climate, topographical structure and erosion potential of Turkey

A large part of Turkey is rated highly susceptible to desertification in terms of climate, soils, topography and land cover status. 90 percent of Turkey's total land area is climatologically classified as arid and semi-arid regions. Soil profile development is shallower due to that the country generally has a mountainous topography with higher slope degrees. 47.98 percent of the total land being 'steepness of slope greater than 20 percent and 62.15 percent of land, the slope is greater than 12%. Totally, 29.7 million ha land has between 2 and 20 percent slope steepness in Turkey. In addition the fact that, organic matter content is less than one percent coverage in two-thirds of soils (Anonymous 1978; Anonymous 1982a; Çanga and Erpul 1994). Soil erosion is dominant problem in these conditions makes land degradation progress more rapidly. 16.4 million ha of the 27.7 million hectares of agricultural land soil erosion is the major problem. To make overall evaluation for erosion potentials of soils of the country, one can say that more than %75 of land in Turkey is under the risk of erosion at different levels (Özden et al. 2000; Cetin et al. 2007).

According to the detailed river observation in Turkey, calculated suspended sediment yield is 155 ton y-1 km-2 or 119 m3 y-1 km-2 (EIEI 2006). Anthoni (2000) state that soil formation rate is naturally 1 mm within 200 - 400 years. Considering the upper limit of this range for arid and semi-arid conditions, soil formation rate can be calculated as "0,025 mm y-1, 0,025 m3 ha-1 y-1or 0,0325 ton ha-1 y-1 for semi arid and arid conditions of Turkey (Erpul and Saygýn 2012). It is also well known that for agricultural purposes the breaking of the natural soil formation rates 40 times and for other reasons, such as breaking with up to 100 times more soil losses occurred in worldwide (Anthoni 2000; Lang 2006). Accordingly, Erpul and Saygýn (2012) have made a risk assessment of erosion, based upon the available sediment data set at national scale and informed that the rate of soil loss is approximately 48 times higher than the rate of soil formation.

Erosion risk assessment attempts in Turkey

Some empirical and process based models with integrated GIS tools permit to the environmentalists, conservationist and engineers to quantitative evaluation and the spatial distribution of erosion risk in any region. These models have been widely used in Turkey since 2000 by many researcher and many erosion risk assessments have been made as for the future projections in Turkey as well as the world by using these models (Baskan et al. 2010; Dogan 2002; Fistikoglu and Harmancioglu 2002; Ekinci 2005; Bayramin et al. 2006; Erdogan et al. 2007; Irvem et al. 2007; Tagil 2007; Karabulut and Kucukonder 2008; Efe et al. 2008a, b; Ozcan et al. 2008; Yuksel et al. 2008; Karaburun 2009; Karaburun et al. 2009; Saygýn et al. 2011; Saygýn et al. 2013). But most of them just aim to evaluate soil erosion risk under parcel or small basin scale. To make more compressive and effective planning of natural resources is essential to be done soil erosion risk assessment under regional and national scale.

To combat soil erosion at national scale in Turkey, some effective action plans have been taken and these have already been underway by the collaboration between Ankara University and Ministry of Forestry and Water Affairs and Ministry of Food, Agriculture and Livestock. A national "Soil Erosion Map" generated by USLE/RUSLE algorithm (Universal Soil Loss Equation – Revised Universal Soil Loss Equation) (Wischmeier and Smith 1965, 1978; Renard et al. 1997) (General Directorate of Combating Desertification and Erosion [ÇEM], 2013) is one of the most important attempts.

To make this evaluation used digital databases (raster and vector) together with the USLE/RUSLE technology are following:

- Topographical maps (1:25.000)
- Digital elevation models (1:25.000)
- Forest maps (1:25.000)
- Forest management plans
- Soil maps (1:25.000) (Anonymous 1982b; GDPS, 1986)

- Land use data (CORINE 2006)
- Catchment and river data (DSÝ)
- Dams data (DSÝ)
- River sediment data (EIEI 2006)
- Turkey Erosivity Map (Kaya 2008; Erpul et al. 2009).

Firstly, boundaries of 25 major basins have been updated by considering the Digital Elevation Model to derive hydrological DEM as shown in Fig. 2. For that drainage network of Turkey has been created Micro catchment has been specified with the aid of drainage network by using ArcGIS 9.3. Software, Hydrology Tools.

Fig. 2. Major basins of Turkey

Basins have firstly divided into sub-basin levels and then micro-basins by using river data base and drainage patterns. And totally, 14,608 micro-basins were defined in the database, the smallest of which has a area of 1.1 ha (Fig. 3).

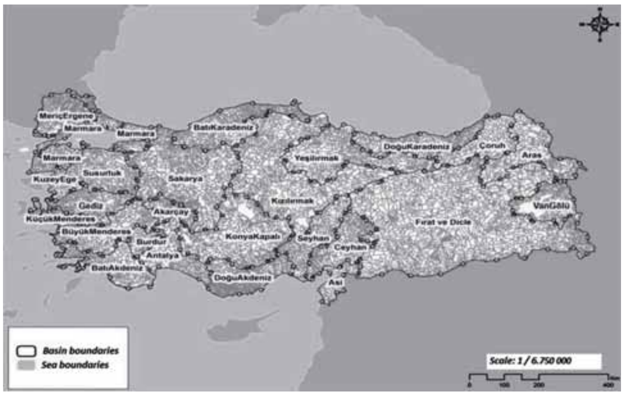

Fig. 3. Micro-basin boundaries in Turkey

To make potential water erosion risk assessment the USLE/RUSLE algorithm (Universal Soil Loss Equation – Revised Universal Soil Loss Equation) (Wischmeier and Smith 1978; Renard et al. 1997), the most widely used approach in world, is used and it can provide a parametric evaluation system for the land degradation in terms of the soil erosion since it successfully integrates parameters of climate, soil, topography and vegetation and introduces a quantitative method for agricultural and bio-engineering conservation measures in order to sustain the natural resources with Eq. [1]:

$$A = R \cdot K \cdot L \cdot S \cdot C \cdot P \qquad [1]$$

Where, A is the mean annual soil loss (t ha^{-1} year^{-1}), R is the rainfall erosivity factor (MJ mm ha-1 h-1 year^{-1}), K is the soil erodibility factor (t ha h ha^{-1} MJ^{-1} mm^{-1}), L is the slope length factor, S is the slope steepness factor, C is the cover management factor, and P is the support practice factor.

Rainfall–runoff erosivity factor (RUSLE-R) is calculated as a product of the annual total energy of rainstorm (E, MJ ha-1 y-1) and the maximum 30-min intensity (I30, mm h-1) (E x I30) (Wischmeier and Smith 1958; Foster et al. 1981; Renard et al. 1997), was directly taken from the study of Kaya (2008) and a scientific project report (Erpul et al., 2009), in which the E x I30 values (MJ mm ha-1 h-1 y-1) were calculated either by Eq. [2] or by Eq. [3] based on the conditions where I d" 76 mm h"1 and I e" 76 mm h"1, respectively for 252 climate stations in the period of 1993-2007 all over Turkey as shown in Fig. 4.

$$E = 0.29\left[1 - 0.72e^{(-0.05I)}\right] \qquad [2]$$

$$E = 0.293 \qquad [3]$$

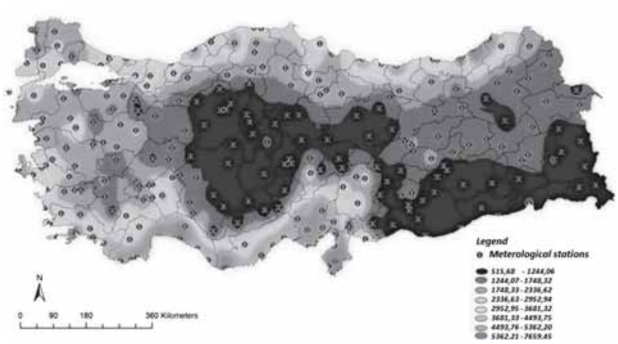

Fig. 4. Rainfall–runoff erosivity factor (RUSLE-R) map

Soil erodibility factor (RUSLE-K) is defined as sensitivity to transportation and deposition of soil that consisted in consequence of precipitation and runoff. In this study, 1/25000 scaled soil map of Turkey (GDPS, 1986) has been used in order to calculate the RUSLE-K. It is calculated with the aid of combinations of slope-depth combine, permeability-texture combine and slope-texture-depth combine in soil maps per great soil groups by using Eq. [4] that constituted by (Romkens et al. 1986 ve Renard et al. 1997).

$$K = 0.0034 + 0.0405.\exp\left(-0.5\frac{(\log D_g + 1.659)^2}{0.7101}\right) \quad [4]$$

where, K is soil erodibility factor (t ha h ha-1MJ-1mm-1) and D g is geometric mean weight diameter of the primary soil particles (mm) and can be calculated by:

$$D_g = \exp\left(\sum fi.\ln\left(\frac{(d_i + d_{i-1})}{2}\right)\right) \quad [5]$$

where, di is the maximum diameter (mm), di-1 is the minimum diameter and f i is the corresponding mass fraction for each particle size class of clay, silt, and sand.

Obtained soil erodibility map for Buyuk Menderes basin is shown in Fig. 5 derived by using these equations.

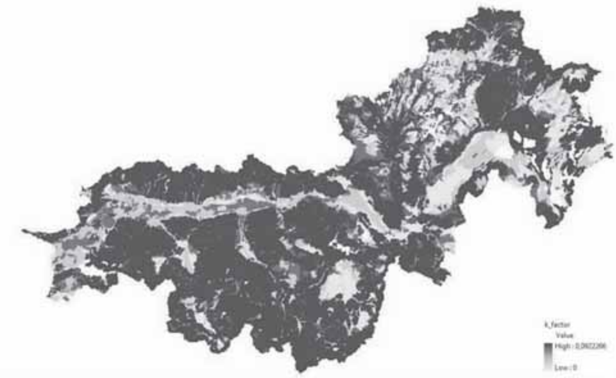

Fig.5. Soil erodibility factor (RUSLE-K) map for Buyuk Menderes Basin

$$LS = \left(\frac{\chi\eta}{22.13}\right)^{0.4} \cdot \left(\frac{\sin\theta}{0.0896}\right)^{1.3} \quad [6]$$

Where, ÷ is the flow accumulation and was derived from DEM using a GIS accumulation algorithm, which employs the watershed delineation tool of Arc view 9.2 (Lee, 2004), η is the cell size, and θ is the slope steepness in degrees.

Obtained RUSLE-LS map for Dogu Akdeniz basin is shown in Fig. 6 derived by using Eq. [6].

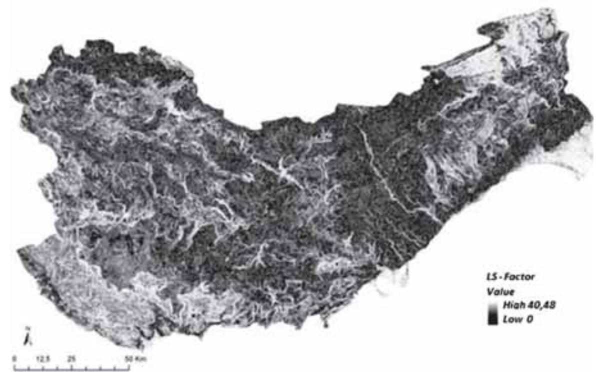

Fig.6. Slope Length (L) and Steepness (S) Factor (RUSLE-LS) map for Dogu Akdeniz Basin

Cover management factor of the RUSLE (RUSLE-C) was computed based on Land use map, satellite images and CORINE Land Cover raster data (2006). Land use classification has been carried out by the aid of CORINE data. Obtained main land use types are classified under the six heads as forest, agriculture, pasture, settlement, water surface and the others.

For forests, 1/25000 scaled forest stand maps and forest management plans (OGM 2010) were used with CORINE land use data. C factor values have been calculated by using forest stand boundries, tree species and highness, canopy cover and surface cover information by the help of Eq.[7]. For agricultural areas and pastures, coefficients that Wischmeier and Smith (1978) obtained from RUSLE parcels have been used.

$$C = C_{PLU} \times C_{CC} \times C_{SC} \times C_{SR} \times C_{SM} \quad [7]$$

Where, C_{PLU}: Prior land use, C_{CC}: canopy cover, C_{SC}: surface cover, C_{SR}: surface roughness and C_{SM}: soil moisture condition.

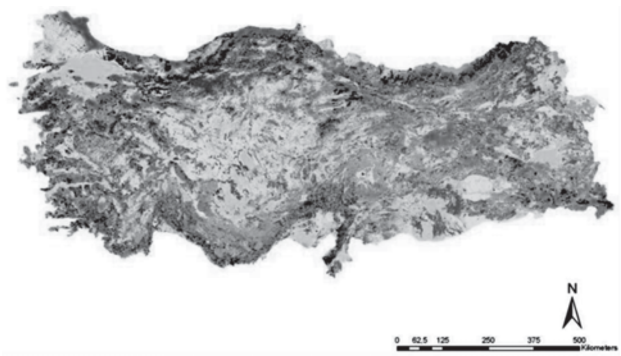

Fig. 7. Cover Management factor map obtained from CORINE, NDVI and GIS tools.

Support practice factor (RUSLE-P) was assumed as 1 (RUSLE-P = 1) because of obtaining to the potential erosion risk for all country. And then, the soil loss prediction (t ha″1 year″1) was performed

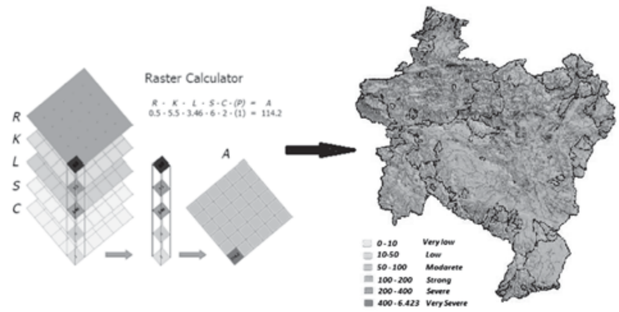

Fig. 8. Soil loss prediction process for Sakarya Basin

for 14,608 micro-basins, delineated in Fig. 3, by the factor layers obtained by GIS (ArcGIS 9.2 software) as raster format. The procedure is summarized as Fig. 8 for the Sakarya Basin.

At this stage of project, 'Erosion Monitoring System' is preparing for monitoring of studies and creating of data archive in web-based. At now, controlling and testing stages are being gone on by national experts. The main objectives of this study are to gather the available information throughout the country related to the applied or planned soil conservation practices and to develop this data base with new data obtained future projections in country. This web-available system is also supported to the user for applying different scenarios to estimate its effects on soil loss ratios (Fig. 9).

Fig. 9. Erosion monitoring system view for basins (CEM, 2013)

In Turkey, 57,15 million ha of land is exposed to water erosion in contrast to wind erosion is not very common, and a total of 506.309 ha in different levels of wind erosion (Erpul and Saygýn 2012). As many researchers approved that especially in arid, semi-arid and dry sub-humid regions, the most sensitive areas for wind erosion process wind erosion is the dominant degrading process (Lal 1990; Leenders et al. 2011; Maurer et al. 2010; Shao 2008; Stroosnijder 2005; Youssef et al. 2012 a, b).

At this point, it can be said that another important facility for erosion studies in Turkey is "Wind Erosion Risk Assessment" by Revised Wind Erosion Equation (RWEQ) in Regional Scale. It is the first systematic wind erosion study and outcomes of it provide significant data for watershed or regional-based wind erosion modeling researches. Project was supported by the Turkish Scientific and Technological Research Council (TUBITAK) (Project number: TOVAG-110O296)

The main objective of this study was summarized as to assess the aeolian sediment transport from different land and surface conditions in the region of Karapýnar Turkey (Fig. 10). Karapýnar, which has driest climate in Turkey with an annual precipitation of 275 mm and an average daily temperature of 11.5°C, undoubtedly comes to first to mind when mentioned wind erosion in Turkey (Desire 2008). Although wind erosion is a major environmental problem in Konya basin, Turkey, until nowadays, measurements on this problem were quite limited and there were no reliable researches on a regional scale based. The available wind erosion data represented small area and single land use in the region.

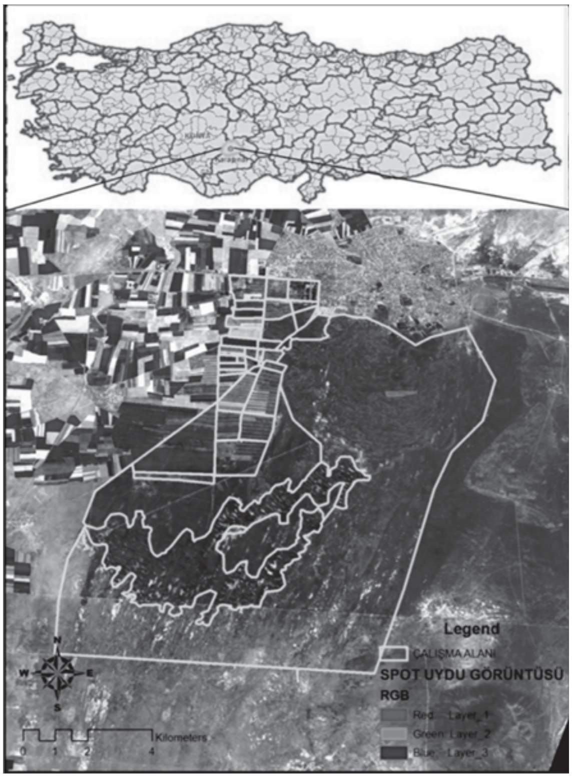

Fig. 10. Spot Satellite image of Karapýnar Region

In the performed study, measurements took place in the wind erosion season of 2011 and 2012 in a total number of seven plots, and these plots represented the land covers of agricultural fields, fallow fields, sand dunes and pastures. At each plot, a minimum number of 20 BEST (Basaran & Erpul Sediment Trap) (Basaran et al. 2011) were mounted for sampling the eroded material (Fig. 11). Besides the sampling of transported aeolian sediment, climate variables (wind profile, temperature and relative humidity) were measured by installing a climate station at each measurement plot. Collected data were analyzed and the wind-value standardized mass transport (MS) was used to compare the erodibility for different land covers.

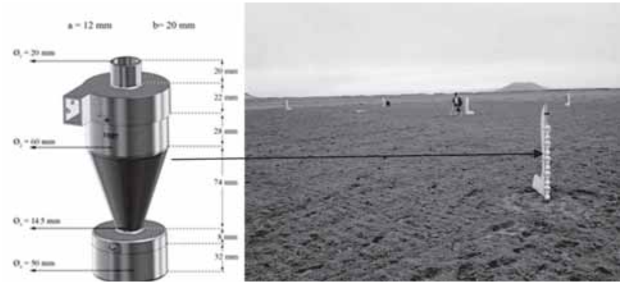

Fig. 11. BEST sediment trap (BASARAN et al., 2011)

For modeling the wind-blown sediment transport in field scale the Revised Wind Erosion Equation (RWEQ) reported by Fryrear et al. (1998) was used. It is a process-based, field-scale, empirical model with the ability to estimate annual or period wind erosion based on single-event. Model calculates to the potential average soil loss in terms of ton da^{-1} year^{-1}. Physical parameters of it could be simply illustrated as shown Fig. 12 derived by Youssef (2012).

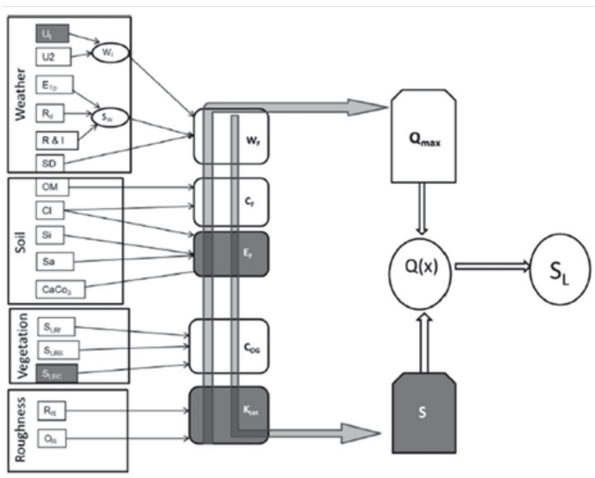

Fig. 12. Soil loss (SL) and mass transport Q(z) calculation steps in RWEQ derived by Youssef (2012)*

Ut, threshold velocity at 2 m height; U2, wind speed at 2 m height; Wf, wind factor; ETp, potential relative evapotranspiration; Rd, number of rainfall/irrigation days; R&I, rainfall and irrigation; SD, snow depth; SW, soil moisture; WF, weather factor; OM, content of organic matter; Si, content of silt; Cl, content of clay; Sa, content of sand; CaCO3, calcium carbonate ;CF, crust factor; EF, erodible fraction; SLRf, flat residue; SLRs, standing residue; SLRc, crop cover; COG, combined crop factors; RR, random roughness; OR, orientated roughness and Ktot, single soil roughness factor.

As a result, the spatial distribution of transported sediments in the region was mapped by evaluating the scope of geo-statistic and GIS approaches for totally 16 wind erosion events (Fig. 13).

Until nowadays, performing studies clearly point that evaluation of wind erosion in regional scales is urgently necessary to draw the sustainable policies for future land uses (Bunn 1997; Nicholson

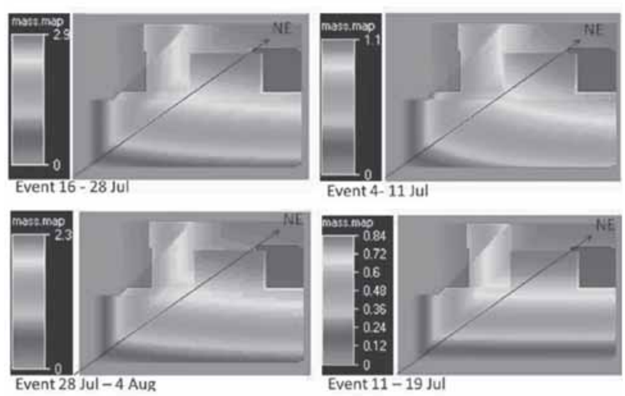

Fig. 13. Sample illustration of spatial distribution of transported sediments derived by Youssef (2012)

2000; Nordstrom and Hotta 2004; Andrew 2007; Warren 2010; Almansa et al. 2012, Youssef 2012). In this context, Karssenberg (2006) and Youssef (2012) figure out the probabilistic (stochastic) spatial genelization method for wind erosion models to transit from high resolution to low resolution (Fig. 14).

For this transition, focusing on upscaling techniques integrated with GIS, Geostatistics etc. will be inevitable for natural resource professionals.

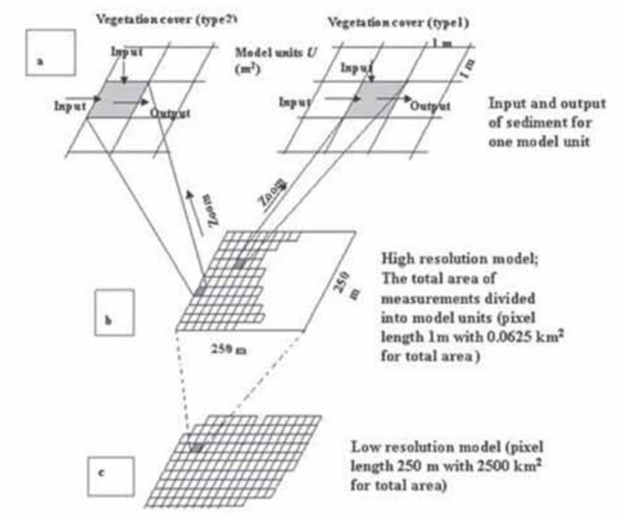

Fig. 14. Probabilistic (stochastic) spatial genelization method (Karssenberg 2006; Youssef 2012)

CONCLUSION

Evaluation to the water and wind erosion potentials and identifying problem areas are essential to make effective land use plans based on soil conservation strategies as mentioned above parts. In this context, one of the most important points to be modeling of the natural resources as physical and process-based is to have quantitative databases which are classified as climate, soil, topography and land cover to produce soil erosion risk maps derived from process-based physical models such as RUSLE and RWEQ. These models also provide an opportunity to set quantitative boundary conditions on the rates of soil formation and loss, which could be used for sustainable resource management in land use planning. In addition to these mentioned attempts, more detailed surveys on model variables should be performed for scale transitions.

REFERENCES

Almansa, C., Calatrava, J., Martínez-Paz, J.M. 2012. Extending the framework of the economic evaluation of erosion control actions in Mediterranean basins. Land Use Policy, 29(2):294-308.

Andrew, W. 2007. Sustainability: A view from the wind-eroded field. Journal of Environmental Sciences, 19(4):470-474.

Anonymous 1978. Türkiye Arazi Varlýðý. Toprak-Su Genel Müdürlüðü, Ankara (in Turkish).

Anonymous [1982a]. Türkiye Genel Toprak Amenajman Planlamasý. Köy Hizmetleri Genel Müdürlüðü, Ankara (in Turkish).

Anonymous. 1982b. Türkiye Genel Toprak Haritasý Sayýsal Toprak Veritabaný. Türkiye Toprak ve Su Kaynaklarý Ulusal Bilgi Merkezi (UBM) Köy Hizmetleri Genel Müdürlüðü, Ankara (in Turkish).

Anthoni, J. F. 2000. Soil geology. http://www.seafriends.org.nz/enviro/soil/ (last visited 16/01/2014)

Basaran, M., Erpul, G., Uzun, O., Gabriels, D. 2011. Comparative efficiency testing for a newly designed cyclone type sediment trap for wind erosion measurements. Geomorphology, 130(3-4): 343-351.

Baskan, O., Cebel, H., Akgul, S. 2010. Conditional simulation of USLE/RUSLE soil erodibility factor by geostatistics in a Mediterranean Catchment, Turkey. Environ Earth Sci 60(6):1179–1187.

Bayramin, I., Erpul, G., Erdogan, H.E. 2006. Use of CORINE methodology to assess soil erosion risk in the semi-arid area of Beypazari, Ankara. Turk J Agric For 30:81–100.

Bunn, J.A. 1997. The implications of alternative beliefs about soil-erosion-productivity relationships and conservation treatments for the economic dynamics of soil erosion on the southern Texas High Plains. Journal of Soil and Water Conservation, 52(5), 368-375.

CORINE. 2006. Corine Land Cover Raster Data. European Environment Agency. http://www.eea.europa.eu/data-and-maps/data/corine-land-cover-2006-raster-2 (last visited 16/01/2014)

Çanga, M., Erpul, G. 1994. Toprak Ýþlemeli Tarým Alanlarýnda Erozyon ve Kontrolü. Topraksu, 3(2), 14-16 (in Turkish).

ÇEM 2013. Soil Erosion Map. General Directorate of Combating Desertification and Erosion. http://www.cem.gov.tr/erozyon/AnaSayfa/faaliyetlerimiz/ulusal_izleme_sistemlerimiz.aspx?sflang=tr (last visited 16/01/2014)

Cetin, C.S., Karaca, A., Haktanýr, K., Yýldýz, H. 2007. Global attention to Turkey due to desertification. Environmental Monitoring and Assessment 128 (1-3): 489-93.

Desire 2008. http://www.desire-project.eu/index.php?option=com_content&task=view&id=40&Itemid=40 (last visited 16/01/2014).

Dregne, H.E., Chou, N.T. 1992. Global desertification dimensions and costs, in degradation and restoration of arid lands. Lubbock: Texas Tech University.

Dogan, O. 2002. Erosive potentials of rainfalls in Turkey and erosion index values of Universal Soil Loss Equation (publication no. 220, Report no. R-120). Ankara, Turkey: Publications of Ankara Research Institutes, General Directorate of Rural Service.

Efe, R., Ekinci, D., Curebal, I. 2008a. Erosion analysis of Fýndýklý Creek watershed (NW of Turkey) using GIS based RUSLE (3D) method. Fresen Environ Bull 17(5):568–576.

Efe, R., Ekinci, D., Curebal, I. 2008b. Erosion analysis of S ahin Creek watershed (NW of Turkey) using GIS based RUSLE (3D) method. J Appl Sci 8(1):49–58.

EIEI 2006. Elektrik Ýþleri Etüd Ýdaresi Genel Müdürlüðü. Türkiye Akarsularýnda Süspanse Sediment Gözlemleri Yýllýðý (1999-2005), Ankara (in Turkish).

Ekinci, D. 2005. Erosion analysis of Kozlu River basin with the GIS based a modified Rusle method. IU Geogr Bull 13:109–119.

Erdogan, E.H., Erpul, G., Bayramin, I. 2007. Use of USLE/GIS methodology for predicting soil loss in a semiarid agricultural watershed. Environ Monit Assess 131:153–161.

Erpul, G., Bayramin, I., Topcu Kaya, P., Saygýn D.S. 2009. Türkiye'de Su Erozyonu Çalýþmalarý için Uzun Dönem Meteoroloji Verileri Kullanarak Ulusal Ölçekte Yaðýþ Enerji ve Þiddetlerinin Belirlenmesi, TÜBÝTAK Projesi, Araþtýrmacý, PROJE NO: CAYDAG 107 Y 155 (in Turkish).

Erpul, G., Saygýn, S.D. 2012. What sould be done on soil erosion problem in Turkey? Soil Science Society of Turkey. Journal of Soil Science and Plant Nutrition. 1: 26-32 (In Turkish).

FAO 1993. Guidelines for land use planning. FAO Development Series 1. ISSN 1020-0819.

Fistikoglu, O., Harmancioglu, N.B. 2002. Integration of GIS and USLE in assessment of soil erosion. Water Resour Manag 16:447–467.

Foster, G.R., Jane, L.J., Nowlin, J.D., Laflen, J.M., Young, R.A. 1981. Estimating erosion and sediment yield on field size areas. Trans ASAE 24(5):1253–1262.

Fryrear, D.W., Saleh, A., Bilbro, J., Schomberg, H., Stout, J., Zobeck, T. 1998. Revised Wind Erosion Equation (RWEQ). Wind Erosion and Water Conservation

Research Unit, Technical Bulletin 1. Southern Plains Area Cropping Systems Research Laboratory, USDA-ARS.

GDPS (General Directorate of Rural Service) 1986. 1/25000 Soil Map of Ankara, Turkey. Digital Soil Database: Soil and Water Resources National Information Centre, Turkey.

Irvem, A., Topaloglu, F., Uygur, V. 2007. Estimating spatial distribution of soil loss over Seyhan River Basin in Turkey. J Hydrol 336:30–37.

ISRIC/UNEP 1991. World Map of the Status of Human-Induced Soil Degradation, Global Assessment of Soil Degradation, UNEP, Nairobi.

Karabulut, M., Kucukonder, M. 2008. Kahramanmaras Ovasý ve Cevresinde CBS Kullanýlarak Erozyon Alanlarýnýn Tespiti. KSU Fen ve Muhendislik Dergisi 11(2):14–22 (in Turkish).

Karaburun, A. 2009. Estimating potential erosion risks in Corlu using the GIS-based RUSLE method. Fresen Environ Bull 18(9):1692–1700.

Karaburun, A., Demirci, A., Karakuyu, M. 2009. Erozyon Tahmininde CBS Tabanlý RUSLE Metodunun Kullanýlmasý: Büyükçekmece Örneði. 3. Ulusal DEÜ CBS Sempozyumu. CBS ve Bilgi Teknolojileri Bildiriler Kitabý. Izmir, Turkiye (in Turkish), pp 43–49.

Karssenberg, D. 2006. Upscaling of saturated conductivity for Hortonian runoff modelling. Advances in Water Resources 29:735-759.

Kaya, P. 2008. Türkiye' de Uzun Dönem Verileri Kullanýlarak Ulusal Ölçekte RUSLE-R Faktörünün Belirlenmesi. Ankara Üniversitesi Fen Bilimleri Enstitüsü Yüksek Lisans Tezi (in Turkish).

Lal, R. 1990. Soil erosion in the tropics : Principles and management. McGrawInc., New York.

Lang, S.S. 2006. Slow, insidious' soil erosion threatens human health and welfare as well as the environment. Chronicle Online, Cornell University. http://www.news.cornell.edu/stories/2006/03/slow-insidious-soil-erosion-threatens-human-health-and-welfare (last visited 16/01/2014).

Lee, S. 2004. Soil erosion assessment and its verification using the Universal Soil Loss Equation and geographic information system: a case study at Boun. Korea Environ Geol 45:457–465.

Leenders, J.K., Sterk, G., Van Boxel, J.H. 2011. Modelling wind-blown sediment transport around single vegetation elements. Earth Surface Processes and Landforms, 36(9), 1218-1229.

Maurer, T., Herrmann, L., Stahr, K. 2010. Wind erosion characteristics of Sahelian surface types. Earth Surface Processes and Landforms, 35(12), 1386-1401.

MEA 2005. Millennium Ecosystem Assessment. Ecosystems and human well-being: Desertification synthesis. Washington: World Resource Institute.

Moore, I.D., Burch, G.J. 1986a. Modeling erosion and deposition. Topographic effects. Trans Asae 29:1624–1630.

Moore, I.D., Burch, G.J. 1986b. Physical basis of the length–slope factor in the Universal soil loss equation. Soil Sci Soc Am J 50:1294–1298.

Nicholson, S. 2000. Land surface processes and Sahel climate. Reviews of Geophysics, 38(1):117-139.

Nordstrom, K.F., Hotta, S. 2004. Wind erosion from cropland in the USA: A review of problems, solutions and prospects. Geoderma, 121(3-4), 157-167.

Ogawa, S., Saito, G., Mino, N., Uchida, S., Khan, N.M., Shafiq, M. 1997. Estimation of soil erosion using USLE and Landsat TM in Pakistan (ACRS 1–5). Retrieved from GIS development.net.

OGM 2010. Forestry Statistics, Republic of Turkey, Ministry of Forestry and Water Affairs ISBN 978-605-4610-00-6. pp. 103.

Oldeman, L.R. 1991. Global extent of soil degradation. Bi-annual Report. International Soil Reference and Information Center. Wageningen, The Netherlands: pp. 19-36.

Ozcan, A.U., Erpul, G., Basaran, M., Erdogan, H.E. 2008. Use of USLE/GIS technology integrated with geostatistics to assess soil erosion risk in different land uses of Indagi Mountain Pass–C ankiri. Turkey Environ Geol 53:1731–1741.

Özden, D.M., Dursun, H., Sevinç, A.N. 2000. The land resources of Turkey and activities of general directorate of rural services. Proceedings of international symposium on desertification, (pp. 1–13) 13–17 June 2000, Konya, Turkey.

Renard, K.G., Foster, G.R., Weesies, G.A., McCool, D.K., Yoder, D.C. 1997. Predicting soil erosion by water—a guide to conservation planning with the Revised Universal Soil Loss Equation (RUSLE). United States Department of Agriculture. Agricultural Research Service (USDA-ARS) Handbook No. 703. United States Government Printing Office. Washington. DC.

Romkens, M.J.M., Prasad, S.N., Poesen, J.W.A. 1986. Soil erodibility and properties. In: Proceedings of 13th Congress. International soil science society. Hamburg, Germany, 5:492–504.

Saygýn, D.S., Basaran, M., Ozcan, A.U., Dolarslan, M., Timur O.B., Yilman, F.E., Erpul, G. 2011. Land degradation assessment by geo-spatially modeling different soil erodibility equations in a semi-arid catchment. Environmental Monitoring and Assessment, 180(1-4): 201-215.

Saygýn, D.S., Ozcan, A.U., Basaran, M., Timur, O.B., Dolarslan M., Yilman, F.E., Erpul, G. 2013. The combined RUSLE/SDR approach integrated with GIS and geostatistics to estimate annual sediment flux rates in the semi-arid catchment, Turkey, Environmental Earth Sciences, DOI 10.1007/s12665-013-2565-y.

Shao, Y. 2008. Physics and Modelling of Wind Erosion. Springer, Berlin, Heidelberg, New York.

Stroosnijder, L. 2005. Measurement of erosion: is it possible? Catena, 64(2-3): 162-173.

Tagil, S. 2007. Monitor land degradation phenomena through landscape metrics and NDVI: Gordes, Kavacik, Ilicak, Kumcay and Marmara Lake Basins (Turkey). J Appl Sci 7:1827–1842.

UNCCD 1994. Elaboration of an international convention to combat desertif ication in countries experiencing serious drought and/ or desertif ication, particularly in Africa. U.N. Doc.A/AC.241/ 27, 33 I.L.M. 1328.

Warren, A. 2010. Sustainability in aeolian systems. Aeolian Research, 1(3-4): 95-99.

Wischmeier, W.H., Smith, D.D. 1958. Rainfall energy and its relationship to soil loss. Transactions-American Geophysical Union. 39(2): 285–291.

Wischmeier W.H., Smith D.D. 1965. Predicting Rain-fall Erosion Losses from Cropland East of the Rocky Mountains. Agricultural Handbook No. 282, USDA, Washington, D.C.

Wischmeier, W.H., Smith., D.D. 1978. Predicting rainfall erosion losses. A Guide to conservation planning. United States Department of Agriculture. Agricultural Research Service (USDA-ARS) Handbook, No. 537. United States Government Printing Office, Washington. DC.

Youssef, F. 2012. Effect of vegetation cover and transitions on regional wind erosion in drylands. Doctorate thesis, Wageningen University, Wageningen, NL. ISBN 978-94-6173-342-9. pp. 138.

Youssef, F., Visser, S., Karssenberg, D., Bruggeman, A., Erpul, G. 2012a. Calibration of RWEQ in a patchy landscape; a first step towards a regional scale wind erosion model. Aeolian Research, 3(4): 467-476.

Youssef, F., Visser, S., Karssenberg, D., Erpul, G., Cornelis, W.M., Gabriels, D., Poortinga, A. [2012b], The effect of vegetation patterns on wind-blown mass transport at the regional scale: A wind tunnel experiment. Geomorphology. 159-160, 178-188.

Yüksel, A., Akay, A.E., Gundogan, R., Reis, M., Cetiner, M. [2008], Application of GeoWEPP for determining sediment yield and runoff in the Orcan Creek Watershed in Kahramanmaras, Turkey. Sensors 8: 1222–1236.

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Hydrological design of contour bund and contour trench in Khalikani watershed of Odisha

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ABSTRACT

A study was undertaken to carry out the hydrological design of contour bund (CB) with surplus weir (SW) system and continuous contour trench (CCT) to reduce surface runoff and soil loss in Khalikani watershed of Odisha. One day maximum rainfall of 183.25 mm predicted by the best fit Generalized Pareto Distribution at 5 years return period was used to compute the surface runoff by SCS curve number method and the values for up and medium arable land were obtained to be 140.2 and 128.4 mm, respectively and that for non-arable forest land was 108.4 mm. The above computed surface runoff values were used for the hydrological design of CCT in non-arable forest land and CB with SW system for arable up and medium land conditions. The study revealed that for arable upland, design dimensions of CB are: top width = 45 cm, height of bund = 1.04 m, base width = 3.57 m, side slope = 1.5 : 1 and should be laid at horizontal interval (HI) of 30.5 m and vertical interval (VI) of 1.53 m. Similarly, for arable medium land, design dimensions of CB are: top width = 45 cm, height of bund = 0.59 m, base width = 2.22 m, side slope = 1.5: 1 and should be laid at HI of 91.5 m and VI of 0.915 m. Design dimensions of CCT (rectangular size) for non-arable forest lands are: width of trench = 90 cm and depth = 60 cm and should be laid at HI of 5.0 m and VI of 1.0 m. Moreover, it was observed that a waste/surplus weir of length 1.82 m with depth of weir (rectangular) of 25 cm above the top of CB is required to dispose off peak runoff from arable upland whereas in arable medium land, no such weir is required.

Key words: Contour bund, Contour trench, Hydrologic design, Runoff, Probability

INTRODUCTION

Soil and water are the two important natural resources which are highly essential for agricultural production. The net productivity of crops depends on proper management and utilisation of these vital resources. Uneven distribution of rainfall and absence of suitable soil and water conservation structures cause great loss to crop production in upland of watershed due to water scarcity problem and in lowland due to water impounding conditions. Land degradation, particularly in watersheds together with pressure of ever growing demands for food, fuel and fibre has further aggravated the situation by increasing the needs for intensive cultivation. Degraded lands in the watersheds are characterised by their low productivity potential due to various kinds of constraints related to rainfall management, soil, topography and biotic interference.

Construction of rainwater harvesting structures, contour bunds (CB), contour trenches, earthen embankments, masonry check dams etc. are some of the important activities undertaken in watershed development programs. Contour trench is one of the most efficient technologies for restoration of degraded lands which brings desirable changes through *in-situ* conservation of soil moisture and nutrients. Contour trench in non-arable uplands and barren hillocks forms the most important measure and is given the highest priority for treatment of sloping lands in watershed rehabilitation programs (Samra *et al.*, 2004; Mishra *et al.*, 2006; Kurothe *et al.*, 2012). CB is another important soil and water conservation measures adopted mostly in areas where sheet and rill erosion are prevalent. It is generally adopted in medium sloppy lands with slope less than 5 percent. It is practised in medium depth of soil

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falling under land class IV. In order to protect CB from breaching, surplus weir above CB is required to drain the excess rainwater (Mishra *et al*., 2006).

A number of agencies are engaged in implementing the construction of different soil and water conservation structures including contour trench and contour bund in watershed. However, these structures are constructed in massive scale in large number of watersheds without any scientific design. Most of the times, the soil and water conservation structures constructed with huge investments and labour fail during the flash floods because of under as well as inaccurate design. Hence, it is imperative to undertake scientific design of these structures taking into account the soil, topography, climate etc. For hydrologic design of soil and water conservation structures like contour bund, counter trench, spillways of different water harvesting etc., analysis of one day maxium rainfall is of great importance (Ravi Babu *et al*., 2006). The analysis of rainfall data for the prediction of expected rainfall at a given return period is commonly done by utilising different probability distribution functions (Kumar, 1999; Ravi Babu *et al*., 2006). For design of soil and water conservation structures, reliable estimate of surface runoff from a watered is very much essential (Singh *et al*., 1994). Soil Conservation Service-Curve Number (SCS-CN) method is accepted these days as a reliable method for estimation of runoff from small agricultural watersheds. Mishra *et al.* (2005) investigated the applicability of SCS-CN method for the estimation of runoff in laterite zone of West Bengal based on daily total rainfall of two watersheds.

In the present study, one day maximum rainfall was predicted by fitting 12 probability distribution functions i.e. (i) Normal, (ii) Log Normal (2-p), (iii) Log Normal (3-p), (iv) Gamma (v) Extreme value (maximum), (vi) Extreme value (minimum), (vii) Exponential, (viii) Pearson, (ix) Log Pearson, (x) Extreme value type III, (xi) Generalised extreme value and (xii) Generalised Pareto distribution through a software called as FLOOD and predicting the event by the best fit distribution as decided by five statistical tests *i.e.* chi-square, mean absolute relative error (MARE), root mean square error (RMSE), model efficiency (ME) and coefficient of determination (CD) at desired return period of 5 years. This predicted rainfall was used to compute the runoff for non-arable upland (forest land) and arable up and medium land of the watershed by SCS-CN method. The so predicted runoff values were utilised to design the contour trench for non-arable forest lands and contour bund with surplus weir system for arable up and medium land in Khalikani watershed.

MATERIALS AND METHODS

Watershed and Data Collection: The present study was undertaken in Khalikani watershed of Bolangir district of Odisha. The latitude, longitude and altitude of the watershed area varies from 20^0 38′ 30" N to 20^0 39′ 30" N, $83^0$26′ E to $83^0$26′ 30" E and 215 to 360 m, respectively. Average annual rainfall is 1588 mm. Average maximum and minimum temperatures are 45.3 and 11.8^{0}C, respectively. Relative humidity ranges from 72 to 82% in rainy season and 38 to 70% in remaining months. Crops grown in the area are mainly rice followed by pulses.

The major soil types of the study area red (alfisols), laterite and lateritic (ultisol and oxisol) with limited patches of forest humus soil. About 41% of soils are acidic, 47% are neutral and rest are alkaline in reaction. The area is composed of undulating topography of high ridges and low vallies. The watershed is surrounded by hillocks and forest area which contributes to the internal drainage system of the project area. The general drainage pattern is dendrites. Crop production in the watershed is entirely dependent on rainfall. Rainfall distribution in the area is very much erratic and uneven which causes drastic yield reduction of crops. At times, there is *in-situ* drought and flood which also hampers crop production. High velocity of water flowing over the sloppy land in the watershed also causes severe soil and water erosion. There is no scope of irrigation except conservation and management of excess rainfall in different soil and water conservation structures. Methodologies adopted for design of continuous contour trench (CCT) and contour bund (CB) with surplus weir (SW) are employed by the following steps as mentioned below.

Prediction of One Day Maximum Rainfall: Daily rainfall data of 24 years (1986-2009) of the watershed was collected from the meteorological station located in the vicinity of the watershed which gave one day maximum value for each year. These data were used to predict one day maximum rainfall by fitting 12 probability distribution functions as mentioned earlier through software FLOOD. Five statistical tests as presented earlier were employed to find out the best fit distribution out of the tested 12 distributions. Table 1 represents the estimated values of different statistical test parameters. Observed values of daily maximum

Table 1. Statistical parameters for best fit probability distribution function

Distribution	Chi-square	MARE	ME	RMSE	CD
Normal distribution	3.42	0.046	0.967	7.67	0.72
Log normal (2-p) distribution	2.66	0.049	0.981	6.07	0.83
Log normal (3-p) distribution	2.76	0.038	0.977	6.48	0.76
Gamma distribution	3.49	0.053	0.973	7.15	0.77
Extreme value (max) distribution	5.09	0.064	0.961	8.43	0.69
Extreme value (min.) distribution	9.30	0.072	0.919	12.09	0.69
Exponential distribution	5.32	0.053	0.953	9.21	0.65
Extreme value (Type III) dist.	2.22	0.035	0.980	5.96	0.76
Log Pearson distribution	2.58	0.039	0.978	6.30	0.74
Pearson distribution	1.58	0.034	0.987	4.78	0.82
GEV distribution	2.43	0.039	0.980	6.03	0.75
Generalized Pareto distribution	0.89	0.022	0.990	3.96	0.94

rainfall at 10 to 90% PE levels were predicted by Weibull's distribution. The value predicted at 50% PE level by Weibull's distribution is considered as the mean of the observed data. The study revealed that Generalised Pareto distribution (GPD) was the best fit distribution and hence using this distribution, values of one day maximum rainfall was predicted at different probability of exceedence (PE). Since small water harvesting structures are designed at 20% PE level, one day maximum rainfall at 20% PE level was predicted by the above mentioned best fit distribution which was 183.3 mm.

Prediction of Surface Runoff by SCS-CN Method: As suggested by (Panigrahi, 2011), SCS-CN method also called as US Soil Conservation Service (SCS) method was used to predict the daily surface runoff for non-arable upland (forest land) and arable up and medium land. The values of curve number at antecedent moisture condition (AMC II) i.e. CN_2 depends on land type, land cover, treatment practice, hydrologic soil condition and hydrologic soil group. For Khalikani watershed, the values of CN_2 for arable up lands is 75 and that of arable medium lands and non-arable upland (forest land) are 71 and 66, respectively. Using the above mentioned values of CN_2 and following the suggestions and procedures as proposed by Panigrahi (2011), values of surface runoff (for rainfall value of 183.3 mm) for non-arable forest land, arable up and medium lands of Khalikani watershed are found to be 108.4, 140.2 and 128.4 mm, respectively. These obtained values of surface runoff were used for design of CCT and CB.

Design of Continuous Contour Trench (CCT): The upper reaches of the watershed is forest with non-arable upper lands having average slope of 20 percent. The land has no protective bund and has a poor pasture cover. The uncontrolled runoff from these areas cause extensive damage to the adjoining arable lands situated below. Hence, primary focus must be given to arrest soil erosion in these areas first with proper structural measures. As suggested by Kurothe *et al.* (2012) and Mishra *et al.* (2006), CCT is suggested as the right soil conservation measures in such type of areas. CCT refers to the excavation of a long and narrow trench along the contour; the soil dug during the construction of the trench is used as a bund on the down slope side. Design dimensions of CCTs (rectangular size) to handle the estimated runoff were found out using the formula (Tideman, 1996) as:

$$Q \times HI = W \times D \quad (1)$$

Where, Q = Surface runoff (m) predicted by the SCS-CN method for non-arable forest land as discussed above i.e. 108.4 mm = 0.1084 m; HI = Horizontal interval between two successive contours (m); W = Width of trench (m) and D = Depth of the trench (m).

The value of HI between the two successive contour lines for the study site was found to be 10 m using the generalised relationship for high rainfall areas as suggested by Tideman (1996). The vertical interval (*VI*) was then calculated by the equation as:

$$VI = (S \times HI)/100 \quad (2)$$

Where, *VI* and *HI* are vertical and horizontal intervals, respectively (m) and *S* is land slope (20%).

Depth of CCT was set equal to the depth of available cut of the soil (Kurothe *et al.*, 2012; Samra *et al.*, 2004). Since, the soil of the proposed site where CCTs were to be constructed was medium to deep with depth of maximum available cut was about 60 cm, the depth of the CCTs in the study was assumed as 60 cm. After fixing the depth of trench, *HI* and surface runoff, the width of the trench was calculated by Eqn.(1). After fixing the design dimensions, the volume of earthwork involved per hectare of land was estimated.

Contour Bund and Surplus Weir: Contour bund (CB) is the appropriate structure to be constructed in soils having medium to low slope (usually up to 5%) where sheet and rill erosion is prevalent. It can be constructed both in upland and medium land (Mishra *et al.*, 2006). Since the arable upland and medium land of the Khalikani watershed have 5 and 1% slope, respectively, CB was taken as the appropriate soil conservation measure. Design of CB involves determination of spacing between the bunds, dimensions of the bunds and that of the surplus weir (SW) required disposing off the excess runoff from the land. Value of VI between two successive CBs for both arable up and medium lands was worked out by generalised relationship for high rainfall areas as suggested by Tideman (1996). As the soil was sandy loam with moderate infiltration capacity, an extra spacing of 25% was added to the value of VI as worked out above for both arable up and medium lands (Singh *et al.*, 1994). HI for above mentioned two cases was worked out by Eq. (2). VI and HI for arable upland are found to be 1.525 m and 30.5 m, respectively. Similarly these values for arable medium lands are found to be 0.915 m and 91.5 m, respectively. Length of the CCB per hectare was worked out by dividing the area with values of HI.

Depth of impounded water against the CB is estimated by the formula (Singh *et al.*, 1994) as:

$$h = \left(\frac{Q \; x \; VI}{50} \right)^{1/2} \qquad (3)$$

Where, h = Depth of impounded water against CB (m), Q = Surface runoff (m) predicted by SCS-CN method which is 140.2 mm = 0.1402 m for arable upland and 128.4 mm = 0.1284 m for arable medium land, respectively and *VI* = vertical interval (m) which is 1.525 m for arable upland and 0.915 m for arable medium land, respectively.

In the design of CB, the bund side slope and gradient of the seepage line through the CB were assumed as 1.5:1 (horizontal: vertical), respectively based on the texture of the soil. CBs were assumed to have trapezoidal section. Top width of CB was assumed 45 cm as commonly adopted in the construction of the structure by department of Soil Conservation. As CBs require protection from excess rainfall, SWs are required to be incorporated in design of the CBs for disposing the excess rainfall safely. It was assumed that the crest of the SW would be maintained at a height equal to the depth of water impounding against the CBs as calculated by Eqn. (3). Assuming that SW is provided at the lowest place in the watershed area, where water stagnation is expected due to deviation of CB to conform to field boundary, maximum length of flow, total fall in the catchment of bund, time of concentration and time to peak were estimated. Using information from toposheet of watershed and knowing bund catchment area and time to peak, peak flow rate was estimated. Time of concentration *(T_c)*, considering the overland flow and time to peak were calculated as suggested by Haan *et al.* (1982). Considering 1 ha area of the watershed for which CB and SW are to be designed, the peak flow rate was computed as:

Q_p = (Area of the watershed x surface runoff generated in the watershed)/ time to peak (4)

In Eqn. (4), Q_p is in cumec, area is in m^2, surface runoff is in m and time to peak is in sec.

The available storage area against CB was computed taking into the account the length of spread of water and depth of water impounding against the CB (*h*) as calculated by Eqn. (3) as:

Available storage area = ½ x h x (100/S) x h (5)

Where, available storage area is in m^2, *h* is in m and *S* is land slope in percent.

The storage capacity of CB is given as the product of available storage area (calculated by Eq. 5) and length of CB per ha area. It was assumed that there was no stored water behind the CB before occurrence of peak rainfall. Time required to fill up the storage capacity of the CB was worked out by dividing the storage capacity of CB with peak flow. Thereafter, the excess volume of water to be removed and time required for its disposal was found and then the design rate of flow through the SW was worked out. The depth of flow over the crest of SW is assumed as 25 cm and then using standard rectangular weir formula, crest length of SW was computed. Height of the CB was computed as sum of values of depth of water impounding against CB, free board an depth of flow over the crest of SW. Free board was taken as 20% of depth of water impounding against CB. After ascertaining the height, side slope and top width of CB, the base width of the CB was worked out. Now with the known dimensions, the cross sectional area of CB was calculated and the volume of earthwork involved per hectare of land was estimated.

RESULTS AND DISCUSSIONS

Design of CCTs: The value of *VI* between the two successive contour lines for the study site was found to be 1 m using the generalised relationship for high rainfall areas as suggested by Tideman (1996). Since the land has slope of 20%, the value of HI was obtained as 5 m using Eqn. (2). Depth of the trench was assumed as 0.6 m. Width of the trench was computed by Eqn.(1) and obtained as 0.9 m.. Thus, the study revealed that in non-arable forest land in the Khalikani watershed, CCTs should be constructed with cross sections of 90 cm x 60 cm (width and depth, respectively) with *VI* of 1 m and *HI* of 5 m. In order to calculate the volume of earth work per hectare, the field was assumed as square (100 m x 100 m) for simplicity in calculation. The number of trenches was computed by dividing the length of the field with *HI* and the value was found to be 20. Thus, 20 trenches, each of length 100 m and cross section 90 cm x 60 cm per hectare of land are required. Volume of earth work for 20 trenches covering an area of 1 ha was worked out to be 1080 m^3. The design dimensions of CCTs in the area are presented in Table 2.

Table 2. Design dimensions and volume of earth work of continuous contour trench

Parameters	Specification/details
Slope of the area	20 percent
Vertical interval	1 m
Horizontal interval	5 m
Dimensions of CCT (assuming square field)	
(i) Length	100 m
(ii) Width	0.9 m
(iii) Depth	0.6 m
Number of lines/ha	20
Volume of earth work per one CCT and per ha area	54 m^3 and 1080 m^3, respectively

Design of CBs and SW in Arable Upland: Contour bunds were constructed in both arable up and medium lands. The average land slope of arable upland was 5%. The values of VI and HI were worked out to be 1.525 m and 30.5 m, respectively. For computational purpose, let us consider a field of area 1 hectare where the CBs and SW are to be constructed. The length of bund per hectare was calculated as 328 m. The value of surface runoff for arable upland is earlier reported as 140.2 mm which was used for design of CBs and SW. Depth of impounded water against the CB is estimated as 0.66 m. Considering free board of 20%, the maximum impounding depth was fund to be 0.79 m. The maximum length of flow from the catchment of the bund was estimated at 359 m. Time of concentration and time to peak was computed to be 26.35 and 55.8 min, respectively. The peak flow rate from 1 hectare area was worked out as 0.42 cumec =1505 m^3/hr. Available storage area was computed as 4.29 m^2 and the storage capacity of the bund was worked out at 1407 m^3. Time required to fill up the storage capacity of 1407 m^3 of the CB was found to be 56.1 min. Thus, the balance amount of 98 m^3 (1505 – 1407 = 98) is to be disposed off in 3.9 min (60 – 56.1 = 3.9) which gives a value of 25.13 m^3/min = 418.8 lit/sec as the design discharge rate through the SW. Assuming the depth of flow over the crest of SW as 25 cm and using Eqn. (8), length of crest of the SW was calculated as 182 cm = 1.82 m.

Total height of the CB is calculated as sum of the values of depth of water impounding against the CB + free board + depth of flow over the crest of SW and was computed as 1.04 m. With consideration of 45 cm top width, side slope 1.5:1 and total height of CB as 1.04 m, the base width was worked out to be 3.57 m. With the above dimensions, the cross sectional area of CB and the total volume of earth work for an area of 1 ha were worked out to be 2.09 m^2 and 685.5 m^3, respectively. The design dimensions of CB and SW are presented in Table 3. In the present practice, the cross sections

Table 3. Design dimensions of contour bund and surplus weir

Parameters	Specification/details for land types	
	Arable upland	Arable medium land
Slope of the area	5 percent	1 percent
Vertical interval	1.525 m	0.915 m
Horizontal interval	30.5 m	91.5 m
Top width of CB	0.45 m	0.45 m
Base width of CB	3.57 m	2.22 m
Depth of water impounding against CB	0.66 m	0.49 m
Depth of SW	0.25 m	No SW required
Free board	0.13 m	0.10 m
Total height of bund (6) + (7) + (8)	1.04 m	0.59 m
Height of crest of SW above CB	0.66 m	No SW required
Side slope of CB (H:V)	1.5:1	1.5:1
Cross sectional area of CB	2.09 m^2	0.79 m^2
Volume of earth work of CB per ha area	685.5 m^3	158.8 m^3
Depth of SW including free board	0.35 m	No SW required
Length of crest of SW	1.82 m	No SW required

of the CB in arable upland in the watershed vary from 0.8 to 1.25 m^2 which is inadequate to accommodate the runoff. It is suggested that the above mentioned design dimensions of CB and SW can be safely used in Khalikani watershed as an important soil and water conservation structure.

Design of CBs and SW in Arable Medium Land: The average land slope of arable medium land was 1%. The values of VI and HI were worked out to be 0.915 m and 91.5 m, respectively. Considering 1 ha field area, length of bund per hectare was calculated as 109 m. The value of surface runoff for arable medium land was calculated as 128.4 mm which was used for design of CBs and SW. Depth of impounded water against the CB is estimated to be 0.49 m and with consideration of free board of 20%, the maximum impounding depth is worked out to be 0.58 m. The maximum length of flow from the catchment of the bund was estimated as 201 m. Time of concentration and time to peak were computed to be 38.4 and 71.0 min, respectively. The peak flow rate from 1 ha area was worked out as 1085 m^3/hr. Available storage area was computed as 12.0 m^2 and the storage capacity of the bund was worked out at 1308 m^3. Since, available storage capacity is more than peak flow rate, there is no need to have SW in the CB of arable medium land. In this case, total height of the CB is calculated as sum of the values of depth of water impounding against the CB + free board and is computed as 0.59 m. With consideration of 45 cm top width, side slope 1.5:1 and total height of CB as 0.59 m, the base width was worked out to be 222 cm = 2.22 m. With the above dimensions, the cross sectional area of CB and the total volume of earth work for an area of 1 ha were worked out to be 0.79 m^2 and 158.8 m^3, respectively. Table 3 represents the design dimensions of CB for arable medium land.

CONCLUSION

One day maximum rainfall of 183.25 mm predicted by Generalized Pareto Distribution at 5 years return period was used to compute surface runoff by SCS curve number method. The values of surface runoff for non-arable up land was computed as 108.4 mm and that for arable up land and medium land were obtained as 140.2 and 128.4 mm, respectively. The above computed surface runoff values were used for hydrological design of CCT in non-arable upland and CB with SW system for arable up and medium land in Khalikani watershed. Design dimensions of CCT for non-arable uplands are worked to have width of 90 cm and depth 60 cm and are to be laid at *HI* of 5.0 m and *VI* of 1.0 m. Design dimensions of CB for arable upland are: top width = 45 cm, height = 1.04 m, base width = 3.57 m, side slope = 1.5 : 1 and should be laid at *HI* of 30.5 m and *VI* of 1.53 m. Similarly, for arable medium land, design dimensions of CB are: top width = 45 cm, height = 0.59 m, base width = 2.22 m, side slope = 1.5: 1 and should be laid at *HI* of 91.5 m and *VI* of 0.915 m. SW of length 1.82 m with depth of weir of 25 cm above the top of CB is required to dispose off peak runoff from arable upland whereas in arable medium land, no such weir is required.

REFERENCES

Haan, C.T., Johnson, H.P.and Brakensick, D.L. 1982. Hydrologic Modeling of Small Watersheds. American Society of Agricultural Engineers, St. Joseph.

Kurothe, R.S., Vishwakarma, A.K., Sena, D.R., Kumar, G., Rao, B.K. and Pande, V.C. 2012. Decision support system for contour trenching. *In:* Natural Resources Conservation: Emerging Issues and Future Challenges, Edited by M. Madhu, P. Jakhar, P.P. Adhikari, H. Gowda, V.N. Sharda, P.K. Mishra and M.K. Khan. Satish Serial Publishing House, Delhi.

Laogue, K.M. and Green, R.E. 1991. Statistical and graphical methods for evaluating solute transport models. Journal of Contaminant Hydrology, Vol. 7: 51-73.

Mishra, P., Mazumdar, A.,and Ravi Babu, R. 2006. Application of probability analysis of rainfall for design of continuous contour trenches, contour bund and waste weirs in Bankura. Journal of Agricultural Engineering. Vol. 43(4): 22-27.

Mishra, P., Mazumdar, A.,Roy, D and Ravi Babu, R. 2005. Application of SCS-CM model for runoff estimation in laterite zone of West Bengal using daily total rainfall. Journal of Interacademecia.

Nash, J.E. and Sutcliffe, J.V. 1970. River flow forecasting through conceptual model: Part I. A discussion of principles. Journal of Hydrology, Vol.10: 282-290.

Panigrahi, B. 2011. Irrigation Systems Engineering. New India Publishing Agency, New Delhi.

Ravi Babu, R., Mishra, P., Mazumdar, A and Roy, D. 2006. Probability analysis of rainfall of Bankurafor design of soil and water conservation structures. Journal of Agricultural Engineering. Vol. 43(1): 22-29.

Samra, J.S., Chandra Prakash, S.G. and Raizada, A.2004. Technical Manual on Contour Trenching for Rehabilitation for Degraded Lands. Published by the Director, CSWCRTI, Dehradun.

Singh, G., Venkata, R.C., Sastry, G. and Joshi,B.P.1994. Mannual of Soil and Water Conservation Practices. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.

Tideman, E.M. 1998. Watershed Management-Guidelines for Indian Conditions. Omega Scientific Publishers, New Delhi.

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Soil health and water quality problems by inorganic pollutants and their remedial measures

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ABSTRACT

Inorganic chemical contamination has become a widespread phenomenon and the problem attains greater significance due to its persistence in soil for longer period. The soil is a primary recipient by design or accident of a myriad of waste products and chemicals used in modern society. Every year millions of tons of products from variety of sources – industrial, domestic and agricultural find their way into the world's soils. Once these materials enter the soil, they become part of the biological cycles that affect all forms of life. Soil act as a physical filter by its sieving action, chemical filter by adsorbing and precipitating the chemical substances and a biological filter by decomposing organic materials. But, owing to non-judicious use of manures, fertilizers, pesticides and waste materials into the soils, ground and surface waters get contaminated by excess quantities of nutrients, heavy metals and pollutants. As per an estimate of United Nation Environment Programme (UNEP), 2 billion hectares of land that was once productive has been irreversibly degraded in the past 100 years due to contamination and inaccessibility. Extent of water pollution depends on the solubility of contaminants, size of the contaminants and soil type. Inorganic contaminants such as arsenic, nickel, selenium, zinc, nitrogen and lead are proving quite hazardous for plant and animal health due to bioaccumulation and subsequent biomagnifications in the food web. In order to reduce the impact of inorganic chemical contaminants on human health by preventing their transfer to the food web, there is an urgent need to reduce their transfer to agricultural plants. In view of above facts, an attempt has been made to review the sources of inorganic contaminants, potential hazards and remediation of contamination in the present text.

Keywords: Inorganic chemical contaminants, health hazard, pollutants, amelioration of soil and water

INTRODUCTION

Inorganic chemical contaminants enter into the soil or water either through pedogenic or anthropogenic or both pathways. If parent materials of the soil have higher concentration of heavy metals or pollutants then certainly the developed soils and water bodies of nearby area will have higher concentration of inorganic chemical contaminants. Industrialization, faulty method of waste disposal, faulty agricultural practices, mining of minerals and unscientific drainage of effluents are few important anthropogenic sources of chemical contaminants. The toxicity of inorganic contaminants released into environment every year is now estimated to exceed that from organic and radioactive sources combined. The greatest problems most likely involve arsenic, lead, mercury, cadmium, nickel, copper, zinc, chromium, molybdenum, manganese, selenium, fluoride and boron (Kabta-pendia and Pendias, 1992). To greater and lesser degree, all of these elements are toxic to humans and animals. Cadmium and arsenic are extremely poisonous; lead, mercury, nickel and fluoride are moderately so; boron, copper, manganese and zinc are relatively lower in mammalian toxicity (Moore and Ramamoorthy, 1984). Table 1 provides background information on the uses, sources and effect of some of these elements.

Irrespective of their sources, toxic elements can and do reach the soil, where they become part of the food chain : Soil→ Plant→Animal→ Human

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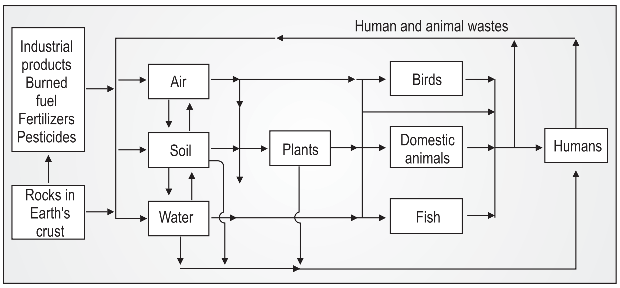
Table 1. Sources and human health effects of inorganic soil pollutants

Chemicals	Major uses and sources of soil contaminants	Organisms principally harmed	Human health effects
Arsenic	Pesticides, animal feed additives, coal, petroleum, irrigation water, plant desiccants, detergent	H,A,F,B	Cancer, skin lesions, cumulative poison
Lead	Combustion of oil, gasoline and coal, steel and iron production, solder in water pipes, paint pigment	H,A,F,B	Brain damage, convulsions
Cadmium	Electroplating, pigments for plastic and paints, plastic stabilizers, batteries and phosphate fertilizers	H,A,F,B, P	Heart and kidney disease, bone embrittlement
Chromium	Stainless steel, chrome plated metals, pigments, leather tanning and refractory brick manufacture	H,A,F,B	Mutagenic
Copper	Fly ash, fertilizers, wind-blown copper containing dust, water pipes and mine tillage	F,P	Rare, essential nutrients
Mercury	Pesticides, catalyst for synthetic polymers, metallurgy and thermometers	H,A,F,B	Nerve disease
Nickel	Combustion of coal, gasoline and oil, alloy manufacture, electroplating, batteries and mining	F,P	Lung cancer
Selenium	High se geological formation and irrigation water containing high content of se	H,A,F,B	Rare, loss of hair and nail, deformities
Zinc	Galvanized iron and steel, alloys, batteries, brass, rubber manufacture, mining and old tires	F, P	Rare, essential nutrients

H = Human, A = Animals, F = Fish, B = Birds, P = Plants
Source : Brady and Well (2007)

(Fig. 1). Unfortunately, once the elements become part of this cycle, they may accumulate in animal and human body to toxic levels. This situation is especially critical for fish and other wildlife and for human at the top of the food chain. It has already resulted in restrictions on the use of certain fish and wildlife for human consumption. Also, it has become necessary to curtail the release of these toxic elements in the form of industrial waste.



Permissible limits of heavy metals in soil food and drinking water

Heavy metals entered into living bodies depletes some essential nutrients that are further responsible for decreasing immune biological defenses, intrauterine growth retardation, impaired psychosocial faculties, disabilities associated with malnutrition and high prevalence of upper gastrointestinal cancer rates (Singh, 2011). Serious systemic health hazards can develop as a result of extreme dietary accumulation of heavy metals. Permissible limits of heavy metals in soil, food and drinking water reported by Awasthi (2000) are presented in table 2.

Table 2. Indian standards for heavy metals in soil, food and drinking water

Heavy metal	Soil (mg Kg^{-1})	Food (mg Kg^{-1})	Water (mg L^{-1})
Cd	3-6	1.5	0.01
Cr	-	20	0.05
Cu	135-270	30	0.05
Fe	-	-	0.03
Ni	75-150	1.5	-
Pb	250-500	2.5	0.10
Zn	300-600	50	5.00
As	-	1.1	0.05
Mn	-	-	0.10

Potential of wewage-sludge to cause chemical hazards

Application of sewage and sludge in soil for crop production is quite common practice adopted by the farmers in India and abroad. It has been concluded on the basis of data presented by Juwarker *et al.* (1991), and Maiti *et al.* (1992) that high concentrations of heavy metals in untreated sewage-sludge cause chemical pollution in soil (Table 3). It has been reported by Taywade and Prasad (2008) that continuous supply of sewage water increases pollutant concentration in soil (Table 4). So, sewage should be applied in field for

Table 3. Regulatory limit and pollutant loading rates of heavy metals in sewage-sludge

Elements	Maximum concentration in sludge USEPA mg/kg	Heavy metals loading rate (mg/kg) in different cities				
		Delhi	Chennai	Nagpur	Ahmedabad	Jaipur
As	75	-	-	-	-	-
Cd	85	5.5	8.3	1.5	3.5	7.3
Cr	3000	53.5	38.5	49.2	60.4	176
Cu	4300	440	210	272	535	265
Hg	57	-	-	-	-	-
Mo	75	-	-	-	-	-
Ni	420	815	60.5	14.8	32.3	37.5
Pb	840	34.5	16.6	24.3	76.8	66.9
Se	100	-	-	-	-	-
Zn	7500	1610	935	832	2141	1720

USPEA = US environmental protection agency (1993)

Table 4. Availabilities of micronutrients and heavy metals of top soil (0-16cm) as affected by sewage irrigation for thirty years in Nagpur district of Maharashtra

Location	Irrigation status	Nutrient content (mg/kg)						
		Fe	Cu	Zn	Mn	Pb	Cr	Cd
Chafegadi	Non irrigated	9.87	1.97	0.25	12.04	0.13	0.018	0.012
	sewage irrigated	19.13	2.91	0.11	12.13	0.28	0.042	0.018
Kuhi	Non irrigated	9.36	2.20	0.14	9.45	0.93	0.018	0.016
	sewage irrigated	17.05	7.69	0.51	14.16	0.70	0.028	0.012
Asoli	Non irrigated	2.12	5.99	1.66	4.13	0.78	0.026	0.010
	sewage irrigated	8.54	8.22	6.11	24.44	2.01	0.030	0.040

agriculture purposes only after treatment with suitable amendment. It is pertinent to mention that in some of the cases inorganic chemicals are not sufficiently high to be toxic to the plants and living organisms but biomagnifications makes the concentration of heavy metal toxic to the living organisms.

Forms of heavy metals in soil

On the basis of experimental results it has been found that heavy metals are found in four major forms in our soil system. 1. Soluble or exchangeable forms, which are available to the plants for uptake. 2. the elements are bounded by the soil organic matter and may be released over a period of time. 3. Association of heavy metals in soils is with carbonates 4. Association of heavy metals in soils with oxides of iron and manganese.

Prevention and elimination of inorganic chemical contamination

Three primary methods of alleviating soil contamination by toxic inorganic compounds are: (1) to eliminate or drastically reduce the soil application of the toxins; (2) to immobilize the toxin by means of soil management, to prevent it from moving into food or water supplies; and (3) in the case of severe contamination, to remove the toxin by chemical, physical or biological remediation.

Reducing soil application

The first method requires action to reduce unintentional aerial contamination from industrial operations and from automobile, truck and bus exhausts. Anthropogenic activities including the indiscriminate dumping of urban and industrial effluents responsible for heavy metal accumulation in soil (Lal *et al.*, 2008) must be stopped or decreased soon. Also, there must be judicious reduction in intended applications of the toxins through chemical pesticides, fertilizers, irrigation

Table 5. Mineral amendments used for the reduction of heavy metals

Amendment	Metals immobilized
Al-Montmorillonite	Cd, Ni, Zn
Clinoptilolite	Cd, Pb, Zn
Di ammonium phosphate	Cd, Pb, Zn
Ferrous sulphate	As, Cr
Hydroxyappetite	Cd, Cu, Ni, Zn
Lime	Cd, Cu, Ni, Zn, Pb
Manganese oxide	Cd, Pb
Water treated sludge	Cd, Cu, Pb, Ni, Zn

water and solid wastes which is possible by popularizing bio-pesticides, bio-fertilizers and treatment of water and wastes by suitable materials. Inorganic amendments used for the reduction of heavy metals are presented in table 5.

Immobilizing the toxins

Soil and crop management can help to reduce the continued cycling of these inorganic chemicals. This is done primarily by keeping the chemicals in the soil rather than encouraging their uptake by plants. The soil becomes the sink for the toxins, and thereby breaks the soil-plant-animal cycle through which the toxins exert its effect. The soil breaks the cycle by immobilizing the toxins. For example, most of these elements are rendered less mobile and less available if the pH is kept near neutral or above (Ellior *et al.*, 1986). Draining of wet soils will be beneficial, since the oxidized forms of several toxic elements are generally less soluble and less available for plant uptake than the reduced forms. However, the opposite is true for chromium, which occur principally in two forms Cr^{3+} and Cr^{6+}. Hexavalent chromium forms compound that are mobile under a wide range of pH conditions and are highly toxic to humans. Trivalent chromium on the other hand forms oxides and hydroxides that are quite immobile except in very acid soil (Brady and Well, 2007). Fortunately, active soil organic matter is quite effective at reducing chromium (Lossi and Frankenberger, 1994).

Heavy phosphate applications reduce the availability of some metal cations but may have opposite effect on arsenic. Leaching may be effective in removing excess boron, although moving the toxin from soil to water, so bioremediation should be alone to save the human being from B toxicity. Covering of soil with unpolluted soil may be useful to reduce lead uptake by the plants.

Care should be taken in selecting plants to be grown on metal contaminated soil. Generally plants translocate much larger quantities of metals to their leaves than to their fruits or seeds (Dowdy *et al.*, 1994). So, leafy vegetable crops are not grown in this soil.

Bioremediation

Certain plants have been reported to accumulate heavy metals in considerably higher proportions without showing any toxicity symptoms (Beltagi *et al.*, 2002). Plants have been found that accumulate more than 20,000 mg/kg nickel, 40,000 mg/kg zinc and 1000 mg/kg cadmium. These hyper accumulating plants would pose a serious health hazards if consumed by animals or human beings. But, they may facilitate a new kind of bioremediation for metal contaminated soils because the traditional physico-chemical methods to clean up the polluted soils are typically cost-prohibitive and destructive (Patel *et al.*, 2005). Conclusively, it can be stated that a viable and remunerative option could be the cultivation of non-edible crops, which are economically remunerative as well, like cut flower, aromatic and medicinal plants etc. (Lal *et al.*, 2008).

Genetic and bioengineering techniques are being utilized to develop high yielding hyper accumulating plants that can remove larger quantities of heavy metals contaminating from soils. Also, research to insert genes responsible for contaminant accumulation into other higher yielding plants, such as canola and Indian mustard is underway.

A combination of chelates and phytoremediation has been used to remove lead from contaminated soil. Treatment of lead and arsenic contaminated water with harmless chelating legends may be useful for making the water usable and harmless.

Nano Particles

In situ stabilization by nano particles having low environmental impact is one of the most promising techniques. This technique is helpful in reducing the risk of ground water contamination, plant uptake of heavy metals, and exposure of other living organisms to heavy metal ions (Boisson *et al.*, 1999).

CONCLUSION

Inorganic chemical contamination in soil, water and food has now become a noticeable issue for thinkers, planners, politicians and scientists because it has started to cause human health hazard. Natural mechanisms governing the maintenance of the ecological and agricultural functions of soil are being jeopardized with the increase in soil contamination brought about by anthropogenic activities. This is very high time to understand about the sources of inorganic chemical contamination and to adopt the preventive or curative measures. Numerous organic materials or inorganic chemicals offer quick remediation of contaminated soil and water to reduce inorganic chemical contamination level in food plants and ultimately to save the humanity.

REFERENCES

Adejumo, S.A., Togum, A.O., Adediran, J.A. and Ogundiron, M.D. 2010. Effect of compost application on remediation and growth of maize planted on lead-contaminated soil. Soil Solution for changing world, *19th World Congress of Soil Science*, 1-6 August 2010, Brisbane, Australia.

Awasthi, S.K. 2000. Prevention of Food Adulteration Act no 37 of 1954. Central and State Rules as Ammended for 1999, Ashoka Law House, New Delhi.

Beltagi, M. S., Saleh, A. H. and El-Melelgy, S. A. 2002. Effect of paclobutrazol on Anaerobic capacities and electrophoteric protein pattern in peanut plant. *Pakistan J. of Biological Science*, 5 : 200-202.

Boisson, J., Ruttens, A., Mench, M. and Vangronsveld, J. 1999. Evaluation of hydroxyappatite as a metal immobilizing soil additive for the remediation of polluted soils. Part I. Influence of hydroxyl appatite on metal exchangeability in soil, plant growth and plant metal accumulation. Environmental pollution 104:225-233.

Brady, N. C. and Well, R. R. 2007. Soils and chemical pollution. In Nature and properties of soils. *Pearson Printice Hall Publication*. 812-855.

Dowdy, R. H., Clapp, C. E., Linden, D. R., Larson, W. E., Halbach, T. R. and Polta, R. C. 1994. Twenty years of trace metal partitioning on the rosemount sewage sludge watershed. *In C. E. Clapp, W. E. Larson and R. H. Powdy (eds.) Sewage sludge*. 149-155.

Elliot, H. A., Liberati, M. R. and Huang, C. P. 1986. Competitive adsorption of heavy metals in soils. *J. Environ. Qual.*, 15 : 214-219.

Juwarker, A. S., Juwarker, A., Desnbhratar, P. B. and Bal, A. S. 1991. Exploitation of nutrient potential of sewage and sludge through land application. In Asian experience in integrated plant nutrition. *FAO Publication*. pp. 178-201.

Kabata-pendias, A. and Pendias, H. 1992. Trace elements in soils and plants. *(Boca Ratan, Fla : CRC Press)*.

Lal, K., Minhas, P. S., Chaturvedi, P. K. and Yadav, R. K., 2008a. Cadmium uptake and tolerance of three aromatic grasses on the Cd-rich soil. *Journal of Indian Soc. of Soil Sc*. 56 (3) PP 290-294.

Lal, K., Minhas, P. S., Sipra, Chaturrvedi, R. K. and Yadav, R. K. 2008b. Extraction of Cadmium and tolerance of three annual cut flowers on the Cd-contaminated soil. *Bioresource Technology* 99 (3) : 1006-1011.

Losi, M.E.C.A. and Frankenberger, J. 1994. Bioremadiation of chromatic contaminated ground water by reduction and precipitation in surface soils. *J. Environ Qual*. 23:1141-1150.

Maiti, P. S., Sah, K. D., Gupta, S. K. and Banaryee, S. K. 1992. Evaluation of sewage sludge as a source of irrigation and manure. *J. of Indian Society of Soil Science*. 40:168-172.

Moore, J. W. and Ramamoorthy, S. 1984. Heavy metals in natural waters. (New York : Springer-verlag).

Patel, M. J., Patel, J. N. and Subramanian, R. B., 2005. Effect of cadmium on growth and activity of H_2O_2 scavenging emzymes in colocasia. *Plant and Soil*. 273 :183- 188.

Singh, B. 2002. Soil pollution and its control. In *Fundamentals of Soil Science. ISSS Publication*. 499-514.

Singh, A.P. 2011. Use of Ameliorants in metal-contaminated soils, *J. of Indian Soc. of Soil Sci*. 59: S74-S80.

Taywade, S. S, and Prasad, J. 2008. Characterization of sewage water irrigated and non irrigated soils in nag river ecosystem of Nagpur, Maharastra. *J. of Indian Soc. of Soil Sci*. 56 (3):247-253.

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Monitoring ecosystem of North Tripura using remote sensing techniques

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ABSTRACT

Land use / land cover being a critical component of ecosystem controls the interactions with the biosphere to provide the needful services to the mankind. Hence management of land use/ land cover is vital to sustain life support system. This dynamic attribute of earth could be monitored with modern tool such as remote sensing by virtue of its tremendous capabilities and compatibility with advanced computer system with multi-temporal data. IRS P6 and IRS LISS III data pertaining to 2005 and 2009 were used to study the land use/ land cover condition and overall biomass changes of North Tripura district, Tripura over a time-scale as shifting cultivation is a crucial factor in the north eastern region that governs the stability of ecosystem of the district. Supervised classification of digital image reveals that forest coverage of north Tripura district has been reduced from 50.2% to 40.8% whereas the extent of permanent agriculture land has been increased from 18.3% to 22.9% during2005 to 2009. The current jhum area has been reduced by 1% where abandoned jhum land is found almost static during the period. However, the declining trend of overall biomass from higher categories to lower categories as revealed from NDVI analysis portrays a clear picture of degradation of ecosystem. Such periodical monitoring using remote sensing and GIS will serve as a decision support system to manage the ecosystem effectively for better services to mankind.

Key words: Ecosystem, Land Use/ Land Cover, Jhum cultivation, Remote Sensing, NDVI

INTRODUCTION

Land use/land cover changes play an important role in the environmental processes and also act as a sensitive indicator for environmental and global changes (Van Wijngaarden 1991). Thus monitoring land use/land cover at certain periodicity may be a vital tool to monitor the ecosystem.

Traditional method to monitor the vegetation is by field investigation. It is low efficiency and high labor demanding, especially for large scale area, and impossible to conduct continuously investigation and that too for inaccessible area (Li et al. 2010).

Remote Sensing (RS) is nowadays, an advanced powerful monitoring tool for its convenience and high efficiency. Thereby, it has been widely employed to monitor the vegetation changes (Townshend et al. 1986; Al-Bakri et al 2003; Kotoky et al. 2012; Das et al. 2013; Rawat et al. 2013). Satellite remote sensing by virtue of tremendous capability in terms of synoptic view, multi-spectral sensing, multi-temporal data acquisition, real time data acquisition and computer compatibility serve as a potent tool to study the land resources of inaccessible terrain, mountains, hills and remote villages in the country from laboratory using image analysis system.

Vegetation coverage, leaf area index and vegetation index are the main indices of vegetation information. However vegetation coverage and leaf area index are often obtained based on vegetation index. Vegetation index is a simple numerical indicator, which can be derived directly from remote sensing image. NDVI is one of the most important and commonly used vegetation indexes, defined as follows:

$$NDVI = \frac{(NIR - RED)}{(NIR + RED)}$$

where RED is the reflectance in the red band and NIR is the reflectance in the near-infrared band.

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The RED and NIR band contain more than 90% of vegetation information (Baret et al. 1989). The NDVI can be derived from many different kinds of images, e.g. Landsat, Spot, IRS data etc. with different spatial and temporal resolution.

The paper deals with the land use/ land cover changes and overall changes of biomass in North Tripura district, Tripura by employing IRS LISS III and IRS P6 satellite data that would serve as indicators for monitoring the ecosystem.

Methodology

The North Tripura District lies between 23^0 36′ 26" to 24^0 34′ 22" North Latitude and 91^0 52′ 20" to 92^0 51′ East Longitude and covers an area of 210616 ha.The district is divided into three sub-divisions viz., Dharmanagar, Kanchanpur and Panisagar. Two hill ranges namelyJamui and Sakan run almost parallel to each other in the district. The district is drained by major rivers such as Deo, Mann, Longai and Juri. Forest is the dominant land use (122331 ha) where agriculture is confined to 73023 ha area in North Tripura (Anon 2012). The dominant forest species are Teak (Tectonagrandis); Gamar (Gmelinearborea) and Chamal (Artocarpus) besides numerous bamboo species (Bambusabalcooa; Bambusatulda; Bambusapolymerpha etc.). Paddy is the major agriculture crop with pulses, jute sugarcane at places. The traditional method of jhum cultivation is practiced in the district.

Digital image processing and analysis have been carried out covering the following steps:

- Selection of cloud free data through browsing website of NRSC (www.nrsc.gov.in)
- Procurement of multidate /multitemporal digital data (IRS-P6; LISS-III) from NRSC (Fig.1)

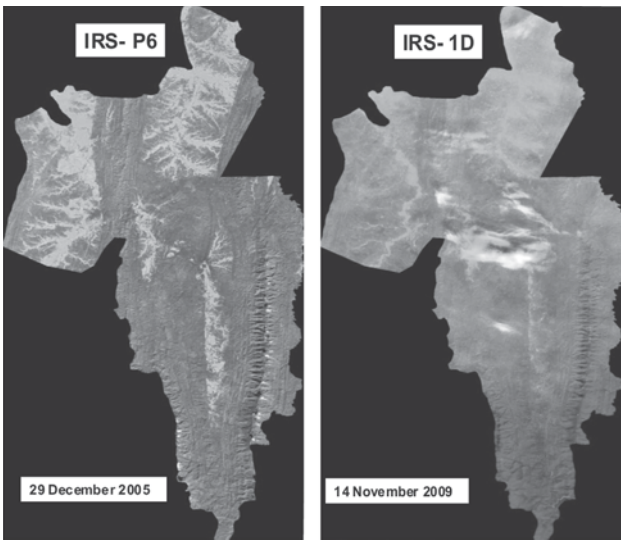

Fig. 1. Satellite imagery of North Tripura District, Tripura (2005 and 2009)

- Stacking of different layers (bands) to make a composite multi-spectral image using Layer Stacking commands of ERDAS IMAGINE 9.2 software.
- Scanning of SOI toposheets on 1:50000 scale to .tiff format
- Geometric correction of each SOI toposheet using 16 GCPs and GCS-Everest 1956, India (India, Nepal)
- Image to image rectification of re-projected 2005 and 2009 digital IRS data using rectified SOI topographical sheet as reference base
- Mosaicing of geo-rectified image of adjacent path and row
- Preparation of district shape file polygon vector layer of appropriate projection system
- Generation district AOI layer from district vector layer
- Preparation of district subset from district AOI layer
- Generation of un-supervised Classified images from district subset images for necessary Ground truth collection

Supervised classification

Supervised classification of digital satellite data pertaining to 2005 (IRS P6) and 2009 (IRS LISS III) have been carried out with following approach:

- Ground truth collection
- Supervised classification of summer images based on ground information
- Extraction of aerial expunge of shifting cultivation and permanent cultivation area
- Generation of statistics on different land use / land cover classes
- Generation of NDVI for evaluation of biomass content
- Change detection analysis (2005 and 2009) using NIR band and NDVI to evaluate the overall impact of vegetation index over a time span of 5 years

RESULTS AND DISCUSSION

The supervised classification of images (2005 and 2009) indicated that the area under shifting cultivation is decreasing at a very low pace and permanent cultivation area is increasing at a higher pace in North Tripura district during five years span. The area covered by abandoned Jhum and current Jhum land has decreased to 0.1% (2009) from 0.9% (2005). However, the extent of permanent agriculture land has comparatively increased to 22.9% (2009) from 18.3% (2005). Such increase may be due to stabilization of abandoned jhum land into permanent agriculture land. The only positive sign is that shifting cultivation practice has been discouraged by the state that would help to sustain the ecological balance. An inverse relationship noticed between jhum land and permanent agriculture land in north Tripura district, Tripura (Fig. 2, 3 and Table 1).

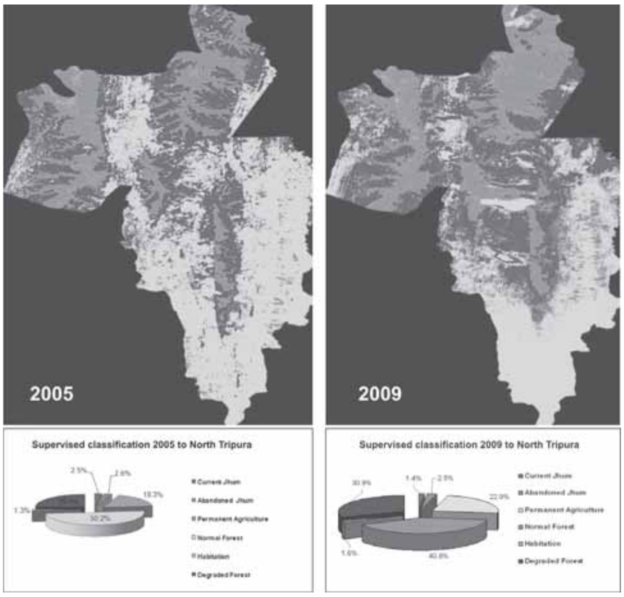

Fig. 2. Land Use/ Land Cover Changes during 2005 and 2009

Table 1. Land Use/ Land Cover Status of North Tripura

Land Use / Land Cover	2005		2009	
	Area (ha)	%	Area (ha)	%
Current Jhum	5203	2.5	3038	1.4
Abandoned Jhum	5495	2.6	5167	2.5
Permanent Agriculture	38440	18.3	48143	22.9
Forest	105394	50.2	85646	40.8
Habitation	2752	1.3	3260	1.6
Degraded Forest	52783	25.1	64811	30.9

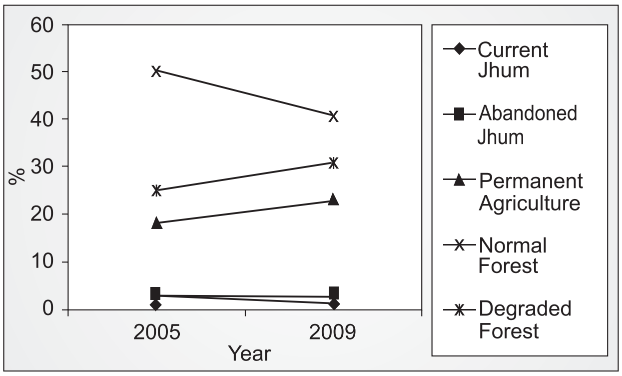

Fig. 3. Scenario of Current Jhum and Abandoned Jhum land during 2005 and 2009

It is seen that the extent of overall biomass classes under lower categories such as very low, low and medium have been substantially increased while extent under high and very high categories have declined steadily (Fig. 4, 5 and Table 2). These are all indicative of fragility in ecosystem due to changes of land use/ land cover during the span of five years. Remote sensing tool thus could be utilized to monitor the changes of land use/ land cover and overall changes of biomass to monitor the ecosystem of North Tripura to sustain agriculture growth and environmental security.

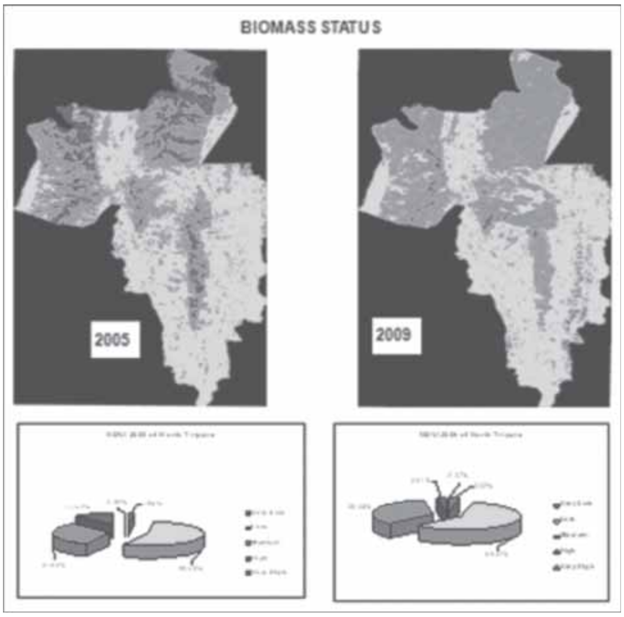

Fig. 4. NDVI analysis for Biomass change during 2005 and 2009

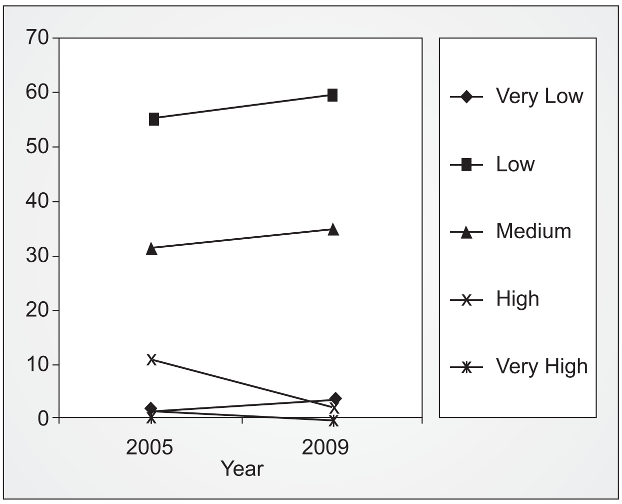

Fig. 5. Trend of Overall change of Biomass during 2005 and 2009 in North Tripura

Table 2. Statistics of Biomass Classes (NDVI) during 2005 and 2009

Biomass Class	Area(ha)	Area(ha)
	2005	2009
Very Low	3230	6343
Low	116271	124714
Medium	66430	73605
High	23261	5264
Very High	875	141
Total	210067	210067

CONCLUSION

Land use/ land cover change is one of the key indices to induce climate change. Degradation of land use/ land cover aggravate soil erosion and depletion of soil moisture condition that adversely impact soil biota and the ecosystem resulting depletion of soil productivity and agricultural production. Monitoring of land use/ land cover at certain time scale using remote sensing and GIS would allow to monitor the ecosystem that eventually will contain the adverse impact of climate change.

REFERENCES

Al-Bakri J T and Taylor J C, 2003. Application of NOAA AVHRR for monitoring vegetation conditions and biomass in Jordan, Journal of Arid Environments; 54, pp.579-593.

Anon, 2012. Ground Water Information Booklet, North Tripura District, Tripura; Technical Report Series: D , No. 56/2011-12; Central Ground Water Board, North Eastern Region, Ministry of Water Resources, Guwahati.

Baret F, Guyot G and Major D J, 1989. TSAVI: A vegetation index which minimizes soil brightness effects on LAI and APAR estimation. Proceedings of the 12th Canadian Symposium on Remote Sensing.Vancouver, Canada, 1989, pp. 1355-1358.

Das S. N and Saha S, 2013. Study of the shifting cultivation scenario of Aizwal district, Mizoram using remote sensing techniques, Jr. of Soil and Water Conservation, 12 (2), pp149-152.

Lie S and Bian Z, 2010. Analysis of Spatiotemporal Difference of NDVI in an Arid Coal Mining Region Using Remote Sensing, ISPRS TC VII Symposium – 100 Years ISPRS, Vienna, Austria, July 5–7, 2010, IAPRS, Vol. XXXVIII, Part 7A.

Kotoky P, Dutta M K and Borah G C, 2012. Changes in Land Use Land Cover along Dhansiri River Channel, Assam – A Remote Sensing and GIS Approach. Journal Geological Society of India, Vol. 79, January 2012, pp 61-68.

Rawat J S, Biswas Vivekananda and Kumar M, 2013. Changes in Land Use/ Cover using Geospatial Techniques: A Case study of Ramnagar Town Area, Uttarakhand, India; The Egyptian Journal of Remote Sensing and Space Science, Volume 16, Issue 1, Pages 111-116.

Townshend J R G and Justice C O, 1986. Analysis of dynamics of African vegetation using the NDVI, International Journal of Remote Sensing; 7, pp. 1224–1242.

Van Wijngaarden W, 1991. Thegreen cover of the Earth: a dynamic resource in a changing environment, ITC Journal; 3, pp.113–121.

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Estimation of runoff of Western Himalayan watershed using Remote Sensing and Geographical Information System

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ABSTRACT

Water is continuing one of the most critical resources for development. Surface runoff is the major input for soil erosion as well as surface water bodies like tanks and reservoir. Since most of Indian watershed are ungauged but estimation of depth and rate of runoff are the key parameters for management of watershed programme. Estimation of runoff is not help for designing the engineering structures within the watershed but also help in prioritization of sub watersheds within the watershed. In present study, Soil Conservation Service Curve Number (SCS-CN) method has been applied to asses the runoff of Badri Gad watershed of Uttarakhand India. The SCS curve number is widely accepted for estimation of runoff for ungauged watershed. Geographical Information System (GIS) and Remote Sensing (RS) used in the study area to create the database required for the preparation of most of the input data used in SCS-CN method. Annual runoff was calculated for 24 years period (1985 to 2008). It was observed that runoff varied from 2.03 to 27.30 per cent of the annual rainfall for the years 2001 and 1998, respectively. The average annual runoff was found to be 187.60 mm

Key words: Watershed, Ungauged, RS, GIS, Curve Number and runoff

INTRODUCTION

Himalayan region characterized by young fragile ecosystem, diminishing bio diversity, marginalized and resources poor inhabitants with inadequate infrastructural facilities. Most of the Indian hilly watersheds are ungauged hence could not get much attention of the researchers due lack of quality data. Moreover collection of data in such locations is tedious and difficult. Nowadays, watershed management is becoming a blue print for agricultural development in most parts of the country. Watershed management implies the proper use of all land and water resources for optimum production with minimum hazard to natural resources. The success of planning for developmental activities depends on the quality and quantity of information available on both natural and socio-economic resources. Remote Sensing and GIS are commonly used to get the reliable data base generation for devising the ways for optimal planning and management of watersheds.

Integrated use of remote sensing and GIS techniques can be used in runoff estimation, soil erosion assessment and watershed prioritization (Deshmukh et al. (2004). The input parameters, required for soil erosion modelling, can be generated by remote sensing. Geographical Information System helps in creating a database for the watershed, which is very much useful for carrying out spatial analysis thereby helping the decision makers in framing appropriate measures for critically affected area. Assessment of surface runoff is pre requisite for designing the different soil and water conservation measures within the watershed The Soil Conservation Service (now Natural Resources Conservation Service) Curve Number (SCS-CN) method (SCS, 1956) is one of the most popular method for computing depth of runoff for a given rainfall event from small agricultural, forest and urban watershed. This method is widely used foe estimating runoff of un gauged watershed Kavita et al. (2004), Amutha et al. (2009). The curve number method requires

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individual storm rainfall, land use type, hydrologic soil group and antecedent moisture condition of watershed as input.

MATERIALS AND METHODS

Study area

The study area is located in Narendra Nagar block of Tehri Garhwal district of Uttrakhand as shown in Figure 1. The outlet of the watershed is located near the Yamuna bridge on the Dehradun-Yamunotri National Highway route, which is about 55 km away from Dehradun. The watershed is located in between the longitudes of 78^0 00′ 21.02"E and 78^0 10′ 21.43" E, and latitudes of 30^0 32′ 23" and 30^0 38′ 19.63" N. The total area of the watershed is 11,668.20 ha (116.68 km^2) with a perimeter of 51.82 km. The elevation of the watershed varies from 760 to 3000 m above mean sea level (AMSL). About 70% of the watershed area is having a land slope of 15-50%.

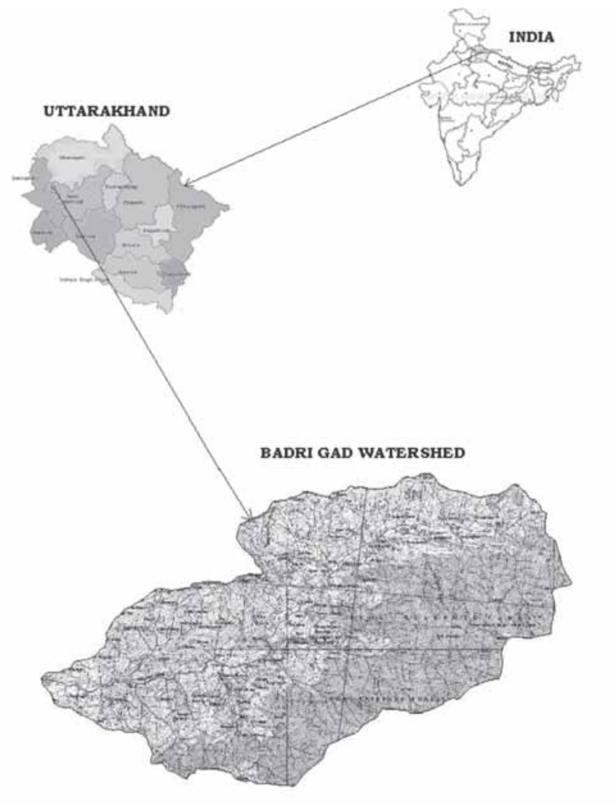

Fig. 1. Index map of Badri Gad watershed

The climate of the study area is humid temperate with an average rainfall of 1234.76 mm (1985-2008) of which about 70 to 80% is received during June to September. The average temperature in this area varies from 3^o C to 30^o C. Forest is the dominating land cover which mainly lies above 1600 m AMSL. However, a major part of the agricultural area is found at the elevations of about 1200 to 1600 m AMSL. Soil textural and chemical prosperities were estimated by processing the soil samples. The soil samples were collected from different locations with the help of a soil auger taking 0-15 cm surface soil and 15-30 cm sub-surface soil, separately. The soil samples were air dried on ground with wooden roller, separately. Each sample was then passed through two millimeter round hole sieve. Each sample was thoroughly mixed and stored in the labelled polythene bags for laboratory analysis.

Infiltration study was conducted in the watershed to know the effect of elevation on infiltration rate. Two concentric cylinders were installed about 10 cm deep in the soil, at different locations in the watershed. The lateral movement of water from inner cylinder was minimised by ponding water in a guard cylinder of 50 cm diameter around the inner cylinder of 25 cm diameter. The average depth of water maintained in the cylinder was 12 cm. The infiltration characteristics of the soil were determined by the rate at which water level lowered in the inner cylinder. The lowering of water level was observed with the help of hook gauge and stop watch. After completion of observation, the relationship between infiltration rate vs. elapsed time were plotted.

The chemical properties of the soils in the study area are neutral to slightly acidic with high organic matter content, which are shallow in depth and fairly highly permeable. At the mid and lower hills (1500-2200 and 800-1500 AMSL) , sandy clay loam and clay loam soils are found, whereas sandy loam soils are found at higher elevation (2200-2900 AMSL).

Data acquisition

The meteorological data were collected, for a period of 24 years (1985 to 2008), from Agro-meteorological observatory, College of Forestry, Hill Campus, Ranichauri of G.B. Pant University, Pantnagar. The soil samples were collected from different locations with the help of a soil auger taking 0-15 cm surface soil and 15-30 cm sub-surface soil, separately. Toposheet (53 J/2) of Survey of India, of the scale 1: 50000, was used for the analysis of slope-area classification and watershed delineation. The Landsat 7 ETM^+ satellite data of the study area were analyzed, for their characterization of various land forms by preparing False Colour Composite (FCC) with the help of 'translate and transfer' utilities of GIS software 'Geomatica v 10.0' using three spectral bands (B_2 : 0.52 – 0.60 mm, B_3 : 0.63 – 0.69 mm and B_4 : 0.76 – 0.90 mm). The Satellite data were of 22 December, 2003.

SCS curve number method

This method was applied to the Badri Gad watershed. Daily rainfall data were collected. As the rainfall data were available for daily rainfall occurring in a calendar year, SCS curve number method was used to estimate runoff for individual storm in the 24 hr period.

For a simple storm, the relationship between rainfall, runoff and retention, in which rainfall and runoff begin simultaneously over a watershed, is given as,

$$\frac{F}{S'} = \frac{Q}{P} \quad \ldots (1)$$

where F = actual retention, mm
S′ = potential maximum retention (S′ ³ F), mm
Q = actual runoff, mm
P = potential maximum runoff (P≥Q), mm

The parameter S′ in Equation (1) did not contain the initial abstraction. The retention S′ is a constant for a particular storm because it is the maximum possible retention over a watershed under existing conditions. The retention (F) varied because it was the difference between P and Q at any point on the mass curve, i.e.

$$F = P - Q \quad \ldots (2)$$

Then Equation (1) becomes :

$$\frac{P-Q}{S'} = \frac{Q}{P} \quad \ldots (3)$$

Solving for Q, Equation (3) results in :

$$Q = \frac{P^2}{P+S'} \quad \ldots (4)$$

It represented the rainfall runoff relationship in which the initial abstraction was ignored. Taking initial abstraction into account and replacing retention parameter S′ by S, the Equation (3) becomes,

$$\frac{F}{S} = \frac{Q}{P-I_a} \quad \ldots (5)$$

where I_a is the initial abstraction, $F \geq S$ and $Q \leq (P-I_a)$

The parameter S includes I_a i.e. $S = S' + I_a$

Equation (2) becomes,

$$F = (P - I_a) - Q \quad \ldots (6)$$

Equation (3) becomes,

$$\frac{(P-I_a)-Q}{S} = \frac{Q}{P-I_a} \quad \ldots (7)$$

Solving Equation (7) for Q gives

$$Q = \frac{(P-I_a)^2}{(P-I_a)+S} \quad \ldots (8)$$

This is the rainfall-runoff relationship with the initial abstraction.

where Q = Runoff depth, mm
P = Rainfall depth, mm
S = Maximum retention potential, mm
I_a = Initial abstraction, mm

The initial abstraction consisted mainly of interception, infiltration and surface storage, which occur over the watershed before runoff begins. The relation between I_a and S was developed by using rainfall and runoff data from experimental small watersheds is as follows:

$$I_a = 0.2S \quad \ldots (9)$$

Therefore, the Equation for runoff estimation expressed as,

$$Q = \frac{(P-0.2S)^2}{(P+0.8S)} \; for\ P < 0.2S \quad \ldots (10)$$

$$Q = 0 \; for\ P \leq 0.2S \quad \ldots (11)$$

Dhruva Narayan (1993) suggested following formulae for different regions of India.

$$Q = \frac{(P-0.3S)^2}{(P+0.7S)} \; for\ all\ regions \quad \ldots (12)$$

and

$$Q = \frac{(P-0.1S)^2}{(P+0.9S)} \; for\ black\ soil\ region \quad \ldots (13)$$

The retention parameter (S) is determined on the basis of antecedent moisture condition (AMC) and given by the following relationship (USDA, SCS, 1972),

$$S = \left(\frac{25400}{CN}\right) - 254$$

RESULTS AND DISCUSSION

Land use map

Different land uses/land covers were obtained with GIS environment by unsupervised classification technique, available in image processing module of the Geomatica v 10.0 software, using satellite data for the year 2003. False colour composite (FCC) for the study area was prepared from Landsat ETM+ satellite data set (Fig. 2).

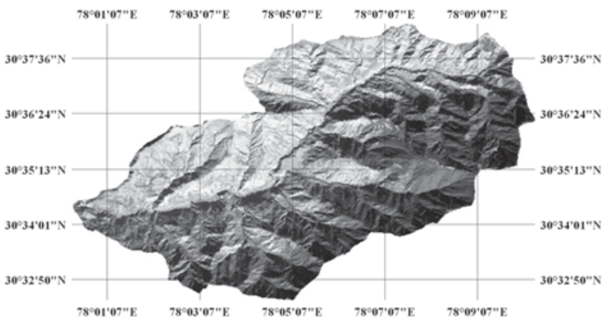

Fig. 2. Satellite imagery (FCC) of Badri Gad watershed

During field visit, the image elements, obtained by Unsupervised Classification Technique, were correlated with the ground truthing. Satellite data were classified into dense forest, mixed forest, chir pine forest, agriculture, agriculture fallow, agri-horticulture, clear barren and barren with vegetation (Fig. 3). Areal extent of various land use classes shown in Table 1. Forest area was mainly observed at higher altitude (more than 1900 m), whereas major agriculture and barren land lied at less than 1900 m elevation. Most of the villages lied at the altitude of 1400 -1900 m. Dense forest area was dominated by *deodar*, *oak*, *and sal* whereas mixed forest area was dominated by *buranse*, *cyprus*, *bangh*, *aunger*, *panger*, *moru* and *khoru*. Major agricultural crops being grown were *manduwa*, *sawan*, paddy, wheat, barely, *rajmas*, black gram, green gram and maize and in valley portion where irrigation was available, some vegetables and spice crops like tomato, potato, capsicum, cauliflower, peas, *arabi*, turmeric, ginger, onion and garlic were

Fig. 3. Land use on the basis of satellite imagery for the year December, 2003

Table 1. Areal extent under different land use on the basis of imagery of Badri Gad watershed

Land use		Area	Percent of
Main class	Sub class	(ha)	total area
Forest	Dense forest	3373.89	28.92
	Mixed forest	1787.30	15.32
	Chir pine forest	956.32	8.20
	Total Forest	**6117.52**	**52.43**
Agricultural Land	Agriculture	1499.21	12.85
	Agriculture fallow	1813.03	15.54
	Agri-horticulture	917.86	7.87
	Total Agricultural land	**4230.10**	**36.25**
Barren Land	Clear barren	436.37	3.74
	Barren with vegetation	884.22	7.58
	Total Barren Land	**1320.59**	**11.32**
	Total	11668.21	100.00

being grown. It is evident from Table 1 that out of the total area under study, 28.92 per cent area was under dense forest, followed by agriculture fallow land (15.54 %), mixed forest (15.32 %), agriculture (12.85 %), chirpine forest (8.20 %) agri-horticulture (7.87 %), barren with vegetation (7.58 %) and clear barren (3.74 %).

Soil characterization

Soil texture of the study area was found sandy loam, sandy clay loam and clay loam. Soils of the Badri Gad varied from neutral to slightly acidic in nature as pH value varied from 5.11 to 7.31. Organic matter content was observed in the range of 0.69 to 3.90 per cent. These soils were rich in organic matter. EC value was of low magnitude and ranged from 0.03 to 0.26 dSm^{-1}. Mean value of available nitrogen was 327.22 kg/ha. The available nitrogen was found lower to medium. The mean value of available phosphorous and potassium were found to be 10.15 kg/ha and 35.26 kg/ha, respectively, and both were found low.

Infiltration study was conducted at eleven locations, located at different elevations in the watershed. Four points, were located at the elevation varying from 800 to 2200 m above msl, were under the texture class of sandy loam whereas other four locations were having sandy clay loam soil at the elevation varying from 1070 to 1750 m above msl. Remaining three locations were having clay loam soil where elevation varied from 1330 to 1560 m above msl. In general, infiltration rate was increasing with decreasing of elevation in the watershed, irrespective of soil texture.

Highest infiltration rate was found in sandy loam soil (average 16.03 cm/h) followed by sandy clay loam (average 15.47 cm/h) and clay loam (2.87 cm/h). Infiltration rate varied from 1.61 to 25.42 cm/h as elevation ranged from 800 to 2300 m.

Soil map

Soil samples were collected at different elevations of the watershed and their location was recorded with the help of GPS. Elevation wise soil texture was studied. With the help of DEM of the area, soil map was developed in GIS environment. Spatial distribution of various soil textural classes is shown in Fig. 4. It was found that 39.51 per cent land was occupied by sandy clay loam followed by 38.77 per cent clay loam and 24.02 per cent sandy loam types of soil respectively. The study of land use map along with soil map showed that areas under agricultural land were having sandy clay loam and sandy loam, whereas dense forest area was mainly confined in sandy loam

SCS – Curve Number Analysis

The layers like land use map (based on satellite imagery) and soil map, were overlaid using GIS utility of Geomatica (Focus module). Information generated through overlay analysis is shown in Table 2 for Badri Gad watershed.Curve numbers (CN) were obtained using standard table for curve number (USDA-SCS, 1972) and weighted CN values for Antecedent Moisture Condition – II (AMC-II condition were worked out, for the study area. The weighted curve numbers for Badri Gad watershed was found to be 69.26.

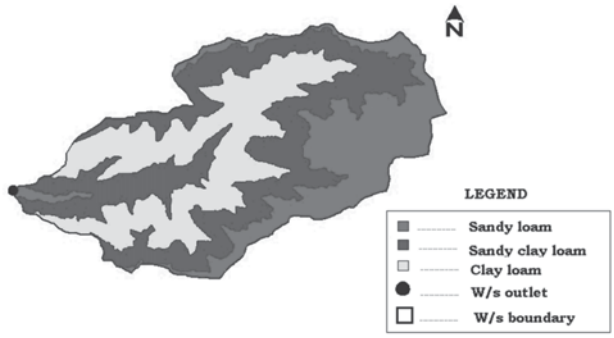

Fig. 4.. Soil map of the study area.

Table 2. Weighted curve number for Badri Gad watershed.

Land use	Soil type	Hydrological group	Area(ha)	CN
Dense forest	Sandy loam	A	1173.54	25.00
	Sandy clay loam	C	1241.94	70.00
	Clay loam	D	958.40	77.00
Mixed forest	Sandy loam	A	578.74	36.00
	Sandy clay loam	C	488.98	73.00
	Clay loam	D	719.60	79.00
Barren with vegetation	Sandy loam	A	130.96	68.00
	Sandy clay loam	C	332.00	86.00
	Clay loam	D	421.26	89.00
Chir-pine forest	Sandy loam	A	331.88	45.00
	Sandy clay loam	C	320.99	73.00
	Clay loam	D	303.46	83.00
Agriculture	Sandy loam	A	189.24	59.00
	Sandy clay loam	C	575.30	78.00
	Clay loam	D	734.67	81.00
Agriculture fallow	Sandy loam	A	229.51	61.00
	Sandy clay loam	C	1013.32	79.00
	Clay loam	D	570.20	82.00
Agri-horticulture	Sandy loam	A	141.63	59.00
	Sandy clay loam	C	347.69	78.00
	Clay loam	D	428.53	81.00
Clear barren	Sandy loam	A	28.13	77.00
	Sandy clay loam	C	289.95	91.00
	Clay loam	D	118.29	94.00
	Weighted curve number	69.26		

Estimation of runoff using SCS curve number method

The weighted curve number for Badri Gad watershed was calculated for Antecedent Moisture Condition – II (AMC-II). As per need weighted curve number were converted for AMC-I, and III conditions using conversion factor. The weighted curve number values for entire watershed for AMC-I, AMC-II and AMC-III were found to be 50.21, 69.26 and 84.22, respectively. The daily surface runoff was estimated by using the SCS Curve Number method for the period 1985 to 2008. On the basis of estimated daily runoff values, the annual runoff for each year was computed and is shown in Fig.5. The annual runoff value and runoff as percentage of total rainfall are shown in Table 3.

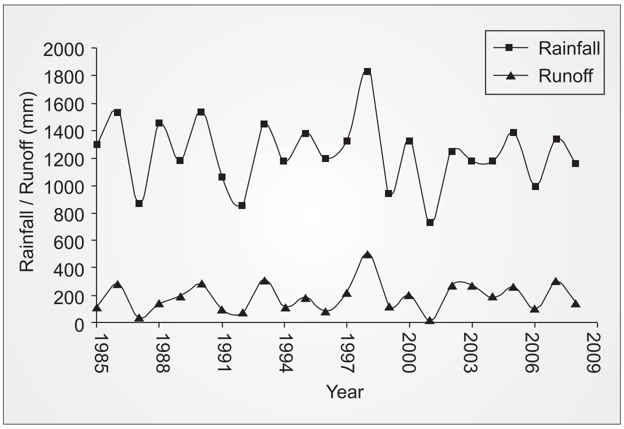

Fig. 5. Variation in rainfall and runoff values during the period of study (1985 – 2008)

During the period of 24 years (1985-2008), rainfall varied from 719.1 to 1840.2 mm. It is clear from the Table 3 that runoff varied from 2.03 to 27.30 per cent for the years 2001 and 1998, respectively. The average value of annual runoff was found to be 187.60 mm. During the study period, the maximum annual runoff was found to be 502.62 mm during the year 1998 and the minimum value of 14.59 mm during the year 2001.

CONCLUSION

Weighted curve number of the was found 69.26. Annual runoff was estimated for 24 years' period (1985 to 2008). The runoff varied from 2.03 to 27.30 per cent of the annual rainfalls of the years 2001 and 1998, respectively. The average annual runoff was found to be 187.60 mm. During the study period of 24 years, the maximum annual runoff was found to be 502.62 mm during the year 1998 and minimum was 14.59 mm during the year 2001. The estimated runoff was used for designing the water harvesting structures and prioritization of mini watershed within the Badri Watershed.

Table 3. Rainfall, total runoff and runoff as percentage of total rainfall

Year (mm)	Rainfall (mm)	Runoff	Runoff as Percent of total rainfall
1985	1299.80	116.86	8.99
1986	1532.20	283.99	18.53
1987	858.00	34.77	4.05
1988	1452.34	143.20	9.86
1989	1185.00	191.45	16.16
1990	1542.20	280.71	18.20
1991	1056.70	89.65	8.48
1992	855.30	79.40	9.28
1993	1452.20	315.89	21.75
1994	1175.50	116.82	9.94
1995	1386.80	184.36	13.29
1996	1196.50	83.10	6.95
1997	1328.40	221.59	16.68
1998	1840.20	502.62	27.31
1999	939.70	123.73	13.17
2000	1334.40	203.30	15.24
2001	719.10	14.59	2.03
2002	1255.40	273.01	21.75
2003	1173.80	266.29	22.69
2004	1174.90	181.10	15.41
2005	1386.90	262.31	18.91
2006	997.90	94.86	9.51
2007	1343.10	298.68	22.24

REFERENCES

Amutha, R. and Porchelvan, 2009. Estimation of surface runoff in Malattar sub-watershed using SCS-CN method. *Journal of the Indian Society of Remote Sensing*, 37 : 261-274.

Deshmukh, A. G.; Rao, E. P. and Eldho, T. I., 2004. Surface runoff estimation using remote sensing, G.I.S. and SCS method. Proceeding of the International conference on "*Advanced Modelling Technique for Sustainable Management of Water Resources*". held at NIT Warangal, India, 333-337

Dhruva Narayana, V.V., 1993. Soil and Water conservation Research in India. ICAR, New Delhi.

Durbude, G. Dilip; Purandara, B.K. and Sharma, Arun, 2001. Estimation of surface runoff potential of a watershed in semi-arid envoronment- A case study. *Journal of the Indian Society of Remote Sensing*, 29 (1&2): 47-58.

Kavita, K.; Malleswara Rao, B. N. and Umamahesh, N. V., 2004. Prediction of runoff from ungauged watersheds a G.I.S. approach. Proceeding of the International conference on "*Advanced Modelling*

Technique for Sustainable Management of Water Resources". held at NIT Warangal, India, 320-326.

NRCS, Soil Conservation Service, 1986. Urban hydrology for small watersheds. Technical Release 55, U.S. Department of Sgriculture, Washington, D.C.

Sarangi, A.; Bhattacharya, A.K.; Singh, A.K. and Sambaiha, A., 2005. Performance of Geomorphologic Instantaneous Unit Hydrograph (GIUH) model for estimation of surface runoff. In: International conference on "Recent Advances in Water Resources Development and Management", 23-25 Nov.,IIT, Roorkee,Uttaranchal, India: 569-581

USDA, Soil Conservation Service, 1972. Hydrology in SCS National Engineering Handbook. D.C. US Department of Agriculture, Section 4.

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GIS mapping of groundwater quality of Bahadurgarh block of Jhajjar district (Haryana)

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ABSTRACT

This paper examines the quality of groundwater in a 51408 ha region comprising Bahadurgarh block of Jhajjar district of Haryana state, lies on the western border of New Delhi. 171 groundwater samples from running tubewells in the block have been analyzed for ionic concentrations of CO_3^{2}, HCO_3^-, Cl^-, SO_4^{2-}, Ca^{2+}, Mg^{2+}, Na^+ and K^+. Parameters such as electrical conductance (EC), sodium absorption ratio (SAR) and residual sodium carbonate (RSC) have been evaluated. According to AICRP classification, it was found that 25.9 % water samples were of good quality, 56.9 % saline and 17.2 % alkaline in nature. Out of the saline water, 19.8, 2.5 and 34.6 % were marginally saline, saline and high SAR saline, respectively. But on the basis of GIS mapping, maximum area (27350 ha) of the block was found in good category followed by marginally saline category (16884 ha) and minimum area (35 ha) was found under saline category. In alkali group, 4.9 and 12.3 % were alkali and high alkaline, respectively. The study revealed that 65.5 % of the samples showed EC upto 4 dS m^{-1} and the maximum value of EC (12.24 dS m^{-1}) was found in village Kanaunda. Residual sodium carbonate (RSC) and sodium adsorption ration (SAR) varied from nil to 7.60 me L^{-1} and 2.50 to 21.87 (m mol $L^{-1})^{1/2}$, respectively. Contour maps of EC, SAR, RSC and water quality of groundwater used for irrigation in the block were plotted to study spatial variability of these parameter in the block.

Key words: Bahadurgarh, Electrical Conductivity, Geographical Information System, groundwater, Residual Sodium Carbonates, Sodium Adsorption Ratio, salinity, alkalinity / sodicity

INTRODUCTION

India has 2.2 per cent of the global land, 4 per cent of the world water resources and 16 per cent per cent of the world's population (Ramesh and Elango, 2011). Among water resources, groundwater is the major source for domestic, agricultural and industrial purposes in semiarid and arid regions of India. This lead to the overexploitation of the groundwater and are evident from the fact that "overexploited" and "dark blocks" in the country have increased from 250 in 1985 to 1098 in 2005 (India, 2006). The present trend of declining groundwater depth (0.66 % per year) could reduce India's total food grain production by around 25 % or more by 2050 (Gupta and Deshpande, 2004). Apart from water table decline, groundwater quality is also a major concern in many parts of the country. Groundwater quality is influenced by natural and anthropogenic effects including local climate, geology, irrigation practices and industrial pollution. Groundwater contamination reduces its safe supply for irrigation and drinking, posing a threat to agriculture and public health and a challenge to water managers and strategists.

In the area of Bahadurgarh block of Jhajjar district, Haryana state surrounding the western part of Delhi, intensive agriculture become the back bone of livelihood of the peoples residing in these areas and for this, they are extracting huge amount of groundwater resulting depletion of water table and deterioration of groundwater quality. The poor quality of underground water is mainly due to drawing of salty water from lower aquifers. The

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indiscriminate use of agro-chemicals like fertilizers and pesticides and their leaching with the rain and irrigation water further deteriorate the quality of groundwater. So there is an urgent need for the planners and the decision makers to characterize the groundwater quality for a useful and sound method for monitoring of groundwater resources. Adhikary *et al*. (2009) also indicated the nitrate pollution is predominant in western part of Delhi. Therefore, the present study envisaged to categorise the groundwater of Bahadurgarh block of district Jhajjar and illustrated the spatial variability of various parameters of groundwater quality i.e. electrical conductivity (EC), residual sodium carbonate (RSC), sodium adsorption ration (SAR) and quality categorisation by using Geographic Information System (GIS). GIS can be used as a powerful tool for developing solutions for water resources problems for assessing water quality, determining water availability, preventing flooding, understanding the natural environment and managing water resources on a local or regional scale (Ferry *et al.*, 2003).

MATERIALS AND METHODS

The survey and characterization of groundwater of Bahadurgarh block was undertaken during 2011-12. The block lies on the southern side of Jhajjar district between 28°29′51″ to 28°49′32″N latitude and 76°40′51″ to 76°58′08″E longitude (Fig.1). The block consists of 63 villages with flat and level area of 51408 ha. In order to avoid floods, Pakasma and KCB drains have been dug out in the block which are connected to west Jua drain and ultimately joined to Mungeshpur drain in the western part of Delhi. Dulehra distributary nourishes the water requirement of the block. The average rainfall of Jhajjar district is 520 mm (Average of last years). In shallow aquifers zones, groundwater occurs under watertable conditions, whereas, in the deeper zones, confined/semi-confined conditions exist. Average water table in the block is ranging between 1 to 5 m.

Eighty one groundwater samples were collected during the year randomly at an interval of three to four kilometers by thorough covering the whole

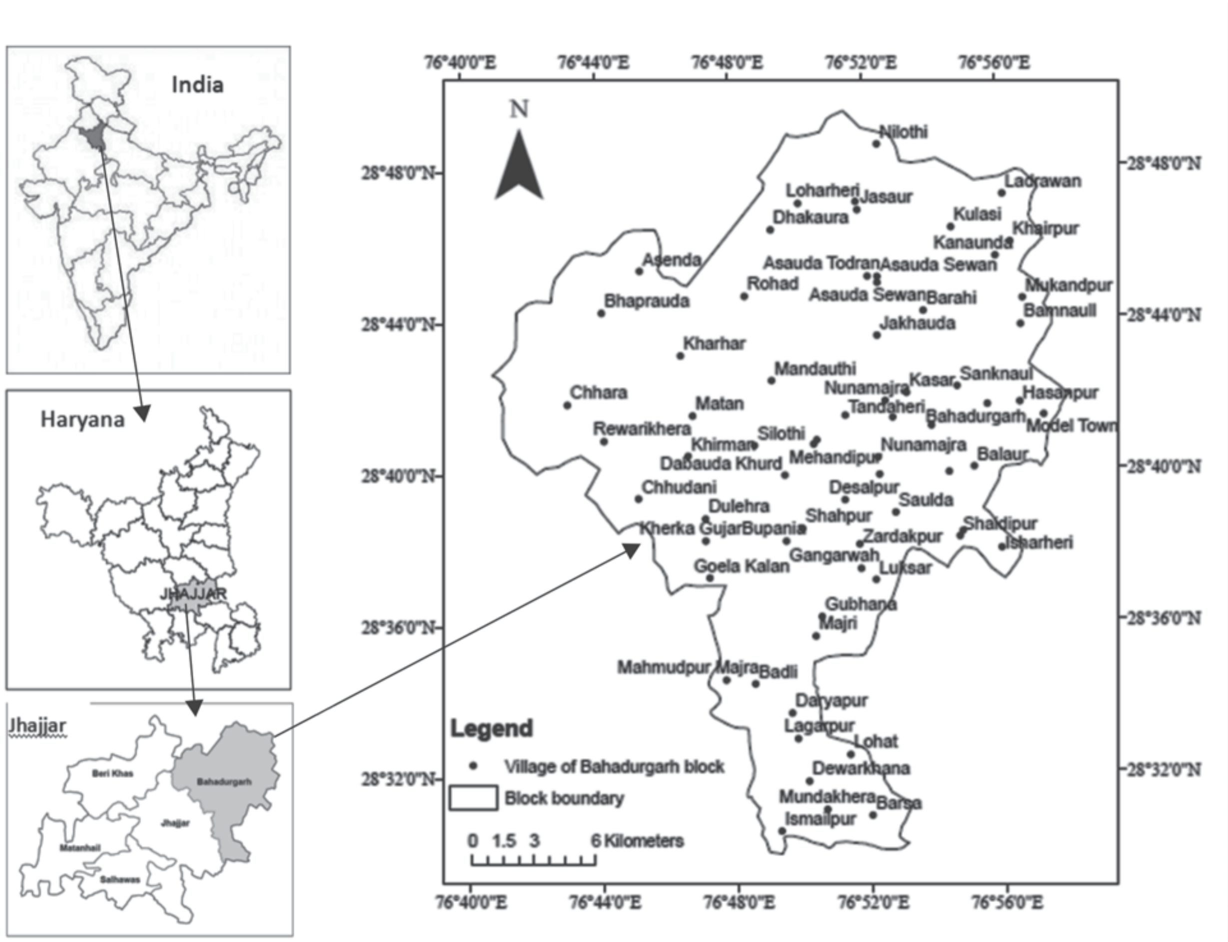

Fig.1. Location map of the Bahadurgarh block of Jhajjar district in Haryana state

block from running tube wells being extensively utilized for irrigation purposes (Fig.2). The elevation, longitude and latitude angles of the sampling points were recorded by GPS at each location. The samples were analyzed for EC, pH, CO_3^{2-}, HCO_3^-, Cl^-, SO_4^{2-}, Ca^{2+}, Mg^{2+}, Na^+ and K^+ by following the procedures outlined in USDA Handbook No. 60 (Richards, 1954) and categorized on the basis of criteria adopted by All India Coordinated Research Project on Management of salt affected soil and use of saline water, through the values of EC, SAR and RSC of the samples (Gupta *et al.*, 1994).

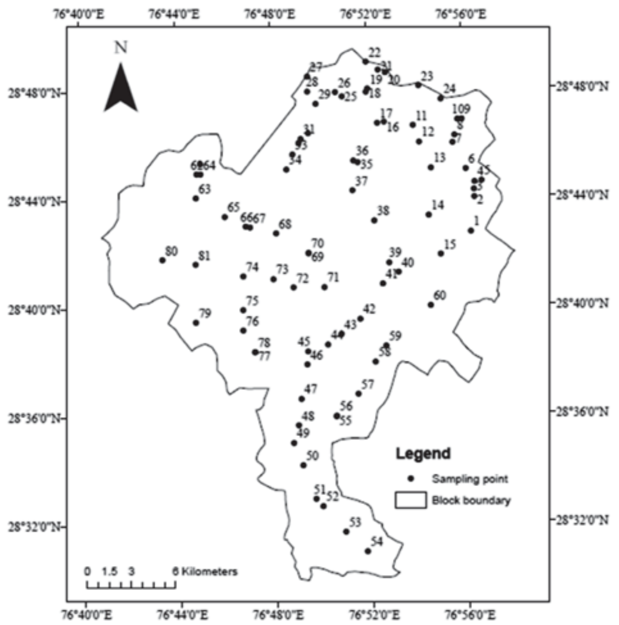

Fig. 2. Location map of the sampling points in Bahadurgarh block of Jhajjar district

RESULTS AND DICUSSION

In the present study, it has been found that the electrical conductivity (EC) ranged from 0.30 to 12.24 dS m^{-1} with a mean of 3.45 dS m^{-1} (Table 1) in the Bahadurgarh block. The lowest EC (0.30 dS m^{-1}) in groundwater samples was observed in village Lagarpur and the highest (12.24 dS m^{-1}) in village Kanaunda. The study revealed that 65.5 % of the samples showed EC upto 4 dS m^{-1}. Location specific variability of EC in the block is shown by spatial variable map (Fig.3). In the spatial variable map of EC, the contours for EC values were plotted at an interval of 2 dS m^{-1}. EC of groundwater was very scatter but EC in the central and southern parts of the block was lower (0-4 dS m^{-1}) than other parts of the block. The most dominating range of EC in the block is 0-2 dS m^{-1}. The highest EC range (>10 dS m^{-1}) was observed at one spot which lies on the eastern side of the block close to Delhi border.The areas with high EC can be reclaimed by leaching with good irrigation canal water along with provision of underground drainage system .

Table 1. Range and average of different water quality parameters in Bahadurgarh block

Parameters	Range	Average
EC (dS m^{-1})	0.30 - 12.24	3.45
CO_3^{-2} (me L^{-1}l)	0.00 - 3.20	0.33
HCO_3^- (me L^{-1})	0.00 -10.00	4.05
Cl^- (me L^{-1})	2.00 - 112.00	26.24
SO_4^{-2} (me L^{-1})	0.00 - 17.50	3.92
Ca^{+2} (me L^{-1})	0.20 - 11.20	2.45
Mg^{+2} (me L^{-1})	0.60 - 33.38	7.40
Na^+ (me L^{-1})	2.40 - 92.79	24.28
K^+ (me L^{-1})	0.00 - 4.00	0.61
RSC (me L^{-1})	0.00 - 7.60	1.00
SAR (m mol L^{-1} $)^{½}$	2.50 - 21.87	11.12

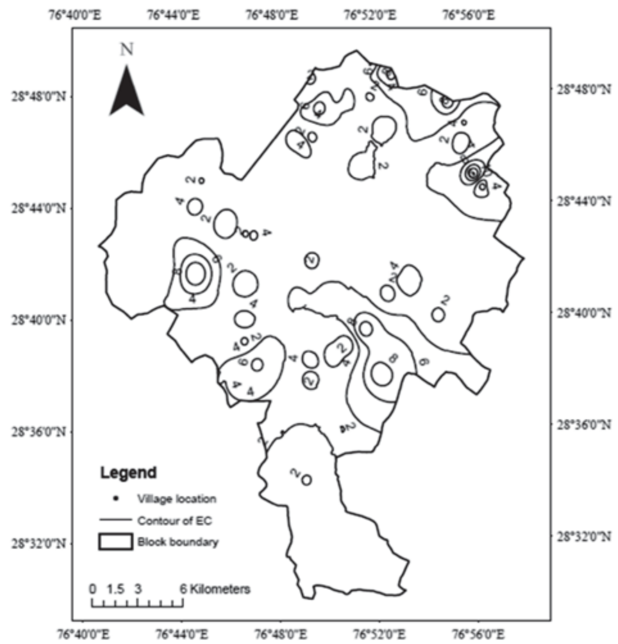

Fig. 3. Contour map of EC of groundwater in Bahadurgarh block

Calculation of SAR value for groundwater provides a useful index of the sodium hazard of water for soils and crops of particular area. The high sodium water may produce harmful levels of exchangeable sodium in most soils and requires special soil management like irrigation with good quality canal water for leaching of soluble salts and addition of gypsum, organic matter and green manuring. The SAR in the block ranged from 2.50

to 21.87 (m mol L^{-1})^{½} with a mean value of 11.12 (m mol L^{-1})^{½}. The lowest SAR was observed in village Ladrawan and the highest value in Kanaunda village. The variations in values of SAR of this block is shown by contour map (Fig.4) in which the SAR values are divided into 6 classes with an interval of 4 (m mol L^{-1})^{½}. It is observed from the spatial variable map that the SAR of groundwater is ranging from 8-12 (m mol/l)^{½} in the central and southern parts of the block where EC was also low (0-4 dS m^{-1}). The highest SAR range (20-24) was observed at same spot where EC was highest. Overall SAR is higher on the northern side in comparison to other parts of the block.

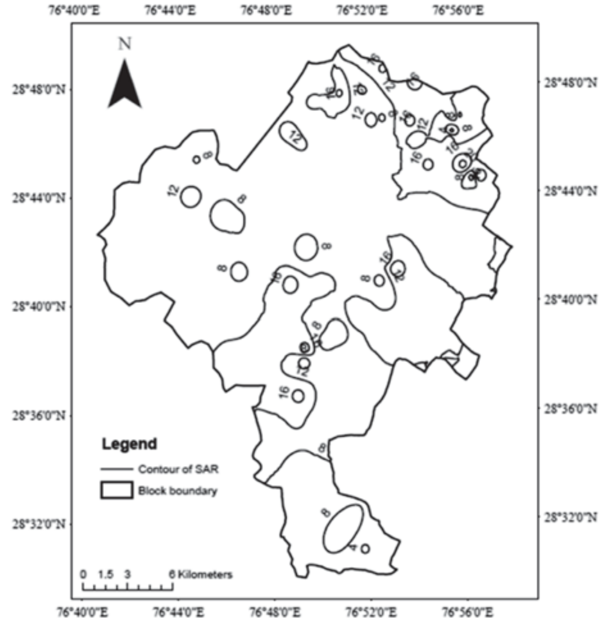

Fig. 4. Contour map of SAR of groundwater in Bahadurgarh block

The RSC varied from nil to 7.60 (me L^{-1})with an average value of 1.00 (me L^{-1}). Maximum value of the RSC was found in the village Luharhari. It is observed from the spatial variable map (Fig.5) that the RSC of groundwater is nil in the central and southern parts of the block but its variation did not match this EC which indicates that the RSC has no relation with the EC. Overall RSC is higher on the southern side in comparison to other parts of the block.

In case of cations, sodium was dominant ion which ranged from 2.40 to 92.79 (me L^{-1})followed by magnesium (0.60 to 33.38 (me L^{-1})), calcium (0.20 to 11.20 (me L^{-1})) and potassium (0.00 to 4.00 (me L^{-1})). Mean value for Na^+, Mg^{2+} Ca^{2+} and K^+ were 24.28, 7.40, 2.45 and 0.61 (me L^{-1}), respectively. In case of anions, chloride was the dominant ion with

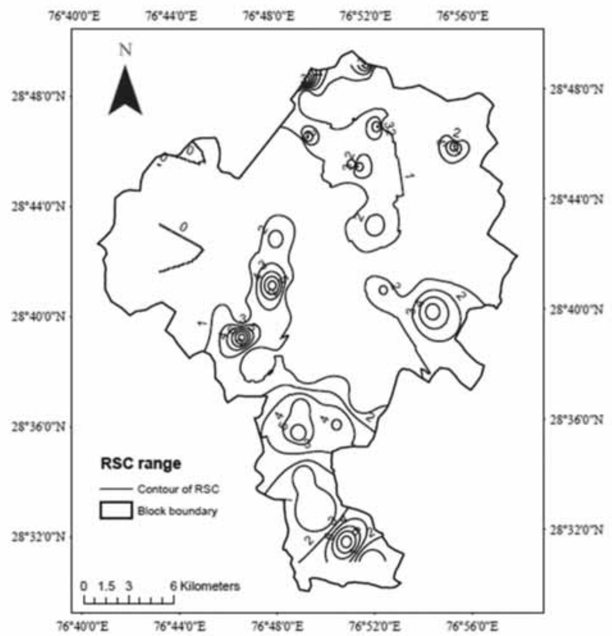

Fig. 5. Contour map of RSC of groundwater in Bahadurgarh block

maximum value of 112.00 me/l observed in village Kanaunda and minimum value of 1.30 (me L^{-1})in village Dewar Khana. Mean value for CO_3^{-2}, HCO_3^-, Cl^- and SO_4^{-2} were found to be 0.33, 4.05, 26.24 and 3.92 (me L^{-1}), respectively. Shahid *et al.* (2008) also reported the similar results in Julana block of Jind district. Analytical results of groundwater quality indicated that the order of abundance of cation concentration were $Na^+ > Mg^{+2} > Ca^{+2} > K^+$ while those of the anions were $Cl^- > HCO_3^- > SO_4^{-2} > CO_3^{-2}$. In arid and semi-arid regions, various workers have reported the dominance of sodium and chloride ions in irrigation waters (Shahid *et al.*, 2008).

The mean chemical composition and related quality parameters in different EC ranges for Bahadurgarh block are given in Table 2. Maximum per cent (22.3) of samples were in the EC range of 2-3 dS m^{-1}. Number of samples upto EC of 3 dS $m^{-1}$was increased but with further increase in EC, the number of samples deceased and its number was reduced significantly after an EC of 6 dS m^{-1}. Concentration of Na^+, Mg^{2+} and Ca^{2+} increased with increase in the EC of the water samples and the magnitude of increase in Na^+ and Mg^{2+} concentration was much higher than Ca^{2+}. Similarly, concentration of Cl^- anions increased with the increase in the EC of the water samples. SO_4^{2-} and HCO_3^- was also found to be in appreciable quantities, whereas, K^+ and CO_3^{2-} were in low quantities and their concentration did not show any relation with EC of irrigation water.

Table 2. Chemical composition of groundwater samples of Bahadurgarh block in different EC classes

EC classes (dS m^{-1})	% of samples	CO_3	HCO_3	Cl	SO_4	Ca (me/l)	Mg	Na	K	RSC	SAR (m mol $L^{-1})^{1/2}$
0-1	17.3	0.15	1.46	4.59	0.43	0.41	1.24	5.01	0.36	0.48	5.59
The sum of cations should be equal to anions											
1-2	18.5	1.07	5.31	7.43	1.39	0.76	2.29	11.97	0.30	3.67	10.45
2-3	22.3	0.47	5.22	15.39	4.01	1.67	5.17	17.60	0.92	1.07	9.96
3-4	7.4	0.00	3.83	27.00	3.47	2.38	7.45	22.97	0.91	0.00	10.38
4-5	8.6	0.00	3.74	35.00	7.11	2.76	8.24	35.39	0.54	0.00	15.45
5-6	12.3	0.00	4.95	44.25	6.61	3.53	10.69	40.99	0.64	0.00	15.76
6-7	1.2	0	5.40	52	1.2	4.8	13.6	39.9	1.29	0	13.15
7-8	4.9	0.00	3.50	62.75	7.15	6.10	16.76	47.14	0.95	0.00	13.96
8-9	1.3	0	4.00	75	7.2	6.3	19.7	60.39	0	0	16.75
9-10	4.9	0.00	1.95	83.35	9.63	9.43	29.45	55.77	0.24	0.00	12.80
10-11	0.0										
11-12	0.0										
12-13	1.3	0	4.00	112	6.5	8.9	27.1	92.79	0.87	0	21.87

According to AICRP classification, it was found that 25.9 % water samples were of good quality, 56.9 % saline and 17.2 alkali in nature (Table 3). Out of the saline water, 19.8, 2.5 and 34.6 % were marginally saline, saline and high SAR saline, respectively. In alkali group, 4.9 and 12.3 % were alkali and high alkali, respectively. Out of six categories of the water, maximum (34.6) % of samples were found in high SAR saline and minimum (2.5 %) in saline category. To study the spatial trend of groundwater quality, spatial variable map was plotted (Fig.6) and by using different features of GIS, area under different category was also calculated and presented in Table 3.

Table 3. Per cent samples and per cent area lies in different categories of Bahadurgarh block of Jhajjar district

Category of groundwater	Per cent sample of the block	Area under different categories (hectares)	Per cent area of the block
Good	25.9	27350	53.2
Saline			
i. Marginally saline	19.8	16884	32.9
ii. Saline	2.5	35	0.1
iii. High SAR saline	34.6	5206	10.1
Alkali			
i. Marginally alkali	0.0	0.00	0.0
ii. Alkali	4.9	170	0.3
iii. High alkali	12.3	1763	3.4

No particular trend in the variation of groundwater quality is present in the block but western part of the block has more good quality groundwater in relation to other parts of the block. This reflects that quality of groundwater is better in the areas away from Delhi. In the central part of the block, quality of groundwater is good as well as marginally saline, whereas, in the eastern side adjoining to Delhi, quality of groundwater is varying from good to high SAR saline. Better quality of groundwater in western and central parts of the block may be due to Pakasma and KCB drainages which are passing through these area and salts may be transported with rain water. By analysing the area under different contours (Fig. 6), it was found that out of six categories, the maximum area (27350 ha) of the block was estimated under good category of groundwater and minimum (35 ha) under saline category. Per cent samples in the high SAR saline category was highest (34.6 %) but highest per cent area (53.2) of the block is under good quality. This means more number of tubewells are operated in high SAR saline groundwater pockets which are adjoining to Delhi to fulfil the demand high irrigation intensity and these tube wells are also congregate in the area due which more samples are being collected from that area. Evaluation of area under different categories through GIS technique is more realistic in comparison to percent samples in different categories because GIS works on the principle of spatial variability and not on the per cent samples.

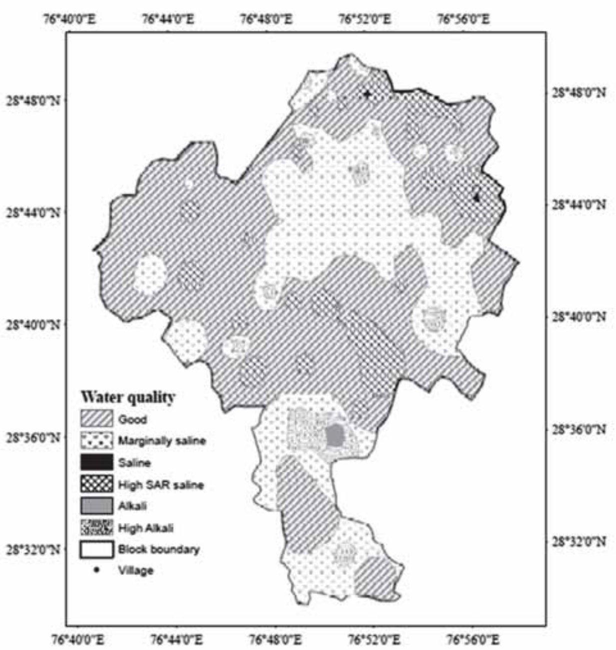

Fig. 6. Spatial variable map of groundwater quality in Bahadurgarh block

CONCLUSION

In this study, the assessment of groundwater for irrigation has been performed on the basis of AICRP guidelines. The study has also demonstrated the utility of GIS technology combined with laboratory analysis in evaluation and mapping of groundwater quality in the block. Out of six categories, maximum area (27350 ha) of the block was found in good category followed by marginally saline category (16884 ha) and minimum area (35 ha) was found under saline category. Groundwater quality in the area of the block adjoining to Delhi is varying from good to high SAR saline The spatial distribution maps generated for various physicochemical parameters using GIS techniques could be useful for planners and decision makers for initiating groundwater quality development in the area.

REFERENCES

Adhikary, P. P., Chandrasekharan, H., Chakraborty, D., Kumar, B. And Yadav, B.R. 2009. Statistical approaches for hydrogeochemical characterization of groundwater in west Delhi, India. Environment *.Monitoring and Assessment*, **154**: 41-52.

Ferry, L. T., Akihiko, K. and Mohammed Aslam, M. A. 2003. A conceptual database design for hydrology using GIS. Proceedings of Asia Pacific Association of Hydrology and Water Resources, March 2003, 13-15, Kyoto, Japan.

Gupta, R. K., Singh, N. T. and Sethi, M. 1994. Water quality for irrigation in India. Tech. Bull. 19, CSSRI, Karnal, India.

Gupta, S. K. and Deshpande, R. D. 2004. Water for India in 2050: first-order assessment of available options. *Current Science*, **86(9):** 1216-1223.

India. 2006. Publication Division, Ministry of Information and Broadcasting, Government of India, New Delhi, India.

Ramesh, K. and Elango, K. 2011. Groundwater quality and its suitability for domesticand agricultural use in Tondiar river basin, Tamil Nadu, India. Environ Monit Assess. DOI 10.1007/s10661-011-2231-3.

Richards, L. A. (ed.) 1954. Diagnosis and improvement of saline and alkali soils. U.S.D.A. Hand Book No. 60. Oxford & IBH Publishing Co., New Delhi.

Satyawan, Phogat, V., Kumar, S., Kaushik, R. D. and Dahiya, S. S. (2006). Assessment of ground water quality for irrigation in Barwala block of Hisar district of Haryana. Indian *Journal Agricultural Research* **40(1):** 60-63.

Shahid, M., Singh, A. P., Bhandari, D. K. and Ahmad, I. 2008. Groundwater quality appraisal and categorization in Julana block of Jind district, Haryana. *Journal of the Indian Society of Soil Science*, **56(1):** 123-125.

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Effect of integrated nutrient management on soil fertility and crop productivity in rice (*Oryza sativa* L.) - wheat (*Triticum aestivum*) cropping system

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ABSTRACT

A field experiment was conducted during 2008-09 and 2009-10 on a sandy loam soil at CCS Haryana Agricultural University, KVK Sonipat farm to study the effect of integrated nutrient management on crop productivity and soil fertility in rice –wheat cropping system. The results showed that the rice yields were significantly higher in treatments that received recommended dose of fertilizers i.e. 100% NPK plus $ZnSO_4$, green manure or FYM than in the treatments that received only N, NP, or NPK. The residual effect of organic manure and NPK was also observed on succeeding wheat crop. The application of 100% NPK in combination with green manure recorded highest grain yield and uptake of N, P, K followed by 100% NPK + FYM @15 t ha^{-1}, 125% NPK and 100% NPK + PSB in rice crop under rice –wheat cropping system. In wheat crop the highest grain yield was recorded with 100% NPK + green manure in preceding rice crop. The combined use of organic manure (green manure or FYM) and bio-fertiliser (PSB) along with the inorganic fertilizers increased the nutrient use efficiency, factor productivity and available nutrient status of the soil. Integrated application of green manure along with 100% NPK was found to be the best combination of treatment for sustaining crop yield and maintaining soil fertility.

Key words: Grain yield, nutrient uptake, nutrient use efficiency, green manure and FYM

INTRODUCTION

The continuous adoption of rice wheat cropping system has resulted in decline in factor productivity (Yadav, 1998) and an eclipse on sustainability of soil productivity (Rattan and Singh, 1997) as it is an intensive cropping system and removes about 350 to 550 kg NPK ha^{-1} $year^{-1}$ (Mondal and Mondal, 1996). Maintenance and enhancement of soil productivity is a major issue in this cropping system and high level of management is required to realize the potential yields of both the crops. The Green Revolution technologies involving greater use of synthetic agrochemicals such as fertlisers and pesticides with adoption of nutrient-responsive, high yielding varieties of crops have boosted the production output per hectare in most of the cases. Major constraint analyses have identified the declining of organic matter status of soil. There have been several reports from the farmers that they have to use more and more fertilizers each year to obtain the same yield as obtained in previous years. Even excessive use of fertilizers could not increase yield of crops rather there are indications of decline in growth of productivity and production (Antil and Narwal, 2007). Thus, only way to check decline in growth of productivity and production, and further nutrients mining to sustain the crop productivity as well as soil health is possible through different nutrient management practices.

The current energy crisis prevailing higher prices and lack of proper supply system of fertilizer calls for more efficient use of organic manures, green manure and bio-fertilizers with inorganic fertilizers to sustain yield levels. The country is thus in great need for alternate source which can partially or wholly supplement the use of chemical fertilizers. The supplementary and complementary use of organic manures and inorganic fertilizers augment the efficiency of both the substances to

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maintain a high level of soil productivity (Thakuria *et al* 1991). However, due to paucity of organic sources and their inability to meet total nutrient requirement in sustaining high level of productivity in order to meet out the demands of fast growing population and to safe guard the soil health, there is a need to promote integrated use of organic manure with chemical fertilizer. Keeping in view of the above, the present experiment was conducted to study the effect of integrated use of inorganic and organic sources on yield and nutrient uptake in rice-wheat cropping system in Haryana.

MATERIALS AND METHODS

A field experiment was conducted during 2008-09 and 2009-10 in rice-wheat cropping system on alluvial soil at the KVK, Sonipat Farm of CCS Haryana Agricultural University Hisar. The soil of the experimental field was collected and analysed for physico-chemical properties by using standard methods (Jackson, 1942). The soil was having pH (1:2) 8.2, EC (1:2) 0.16 dS m^{-1}, organic carbon 1.2 g kg^{-1}, Olsen's P 5.2 kg ha^{-1} and available K 160 kg ha^{-1}. The experiment was laid out in a RBD with twelve treatments replicated thrice *viz.* T1- Control (No Fertilizer), T2 -Recommended dose of N, T3-Recommended dose of NP, T4-Recommended dose of NPK, T5- Recommended dose of NPK + $ZnSO_4$, T6-125% NPK, T7-Recommended dose of NPK +Farm Yard Manure (FYM) (@ 15 t ha^{-1}), T8- Recommended dose of NPK+ Green manuring with Sesbania, T9-Recommended dose of NPK+PSB (2.5 kg ha^{-1}), T10 - 75% NPK +FYM (15 t ha^{-1}), T11 - 75% NPK+ Green manuring with Sesbania and T12 - 75% NPK+PSB (2.5 kg ha^{-1}). The recommended dose of fertilizer for rice was 100 kg N ha^{-1}, 50 kg P_2O_5 $ha^{-1}$and 40 kg K_2O ha^{-1}.

The above nutrient management practices were applied to the rice in both the years. Wheat (PBW-502) was sown after rice in the same plots with recommended dose of fertilizers (150 kg N, 60 kg P_2O_5 $ha^{-1}$and 30 kg K_2O ha^{-1}). Organic sources namely well decomposed FYM (0.26 and 0.22% N and 0.10 and 0.10% P and 0.46 and 0.36% K during the year 2008-09 and 2009-10, respectively) was applied uniformly and incorporated in soil 15 days before the sowing of paddy crop both the years. The *Sesbania* green manure was grown *in situ* for 45 days in the plots of green manure treatment and fresh biomass was incorporated into soil 5 days before transplanting of rice. One third dose of N and full dose of P, K and $ZnSO_4$ were applied as basal in the form of urea, diammonium phosphate and muriate of potash, respectively and remaining N was applied equally after three and six weeks of transplanting. Paddy (Cv. Pusa 1121) in *Kharif* (2^{nd} and 7^{th} July) and wheat (PBW-502) in *Rabi* (on 18^{th} and 24^{th} November) were grown in sequence by adopting standard agronomic practices in both the years (2008-09 and 2009-10). Crops were harvested after maturity and their grain yield was recorded treatment wise. Grain samples were collected and analysed for N by Nessler's Reagent method (Linder, 1944), P by Vanadomolebdo phosphoric acid yellow colour method (Koenig and Johnson, 1942) and K by flame photometer method. The total N, P and K uptake, yield response, agronomic nutrient use efficiency and factor productivity of N, P and K were computed by standard methods. Grain yield of both the crops were recorded at harvest. Soil samples were collected from 0-15 cm depth after harvesting of two cycles of rice-wheat cropping system in 2010 and analysed for available N, P and K by using standard methods of analysis (Jackson, 1942).

Yield response, nutrient use efficiency and factor productivity of nutrients were worked out as follows:

Yield Response (%) = {(Treatment yield-Control yield)/ Control yield}X 100

Nutrient Use Efficiency (kg grain per kg nutrient applied) = (Treatment yield-Control yield)/ Amount of nutrient applied

Partial Factor Productivity of applied nutrients(kg/kg) = Yield due to nutrient/ Applied fertilizer nutrient

RESULTS AND DISCUSSION

Grain yield of rice

A perusal of data (Table 1) revealed that grain yields of rice increased significantly with the application of chemical fertilizer and organic manures over control. The rice yield ranged from 2.14 to 4.32 t ha^{-1} during 2008 and 2.28 to 4.45 t ha^{-1} during 2009. Application of recommended dose of NPK had recorded higher yield response (66.3%) in comparison to NP (55.6%) and N alone (31.4%) over control (Table). It was found that application of N fertilizers in combination with P and K further improved the yield response by 35.3 and 28.0%, respectively, emphasizing the essentiality of balanced fertilization to get better productivity. Lower response to K fertilization may be because

Table 1: Effect of Integrated Nutrient management on grain yield (t ha^{-1})of rice and wheat

Treatments	Yield (t ha^{-1})				% Av. Yield Response	
	Rice	Wheat	Rice	Wheat	Rice	Wheat
	2008-09		2009-10			
T_1- Control	2.14	3.84	2.28	4.02		
T_2-N	2.87	4.25	2.94	4.34	68.5	14.38
T_3 -NP	3.42	4.34	3.46	4.65	103.8	14.38
T_4 -NPK	3.60	4.45	3.75	4.75	131.8	17.05
T_5 -NPK+ $ZnSO_4$	3.78	4.48	3.74	4.78	154.8	17.81
T_6 -125% NPK	3.84	4.56	3.92	4.82	169.4	19.34
T_7 -100% NPK+FYM	4.25	4.79	4.34	5.04	212.1	25.06
T_8-100% NPK+Green manure	4.32	4.82	4.45	5.12	224.8	26.46
T_9-100% NPK+PSB	3.68	4.60	3.77	4.93	164.6	21.25
T_{10} -75%NPK+FYM	3.65	4.48	3.72	4.64	140.8	16.03
T_{11}-75%NPK+Green manure	3.82	4.54	3.97	4.72	160.5	17.81
T_{12}-75%NPK+PSB	3.51	4.30	3.62	4.54	136.3	12.47
$CD_{0.05}$	0.14	0.16	0.13	0.17		

of these soils being rich in potassium bearing minerals (Bhardwaj *et.al.*, 1994). The grain yield of rice increased significantly with the increased dose of NPK over control with a mean yield response of 131.8 and 169.4% with application of 100% and 125% NPK, respectively. Thus results showed that super optional doses of fertilizers caused relatively lower crop response as compared to optimum doses of NPK. Addition of $ZnSO_4$ significantly increased the grain yield of rice over NPK in first year and yield was at par during the second year. However, application of PSB did not show significant effect on grain yield of rice over NPK in both the years. This might be due the application of recommended dose of phosphorus in the experimental soil at the time of sowing. Highest grain yield in both the years (4.32 and 4.45 q ha^{-1}) was recorded with the incorporation of green manure along with 100% NPK followed by 100%NPK + FYM@ 15t ha^{-1} (4.25 and 4.34 t ha^{-1}). However, the yield in both the treatments was significantly at par. The grain yield of rice with application of 75% NPK+ Green manuring was also at par with NPK+$ZnSo_4$ treatment showing that application of green manure can reduce the dose chemical fertilizer upto 25%. Better supply of nutrients through incorporation of organic manures ascribed to conducive physical environment leading to better root activity and higher nutrient absorption might have resulted in higher grain yield of rice (Meelu, 1996). Incorporation of green manure recorded an additional average grain yield of 0.71 and 0.50 t ha^{-1} over optimal (100% NPK) and super optimal doses of NPK (125%), however, integrated application of FYM along with 100% NPK produced 0.62 t ha^{-1} additional mean grain yield over 100% NPK. The favourable effect of farm yard manure and green manure on rice yield has also been reported by Ganai *et al* (2013). This favourable influence of FYM and green manure could be attributed to the mineralization and nutrient release from these organics under submerged conditions (Sharma and Mittra, 1991). Decomposition of organic manures is accompanied by the release of appreciable quantities of CO_2, which dissolved in water to form carbonic acid which was responsible for decomposition of certain primary minerals and release of appreciable amount of plant nutrients to the soil, which could contribute towards higher crop yields (Bharadwaj and Omanwar, 1994).

Grain yield of wheat

The grain yield of wheat increased significantly in the plots in which chemical fertilizer and organic manures were applied in preceding rice crops over the control plots. The grain yield ranged from 3.84 to 4.82 t ha^{-1} during year 2008-09 and 4.02 to 5.12 t ha^{-1} during the years 2009.10. These results clearly depicted the positive significant residual effect of application of fertilizers and manures on grain yield of wheat after rice. The residual effect of the application of NPK+ green manure had highest yield response (26.5%) over control followed by NPK+FYM (25.1%) and 125% NPK (19.3%). The results clearly depicts that application of organic manure had higher residual effect on succeeding crop. The results are in conformity with those of Sharma *et al* (2009).

Total nutrients uptake

The data (Table 2) indicated that the uptake of N, P and K in all the treatments with fertilizer and manures increased significantly over the control plot in both rice and wheat crops.

A perusal data revealed that highest uptake of N, P and K by rice (102.0, 9.8, and 130.7 kg ha^{-1}, respectively) and wheat (142.2, 19.2 and 142.2 kg ha^{-1}, respectively) was recorded with the application of 100% NPK+ Green manure over the rest of the treatments. Incorporation of green manure increased total uptake of N, P and K to an extent of 40.1, 36.1 and 35.7%, respectively over that of recommended dose of NPK in rice crop and 22.7, 23.1 and 19.8%, respectively in wheat. Green manuring enhanced the availability of essential nutrients and improvement in the nutrient concentration in rice grain. Similar findings were also reported by Swarup (1991). The highest response in terms of total uptake of N, P and K over control (224.8, 276.9 and 178.7%, respectively) was observed with the incorporation of green manure along with the application of 100% NPK followed by NPK + Farm Yard manure (212.1, 253.8 and 165.7%) of N, P and K, respectively). Similar trend in uptake of NPK in wheat was also observed. The increase in uptake of nutrients in the organic manure treated plots may be due to extra amount of nutrients supplied by these organics and providing conducive physical environment which helps in better root growth and absorption of nutrients from the native as well as applied sources which favours highest nutrients uptake (Bharadwaj *et al.* 1994). Application of N, P and K either alone or in combination and graded doses of NPK recorded significantly higher uptake of N, P and K over that of control. Application of P fertilizers enhanced the P uptake by 20% over to N. A significant reduction in P uptake due to Zn application exhibited the antagonistic effect of Zn on P availability and consequently reduced its uptake by the crop. Inoculation of rice seedlings with PSB showed significantly higher P uptake by grains, which might be due to dissolution of insoluble P fractions in the soil (Gaur, 1990). It was observed that the K uptake in increased significantly with the increased doses of NPK application with an uptake response of 105 and 133% under 100 and 125% NPK, respectively. Incorporation of organics and application of optimum doses of NPK recorded 121,178.7, 165.7 and 128.8% K uptake response under100% NPK + $ZnSO_4$, 100% NPK + green manure, 100% NPK + FYM and 100% NPK + PSB, respectively, indicating that the incorporation of organics significantly enhances the nutrient uptake even higher than the optimum doses of NPK application. Increase in the N uptake with integrated use of green manure with mineral fertilisers might be due to early release of N as a result of decomposition of succulent legume crop. Addition of organic matter increased the microbial population with resulted in the enhanced availability of nitrogen. The increase is uptake of panel K particularly by rice crop may be ascribed to more availability of those nutrients from the added fertilizers and also the solubilising action of organic acids produced during decomposition of green manuring, thus rendering more release of P and K from the soil and green manure crop under wetland rice.

Table 2. Effect of Integrated Nutrient management on total uptake of nutrients in rice and wheat

Treatment	Nutrient uptake Rice (kg ha^{-1})			Nutrient uptake Wheat (kg ha^{-1})		
	N	P	K	N	P	K
T_1- Control	31.4	2.6	46.9	77.8	11.1	78.6
T_2- N	52.9	4.2	65.1	102.2	12.8	96.2
T_3 - NP	64	6.1	79.8	110.2	14.7	106.1
T_4 - NPK	72.8	7.2	96.3	115.9	15.6	118.7
T_5 - NPK+ $ZnSO_4$	80	7.2	104	119.4	16.3	122.2
T_6 125% NPK	84.6	8.2	109.4	127.5	17.2	127.6
T_7 -100% NPK+FYM	98	9.2	124.6	138.1	18.3	139.6
T_8-100% NPK+Green manure	102	9.8	130.7	142.2	19.2	142.2
T_9-100% NPK+PSB	83.1	8.1	107.3	130.5	17.9	132.9
T_{10} -75%NPK+FYM	75.6	7.3	101	120	16.2	120.4
T_{11}-75%NPK+Green manure	81.8	8	108.3	122.2	16.7	124.6
T_{12}-75%NPK+PSB	74.2	7.2	96.9	114.9	15.6	112.3
$CD_{0.05}$	1.9	0.4	3.4	2.1	0.5	3.9

The NPK uptake also increased in wheat in the plots treated with organics and bio-fertilizers in preceding rice crop indicating their positive residual effect on nutrient availability and uptake. In wheat crop also maximum uptake of N, P and K in the plots treated with NPK + Green manure in preceding rice crop.

Nutrient use efficiency

A perusal of data (Table 3) revealed that the application of N alone recorded lowest N use efficiency (7.0 kg grain kg^{-1} N) and the efficiency increased to 12.3 and 14.2 kg, 14.7 kg and 15.0 kg grain kg^{-1} N with the application of NP and NPK, ZnSO4, respectively. Thus the results emphasized the need of balanced fertilization of obtain higher productivity as well as nutrient use efficiency. Among the organics, incorporation of green manure and FYM along with the application of optimum doses of NPK showed highest N use efficiency in terms of kg grain kg^{-1} fertiliser N (15.3) followed by 75% NPK+ green manure (14.4), 75% NPK+PSB(13.5) and 75% NPK+ FYM and manure (13.3). It was observed that green manuring 100% NPK + PSB and FYM resulted in higher N use efficiency in comparison to other organic sources over that of 100% NPK. The P use efficiency was found to be the highest with the integrated application of NPK and green manuring (31.1 kg grain kg^{-1} P) with highest contribution of green manuring towards the P use efficiency (11.3 kg grain kg^{-1} P) in comparison to other organic sources. Application of 100% NPK resulted in 5.9 kg grain kg^{-1} K applied and it increased to 78 and 39% with the application of NPK in conjunction with FYM and green manure, respectively. It can be inferred from the results that integrated use of inorganic and organic manures not only enhances the rice productivity but also increased the nutrient use efficiency. These results are in concurrence with the findings of Sharma *et al* (2012), Sharma *et al* (2007) and Laxminarayna & Patiram (2006).

The data (Table 3) revealed that the application of NPK with $ZnSO_4$ recorded highest partial factor productivity of N and P followed by 100% NPK. The partial factor productivity of K was found to be 118.8 with the application of 75% NPK + PSB followed by NPK + $ZnSO_4$. The results clearly showed that there is a need of balanced fertilization forgetting optimum yield in rice- wheat cropping system.

Available nutrients in soil

The available N content of the soil was significantly increased with the integrated application of PNK and different organic manures over that of NPK (Table 4). This may be attributed

Table 4. Effect of Integrated Nutrient management on available nutrients in soil

Treatment	Available nutrient (kg/ha)		
	N	P	K
T_1- Control	132	5.08	122
T_2- N	174	5.28	130
T_3 - NP	182	5.20	132
T_4 - NPK	170	5.34	132
T_5 - NPK+ $ZnSO_4$	184	5.54	142
T_6 125% NPK	211	5.72	148
T_7 -100% NPK+FYM	242	6.96	162
T_8-100% NPK+ Green manure	250	7.54	174
T_9-100% NPK+PSB	204	7.22	150
T_{10} -75%NPK+FYM	218	6.54	156
T_{11}-75%NPK +Green manure	216	6.62	162
T_{12}-75%NPK+PSB	198	6.70	148
$CD_{0.05}$	9.4	0.05	4.3

Table 3. Effect of Integrated Nutrient management on nutrients use efficiency and factor productivity in rice and wheat

Treatment	Nutrient use efficiency			Factor productivity of NPK		
	N	P	K	N	P	K
T_2- N	6.95			29.1		
T_3 - NP	12.3	9.8		34.4	78.6	
T_4 - NPK	14.7	14.5	5.9	36.8	83.3	91.9
T_5 - NPK+ $ZnSO_4$	15.5	16.2	8.0	37.6	85.0	94.0
T_6 125% NPK	13.4	14.9	8.8	35.5	69.9	77.6
T_7 -100% NPK+FYM	15.3	21.1	10.5	31.6	75.0	53.0
T_8-100% NPK+Green manure	15.3	21.1	8.2	30.9	71.7	38.1
T_9-100% NPK+PSB	13.3	10.4	5.9	35.4	59.5	91.9
T_{10} -75%NPK+FYM	13.3	14.3	3.4	33.2	81.4	51.6
T_{11}-75%NPK+Green manure	14.4	17.0	4.3	33.3	79.0	37.1
T_{12}-75%NPK+PSB	13.6	10.7	4.2	35.7	70.5	118.8
$CD_{0.05}$	0.8	0.6	0.2	1.2	1.6	2.4

to N mineralization pattern of these organics under submerged soils conditions and indirect influence on physico-chemical properties of the soil (Sharma and Mittra, 1991). Incorporation of organics along with 100% NPK improved the available N status by 42.3, 47 and 20% in respect of FYM, green manure and PSB over 100% NPK. The increase in available N due to application of organics could also be attributed to the greater multiplication of soil microbes, which could convert organically bound N to inorganic form (Bharadwaj and Omanwar, 1994).

The magnitude of increase in available P under 100% NP and 100% NPK was 2.4 and 5.1% over control, however, the integrated use of recommended doses of fertilizers with PSB recorded highest available P content over the rest of treatments. These results are in conformity with the findings of Subramanian and Kumaraswamy (1989) who reported that the increase in available P content of soil could be attributed to the influence of organic manures which enhanced the labile P in the soil by complexing Ca, Mg and Al. The organic materials also form a cover on sesquioxides and thus reduce the phosphate fixing capacity of the sol and increase the available P in soil solution (Bharadwaj and Omanwar, 1994). Bacterization of seedlings resulted in a significant increase in available P status of the soil which migh be due to release of souble inorganic phosphates into soils through decomposition of phosphate-rich organic compounds and secretion of organic acids which may form chelates with Fe and Al resulting into effective solubilization of phosphates (Subba Rao, 1999).

Highest available K content in the soil was observed with combined application of 100% NPK + green manure (174 kg ha^{-1}) followed by NPK + FYM (168 kg ha^{-1}) and 75% NPK + green manure (162 kg ha^{-1}). Despite the removal of K by crops in quantities higher than that added through fertilizers, increase in available K may be attributed to release of large amounts of non-exchangeable K from the soil. The crop requirements were partly met from the released K and both the applied K and released K caused available K build up in the soil. The differential release pattern of non-exchangeable K from the soil reserve besides variation in K uptake by the crop is also responsible for differences in the available K status of the soil (Yadhuvanshi *et al*. 1985). Increase in available K due to application of organic manures might be attributed to the direction addition of potassium to the available K pool of the soil besides the reduction of K fixation and release of K due to interaction of organic matter with clay (Bharadwaj and Omanwar, 1994). The beneficial effect of green manuring FYM and PSB on available K may be ascribed to the reduction of K fixation, solubilization and release of K due to the interaction of organic matter with clay, besides the direct addition of K to potassium pool of the soil (Tandon, 1987) .

CONCLUSION

Based on the findings of the present investigation it can be concluded that integrated use of recommended dose of chemical fertilizers and organic sources of nutrients enhances the crop productivity, improves the nutrient use efficiency and soil fertility in rice – wheat cropping system. From the present study it was found that treatments namely NPK + green manure and NPK + FYM were best among all other treatments which might be due to better supply of nutrients through incorporation of organic manures. The results also indicated that the dose of chemical fertilizer can be reduced upto 25 percent with the application of organic sources of nutrients to get the same level of productivity.

REFERENCES

Anonymous 2002. Statistical Abstract. Department of Agriculture and Minor Irrigation, Government of Mizoram, Aizawl, pp 6-18

Antil, R. S. and Narwal, R.P. 2007. Indian J. Fertilisers, **3**(9) : 111-121

Bharadwaj, V and Omanwar, P.K. 1994. Long-term effects of continuous rotational cropping and fertilization on crop yields and soil properties - II. Effects on EC, pH, organic matter and available nutrients of soil. Journal of the Indian Society of Soil Science **42** : 387-392.

Bharadwaj, V., Omanwar, P.K., Sharma, R.A. and Vishwanath (1994) Long-term effects of continuous rotational cropping and fertilization on crop yields and soil properties-I. Effects on crop yields and nutrient uptake. Journal of the Indian Society of Soil Science **42** : 247-253.

Ganai, A.Q., Singh, J.P., and Antil, R.S. 2013. Long term effects of continuous cropping and differential nutrient management practices on P and K dynamics under rice wheat cropping system. Indian Journal of Fertilisers **9**(8):26-40.

Gaur, A.A. 1990. Phosphate Solubilizing Microorganisms as Biofertilisers. Omega Scientific Publishers, New Delhi.

Jackson, M.L. 1973. Soil Chemical Analysis. Prentic Hall of India Pvt. Ltd., New Delhi.

Koening R. A. and Johnson C. R. 1942. Colorimetric determination of phosphorus in biological materials.

Indian Engineering Chemistry (Analytical) **14**: 155-6.

Linder R. C. 1944. Rapid analytical methods for some of the most common inorganic constituents of plant tissues. Plant Physiology **19**(1) : 76-8.

Meelu, O.P. 1996. Integrated Nutrient management for ecologically sustainable agriculture. Journal of the Indian Society of Soil Science **44** : 582-593.

Mondal,T.K.; and Mondal, S.S. 1996. Integrated nutrient management for rice based cropping system. *Indian J. Agric. Sciences.* **66**(12): 964-968.

Rattan, R.K. and Singh, A.K. 1997. Role of balanced fertilizers in rice- wheat cropping system. Fertilizer News **42** (4): 79-97.

Sharma, A.R. and Mittra, B.N. 1991. Direct and residual effect of organic materials and phosphorus fertilizer in rice (Oryza sativa)-based cropping system. Indian Journal of Agronomy **36** : 299-303.

Sharma, R., Dahiya, D.S., Bamel, J., Rathee, A., Goyal, N.K. and Singh, D. (2009) To study the effect of green manure crops (summer moong and Sesbania) on grain yield, nutrient uptake, soil fertility and economics of rice wheat cropping system. In Proc. of National Seminar on 'Recent advances in Soil Health and Crop Management for Sustainable agriculture' held at Annamalai University from 26-27 Feb. 2009.

Sharma,R., Bamel, J., Singh, J. P., and Rath, B. 2012. Effect of integrated use of organic manure and nitrogen fertilizer on grain yield, nutrients uptake and use efficiency in wheat (Triticum aestivum l.) in northern India. J Soil & Water Coservation **11**(2): 244-49.

Subba Rao, N.S. 1999. In Soil Microbiology. Fourth Edition of Soil Microoganisms and Plant Growth. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.

Subramanian, K.S. and Kumaraswamy, K. 1989. Effect of continuous cropping and fertilization on chemical properties of soil. Journal of the Indian Society of Soil Science **37** : 171-173.

Swarup, A. 1991. Long-term effect of green manuring (Sesbania Aculeata) on soil properties and sustainability of rice and wheat yield on a sodic soils. Journal of the Indian Society of Soil Science **39** : 777-780.

Tandon, H.L.S. 1987. Phosphorus Research and Agricultural Production in India, FDCO, New Delhi.

Thakuria, K., Borgohain, B. and Sarma, K.K. 1991. Effect of organic and inorganic sources of nitrogen with and without phosphate on fibre yield of white jute (Corchorus Capsularis). Indian Journal of Agricultural Science **61**: 49-50.

Yaduvanshi, H.S., Tripathi, B.R. and Kanwar, B.S. 1985. Effect of continuous manuring on some soil properties of an Alfisol. Journal of the Indian Society of Soil Science 33, 700-703.

Yadav, R.L. 1998. Factor productivity trends in a rice-wheat cropping system under long term use of chemical fertilizers. Experimental

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Viscometry method a tool to study pH and electrolyte concentration effect of humic acid's shape and functions

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ABSTRACT

Viscometry was used to evaluate the effects of pH and supporting electrolyte concentration on the viscosity of humic acid. Humic acid molecule behaves as flexible entities that can swell or shrink in response to change in pH and ionic strength. An increase in the solution pH leads to the development of negative charges in the molecules with the consequent electrostatic repulsion between ionized groups and molecular swelling. Increasing the ionic strength increases the screening of charges and leads to molecular shrinkage. Humic acid was extracted from Raiganj forest soil and subjected to viscometric experiment at different pH (6-9) in water and electrolyte concentration (6ppm and 8 ppm sodium chloride solution). Viscosity decreased in presence of electrolyte, this was undoubtedly caused by a decreased in degree of dissociation of ionizing groups and associated contraction of the particles. And also reduced viscosity values ($K_{sp/c}$) was increased with increasing pH this meant that with increase in pH from 6-9, there was an increase in molecular size or molecular weight.

Keywords: Humic acid, Viscosity, pH, Neutral Electrolyte (NaCl), Soil, Colloid, Macromolecular Polymer

INTRODUCTION

Humus substances are naturally evolved mixtures of organic compounds, representing various steps of transformation of plant and animal residues with or without assistance of micro-organism. It comprises of 60-80% of soil organic matter. Soil organic matter is often divided into non-humified (humin) and humified materials (humic acid and fulvic acid). The humified fraction is known as humic compound. It is poly-functional in nature, macro-molecular (polymer) and amphiphilic in character. The capacity of humic acid is to associate inter-molecularly and change molecular deformation in response to change in pH value, redox potential, electrolyte concentration and functional group binding (Stevension, 1994).

It is generally accepted that parameters of humus substances molecules are a function of concentration of humic substances, presence or absence of monovalent or polyvalent cations, pH and ionic strength of the solution. Therefore, studying these parameters would be important to understand the functions of humus substances (Chen and Schnitzer, 1976). Ghosh and Schnitzer (1980) reported that study on the viscosity parameters can help to understand these function. Visser (1985), while studying the viscosity phenomena, stated variations in properties of humic acids (HAs) in solutions of varying pH and ionic strength as the characteristic of ionic polymers.

The information about the size and shapes of hydrophobic colloids (humic acid) can be obtained by viscosity measurements. If a given volume of solvent of known viscosity η_o, and density d_o, take t_o seconds to flow through the viscometer and the same volume of experimental sample of density d, takes t seconds, then the viscosity will be numerically represented as:

$$\eta = \frac{td}{t_0 d_0}\eta_o \quad [1]$$

The relative viscosity, η_R, is $\eta_R = \frac{\eta}{\eta_0} = \frac{td}{t_0 d_0}$ [2]

The ratio of the change in viscosity, $\eta - \eta_o$, to that of the solvent is referred to as the specific viscosity, η_{sp}, given as:

$$\eta_{sp} = \frac{\eta - \eta_0}{\eta_0} \quad [3]$$

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η_{sp} is a direct measure of the increase in viscosity resulting from the presence of the colloid. The value of $\eta_{sp/c}$ at any given concentration C, is sometimes referred to as the viscosity number, η_z,

$$\eta_z = \frac{\eta_{sp}}{C} \quad [4]$$

Where, C is given as grams per 100 mL solution.

Many studies have placed a special emphasis on the chemical composition and structure of these molecules. Some results indicate their globular shape (Flaig and Beutelspacher, 1954), spherical (Visser, 1964), spherical and linear (Khan, 1971), ellipsoidal shapes (Orlov et.al. 1975), flexible linear configurations (Mukherjee and Lahiri, 1958), spheroid polyelectrolyte (Ghosh and Mukherjee, 1971), randomly folding long chains (Cameron et. al, 1972).

A study conducted by Ghose and Schnitzer (1980) on humic and fulvic acids indicated that both behave like rigid "spherocolloids" at high sample concentrations, low pH, or in the presence of high amount of neutral electrolyte. On the other hand, at low sample concentration, neutral pH or low ionic strengths these behaved like "flexible" linear colloids.

METERIALS AND METHODS

Collection of soil sample

The study area was located in Raiganj village of Uttar Dinajpur District of West Bengal. The surface soil samples (Ap) 0-15cm were collected, dried, powdered and sieved through a 2-mm sieve and were stored in a plastic containers for analytical purpose.

Extraction and purification of humic acid

The extraction and division of humic substances to obtain humic acids, as well as their purification were accomplished my analytical method as given by Schnitzer and khan (1972). The 20 g of air-dried soil sample was passed through 2 mm sieve, collected in a Winchester bottle and 200 mL 0.5N NaOH solution (soil : solution = 1:10) was added to it. The mixture was shaken on a mechanical shaker for one hour and allowed to stand overnight. The supernatant solution was siphoned off and centrifuged (5000 RPM) to separate clay contamination. This process was repeated three times. Then the HCl solution (2 N) was added to the solution until a pH of 2-3 was attained (measured by pH paper). The humic acid (HA fraction, brown to black colour) was precipitated and allowed to stand at room temperature for 24 hours. The soluble portion (FA) was separated from coagulate (HA) by centrifugation. The humic acid (HA) was redissolved in 0.5N NaOH and reprecipitated with 2N HCl. Following centrifugation the HA (coagulate) was transferred to a dialysis bag, dialyzed against distilled water until free from Cl^-. The humic acid was freeze dried, powdered with the help of on agate mortar and stored in a container.

Determination of pH of the soil by pH-meter

The 20 g of the soil sample was taken in a 50ml beaker and 45ml of distilled water was added (1:2.5), then the content of the beaker stirred intermittently with a glass rod for 10 minutes. After 10 minutes pH of the solution was obtained by direct reading of the pH meter.

Determination of electrical conductivity of the soil

After reading of the soil pH, the soil suspension was allowed to stand in the beaker to settle for a minimum of half an hour for determination of EC (electrical conductivity). After half an hour, EC (in dSm^{-1}) was recorded by using of EC meter.

Determination of Organic Carbon (OC) of the soil

The organic carbon percentage of the soil was obtained by walkley and black (1934) method. The 1 g soil sample (passed through 0.2 mm sieve) was taken into 500 mL dry conical flask of borosilicate glass and added 10mL of 1N potassium dichromate solution and 20 mL of conc. sulphuric acid, kept it in dark place about 30 minutes. Then 200 mL water, 10 mL orthophosphoric acid and 1 mL of diphenylamine indicator were added and titrated against 0.5 N ferrous ammonium sulphate solution. These reading were recorded for calculating the OC percentage.

Viscosity measurement of humic acid in different solvent

The 20 mg of humic acid was taken in a 100mL beaker and dissolved in a minimum volume of 0.1 (N) NaOH solution. Then 80mL de-ionized water was added and mixed thoroughly. After that pH of the humic acid solution was adjusted to 9 by adding NaOH and dilute HCl solution. Then the solution was transferred to 100mL volumetric flask and volume was made up to the mark with distilled water (water as solvent). 10mL of humic acid solution (pH 9) was pipette out into an Oswald type viscometer and time of flow was recorded of that solution. Viscosity (ç) and specific viscosity ($ç_{sp}$) were calculated by equation number 1, 3. Same procedure was repeated for humic acid solution (water as solvent) at pH 8, pH 7, pH 6 and also pH 9, pH 8, pH 7, pH 6 for humic acid solution (8 ppm NaCl solution as solvent) and humic acid solution (6 ppm NaCl solution as solvent).

RESULTS AND DISCUSSION

Soil status

The soil pH of study area (Raiganj, District Uttar Dinajpur, West Bengal) was basically acidic (pH 5.38) and non saline in nature (EC 0.063 dSm^{-1}) with an OC percentage was 1.2 (Table -1).

Table 1. Chemical properties of soil

Sample	Soil pH	E.C (dSm^{-1})	Organic C (%)
Raiganj soil	5.38	0.063	1.2

Viscosity measurements of humic acid (HA) solution (in water, 8 ppm NaCl and 6 ppm NaCl) at pH 6, pH 7, pH 8, and pH 9 were conducted respectively. The value obtained were tabulated and given in Table 2, which shows that at higher pH the K_{sp} increased from pH 6 to pH 9 *viz* with increase in pH from 6 to 9 the specific viscosity increased from 0.0416, 0.05, 0.0583 and 0.0666, respectively. This increase in specific viscosity indicated that humic acid molecules behave as flexible entities that can swell or shrink in response to changes in pH and ionic strength (Visser, 1985). An increase in pH of the solution leads to development of negative charges in the molecules with the consequent electrostatic repulsion between ionized groups and molecular swelling. Increasing the ionic strength increases the screening of charges and leads to molecular shrinkage.

Table 2. Viscometric measurement humic acid solution in different solvents and pH

HA solution	pH	ς_{sp}	$\varsigma_{sp/C}$
HA in water	6	0.042	20.80
	7	0.050	25.00
	8	0.058	29.15
	9	0.067	33.30
HA in 8ppm NaCl	6	0.016	8.15
	7	0.025	12.25
	8	0.033	16.35
	9	0.041	20.45
HA in 6ppm NaCl	6	0.0082	4.10
	7	0.0165	8.25
	8	0.0247	12.35
	9	0.0331	16.53

Now plotting $K_{sp/c}$ against pH (Fig. -1), found that viscosity of HA solution (water to 6 ppm NaCl) was reduced in presence of electrolyte (NaCl) from 20.8 (in water)to 4.1 (in 6ppm NaCl) at pH 6, 25.0 - 8.25 at pH 7, 29.15-12.35 at pH 8 and 33.3-16.5 at pH 9. This was caused by a decreased in degree of dissociation of ionizing groups and associated contraction of the particles *(Ghose and Schnitzer, 1980*). The degree of hydration of humic acid differed for different electrolyte concentration. In water humic acid was more hydrated and flexible, so that viscosity was more. Humic acid had an internal structure that limits the expansion of the molecules when the electrolyte concentration decreased.

Fig-1 also revealed the fact that the reduced viscosity values ($K_{sp/c}$) increased with increasing pH. This meant that with increase in pH from 6-9, there was an increase in molecular size or molecular weight. This might be attributed to the molecular association between humic structures through homolytic bonding which was prevalent bonding mode in that pH range.

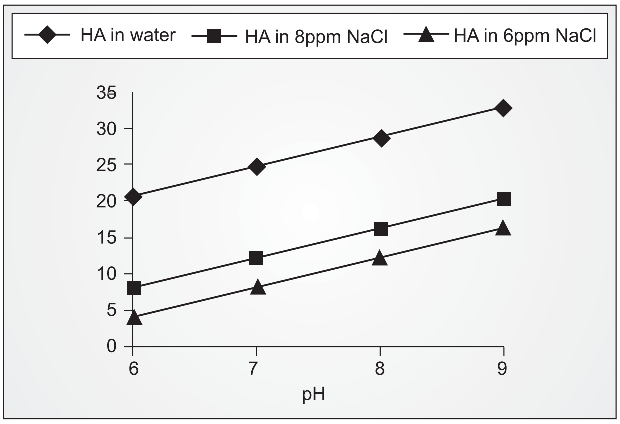

Fig. 1. Viscosity measurement HA solution in different solvents and pH

CONCLUSION

In acidic forest soils of Raiganj village in West Bengal, the viscosity of HA solution decreased in presence of neutral electrolyte and reduce viscosity values ($K_{sp/c}$) increased with increase in pH. It has been inferred from the reduced viscosity measurements that molecular association of humic structures increases with increasing pH from 6-9 *i.e.*, Because of interaction of humic charges at higher pH values, the HAs create agglomerates, resulting in higher viscosity of the solutions.

REFERENCES

Chen, Y., and Schnitzer, M. 1976. Viscosity measurements on soil humic substances. *Soil Sci. Society of America Journal*. 40, 866-872

Cameron, R.S., Thoronton, B.K., and Posner, A.M. 1972. Molecular Weight and Shape of humic acid from sedimentation and diffusion measurements on fraction extract. *J. Soil Sci*. 23, 394-408.

Flag, R. M., and Beutelspacher, H. 1954. Physikalische chemie der huminsauren. Landbouwk. Tijdschr. 66, 306-336.

Ghosh K., and Schnitzer, M. 1980. Macromolecular structures of humic substances. *Journal of Soil Sci*. 129, 401-409.

Ghosh K., and Mukherjee 1971. Hymatomelanic acids as polyelectrolytes: 1 Viscometric and Osmometric studies. *J.Appl. Polym. Sci*.15, 2073-2077.

Khan, S. U. 1971. Distribution and characteristics of organic matter extracted from Black Chernozemic soils of Alberta: The humic acid fraction. Soil science. 112, 401-409.

Kumada, K., Kawamura, Y. 1968. Viscosimetric characteristic of humic acid. *Soil Sci. Plant Nutrition*, 14, 190-197.

Mukherjee, P.N. and Lahiri, A. 1958 . Polyelectrolyte behaviour of humic acids. *Fuel* 37, 220-226.

Orlov, D.S., Ammosova, I.A.G.l. 1975. Molecular parameters of humic acids. *Geoderma*. 13, 211-229.

Schnitzer, M. and Khan, S. U.1972. The retention of hydrophobic organic compounds by humic acid. *Geochimica et Cosmochimica Acta* 36 (7), 745-754.

Stevension, F.J. 1994. Humus Chemistry Genesis, Composition, Reactions. 2nd edition, *John Wiley & Sons, New York*.

Visser, S.A. 1964. A physico-chemical study of the properties of humic acids and their changes during humification. *J. Soil Sci*. 15, 202-219.

Visser, S. A. 1985. Viscosimetric studies on molecular weight fractions of fulvic and humic acids of aquatic, terrestrial and microbial origin. *Plant and Soil* 87 (2), 209-221.

Walkley, A. and Black, I. A. 1934. An examination of Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science* 37, 29-37.

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Effect of inorganic and organic sources of nutrients on the uptake of maize and its economics

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ABSTRACT

Field experiment was conducted during Rabi 2005-06 and 2006-07 at the crop Research Farm, Department of Soil and Environmental Sciences, Allahabad Agricultural Institute – Deemed University, Allahabad, to study the performance of winter maize as affected by inorganic and organic use of nutrients on the yield of Winter Maize (*Zea mays* L.). The experiment was laid out in randomized block with 13 treatments, each replicated three times, using Maize variety Arjun. The experimental observations were recorded during the cropping time are nitrogen content, phosphorous content, potassium content, nitrogen uptake, phosphorous uptake, potassium uptake and economics. All these parameters were recorded highest when 25 percent of poultry manure plus 75 percent nitrogen was applied (T_8), whereas, they were lowest in the case of control (T_0) .

Key words: Inorganic and organic, nutrients, uptake, treatments, variety, manure.

INTRODUCTION

Maize crop is warm weather loving crop and used as test crop. Major nutrients plays important role in maize crops, especially nitrogen in maize is more important than any other nutrient through out its growing period right from seedling stage to grain filling stage and its deficiency at any stage of growth, especially at tasseling and silking stage, may lead to virtual crop failure. The nitrogen utilization pattern is found to be increased from seedling of knee height and reaches to the peak at tasseling stage. Phosphorus helps in development of maize at all phases of growth and shows deficiency mainly at seedling stage and delayed maturity with an imperfect ear formation. Maize plants need more than half of their potash requirement upto or before flowering stage. NPK uptake by all the crops increased with the increase in NPK rate and with farmyard application (Minhas and Sood, 1994).

MATERIALS AND METHODS

Field experiments were conducted during the Rabi seasons of 2005-2006 and 2006-07. The experiment was conducted at Soil Research Farm, Department of Soil and Environmental Science, Allahabad Agriculture Institute of Deemed University, Allahabad, Uttar Pradesh. The soil of experiment was sandy loam. The experiment was laid in randomized block design with four levels of organic manure and four levels of Nitrogen with three replication and thirteen treatment and the crop was applied recommended dose of fertilizers i.e. N, P, K @ 120, 60, 60 Kg ha^{-1}. Half entire dose of Nitrogen and total doses of Phosphorus and Potash were applied as basal dressing before sowing. The rest of the nitrogen was applied in knee height and tasseling stage. The recommended spacing for maize crop is 60 cm x 30 cm (row to row and plant to plant). The uptake of nitrogen, phosphorous and potassium was computed by the formula i.e. (% in straw +seed)* (Straw yield +grain yield) and economics was computed by different formulas.

RESULTS AND DISCUSSION

Nitrogen content

Nitrogen content in maize plant at harvest showed significant variation in nitrogen content in the pooled data as presented in Table 1.

Pooled data of the two years shows that application of organic with inorganic fertilizers significant increase nitrogen content over the

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Table 1: Effect of different treatments on Nitrogen, phosphorous and potassium (%) in plants of maize (*Zea mays L.*) in the pooled data of two year 2005-06 and 2006-07

Treatments	Nitrogen uptake	Phosphorous uptake	Potassium uptake
T_O Control	0.37	0.036	0.372
T_1 100% Farmyard Manure(FYM)	0.40	0.039	0.400
T_2 75% FYM+25%N	0.48	0.047	0.482
T_3 50% FYM+50%N	0.62	0.058	0.618
T_4 25% FYM+75%N	0.77	0.072	0.773
T_5 100% Poultry Manure(PM)	0.45	0.045	0.438
T_6 75% PM+25%N	0.57	0.055	0.575
T_7 50% PM+50%N	0.71	0.069	0.727
T_8 25PM+75%N	0.86	0.083	0.832
T_9 100% Goat Manure(GM)	0.42	0.042	0.425
T_{10} 75% GM+25%N	0.53	0.051	0.525
T_{11} 50% GM+50%N	0.66	0.065	0.675
T_{12} 25% GM+75%N	0.82	0.08	0.810
F-test	S	S	S
S.Ed.($-^{+}$)	0.007	0.0006	0.009
C.D.at 5%	0.015	0.0012	0.019

control. The nitrogen content in the control was 0.37 percent which increased to 0.86 percent at harvest in 25 percent poultry manure plus 75 percent nitrogen (T_8). However, significant differences were obtained in all the treatments. The increase in the nitrogen content due to inorganic application with poultry manures might be attributed to the increased availability of nitrogen at higher levels.

Phosphorous content

Concentration of phosphorous in maize plant are presented in Table 1, it was significantly influenced by the application of graded levels of organic with inorganic application in the pooled data.

Pooled data of the two years shows that concentration was recorded a significant variation due to varying levels of organic with inorganic and organic sources of nutrients. The phosphorus content in the control was 0.036 percent, which increased significantly to 0.083 percent in 25 percent poultry manure plus 75 percent nitrogen (T_8). However, significant difference was obtained between all the treatments. The phosphorus content in plant height be attributed to the increased availability of phosphorous with nitrogen application on account of localized acidity caused in soil and thereby increasing the availability of phosphorous and also due to increased root growth, resulting forage capacity of plant root to absorb the relatively less mobile phosphorus also due to increased root growth.

Potassium content

Potassium concentration in maize plant was significantly influenced by application of different levels of organic with inorganic and their effect in the pooled data presented in Table 1.

Pooled data of the two years shows that graded levels of organic with inorganic significantly increased the potassium concentration in the maize plant. The minimum was 0.372 percent in the control and the maximum was 0.832 percent in 25 percent poultry manure plus 75 percent nitrogen (T_8) respectively. However, significantly differences were obtained between all the treatments.

Nitrogen uptake

Uptake of nitrogen by maize plant at harvest increased significantly with the application of organic with inorganic are presented in Table 2.

Pooled data of the two years shows that nitrogen uptake by maize plant at harvest was 35.65 kg/ha in control which increased to 189.14 kg/ha at 25 percent poultry manure plus 75 percent nitrogen (T_8), respectively. It was statistically at par the 25 percent goat manure plus 75 percent nitrogen (T_{12}). However significant differences were obtained in all treatments (except T_{12}). The increase in the nitrogen uptake might be attributed to a significant increase in nitrogen content and dry matter production of maize. Similar finding was given by Prasad (1986), Jokela (1992) and Korkmaz et al. (2000).

Phosphorous uptake

The graded levels of organic with inorganic and organic have significant influence on the phosphorus uptake by the plant at harvest, which are presented in the Table 2.

Pooled data of the two years showed that among the different level of organic and inorganic, minimum phosphorus uptake 3.48 kg/ha in the control to a maximum of 18.44 kg/ha was observed in 25 percent poultry manure plus 75 percent nitrogen (T_8). It was statistically at par 25 percent goat manure plus 75 percent nitrogen (T_{12}). However significant differences was obtained in all treatment (except T_{12}). The increase in phosphorus uptake due to nitrogen application results from synergistic influence of nitrogen on phosphorus uptake and also from the increase in phosphorus concentration and dry matter production with increase in nitrogen application that enhance phosphorus uptake also from the increase in phosphorus concentration and dry matter production with increase in nitrogen application that enhance phosphorus uptake. Similar results were reported by Nayyar and Sawarkar (1980).

Potassium uptake

In the pooled data over the two years shows that potassium uptake significantly increased with the increased organic with inorganic at harvest stage are presented in the Table 2.

According to the pooled data of the two years, uptake of potassium by the maize plant at harvest significantly increased with increased nitrogen. Maximum potassium uptake 183.65 kg/ha by the maize plant at harvest was observed in 25 percent poultry manure plus 75 percent nitrogen (T_8) as against a minimum uptake 36.18 kg/ha in the control respectively. It was statistically at par with 25 percent goat manure plus 75 percent nitrogen (T_{12}). However, significant difference was obtained in all treatments (except T_{12}). It might be attributed to the beneficial effect of nitrogen, which favored vigorous growth of the plant and in turn increased the potassium concentration and dry matter yield resulting in increased uptake of potassium.

Economic variability of different treatment combination

Economic analysis of the different treatment combination used in the maize are presented in Table 3 was observed that both the net returns and benefit cost ratio was increased over the control with the application of inorganic and organic when both inorganic and organic applied in combined form during both the years. During both the year net returns and benefit cost ratio was higher with application of 25 percent poultry manure and 75 percent nitrogen and benefit cost ratio than sole application.

Among all other treatments combinations the maximum net return of Rs 32819.20 and 38764.74 in 2005-06 and 2006-07 with benefit cost ratio 2.63

Table 2. Effect of different treatments on Nitrogen, phosphorous and potassium uptake (kg/ha) by plants of maize (Zea mays L.) in the pooled data of two years 2005-06 and 2006-07.

Treatments	Nitrogen uptake(kg/ha)	Phosphorous uptake(kg/ha)	Potassium uptake(kg/ha)
T_O Control	35.65	3.48	36.18
T_1 100% Farmyard Manure(FYM)	43.22	4.23	43.83
T_2 75%FYM+25%N	66.56	6.59	67.54
T_3 50%FYM+50%N	99.56	9.37	99.76
T_4 25%FYM+75%N	146.15	13.78	147.47
T_5 100% Poultry Manure (PM)	56.54	5.75	55.57
T_6 75%PM+25%N	86.85	8.46	87.80
T_7 50%PM+50%N	127.36	12.50	130.93
T_8 25PM+75%N	189.14	18.40	183.65
T_9 100%Goat Manure(GM)	48.82	4.88	49.81
T_{10} 75%GM+25%N	78.23	7.66	78.34
T_{11} 50%GM+50%N	111.09	10.93	113.86
T_{12} 25%GM+75%N	163.55	15.94	162.90
F-test	S	S	S
S.Ed.($-^{+}$)	14.76	1.42	15.07
C.D.at 5%	30.46	2.94	31.11

Table 3. Economics of different treatments: 2005-06 and 2006-07

Treatments	Cost of cultivation (Rs ha^{-1})		Yield Grain (q ha^{-1})		Yield (Straw q ha^{-1})		Gross Return (Rs ha^{-1})		Net Return (Rs ha^{-1})		Benefit cost Ratio	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
T_O Control	19947	20572	30.1	32.6	63.3	64.4	28793.2	32023.0	8846.2	11451.3	1.4	1.5
T_1 100% Farmyard Manure(FYM)	31120	31745	33.8	37.6	74.1	76.4	32494.5	37687.0	1374.5	5942.7	1.0	1.1
T_2 75%FYM+25%N	27375	28000	36.9	51.0	94.8	97.8	36151.8	50821.8	8776.8	22821.8	1.3	1.8
T_3 50%FYM+50%N	23630	24255	43.0	53.6	110.9	116.7	42071.5	54146.5	18441.5	29891.5	1.7	2.2
T_4 25%FYM+75%N	19892	20517	49.8	55.1	137.4	139.0	49246.5	56567.0	29354.5	36050.0	2.4	2.7
T_5 100% PoultryManure(FYM)	32320	32945	36.6	47.4	79.6	92.0	35121.6	47290.5	2801.6	14345.5	1.0	1.4
T_6 75%PM+25%N	28275	28900	42.5	53.3	102.7	108.6	41303.5	53400.7	13028.5	24500.7	1.4	1.8
T_7 50%PM+50%N	24230	24855	49.4	54.6	119.0	137.7	47958.5	56028.0	23728.5	31173.0	1.9	2.2
T_8 25%PM+75%N	20192	20817	52.8	56.8	162.6	169.2	53011.2	59581.7	32819.2	38764.7	2.6	2.8
T_9 100% Goat Manure(FYM)	31120	31745	34.8	39.9	77.6	81.3	33519.8	40038.8	2399.8	8293.8	1.0	1.2
T_{10} 75%GM+25%N	27375	28000	40.8	51.2	100.0	105.1	39710.4	51368.7	12335.4	233368.7	1.4	1.8
T_{11} 50%GM+50%N	23630	24255	43.1	54.1	117.5	120.1	42535.5	54724.5	1890.5	30469.5	1.8	2.2
T_{12} 25%GM+75%N	19892	20517	52.1	56.6	142.6	151.3	51443.5	58572.5	31551.5	38055.5	2.5	2.8

Sale Rate- Grain: Rs. 850/q (2005-06) Rs.900/q (2006-07) Straw: Rs. 50/q (2005-06 and 2006-07)

and 2.86 were observed in 25 percent poultry manure plus 75 percent nitrogen (T_8) during both the year. This result was in confirmation of the finding of Chandershekara et al. (2000).

CONCLUSION

The result obtained during the present investigation, it may be concluded that 25 percent nitrogen through poultry manure plus 75 percent nitrogen through urea (T_8) found to be best.

REFERENCES

Minhas, R.S and Sood, A. 1994. Effect of inorganics and organics on the yield and nutrient uptake by three crops in rotation on an acid Alfisal. *Journal Indian Society of Soil Science*. 42(2), 257-260.

Prasad U.K. 1997. Nitrogen and irrigation requirements of winter maize. *Indian Farming, July*; 21-23.

Jokela, WE 1992. Nitrogen fertilizer and dairy manure effects of com yield and soil nitrate. Soil science society of America Journal (USA), 56(1), 148-154.

Korkmaz, A.; Kizilkaya, R.; Haruz, A. and Suruch, A, 2000. Estimation of plant available amount of nitrogen in poultry dried with fan separated by trace technique. *Turkish Journal Agricultural and Forestry* 24(1), 63-70.

Nayyar; D.V. and Sawarbar; N.J, 1980. Trace studies on the uptake and utilization of fertilizer phosphorus by maize as influenced by nitrogen application. *Journal of Indian Society Soil Science* vol.28(4): 537-539.

Chandrashekara, C.P.; Harlopur, S.F.; Muralikrishna, S. and Girijesh G.K., 2000. Response of maize to organic manures with inorganic fertilizers. *Journal Agricultural Science*. 13(1), 144-46.

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Multi-parametric influence of fly ash as a soil ameliorant and its influence on soil microbial properties- A review

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ABSTRACT

Solid waste utilization is assuming an important place in environment-friendly soil amelioration programmes. The need of the hour is to devise long-lasting solution to the ever impending problem of their disposal. Waste utilization for soil amelioration in a scientifically substantiated and conscious manner provides an eco- friendly and affordable alternative for remediation of former mining sites, re-vegetation of barren lands, or amelioration of agricultural lands. This kind of strategy represents a new, holistic approach in waste management and soil amelioration, where the needs of bad quality soils can meet the values of waste materials. Soil ameliorants such as agricultural residues, organic wastes, domestic and poultry waste, fly ash etc. can be characterised and tested for use in agriculture and they can be integrated in nutrient management programmes. Fly ash is one such versatile and heterogeneous waste which upon addition to soil at optimum dose can help in maintenance of soil quality and also contribute to agro-ecosystem protection and environment conservation. The present paper is a comprehensive review of fly ash effect and benefits on soil physical, chemical and microbiological properties in diverse ecosystems in conjunction with nutrient management practices.

Key words: Fly ash, amelioration, soil quality, nutrient management, microbial properties

INTRODUCTION

Soil is the fundamental and irreplaceable part of the terrestrial environment that supports all terrestrial life forms (Nanniperi *et al.*, 2003). The living population inhabiting soil includes macrofauna, mesofauna, microfauna and microflora. Focus on the relationship between microbial diversity and soil functionality has evoked immense interest world over, considering that 80–90% of the processes in soil are reactions mediated by microbes (Coleman and Crossley , 1996 and Nanniperi *et al.*, 2003).

Soil health is the manifestation of a unique balance of physical , chemical and biological (including microbial) components which include soil type and texture (Cavigelli *et al.*, 2005;

Girvan *et al.*, 2003; Ulrich and Becker, 2006), aggregate size (Schutter and Dick, 2002), moisture (Williams and Rice, 2007), predation (Griffiths *et al.*, 1999), pH (Fierer and Jackson, 2006), temperature (Norris *et al.*, 2002), soil microbial community (Schimel, 1995 and Sowerby *et al.*, 2005), heavy metals, water and oxygen availability, along with the host plant, also play a major role in influencing the soil health (Ross *et al.*, 2000 and Ibekwe *et al.*, 2010).

Why soil amelioration?

Agricultural management for maximum productivity and keeping in lines with increasing trend towards business-oriented agriculture involves multi-faceted strategies based on fundamental factors such as tillage (Buckley and Schmidt , 2001a and Cookson *et al.*, 2008), cover cropping (Carrera *et al.*, 2007) and Schutter *et al.*, 2001), fertilizer (Grayston *et al.*, 2004), crop rotation (Olsson and Alstrom, 2000) and amendments in the form of soil ameliorants (Saison *et al.*, 2006 and Buyer *et al.*, 2010).

Plant growth, crop yield and quality depend on the soil's ability to provide nutrients and water at a rate that matches plant requirements and root architecture plays a significant role in this regard (Jones and Ljung, 2012). Nutrients from soil are drawn with the help of plant root system, its depth,

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lateral spread, spatial uniformity, density, and the rate it is able to grow. Changes in root architecture, induction of root-based transport systems and associations with beneficial soil microorganisms allow plants to maintain optimal nutrient content in the face of changing soil environments (Morgan and Connolly, 2013).

In recent years the rising cost of fertilizers to correct nutrient deficiencies and other problems related to soil drainage, compaction, salinity, oxygen stress etc. has made it mandatory to search for alternative cost effective soil ameliorants for the purpose (Lopez *et al*., 2009). Solid waste utilization has opened up new horizons for bringing a long-lasting solution to this problem and also paves a way for their eco-friendly disposal (Jala and Goyal, 2006) ever impending problem of their disposal. Waste utilization for soil amelioration in a scientifically substantiated and conscious manner provide an environmentally friendly and affordable alternative for the remediation of former mining sites, revegetation of brownfields, or amelioration of agricultural lands (Babu and Reddy, 2011). This kind of strategy represents a new, holistic approach in waste management and soil amelioration, where the needs of bad quality soils can meet the values of waste materials.

Soil ameliorants such as agricultural residues, organic wastes, domestic and poultry waste, fly ash etc. can be characterised and tested for use in agriculture. Agricultural and industrial activities have enhanced the pace of degradation of soil resulting in nutrient depletion and loss of biological activity.

Agro ecosystem protection and environment conservation is based on development and implementation of management strategies that maintain the quality of soil, especially organic matter (Saviozzi *et al*., 1999). For this reason it is very important to monitor the ecological state of soil after the application of any ameliorating agent (Kizilkaya and Bayrakli, 2005). Nutrient management practices affect the viability of agro-ecosystems and it is very crucial to develop nutrient balance based on soil and plant analysis under all conditions (Truter, 2002).

Coal Combustion Products (CCPs)

Coal Combustion Products result from the combustion of coal, in coal-fired power stations (Seshadri *et al*., 2010). The volume of waste generated and subsequently their safe disposal is an issue which needs deep introspection and a focussed strategy since they have inherent potential as a cost effective soil amendment (Rethman *et al*., 1999; Rethman and Truter 2001; WEC, 2007). Coal combustion by-products improve soil structure, reduce bulk density of soil, improve water holding capacity and act as a barrier to weeds (Seshadri *et al*., 2010).

The power sector based on the use of coal as the source of energy generates bituminous and sub-bituminous coal combustion by-products (CCPs) (Mattigod, 1990). These include fly ash, bottom ash, boiler slag and flue gas desulfurization (FGD) materials (Vom Berg, 1998). Fly ash is the mineral residue consisting of small particles that are carried up and out of the boiler in the flow of exhaust gases and are collected from the stack gases using electrostatic precipitators (ESP), flue gas desulfurization (FGD) systems and bag houses (Jala and Goyal, 2006).

Fly ash

About 70 % of the by-product is ESP fly ash which is the most difficult to handle. Nearly 10-12 per cent of the by-product is bottom ash, which is coarse and solid mineral residue. Disposal and utilization of fly ash needs careful assessment to prevent conversion of arable land into landfills and accumulation of toxic metals in soil (Petruzzelli, 1989) and use it as an ameliorant for problem soils. Restoration and utilization of fly ash dumps for biomass production can be an adjunct to these efforts based on various attributes of fly ash for its application in agriculture and deriving agronomic benefits (Jala and Goyal, 2006).

Why fly ash?

Fly ash has similar physical and chemical properties to those of soil. The constituents of fly ash as reported in literature have been given (Table 1). It can be used directly as a soil amendment, or in land reclamation, with organic matter, lime or gypsum, in composts, or made into granulated materials or potassium silicate fertilisers (Jala and Goyal, 2006). Fly ash improves the physical properties of the soil, increasing moisture retention in poor soils and aeration. It provides the micronutrients for plant growth, but lacks potassium and only supplies a limited amount of nitrogen (Pathan *et al*., 2003) and available water content of soils (Adriano and Weber, 2001). Major enhancing properties of fly ash include acid neutralization and buffering capacity, presence of essential plant nutrients, gypsum content and optimal particle size distribution for soil manipulation, filling of voids and water

Table 1. Major and trace elements in soil and electrostatic precipitator (ESP) fly ash (Page *et al.*,1979; Jala and Goyal, 2006).

Element	Soil	Fly ash
Major elements in %		
Al	4-30	0.1-17.3
Ca	0.7-50	0.11-22.2
Fe	0.7-55	1-29
Mg	0.06-0.6	0.04-7.6
Na	0.04-3.0	0.01-2.03
K	0.04-3.0	0.15-3.5
S	0.01-2.0	0.1-1.5
P	0.005-0.2	0.04-0.8
N	0.01-1.0	-
Trace elements in ppm		
As	0.1-4.0	2.3-6300
B	2-100	10-618
Cd	0.01-7.0	0.7-130
Co	1-40	7-520
Cr	5-3000	10-1000
Cu	2-100	14-2800
Hg	-	0.02-1.0
Mn	100-4000	58-3000
Mo	0.2-5.0	7-160
Ni	10-1000	6.3-4300
Pb	2-100	3.1-5000
Se	0.1-2.0	0.2-134
Zn	10-300	10-3500
Radioactivity(Bq Kg)		
Ra 226	-	-
Ac 228	-	-
K 40	-	-

holding properties (Dick *et al.*, 2000). Addition of fly ash decreases bulk density and improves water holding capacity due to dominance of silt-sized particles in fly ash (Campbell *et al.*, 1983) and when added to a soil high in clay, the soil texture and other associated physical characteristics, such as bulk density, can be altered to be more desirable for plant growth. Due to the fine nature of fly ash, it improves the water holding capacity of sandy soils and removes the compaction of clay soils (Sharma *et al.*, 2001b). Further beneficial effects are envisaged with plant growth in the fly ash amended soils due to the nutritional advantage to be gained from association with plant roots and exudates in addition to amelioration of the soil physical environment. Nutrient enrichment of soil due to fly ash amendment up to a certain level would be expected to stimulate root growth and excretion of root exudates in the soil (Kohli and Goyal, 2010). This has a cyclic effect; the addition of exudates and root biomass not only ameliorates the soil physical conditions further, but also brings the added nutrients into the biological nutrient cycle, making the soil resurgent and verdant (Kohli and Goyal, 2010).

Fly ash utilization statistics

Fly ash has been applied successfully in specific agricultural projects in many countries, such as Australia, Germany, India, Japan, South Africa, the UK and the USA (Smith, 2005). Approximately 70 million metric tons of fly ash was produced in the United States in 2002, which amounted to 60% of all coal combustion by-products (ACCA, 2003). In India the figure is more than 108 mt per annum (Haque, 2013) of which nearly 4 mt is released into the atmosphere. Presently less than half of total fly ash produced is being utilized properly in India and more than 175 million tonnes of fly ash is expected to be produced in future, thus raising issues of eco-friendly disposal (Savitri and Lasrayza, 2012). Utilization of the total ash generated in different countries amounts to more than 85 % in West Germany and France, 73 % in Denmark, 50 % in UK, 50 % in Poland, 32 % in United States, 45 % in China and 15% in India (Sinha and Basu, 1998). According to the report published by American Coal Ash Association (1997), 32% of the fly ash, 30% of the bottom ash, 94% of the boiler slags and 9% of flue gas desulfurization sludge were used for agriculture, wasteland reclamation and civil engineering purposes.

Properties of fly ash

The mineralogical, physical and chemical properties of fly ash (Carlson and Adriano, 1993) depends on the nature of parent coal, conditions of combustion, type of emission control devices and storage and handling methods. Therefore, ash produced by burning of anthracite, bituminous and lignite coal has different compositions. Fly ash is an amorphous mixture of ferroaluminosilicate minerals generated from the combustion of ground or powdered coal at 400-1500 ^{0}C (Mattigod *et al.*, 1990).

Physical Attributes

Physically, fly ash occurs as very fine particles having an average diameter of <10 µm and has low to medium bulk density, high surface area and light texture. The fine particles are aggregated into micron and sub-micron spherical particles of 0.01 to 100 mm size (Davison *et al.*, 1974; Peng *et al.*, 2004). The specific gravity of fly ash ranges from 2.1 to 2.6 g cm^{-3}. Mean particle density for nonmagnetic and magnetic particles is 2.7 and 3.4 g cm^{-3} respectively (Natusch and Wallace, 1974). Bulk density of fly ash varies from 1 to 1.8 Mg m^{-3} while moisture retention ranges from 6.1% at 15 bar to 13.4% at 1/3 bar. Over all fly ash has lower values for bulk density, hydraulic conductivity and specific gravity compared to mineral soils. Both crystalline (mullite) and amorphous (glass) phases have been identified by X-ray diffraction in fly ash (Mattigod *et al.*, 1990).

Influence on soil

Fly ash addition alters physical properties of soil such as texture, bulk density, water holding capacity and particle size distribution (Sharma, 1989). Fly ash has been observed to have a positive effect on water holding capacity, hydraulic conductivity and pH apart from acting as source of nutrients (Yunusa *et al.*, 2006). Fly ash is predominantly composed of silt-size particles so its addition in soils very high in either sand or clay can improve soil texture by reducing soil bulk density and increasing aeration (Chang *et al.*, 1977). Fly ash addition at 70 t/ha was reported to alter the texture of sandy and clay soils to loamy soils (Capp, 1978) and improve the water-holding capacity of sandy soils (Aitken *et al.*, 1984; Aitken and Bell, 1985). Fly ash application to soil at varying concentrations of 0, 5, 10, 20 and 30% for maintaining nursery of *Populus deltoides led* to a linear decrease in soil bulk density and a linear increase in soil water holding capacity (Kohli and Goyal, 2010).

Chemical attributes

Chemically, 90-99% of fly ash is composed of Si, Al, Fe, Ca, Mg, Na and K with Si and Al forming the major matrix (Adriano *et al.*, 1980). There are mainly two types of ash, i.e: Class F (low lime) and Class C (high lime) based on total amounts of silica, alumina and iron oxide. Al in fly ash is mostly bound in insoluble aluminosilicate structures, which considerably limits its biological toxicity (Page *et al.*, 1979). It is substantially rich in trace elements like lanthanum, terbium, mercury, cobalt and chromium Adriano et al. (1980). Many trace elements in fly ash like As, B, Ca, Mo,S, Se and Sr are concentrated in the smaller ash particles (Page *et al.*, 1979; Adriano et al. 1980). The Fe-oxide contents of spheres influences their color which ranges from water white to yellow orange to deep red or brown to opaque. Fly ash, which can be acidic or alkaline depending on the source, can be used to buffer the soil pH (Rani and Kalpana, 2010; Yeledhalii *et al.*, 2007).

Influence on soil

The electrical conductivity of soil increases with fly ash application and so does the metal content. Lime in fly ash readily reacts with acidic components in soil and releases nutrients such as S, B and Mo in forms and amounts beneficial to crop plants. Fly ash directly used for fertilization, acts as a magnesium and calcium fertilizer (Michalcewicz *et al.*, 2011). Fly ash used in combination with different percentages in a combination with sphagnum peat moss was observed to improve the media texture, regulate pH and bind heavy metals for selected plants of barley, oats, rye, wheat and hybrids such as Re green (wheatgrass X winter wheat) and Triticale (wheat X rye), and perennial ryegrass (Bilski *et al.*, 2011; Bilski *et al.*, 2012). Elseewi and Page (1984) demonstrated that addition of unweathered fly ash can substantially increase soil salinity, alkalinity, concentration of macronutrients and trace elements (Kalembkiewicz *et al.*, 2007 and Wojcieszczuk *et al.*, 2009). The amount of ash needed to raise soil pH to levels conducive to maximum plant growth varies with the composition of ash and the properties of soil (Molliner and Street, 1982; Petruzzelli *et al.*, 1989). Fly ash has immense potential as a soil-ameliorating agent and as an integral component of any Integrated Plant Nutrition System in combination with organic manure, farmyard manure, paper factory sludge and chemical fertilizers for forestry, wasteland reclamation and agriculture which maybe attributed to its heterogenous nature (Reynolds *et al.*, 1999).

An appreciable change in the soil physicochemical properties, rising of pH and increased rice crop yield has been reported upon mixing fly ash with paper factory sludge and farmyard manure (Hill and Lamp, 1980; Molliner and Street, 1982). Combined effect of mixed application of fly ash and organic compost on soil and availability and uptake of elements by various plant species was studied (Menon, 1993). Co-utilization of 'slash,' a mixture of fly ash, sewage sludge and lime in the ratio of 60:30:10 had beneficial soil ameliorating effect (Reynolds *et al.*, 1999).

Biological attributes

Fly ash effect on soil microbes

Experimental plots established for *Zea mays* L. and *Triticum aestivum* L. in rotation or continuous *Festuca arundinacea* Schreb resulted in distinct proliferation of aerobic heterotrophs, ammonium oxidizers and denitrifiers isolated from fly ash amended plots besides doubling of nitrification potentials (Schutter and Fuhermann, 1997). Amendment of soil with fly ash in conjunction with sewage sludge improved microbial count and enzyme activity (Pitchel and Hayes, 1990). This may be attributed to improved CEC, soil moisture and aggregation. The microbes are the important elements of the soil environment as they participate in the degradation of the organic matter and make the nutrients available to other soil organisms. This favors the formation of soil aggregates, immobilizes the heavy metals and stimulates the activity of soil enzymes viz., dehydrogenase, urease and phosphatases etc., (Pati and Sahu, 2004). A large amount of elements (C, K, Ca, Mg, Cu, Zn and Mn) get into the soil as a result of ash used at different doses and may probably change the chemical as well as physicochemical soil properties which in turn may determine the biological properties irrespective of the crop (Ulrich and Becker, 2006; Yelledhalli *et al.*, 2007).

The bacterial number, soil dehydrogenase activity (SDA) and microbial biomass responded in a parabolic manner to increasing levels of fly ash addition (0, 10 and 30 %) in another study where electrostatic precipitator fly ash was admixed with alkaline soil and fly ash application at 10% level was found to be optimum for microbial parameters respectively (Kohli and Goyal , 2010). Koivula *et al.*, (2004) reported improved oxygenation, increased mineralization and humification by admixing ash with organic substances due to enhanced availability of organic matter for microbial enzymatic degradation either indirectly by stimulating plant growth or directly through carbon input. Studies on soil organic carbon and soil dry matter have suggested increased organic matter content in the presence of ash (Jokinen *et al.*, 2006).

Soil dehydrogenase activity (SDA) and rate of carbon-dioxide evolution of a fly ash amended soil was studied as a function of substrate availability where alkaline soil from Patiala, Punjab was amended with varying ESP fly ash (from Yamunanagar thermal power plant) concentrations along with glucose as a carbon source and analysed for the effect on soil dehydrogenase activity and rate of carbon-dioxide evolution (Cassida, 1977; Stotzky, 1965). Increasing substrate availability up to 4 per cent glucose on w/w basis led to a linear increase in SDA for soil with and without fly ash (R^2 = 0.96 and 0.95 respectively) (Fig. 1) while percentage change in soil dehydrogenase activity with fly ash amendment showed a parabolic response (R^2= 0.51) to increase in substrate availability (Fig. 2) (Jala, 2006)

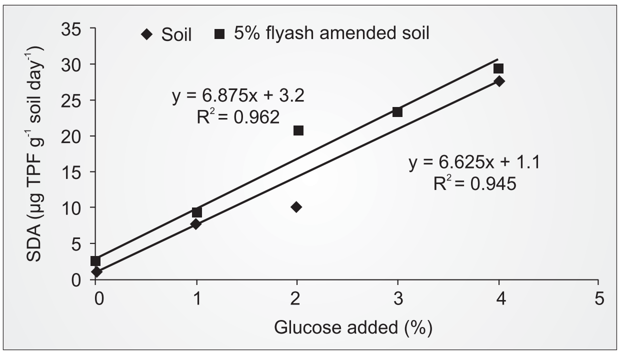

Fig. 1. Soil dehydrogenase activity of soil with and without fly ash amendment at varying levels of substrate availability

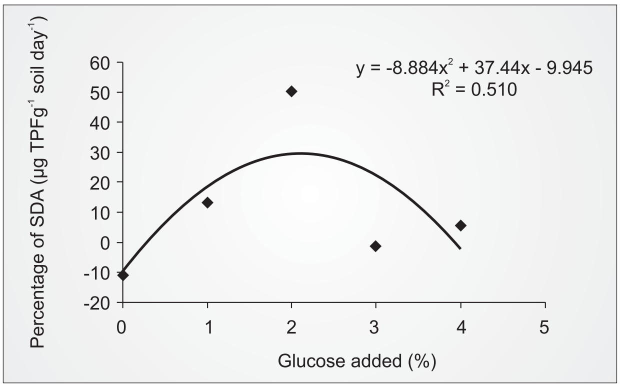

Fig. 2 Percentage change in soil dehydrogenase activity with addition of fly ash (5 %) at varying levels of substrate availability

Mean rate of carbon-dioxide evolution in fly ash amended soil (at 5 per cent fly ash) was only 91 per cent of that observed for soil alone. However upon the addition of substrate in the form of glucose @ 1, 2, 3 and 4 per cent rate of carbondioxide evolution increased to 95, 97, 98 and 100 % of original soil (Fig .3) (Jala, 2006).

Studies on CO_2 evolution and enzyme activities (dehydrogenase, protease and amylase) of fly ash amended soil in the presence and absence of earthworms (*Drawida willsi*, Michaelsen) revealed stimulation of soil respiration and microbial activities (Pati and Sahu, 2004). Increased microbial activity was reported for ash amended soils

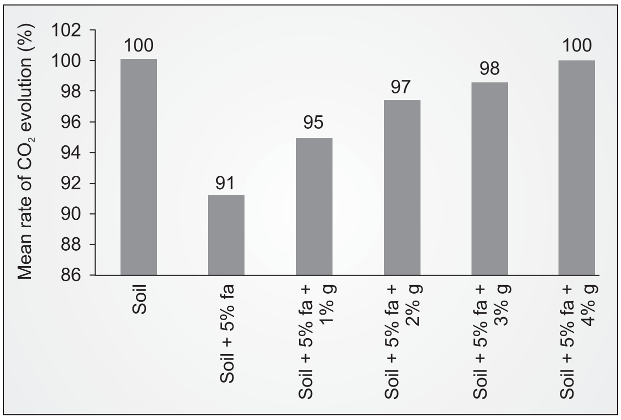

Fig. 3. Mean rate of carbon dioxide evolution from a soil and that influenced with addition of fly ash (5%) at varying levels of substrate availability (at 0, 1, 2, 3 and 4 per cent glucose addition respectively)

containing sewage sludge with the microorganisms invariably adapting to the stressed conditions in the form of a gradual increase in respiration after an initial lag (Pichtel and Hayes, 1990). Presence of organic matter reduces the concentration of toxic metals through sorption, lowers the C/N ratio and provides organic compounds, which promote microbial proliferation and diversity (Wong and Wong, 1986; Pichtel and Hayes, 1990). Fly ash-sludge mixtures containing 10% ash was reported to have a positive effect on soil dehydrogenase activity, N and P cycling and reduction in the availability of heavy metals (Lai *et al*., 1999). Fatty acid methyl ester (FAME) profiles and whole-carbon substrate utilization potential using Biolog (Biolog, Inc., Hayward,California) have been used to estimate microbial community structure in wastes like coal fly ash, coal mine spoil etc. and various groups identified and few were found to be dominant including *Arthrobacter* sp., *Micrococcus* sp. *Psuedomonas* sp. etc (Schutter and Fuhrmann, 2001). Application of fly ash at 40 t/ ha in conjunction with phosphate solubilizer, *Pseudomonas striata* has been reported to increase bean yield and phosphorus uptake by grain without any detrimental effect on the population of *P. striata* in soil (Gaind and Gaur, 2002). In another study, amendment of Class F bituminous fly ash to soil at a rate of 505 Mg/ha did not show any detrimental effect on soil microbial communities and analysis of community fatty acids indicated elevated populations of fungi, including arbuscular mycorrhizal fungi and gram negative bacteria (Schutter and Fuhrmann, 2001, 2002). It has been reported by several investigators that a high proportion of P-solubilizing microorganisms are concentrated in the rhizosphere of the plants (Gaind and Gaur, 2003 a) and their activities are much higher in rhizosphere soil than in bulk soil (Gaind and Gaur, 2003 b).

Synergistic effect of fly ash and chemical fertilizers came to light in field experiments which involved growing forestry species of *Acacia auriculiformis* and *Eucalyptus tereticornis* in fly ash amended Ultisol. A positive influence on N, P, K, soil organic carbon and soil dehydrogenase activity in rhizosphere soil was found as a result of fly ash addition ranging from 12 to 18 % in soil amended with fly ash and fertilizers both (Amonette *et al.*, 2003; Jala, 2006) which may be attributed to cenospheric particles of fly ash (Amonette *et al.*, 2003).

CONCLUSION

Soil is the surface on the earth's crust where geology and biology meet and the land surface that provides a home to plant, animal and microbial life. Although soil sustains an immense diversity nevertheless the individual genera present in soil depends upon various factors like plant roots, seasonal fluctuation, spatial variation, soil type and soil ameliorants such as fly ash, fertilizers, organic manure, sludge, biofertilizers etc. Fly ash generated as a result of coal combustion in thermal power plants is solid waste, the eco-friendly disposal of which is a critical issue needing deep introspection and thought.

Inherent presence of essential plant nutrients in ionic form in fly ash and subsequent ameliorating effect on the physical, chemical and microbial characteristics of soil makes fly ash a significant input for agriculture and forestry species for biomass production, especially on variously degraded soils and wastelands. The need of the hour is to work out a strategy where fly ash is put to use in conjunction with fertilizers, organic manure, sewage sludge, agri-waste or microbial inoculants for improving soil properties and enriching its nutrient status.

REFERENCES

Adriano, D.C., Page, A.L., Elseewi, A.A., Chang, A.C., Straughan, I.,1980. Utilization and disposal of fly ash and other coal residues in terrestrial ecosystems: a review. *J. Environ. Qual.* 9, 333–344.

Adriano, D.C., Weber, J.T., 2001. Influence of fly ash on soil physical properties and turf grass establishment. *J. Environ. Qual.* 30, 596–601.

Aitken, R.L., Bell, L.C., 1985. Plant uptake and phytotoxicity of Boron in Australian fly ashes. *Plant Soil*. 84, 245–257.

Aitken, R.L., Campbell, D.J., Bell, L.C., 1984. Properties of Australian fly ash relevant to their agronomic utilization. *Aust. J. Soil Res.*22, 443–453.

American Coal Ash Association, 1997. Coal Combustion Product (CCP) Production and Use. ACAA, Alexandria, VA.

American Coal Ash Association, ACAA. (2003) Coal combustion production and use survey. www.ACAA-USA.org. Jan 18, 2003.

Amonette, J. E., Kim, J., Russell, C. K., Anthony, V. P. and Daniels, W. L. 2003. Enhancement of soil carbon sequestration by amendment with fly ash. International ash Utilization Symposium, Center for Applied Research, University of Kentucky. Second annual conference on carbon sequestration May 5-8, 2003.

Babu A.G., Reddy M.S., (2011). Dual inoculation of arbuscular mycorrhizal and phosphate solubilizing fungi contributes in sustainable maintenance of plant health in fly ash ponds. *Water, Air and Soil Pollution*, 219: 3-10.

Bilski J, Mclean K, McLean E, Soumaila F, Lander M (2011) Revegetation of coal ash by selected cereal crops and trace elements accumulation by plant seedlings. *Int. J. Environ. Sci.*, 1:1033-1046.

Bilski J., Dissette N., McLean E., Soumaila F. (2012). Amelioration of coal fly ash used as cereal crops growth media by sphagnum peat moss and soil. *Int. J. Agric. Sci*. 2(4): 328-340.

Buckley, D., Schmidt, T. (2001a). The structure of microbial communities in soil and the lasting impact of cultivation. *Microbial Ecology*, 42: 11-21.

Buyer, J.S., Teasdale, J.R., Roberts, D.P., Zasada, I.A., Maul, J.E. (2010). Factors affecting soil microbial community structure in tomato cropping systems. *Soil Biology & Biochemistry*, 42: 831-841.

Campbell, D.J., Fox, W.E., Aitken, R.L., Bell, L.C., (1983). Physicalcharacteristics of sands amended with fly ash. *Aust. J. Soil Res.* 21,147–154.

Capp, J.P., 1978. Power plant fly ash utilization for land reclamation in the eastern United States. In: Schaller, F.W., Sutton, P. (Eds.), Reclamation of Drastically Disturbed Lands. ASA, Madison, WI, pp. 339–353.

Carlson, C.L. and Adriano, D.C. (1993). Environmental impacts of coal combustion residues. *J. Environ. Qual.*, 22: 227-247.

Carrera, L.M., Buyer, J.S., Vinyard, B., Abdul-Baki, A.A., Sikora, L.J. and Teasdale, J.R. (2007). Effects of cover crops, compost, and manure amendments on soil microbial community structure in tomato production systems. *Applied Soil Ecology*, 37: 247-255.

Cassida, L.E., Jr. (1977). Microbial metabolic activity in soil as measured by dehydrogenase determination. *Appl. Environ. Microbiol*. 34: 630-636.

Cavigelli, M.A., Lengnick, L.L., Buyer, J.S., Fravel, D., Handoo, Z., McCarty, G., Millner, P., Sikora, L., Wright, S., Vinyard, B., Rabenhorst, M., (2005). Landscape level variation in soil resources and microbial properties in a no-till corn field. *Applied Soil Ecology*, 29: 99-123.

Chang, A. C., Lund, L. J., Page, A. L., and Warneke, J. E. (1977). Physical properties of fly-amended soils. *J. Environ. Qual.*, 6 (3), 267-270.

Coleman, D.C. & Crossley, D.A. (1996). Fundamentals of Soil Ecology. Academic Press, London.

Cookson, W.R., Murphy, D.V., Roper, M.M., (2008). Characterizing the relationships between soil organic matter components and microbial function and composition along a tillage disturbance gradient. *Soil Biology and Biochemistry*, 40:763-777.

Davison, R.L., Natusch, D.F.S., Wallace, J.R., Evans, C.A., Jr. (1974). Trace elements in fly ash: dependence of concentration on particle size. *Environ. Sci. Technol.*, 8: 1107-1118.

Dick, W. A., Hao, Y., Stehouwer, R. C., Bigham, J. M., Wolfe, W. E., Adriano, D., Beeghly, J. H., and Haefner, R. J. (2000). Beneficial uses of flue gas desulfurization by-products: Examples and case studies of land application. Land application of agricultural, industrial and municipal by products, W. A. Dick, ed., SSSA Book Series No. 6, Soil Science Society of America ,SSSA, Madison, Wis., 505–536.

Elseewi, A.A., Page, A.L., 1984. Molybdenum enrichment of plants grown on fly ash treated soils. *J. Environ. Qual*. 13, 394–398.

Fierer, N. and Jackson, R.B. (2006). The diversity and biogeography of soil bacterial communities. *Proceedings of the National Academy of Sciences of the United States of America*, 103:626-631.

Gaind, S., Gaur, A.C., 2002. Impact of fly ash and phosphate solubilising bacteria on soybean productivity. *Bioresour. Technol.*85, 313–315.

Gaind, S., Gaur, A.C., 2003a. Evaluation of fly ash as a carrier for diazotrophs and phosphobacteria. *Bioresour. Technol.* 95, 187–190.

Gaind, S., Gaur, A.C., 2003b. Quality assessment of compost preparedfrom fly ash and crop residues. *Bioresour. Technol.* 87, 125–127.

Girvan, M.S., Bullimore, J., Pretty, J.N., Osborn, A.M. and Ball, A.S. (2003). Soil type is the primary determinant of the composition of the total and active bacterial communities in arable soils. *Applied and Environmental Microbiology* 69: 1800-1809.

Grayston, S.J., Campbell, C.D., Bardgett, R.D., Mawdsley, J.L., Clegg, C.D., Ritz, K., Griffiths, B.S., Rodwell, J.S., Edwards, S.J., Davies, W.J., Elston, D.J. and Millard, P. (2004) Assessing shifts in microbial community structure across a range of grasslands of differing management intensity using CLPP, PLFA and community DNA techniques. *Applied Soil Ecology*, 25: 63-84.

Griffiths, B.S., Bonkowski, M., Dobson, G. and Caul, S. (1999). Changes in soil microbial community structure in the presence of microbial-feeding nematodes and protozoa. *Pedobiologia*, 43:297-304.

Haque, E.M. (2013) . Indian fly-ash: production and consumption scenario. *Internat. J. Waste Resources*, 3(1): 22-25.

Hill, M.J., Lamp, C.A., 1980. Use of pulverized fuel ash fromVictorian brown coal as a source of nutrients for pasture species.Aust. *J. Exptl. Agric. Animal Husb.* 20, 377–384.

Ibekwe A.M., Poss J.A., Grattan S.R. , Grieve C.M. , Suarez. (2010) Modelling Concepts and Applications: in the Soil–Plant System (eds D.K. Bembi & R. Nieder). The Haworth Press, Binghamton, NY.

Jala, S (2006) Fly ash as an amendment agent for soil fertility. Ph.D. Thesis: Thapar University, Department of Biotechnology and Environmental Sciences, Patiala, India.

Jala, S., Goyal, D., 2006. Fly ash as a soil ameliorant for improving crop production- a review. *Biorersource Technology* 97: 1136-1147.

Jokinen, H.K., Kiikkila, O., Fritze, H., (2006). Exploring the mechanisms behind elevated microbial activity after wood ash application. *Soil Biol. Biochem.* 38: 2285–2291

Jones B., Ljung K. (2012). Subterranean space exploration: the development of root system architecture. *Current opinion in Plant Biology*, 15: 97-102.

Kalembkiewicz, J., Sitarz-Palczak, E., Soèo, E. and Kopacz S. (2007). Lotne popio³y przemys³owe jak potencjalne Ÿród³o emisji kobaltu i manganu do gleby. *Zeszyty Problemowe Postêpów Nauk Rolniczych,* 520: 479-483.

Kizilkaya R., Bayrakli, B. (2005). Effects of N- enriched sewage Sludge on soil enzyme activities. *Appl. Soil Ecol.*, 30: 192-202.

Kohli S.J., Goyal, D (2010). Effect of fly ash application on some soil physical properties and microbial activities *Acta Agrophysica*, 2010, 16,(2), 327-335.

Koivula, N., Ra¨ikko¨ nen, T., Ranta, J., Ha¨nninen, K., (2004). Ash in composting of source separated catering waste. *Bioresour. Technol.*, 93: 291–299.

Lai, K.M., Ye, D.Y., Wong, J.W.C., (1999). Enzyme activities in a sandy soil amended with sewage sludge and coal fly ash. *Water, Air and Soil Pollut.*, 113: 261-272.

Lopez, R., Padilla, E., Bachmann, S., Eichler-Loebermann B (2009). Effect of biomass ashes on plant nutrition in tropical and temperate regions. *J. Agri. Rural Dev. in tropics and subtropics*, 110 (1): 51-60.

Mattigod, S.V., Rai, D., Eary, L.E. and Ainsworth C.C. (1990) Geochemical factors controlling the mobilization of inorganic constituents from fossil fuel combustion residues: I. Review of the major elements. *J. Environ. Qual.* 19: 188–201.

Menon, M.P., 1993. Elements in Coal and Coal Ash Residues and their Potential for Agricultural Crops. Trace Elements in Coal and Coal Combustion Residues. Lewis Publishers, Florida, USA,pp. 259–285.

Michalcewicz,W. Ga³czyñska, M., Stankowski, S., (2011). Contemporary Problems of Management and Environmental Protection, No. 9, *Some Aspects of Environmental Impact of Waste Dumps:* 111-130.

Molliner, A.M., Street, J.J., 1982. Effect of fly ash and lime on growth and composition of corn (Zea mays L.) on acid sandy soils. *Proc.Soil Crop Sci. Soc.*, FL 41, 217–220.

Morgan , J.B. and Connolly, E.L. (2013). Plant Soil Interactions- Nutrient Uptake. *Nature Education Knowledge*, 4(8): 2.

Nannipieri, P., Ascher, J., Ceccherini, M.T., Landi. , Pietramellara L.G Renella, G (2003) Microbial diversity and soil functions. *European Journal of Soil Science*, 54: 655–670.

Natusch, D.F.S., Wallace, J.R., 1974. Urban aerosol toxicity: the influence of particle size. Science 186, 695.

Norris, T.B., Wraith, J.M., Castenholz, R.W., McDermott, T.R., (2002). Soil microbial community structure across a thermal gradient following a geothermal heating event. *Applied and Environmental Microbiology*, 68: 6300-6309.

Olsson, S and Alström, S., (2000). Characterisation of bacteria in soils under barley monoculture and crop rotation. *Soil Biology and Biochemistry*, 3:, 1443-1451.

Page A.L., Elseewi A.A., Straughan I..R., 1979. Physical and Chemical properties of fly ash from coal-fired power plants with special reference to environmental impacts. *Residue Rev.*,71: 83-120.

Pathan, S. M., Almore, L. A. G., Colmer, T. D. 2003. Reduced leaching of nitrate, ammonium, and phosphorous in a sandy soil by fly ash amendment. *Aust. J. Soil Res.* 40 (7), 1201-1211.

Pati, S.S. and Sahu, S.K., (2004). CO_2 evolution and enzyme activities (dehydrogenase, protease and amylase) of fly ash amended soil in the presence and absence of earthworms (*Drawida willsi* Michaelson) under laboratory conditions. *Geoderma* 118: 289-301.

Petruzzelli, G., 1989. Recycling wastes in agriculture: heavy metal bioavailability. *Agri, Eco and Env.*, 27,493–503.

Pitchel, J.R., Hayes, J.M., 1990. Influence of fly ash on soil microbial activity and populations. *J. Environ. Qual.* 19, 593–597.

Rani K and Kalpana S. (2010) Utilization in agricultural and related fields; a better alternative for ecofriendly maintenance of Coal Fly Ash. *J. Chem. Pharm. Res.*, 2 (5):365-372.

Rethman , N.F.G du Toit, Ramagadza, E ., Truter , E., Reynolds K.A, Kruger R.A, (1999). Soil amelioration using waste products. Proc. Remade Lands Recl. Conf. Perth, Western Australia, pp 127-128.

Rethmann, N.F.G and Truter W.F, (2001). Plant Responses on soils ameliorated with waste products, 18th National Meeting of ASSMR, Albuqerque, New Mexico, USA. pp 425.

Reynolds, K.A., Kruger, R.A., Rethman, N.F.G., 1999. The manufacture and evaluation of an artificial soil prepared from fly ash and sewage sludge. In: Proc. *Intl. Ash Utiliz. Sympos.* Lexington, KY,USA. pp. 378–385.

Ross, I.L., Alami, Y., Harvey, P.R., Achouak, W., Ryder, M.H., (2000). Genetic diversity and biological control activity of novel species of closely related pseudomonads isolated from wheat field soils in South Australia. *Applied and Environmental Microbiology*, 66: 1609-1616.

Saison, C., Degrange, V., Oliver, R., Millard, P., Commeaux, C., Montange, D., LeRoux, X., (2006). Alteration and resilience of the soil microbial community following compost amendment: effects of compost level and compost-borne microbial community. *Environmental Microbiology*, 8: 247-257.

Saviozzi A., Biasci A., Riffaldi R., Levi-Minzi R. (1999). Long-term effects of farmyard manure and sewage sludge on some soil biochemical characteristics. *Biol. Fertil. Soils*, 30: 100-106.

Sawitri, D., & Lasryza, A. (2012). Utilization of Coal Fly Ash as CO Gas Adsorbent. *International Journal of Waste Resources (IJWR)*, *2*(2):13-15. doi: http://dx.doi.org/10.12777/ijwr.2.2.2012.13-15.

Schimel D.S (1995). Terrestrial ecosystems and the carbon cycle. *Global Change Biol.*, 1: 77–91.

Schutter, M. E. and Fuhrmann, J. J. (1997). Microbial Responses to Coal Fly Ash under Field Conditions. *Journal of Environmental Quality*, 28(2): 648-652.

Schutter, M.E., Dick, R.P., (2002). Microbial community profiles and activities among aggregates of winter fallow and cover-cropped soil. *Soil Science Society of America Journal*, 66: 142-153.

Schutter, M.E., Sandeno, J.M., Dick, R.P., (2001). Seasonal, soil type, and alternative management influences on microbial communities of vegetable cropping systems. *Biology and Fertility of Soils*, 34: 397-410

Seshadri B, Bolan NS, Naidu R and Brodie K (2010). The role of coal combustion products in managing the bioavailability of nutrients and heavy metals in soils. *J.Soil Sci. Plant Nutr.* 10 (3): 378 – 398.

Sharma, M.P., Tanu, U., Reddy, G., Shyam, A.K., Adholeya, A., 2001b. Herbage yield of *Mentha arvensis* DC. Holms as influenced by AM fungi inoculation and farmyard manure application grown in fly ash over burdens amended with organic matter. In: International Ash Utilization Symposium, KY, USA.

Sharma, S., 1989. Fly ash dynamics in soil water systems. *Crit. Rev. Environ. Control* 19 (3), 251–275.

Sinha, K.S. and Basu, K. (1998). Mounting fly ash problems in growing coal based power stations-few pragmatic approaches towards a solution. In Proc. of Int. Conf. on Fly ash disposal and utilization Vol I. Ed. by C.V.J Verma, P.K. Lal, V. Kumar, R. Lal, R K rishnamurthy, Central Board of Irrigation and Power, New Delhi, India,

Smith, I. (2005). Land uses of coal fly ash –benefits and barriers CCC/96, ISBN 92-9029-411-6, 30 pp.

Sowerby A, Emmett B, Beier C, Tietema A, Peñuelas J, Estiarte M, Van Meeteren M.J.M, Hughes S, Freeman C (2005). Microbial community changes in health and soil communities along a geographical gradient: interaction with climate change manipulations. *Soil Biol. Biochem.*, 37: 1805–1813.

Stotzky, G (1965). Microbial Respiration.pp 1550-1569. In Black, C. A. et al. (ed.), Methods of Soil Analysis. Part 2. Agronomy 9. ASA, Madison, WI.

Ulrich, A., Becker, R., (2006). Soil parent material is a key determinant of the bacterial community structure in arable soils. *FEMS Microbiology Ecology*, 56:430-443.

Vom Berg, W., (1998). Utilization of fly ash in Europe. In Proc. of Int. Conf. on Fly ash disposal and utilization vol. 1.Central Board of Irrigation and Power, New Delhi, India, pp 8-14.

WEC 2007. Survey of Energy Resources. World Energy Council. Sourced on 27/01/2010.http://www.worldenergy.org/publications/survey_of_energy_resources_2007/coal/628.asp

Williams, M.A., Rice, C.W., (2007). Seven years of enhanced water availability influences the physiological, structural, and functional attributes of a soil microbial community. *Applied Soil Ecology*, 35: 535-545.

Wojcieszczuk, T., Meller, E., Sammel, A. and Stankowski, S. (2009) Zawartoœæ i rozpuszczalnoœæ niektórych sk³adników chemicznych w popio³ach o ró¿nym pochodzeniu. *Zeszyty Problemowe Postêpów Nauk Rolniczych*, 535: 483-493.

Wong, M.H., Wong, J.W.C., 1986. Effects of fly ash on soil microbial activity. *Environ. Pollut. Ser.* A 40, 127–144.

Yeledhalli, N.A., Prakash, S.S.,. Gurumurthy S.B and Ravi, M.V. (2007) *Karnataka J. Agric. Sci* 20 (3): 531-534.

Yunus, I. A. M, Eamus, D., DeSilva, D. L, Murray, B R, Burchett, M D., Skilbeck, G C. Heidrich, C. 2006. Fly ash: An exploitable resource for management of Australian agricultural soils. *Fuel* 85, 2337-2344.

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Influence of fertigation on fruit yield, water use and distribution efficiency and economics of guava (*Psidium guajava* L.)

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ABSTRACT

A field experiment was conducted during 2009-2010 and 2010-2011 on a sandy loam soil to assess the fertigation levels on fruit yield, water use and water distribution efficiency and economics of guava *(Psidium guajava L.)*. The treatments consisted of four irrigation levels (i.e. 1.0 IW/CPE, and 0.60, 0.80 and 1.00 ET_C) and three nitrogen fertigation levels (0.80, 1.00 and 1.20 of recommended dose of N) was laid out in a split plot design (SPD) with three replications. The results showed that fruit yield increased significantly with increase in application of irrigation water and nitrogen fertilizer. However, maximum fruit yield, higher water use efficiency, net return and B: C ratio was registered from drip irrigation at 1.00 ET_C. Full recommended dose of nitrogen fertilizer was found to be optimal for maximum fruit yield. The water distribution efficiency in drip irrigation system was uniform and higher near the dripper and then decreased consistently with increase in distance both horizontally and vertically. Thus drip irrigation at 1.00 ET_C with recommended dose of N-fertigation could be recommended for higher fruit yield and economics of guava in the lower Gangetic plain of West Bengal, India. Alternatively, surface irrigation scheduling at 1.0 IW/CPE could be advocated if the initial investment for laying the drip irrigation system is an impediment for the guava growers in this region.

Key words: Guava, drip fertigation, surface irrigation, water use efficiency, distribution efficiency, fruit yield

INTRODUCTION

Water is the vital natural resource for sustainable crop production and also the most limiting factor in Indian agriculture in view of unscientific utilization and competitive demands from other sectors. In the Gangetic plain of West Bengal, the resource poor farmers generally follow the conventional surface irrigation method in guava cultivation. This practice is quite inefficient and causes excessive wastage of water and nutrients in deep percolation below the root zone. It also contributes various problems relating to water logging, soil salinity, poor soil aeration, contamination of water bodies and weed infestation (Veeraputhiram *et al*., 2005). Therefore, some innovative possible approaches are needed for more effective and rational use of limited supplies of water. Drip irrigation is a relatively new technology of irrigation in India and has gained widespread acceptance as an efficient and economically viable method adaptable even in the water-scarce areas. The method has proved its superiority over other traditional methods of irrigation owing to precise amounts of water and nutrients application in right time directly in the vicinity of crop root zone matching with the water and nutrients requirements of crop (Dudey *et al*., 2002; Mohammad and Said, 2003; Hebbar *et al*., 2004; Patel and Rajput, 2004). Fertigation under drip irrigation is being used commonly for the application of nitrogenous fertilizers especially in fruit and vegetable crops. This approach could save about 12 - 84 % of water and increase crop productivity by 10 - 55 % depending upon the crop, soil and climate conditions (Berad *et al*., 1999; Deshmukh and Sen, 2000; Sharma and Kumar,

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2007). A proper design and management of a drip irrigation system is indispensable to deliver frequent application of water to wet only portions of the soil surface (Kumar *et al*., 2005; Pramanik and Biswas, 2012), which helps increasing the water and nutrient use efficiency of crop by way of reducing the leaching and conveyance losses (Raina *et al*., 2011). Drip irrigation has an added advantage that it permits uniform distribution of water in both horizontal and vertical direction compared to the conventional surface irrigation methods (Fasinmirin and Oguntuase, 2008). In this backdrop, the present investigation was undertaken with a view to assess the various drip irrigation and nitrogen fertigation levels compared to the conventional surface irrigation on the fruit yield, water use and distribution efficiency and economics of guava cultivation in the lower Gangetic plain of West Bengal, India.

MATERIALS AND METHODS

Location and soil of the experimental site

The field experiment was carried out during 2009-2010 and 2010-2011 at the Central Research Farm Gayeshpur, Bidhan Chandra Krishi Viswavidyalaya, Nadia under lower Gangetic plain of West Bengal, India. The farm is located at an altitude of 9.75 m above mean sea level and is intersected by 23^0 N latitudes and 89^0 E longitudes. The weather is usually hot and dry from March to May and cold and dry during winter from October to February. The mean monthly maximum and minimum temperature during the crop growing seasons varied from 25.4 to 36.8 ^{0}C and 14.7 to 26.6 ^{0}C, respectively. The daily pan evaporation, on an average, was 1.1-6.5 mm. The average rainfall was 1600 mm each year and the relative humidity varies from 95.8 to 56.3 %. The groundwater fluctuates around 3.2 to 4.8 m bgl. The experimental soil is Gangetic alluvium having sandy loam in texture (Typic Fluvaquent) with bulk density 1.49 Mg/m^3, infiltration rate 13 cm/hr, hydraulic conductivity 22.2 cm/hr with pH 6.9, EC 0.41 dS/m and organic carbon 5.6 g/kg. Available N, P and K status of soil was 186.4, 20.9 and 145.8 kg/ha, respectively. The treatments consisted of four irrigation levels (1.0 IW/CPE, 0.60, 0.80 and 1.0 ET_C) and three nitrogen fertigation levels (0.80, 1.00 and 1.20 of recommended dose of N) was laid out in a split plot design (SPD) with three replications. Healthy, vigorous and disease-free seedlings of guava (cv. Khaja) were planted on 23rd June 2006 at a spacing of 5.0 m x 5.0 m. Every plant received about 2 kg wood ash, 500 g bone meal and 12 kg farm yard manure during planting. The recommended doses of fertilizers was applied @ 200 g N, 160 g P_2O_5 and 260 g K_2O per plant in the form of urea, single superphosphate and muriate of potash, respectively. Phosphorus and potassium were applied in two equal splits broadcasted in mid-January and mid-August every year. Nitrogen as per treatment was applied through fertigation in 11 equal splits, whereas in surface irrigation system, nitrogen was top-dressed in three equal splits in soil. Crop was harvested in several pickings between August to November each year and data were added to calculate the total fruit yield.

In drip system, irrigation water was lifted by hand pump to a 200 Liters capacity over head tank installed at 3.0 m above the ground level. Nitrogen fertilizer was dissolved in the tank and applied through drip irrigation through the gravity flow.

Discharge rate of drippers

Volumetric method was employed for calculating the uniformity coefficients (Uc) of drip irrigation system using the following equation (Nakayama and Bucks, 1986):

Uc = (1-"q)/q, where q is the mean emitter discharge rate (lph) and "q is the mean deviation of the emitter discharge from mean value. Lateral drip lines (12 mm) having emitters at 50 cm distance with a discharge rate of 3.6 lph were placed in between the two rows. The system was operated at a constant pressure of 1.20 kg/cm^2.

Irrigation water requirement

The crop water requirement was computed on daily basis using the following equation (Shukla *et al*., 2001):

$$V = E_p * K_p * K_c * S_c * W_p$$

where, V = volume of water (litre/day/ plant), E_p = open pan evaporation (mm/day), K_p = pan factor or pan coefficient, K_c = crop coefficient, S_c = crop spacing (5.0 m x 5.0 m) and W_p = wetted area (1.0). The effective rainfall was calculated by balance sheet method from the actual rainfall received and was used for daily water requirement of crop. The crop coefficient values used for different phonological stages of crop were computed based on the existing relative humidity and wind velocity (Doorenbos *et al*., 1984). Pan coefficient value was 0.8 as suggested for USDA class A-Pan. Irrigation water was applied bi-weekly through drip irrigation system. Average depth of water applied through drip system at 0.60, 0.80 and 1.00 ET_C was 440.4, 587.2 and 734.0 mm

(11010, 14680 and 18350 Liters), respectively. The amount of water applied in conventional surface irrigation at 1.0 IW/CPE with 50 mm depth was 900 mm (22500 Liters). The water use efficiency was computed by dividing fruit yield of guava with total water used including effective rainfall, soil profile moisture contribution and irrigation water applied.

Moisture distribution efficiency

Soil moisture distribution at 0 (near dripper), 15, 30, 45 and 60 cm away from the dripper laterally and at 0-15, 15-30, 30-45 and 45-60 cm depth vertically was measured for each treatment with gravimetric method. The water distribution efficiency along the drip run was calculated based on the equation, Ed = 100 (1- $\overline{y}$ /d), where Ed = water distribution efficiency in percent, = average numerical deviation in depth of water stored in root zone soil from the average depth of water stored during irrigation and d = average depth of water stored during irrigation.

RESULTS AND DISCUSSION

Uniformity coefficient

The uniformity coefficient of drip irrigation system was found to be 92.3% for the first year and 89.7% for the second year of experiment (Table 1). The low values of coefficients of variation of emitter flow rates indicate the good performance of the irrigation system in supplying water uniformly throughout the lateral lines. These results are in accordance with Pitts (1997) and Kumar *et al.*, (2005) who recorded that uniformity coefficient greater than 90.0% exhibited excellent functioning of the drip system.

Table 1. Uniformity coefficients of drip irrigation system

Year	Uniformity coefficient (%)	CV
2009-10	92.3	0.065
2010-11	89.7	0.086

CV: Coefficient of variation

Fruit yield

The different irrigation levels and nitrogen-fertilizer had pronounced effects on the fruit yield of guava in each year and their pooled values (Table 2). Drip irrigation at 1.00 of crop evapotranspiration (ET_C), irrespective of nitrogen-fertilizer levels, recorded significantly the highest fruit yield and was superior to the conventional surface irrigation at 1.0 IW/CPE than other drip irrigation levels. There was no statistical difference in yields between the drip irrigation level at 0.80 ET_C and 1.0 IW/CPE. The lowest fruit yield of guava was observed at drip irrigation level at 0. 60 ET_C. Irrigation level at 1.00 ET_C, on an average, increased the fruit yield by about 62.3, 16.5 and 11.2 % over drip irrigation at 0.60 ET_C, 0.80 ET_C and surface irrigation, respectively. These variations in yields might be ascribed to the differences in wetting pattern and relative water uses by the crop as influenced by different irrigation levels and amounts of water application. Maximum yield under irrigation level at 1.00 ET_C was might be due to the attainment of favourable soil environment which likely to have facilitated the better water utilization (Raina *et al.*, 1999) and higher uptake of nutrients by crop (Rumpel *et al.*, 2003) and excellent balance of soil-water-air with plenty of oxygen concentration in the root zone (Bangar and Chaudhary, 2004). The lowest fruit yield in surface irrigation, on the contrary, is likely to be water-stress situation during critical period coupled with choked aeration in first few days immediately after irrigation and losses of water and fertilizer nutrients in deep percolation below the crop root zone on heavy load of irrigation water application (Raina *et al.*, 2011).

Table 2. Fruit yield of guava as influenced by irrigation methods and N fertigation levels

Irrigation method	Fruit yield (t/ha)		
N-fertigation	2009-10	2010-11	Pooled
Surface irrigation	18.5	17.1	17.8
Drip 0.60 ET_C	12.8	11.6	12.2
Drip 0.80 ET_C	17.4	16.6	17.0
Drip 1.00 ET_C	20.6	19.0	19.8
CD (P = 0.05)	1.6	1.4	1.5
80% of RDN	14.4	14.2	14.3
100% of RDN	18.8	17.6	18.2
120% of RDN	17.4	17.0	17.2
CD (P = 0.05)	1.4	1.2	1.3

ET_C : crop evapotranspiration,
RDN : recommended dose of nitrogen

Similarly, the fruit yield, regardless of irrigation methods and levels, increased significantly with increase in levels of nitrogen fertilization. Full recommended dose of nitrogen (100 % RDN) recorded maximum yield and was superior to 80 % of RDN, but at par with 120 % of RDN. This reveals to the fact that optimal dose of fertilizer nitrogen applied through drip system is necessary for achieving higher fruit yield. The interaction between irrigation method and nitrogen level on fruit yield was significant (Table not shown). However, drip irrigation at 1.00 ET_C with 100 % of

RDN documented maximum yield and was superior to other irrigation-fertilizer N interactions. This might be ascribed to the timely supply of judicious amounts of water and nitrogen in the root zone matching with the crop demands, which thereby helps in promoting fruit yield of crop. These corroborated the findings of Singandhupe *et al.*, (2003) who observed that N-fertigation through drip irrigation system increased the crop yield significantly.

Water use and water use efficiency

The depth of water applied during the cropping season by drip irrigation at 0.60, 0.80 and 1.00 ET_C was 440.4, 587.2 and 734.0 mm,(11010, 14680 and 18350 Liters) respectively. The corresponding figure for surface irrigation at 1.0 IW/CPE was 900 mm (Table 3). The average effective rainfall was received as 463.8 mm. The soil profile water contribution varied from 32.3 to 39.2 mm depending upon the irrigation methods and levels of application. Thus total water use by the crop was 943.6, 1087.5 and 1231.7 mm through drip irrigation at 60, 80 and 100 % of ET_C, respectively and 1396.1 mm for conventional surface irrigation. The results showed that maximum water use efficiency of 16.1 kg/ha-mm was obtained from drip irrigation system at 1.00 ET_C, followed by that of 15.6 kg/ha-mm at 0.80 ET_C and 12.9 kg/ha-mm at 0.60 ET_C. Minimum water use efficiency of 12.7 kg/ha-mm was observed in surface irrigation method. About 11.8 to 32.4 % of water could be saved with various drip irrigation schedules over conventional surface irrigation. Higher amount of water could be saved with lower level of crop evapotranspiration replenishment. The higher water use efficiency and water saving in drip irrigation as compared to surface irrigation was the results of precise amount of water delivery directly in the crop root zone at right time and better water utilization coupled with minimization of water losses in deep percolation and surface runoff (Bangar and Chaudhari, 2004; Dubey *et al.*, 2002).

Water distribution efficiency

The water distribution efficiency under various drip irrigation schedules during the crop season, in general, indicates that the movement of irrigation water towards vertical direction was relatively more than in lateral direction and it was higher near the dripper, then decreased consistently with the increase in distance both horizontally and vertically (Table 4). In other words, the water distribution pattern in vertical and horizontal pathway was considerably higher at the surface layer, thereafter it decreased stepwise with the increase in soil depth. The values, regardless of drip irrigation levels, varied from 96.4 to 69.5 % and maximum value was found at high soil moisture regime than in low moisture regime. The plausible reason for higher flow of water from dripper towards vertical directions than in horizontal directions might be due to predominant role of gravitational force over capillary force in the sandy loam soil (Rana *et al.*, 2004; Patel and Rajput, 2010; Pramanik and Biswas, 2012). Thus, the drip system of irrigation appeared to decrease the soil moisture loss by way of evaporation and could save more water in the subsurface soil layers for subsequent plant use. On the contrary, in the conventional surface irrigation system, the moisture distribution efficiency in both vertical and horizontal directions was much lower than drip irrigation system and it varied from 83.4 to 62.3 %. These results are in agreement with the findings of (Bharambe *et al.*, 2001; Fasinmirin and Oguntuase, 2008).

Economics

Maximum net return of Rs. 109800/ha with B: C ratio of 3.81 was observed in drip irrigation at 1.00 ET_C and minimum net return of Rs. 57600/ha with B: C ratio of 2.07 in drip irrigation at 0.60 ET_C (Table 5). The conventional surface irrigation at 1.0 IW/CPE recorded net return of Rs. 95600/ha with B: C ratio of 3.29. In terms of economic benefit, drip irrigation at 0.80 ET_C ranked third exhibiting net

Table 3. Water use, water use efficiency and water saving of guava as influenced by drip irrigation method compared with surface irrigation (pooled data of two years)

Irrigation method	Profile water contribution (mm)	Effective rainfall (mm)	Irrigation water applied (mm)	Total water use (mm)	Water use efficiency (kg/ha-mm)	Water saving (%)
Surface	32.3	463.8	900.0	1396.1	12.7	-
Drip 0.60 ET_C	39.2	463.8	440.4	943.4	12.9	32.4
Drip 0.80 ET_C	36.5	463.8	587.2	1087.5	15.6	22.1
Drip 1.00 ET_C	33.9	463.8	734.0	1231.7	16.1	11.8

Table 4. Distribution efficiencies of moisture (%) with drip and surface irrigation method in Guava plantation along the vertical and lateral direction from dripper

Irrigation level	Vertical distance (cm)	Lateral distance from dripper (cm)				
		0	15	30	45	60
Drip 0.60 ET_C	0-15	92.1	89.3	85.4	80.5	77.7
	15-30	89.6	84.9	82.1	78.4	73.3
	30-45	84.7	82.2	80.3	76.5	71.2
	45-60	82.4	80.9	78.2	75.4	69.5
Drip 0.80 ET_C	0-15	93.4	89.4	86.3	82.5	78.3
	15-30	91.2	85.5	85.0	80.8	75.7
	30-45	86.5	84.2	81.2	79.4	73.4
	45-60	83.2	82.3	79.4	77.6	71.9
Drip 1.00 ET_C	0-15	96.4	90.5	89.6	83.3	79.5
	15-30	95.7	87.6	86.5	82.2	77.1
	30-45	93.2	85.4	84.7	79.7	75.5
	45-60	91.2	83.8	81.8	78.1	72.4
Surface irrigation	0-15	83.4	81.2	78.6	75.3	73.1
	15-30	81.7	77.6	76.9	71.4	67.8
	30-45	78.3	75.1	73.6	66.5	64.2
	45-60	73.6	71.4	69.2	64.4	62.3

Table 5. Economics of guava cultivation under drip and surface irrigation method

Particular	Drip irrigation			Surface irrigation
	0.60 ET_C	0.80 ET_C	1.00 ET_C	
Fixed cost				
1. Installation cost (Rs./ha)	80000	80000	80000	-
2. Life (year)	10	10	10	-
3. Depreciation @ 4% (Rs.)	3200	3200	3200	-
4. Interest cost @ 10% (Rs.)	8000	8000	8000	-
Operating cost				
5. Repair and maintenance cost including electrical and labour charge @ 2% (Rs./ha)	1600	1600	1600	-
6. Seasonal system cost (3+4+5) Rs.	12800	12800	12800	8000*
7. Seasonal cost of cultivation	15000	15500	16000	21000**
8. Seasonal total cost (6+7), Rs.	27800	28300	28800	29000
9. Fruit yield (q/ha)	122.0	170.0	198.0	178.0
10. Selling price (Rs./q)	700	700	700	700
11. Gross return (Rs.)	85400	119000	138600	124600

*labour cost for ring construction, channel cleaning, watering and fertilization, **inclusive of extra labour cost for weeding

return of Rs. 90700/ha with B: C ratio of 3.20. It is notable that drip irrigation schedule at 1.00 ET_C is found to be more profitable as compared to the conventional surface irrigation. This was mainly due to increase in fruit yield coupled with reduction on labour cost incurred on weeding and fertilizer application. The economic viability of drip fertigation on various horticultural crops has also been reported by several workers (Samuel *et al.*, 2002; Narayanamoorthy, 2006; Pramanik and Biswas, 2012).

CONCLUSION

Fertigation is an efficient and effective method of applying precise amounts of irrigation water and fertilizer nutrients at right time matching the crop requirements for higher fruit production of guava. Maximum fruit yield, higher water efficiency, net return and B: C ratio could be obtained from drip irrigation at 1.00 ET_C with full recommended dose of nitrogen fertilization. The moisture distribution efficiency in drip system was uniform and much higher than conventional surface irrigation and it was higher near the dripper and then decreased consistently with increase in distance both horizontally and vertically. Thus, drip irrigation at 1.00 ET_C with full recommended dose of drip N-fertigation could be recommended for higher fruit production and economics of guava in the lower Gangetic plain of West Bengal, India. Alternatively, surface irrigation scheduling at 1.0 IW/CPE could be advocated if the initial investment for laying the drip irrigation system is an impediment for the guava growers in this region.

REFERENCES

Bangar A R and Chaudhary B C. 2004. Nutrient mobility in soil, uptake, quality and yield of suru sugarcane as influenced by drip fertigation in medium vertisols. Journal of the Indian Society of Soil Science **52** (2): 164-171.

Berad S M, Shinde S H and Dahiwalker S D. 1999. Effects of drip fertigation and paired planting on productivity and economics of banana. Journal of Maharashtra Agricultural University **23** (3): 288-290.

Bharambe P R, Mungal M S, Shelke D. K, Oza S R, Vaishnava V G and Sondge V D. 2001. Effect of soil moisture regimes with drip on spatial distribution of moisture, salts, nutrient availability and water use efficiency of banana. J. Indian Soc. Soil Sci. **49 (4):** 658-665.

Deshmukh M M and Sen N L. 2000. Studies on irrigation scheduling and point of application through drip irrigation to guava (*Psidium guajava* L.) variety– Allahbad safeda. Haryana Journal of Horticultural Sciences **29**(3/4): 156-158.

Doorenbos J, Pruitt W O, Aboukhaled, A and Dastane A B. 1984. Guidelines for predicting crop water requirements. FAO irrigation and drainage paper no. **24**, FAO, ROME.

Dubey A K, Pathak R A and Pathak R K. 2002. Effect of drip irrigation on guava (*Psidium guajava* L.) on plant growth and nutrient status of leaves. Progressive Horticulture **34** (1): 56-59.

Fasinmirin J T and Oguntuase A M. 2008. Soil moisture distribution pattern in *Amaranthus cruentus* field under drip irrigation system. African Journal of Agricultural Research **3** (7): 486-493.

Hebbar S S, Ramachandrappa B K, Nanjappa H V and Prabhakar M. 2004. Studies on NPK Drip Fertigation in Field Grown Tomato (*Lycopersicon esculentum* Mill.). European Journal of Agronomy **21**: 117-127.

Kumar S, Sharma I P and Raina J N. 2005. Effect of levels and application methods of irrigation and mulch materials on strawberry production in north-west Himalayas. Journal of the Indian Society of Soil Science **53** (1): 60-65.

Mohammad M J and Said Z. 2003. Enhancement of yield and nitrogen and water use efficiencies by nitrogen drip-fertigation of garlic. Journal of Plant Nutrition, **26** (9): 1749-1766.

Nakayama F S and Bucks D A. 1986. Trickle Irrigation for Crop Production. Design, Operation and Management, Elsevier, New York, pp 383.

Narayanamoorthy A. 2006. Efficiency of irrigation: a case of drip irrigation. Occasional Paper National Bank for Agriculture and Rural Development, Mumbai **45**: 38.

Patel N and Rajput T B S. 2004. Fertigation-a technique for efficient use of granular fertilizer through drip irrigation. IEI Journal, 85 : 50-54.

Patel N and Rajput T B S. 2010. Use of simulation modeling for enhancing potato production using sub-surface drip. Potato Journal **37** (1-2), 21-27.

Pitts D J. 1997. Evaluation of Micro irrigation Systems. Southwest Florida Research and education Center, University of Florida

Pramanik Sanjit and Biswas R K. 2012. Effect of drip fertigation on soil moisture distribution and irrigation water use efficiency of banana in West Bengal. Journal of Soil and Water Conservation **11**(3): 210-217.

Raina J N, Thakur B C and Verma M L. 1999. Effect of drip irrigation and polythene mulch on yield, quality and water-use efficiency of tomato (*Lycopersicon esculentum*). Indian Journal of Agricultural Sciences **69** (6): 430-433.

Raina J N, Sharma T and Suman S. 2011. Effect of Drip Fertigation with Different Fertilizers on Nutrient Distribution in Soil, Leaf Nutrient Content and Yield of Apricot (*Prunus aremeniaca* L.). J. Indian Soc. Soil Sci. **59**, 268-277.

Rana S K, Saha S, Zaman A, Goswami S B, Sarkar S and Mallick S. 2004. Response of banana to drip irrigation in new alluvial zone of West Bengal. *Proceedings of national seminar on banana industry – present scenario and future strategies*, held on 11-13 June at BCKV, pp 167-170.

Rumpel J, Kaniszewski S and Dysko J. 2003. Effect of drip irrigation and fertilization timing on yield of onion. Journal of Vegetable Crop Production **9** (2): 65-73.

Samuel Jose C and Singh H P. 2002. *Perspective of Hi –tech horticulture and precision farming*. In Singh, H, P., Singh, Gorakh, Samuel, Jose C. and Pathak, R.K. (eds.) proc. *National seminar- Cum- Workshop on Hi –tech Horticulture and precision farming*. CISH, Lucknow pp 21-34.

Sharma I P and Kumar S. 2007. Effect of drip irrigation and N and P application on soil moisture distribution and water uses efficiency of chrysanthemum (*Dendranthema grandiflorum*) in Inceptisols. Indian Journal of Soil Conservation **35** (1) 50-53.

Shukla K N, Singh P K and Singh K K. 2001. Crop water requirement under drip irrigation. In Plasticulture Development Centre, GBPUAT, Pantnagar, UP, India

Singandhupe R B, Rao G G S N, Patil N G and Brahmanand P S. 2003. Fertigation studies and irrigation scheduling in drip irrigation system in tomato crop (*Lycopersicon esculentum* L.) European Journal of Agronomy **19**: 327-340.

Veeraputhiram R, Kandasamy O S, Singh S D S and Chinnusamy C. 2005. Influence of drip irrigation and nitrogen fertigation on growth and yield of hybrid cotton. Journal of Ecobiology **17**(4): 329-335.

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Production and economics of linseed (*Linum usitatissimum* L.) based double cropping sequences under rainfed condition

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ABSTRACT

Field experiments were conducted at C.S. Azad University of Agriculture and Technology, Kanpur during 2006-07 and 2007-08 in sandy loam soil to evaluate the productivity of linseed-based crop sequences vis-a-vis monocropping of linseed. Linseed was grown in sequence with cowpea, blackgram, greengram, fodder sorhgum, maize and fallow. Linseed was fertilized with 20, 40, 60 and 80 kgNha^{-1}. Total physical production was recorded highest of 24.46 qha^{-1} in maize-linseed sequence followed by cowpea-linseed (24.08 qha^{-1}) and greengram-linseed (23.85 qha^{-1}) sequences against monocrooping of linseed 9.24 qha^{-1}. Economic production in terms of linseed equivalent yield was highest i.e. 23.61 qha^{-1} in greengram-linseed sequence followed by cowpea-linseed sequence (20.13 qha^{-1}) and net profit was significantly high in greengram-linseed sequence at 40 kg Nha^{-1} to linseed with Rs. 48971 ha^{-1} net profit.

Key words: Crop sequences, linseed, nitrogen, production, economics

INTRODUCTION

Linseed is an important oil seed crop of India. It is generally grown in monocrooping system either in pure or mixed stands mostly under rainfed condition and seldomly and/or under fertilized resulting in very low productivity i.e. 382 kgha^{-1} (Rao, 2008). Research evidence are available that linseed may successfully be grown in double cropping system under rainfed condition and its productivity may be enhanced by applying proper dose of fertilizers particularly nitrogen to which crop responds well (Dubey *et al.*, 1993; Chaubey *et al.*, 2004). Such information is virtually lacking for central Uttar Pradesh conditions and hence present study was undertaken.

MATERIALS AND METHODS

The field experiments were conducted at Soil Conservation Farm, Department of Soil Conservation and Water Management, C.S. Azad University of Agriculture and Technology, Kanpur during 2006-07 and 2007-08. Linseed crop was grown in double cropping sequence with cowpea, blackgram, greengram, sorghum (fodder) and maize against monocrooping with fallow in kharif. All kharif crops were raise as per recommended package of practices under rainfed condition. Linseed crop was fertilized with graded levels of N i.e. 20, 40, 60 and 80 kg ha^{-1} along with 40 kg P and 40 kg K ha^{-1}. The promising crop varieties were used *Cv. Pusa Komal* of cowpea, *Cv. Shekhar* of blackgram, *Cv. Samrat* of greengram, *Cv. Bundela* of sorghum, *Cv. Azad Uttam* of maize and *Cv. Padmini* of linseed. Experiment was laid out in split plot design with main plots to kharif crops and sub-plots to N levels in linseed crop. Sowing of kharif crops was done on 8th July 2006 and 21st July 2007 while succeeding linseed was sown on 10th Nov. 2006 and 26th Nov. 2007 during two years. Kharif crops received 406.3 and 474.8 mm rain while linseed crop received 45.7 and 4.6 mm rain during 2006-07 and 2007-08, respectively. Experimental soil was sandy loam, slightly alkaline in nature, low in organic carbon, and medium in available phosphorus and poor in available potassium content.

The soil moisture was determined gravimetrically using a Screw auger at sowing, during crop growth at regular interval and harvest

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at various soil layers viz., 0-25, 25-50, 50-75 and 75-100 cm soil depth from each plot in one replication. Moisture percentage was calculated by employing the following formula:

$$\text{Moisture (\%)} = \frac{\text{Fresh weight of soil (g)} - \text{Oven dry weight of soil (g)}}{\text{Oven dry weight of soil (g)}} \times 100$$

Value of soil moisture percentage was converted into depth of water by the following formula:

$$\text{Water depth (cm)} = \frac{\text{Moisture (\%)} \times \text{BD (Mg m}^{-3}) \times \text{Depth of soil layer (mm)}}{100}$$

Soil moisture data were used to determine the moisture use which was calculated by using following formula:

Moisture use (mm) = [Soil moisture (mm) at the time of crop sowing – soil moisture (mm) at the time of crop harvest] + effective rainfall (mm).

The moisture use efficiency in terms of seed production per unit of water consumed was estimated for different treatment plots with the equation suggested by Viets (1962).

MUE = Y / E T

Where,

MUE = Moisture use efficiency (kg seed ha^{-1} mm^{-1} water)

Y = Seed yield (kg ha^{-1})

ET = Total evapo-transpiration (mm)

The economics of different treatments was calculated by taking in to account the prevailing market price of inputs and outputs. In observation the net profit was calculated by deducting the total cost of cultivation from gross return of each corresponding treatment. The cost benefit ratio is the ratio of gross return to cost of cultivation and find out by dividing the gross return with total cost of cultivation of linseed crop.

RESULTS AND DISCUSSION

Production of crops and crop sequences

Among kharif crops, maize produced highest grain yield followed by cowpea, green gram and poorest in blackgram. The seed yield of linseed was highest in green gram-linseed sequence and lowest in sorghum (fodder)-linseed sequence (Table 1). Total seed production was highest in maize-linseed closely followed by greengram-linseed and cowpea-linseed sequences. The maize-linseed (24.46 qha^{-1}), cowpea-linseed (24.08 qha^{-1}) and greengram-linseed (23.85 qha^{-1}) yielded at par among themselves but higher than other sequences, however fallow-linseed sequence produced lowest yield potential. The varied linseed yield in different crop sequences seems due to the residual effect of preceding kharif crops. On the other hand, preceding cereal crops exhausted the soil which resulted in relatively poor yield of succeeding linseed crop, however variations in total production are attributed mainly to kharif crops production. Sarkar *et al.* (1993) also reported similar results.

The economic yield (linseed equivalent yield) in crop sequence performed some different from physical seed production. It was obtained highest (23.61 qha^{-1}) in greengram- linseed sequence followed by cowpea-linseed sequence (20.13 qha^{-1}) being lowest (9.24 qha^{-1}) was in monocropping of linseed. In general, pulse-linseed sequence gave higher production than cereals which are attributed to higher sale price of pulse crops than cereals. These results confirm the finding of Sarkar *et al.* (1993).

Table 1. Seed yield of different crops and linseed equivalent yield (qha^{1}) as influenced by crop sequences

Treatment	Seed yield (qha^{1})						Mean of Total	Linseed equivalent yield in qha^{1} (pooled)
	2006-07			2007-08				
	Kharif crops	Linseed	Total	Kharif crops	Linseed	Total		
Crop sequence								
Fallow-linseed	-	10.02	10.02	-	8.45	8.45	9.24	9.24
Cowpea-linseed	15.03	10.37	25.40	13.88	8.88	22.76	24.08	20.13
Blackgram-linseed	8.36	10.66	19.02	7.11	9.20	16.31	17.67	16.12
Greengram-linseed	14.47	11.25	25.72	12.30	9.68	21.98	23.85	23.61
Sorghum (fodder)-linseed	52.97(5.30)*	7.89	13.19	45.02(4.50)*	6.76	11.26	12.23	10.88
Maize-linseed	18.09	8.28	26.37	15.38	7.16	22.54	24.46	11.97
S.Em±	1.75	0.32	-	1.46	0.25	-	-	0.38
CD (P=0.05)	5.57	0.71	-	4.65	0.55	-	-	0.80

***** Yield of Sorghum dry fodder converted in cowpea equivalent yield given in parenthesis

Table 1.1. Interaction effect of crop sequence and nitrogen on seed yield (q ha^{-1}) of linseed (pooled 2 yrs.)

Crop sequence	N- levels (kg ha^{-1})				Significance
	20	40	60	80	
Fallow-linseed	7.85	8.78	9.81	10.50	S.Em±
Cowpea-linseed	7.66	9.70	10.64	10.49	N(S) 0.39
Blackgram-linseed	7.94	10.26	10.80	10.71	S(N) 0.34
Greengram-linseed	8.50	11.01	11.12	11.22	CD (P=0.05)
Sorghum (fodder)-linseed	5.63	6.73	8.04	8.89	N(S) 1.09
Maize-linseed	6.05	7.38	8.34	9.10	S(N) 0.98

Moisture use (MU) and Moisture use efficiency (MUE)

MU in linseed was recorded maximum when grown after cowpea followed by greengram, while minimum when grown after sorghum (Table 2). It may be associated with the availability of soil moisture and rooting pattern of crop. At the time of linseed sowing, initial soil moisture was maximum in the plots vacated by cowpea followed by greengram. Thus, linseed crop availed this moisture and increased MU than other crops. On the other hand, in the plots vacated by sorghum, initial moisture was minimum and root development of linseed was also minimum after sorghum. MUE of linseed was calculated highest when grown after greengram followed by blackgram. It was attributed to maximum seed yield of linseed after greengram and normal MU which indicates about efficient use of moisture by linseed grown after greengram. Dutta *et al.* (1995) observed that consumptive use of water increased with increasing levels of N up to 80 kg ha^{-1} where maximum of 207.91 mm water was consumed by linseed crop. Water use efficiency also increased with increasing N levels, but up to the application of 60 kg ha^{-1} beyond which it decreased at 80 kg ha^{-1}. MU and MUE both increased at higher rates of N application up to 80 kg ha^{-1} . Increase in MU might be to meet the water requirement of crop plants for their better growth and development by using higher amounts of nutrients from the soil. Increased MUE with increasing rates of N was attributed to increased seed yield which also increased with each increase in N level. Meena *et al.* (2011) reported that the MUE increased with increasing fertility levels and it was maximum with application of 60:30:30:30 NPKS kg ha^{-1} in linseed crop.

Economics of crop sequences

Gross income and net profit were significantly maximum in greengram-linseed sequence followed by cowpea-linseed sequence (Table 2) owing to linseed equivalent yield. Gross income was

Table 2. Moisture use, moisture use efficiency and eeconomics of linseed as influenced by crop sequences and levels of nitrogen (pooled 2 yrs.)

Treatments	Moisture use (mm)	MUE (kg seed ha^{-1} mm^{-1} of water)	Cost of Cultivation (000 Rs ha^{-1})	Gross income (000 Rs ha^{-1})	Net profit (000 Rs ha^{-1})	Benefit : Costratio
Crop sequences						
Fallow-linseed	137.0	6.8	9.765	26.533	16.768	1.71
Cowpea-linseed	140.3	6.9	20.285	57.394	37.075	1.83
Blackgram-linseed	134.3	7.4	19.405	40.649	27.244	1.40
Greengram-linseed	138.4	7.6	20.225	67.524	47.299	2.34
Sorghum(fodder)- linseed	128.6	5.7	17.615	30.835	13.220	0.75
Maize-linseed	131.4	5.9	20.325	36.259	15.934	0.78
S.Em±	-	0.1	-	0.662	0.589	0.04
CD (P=0.05)	-	0.3	-	1.381	1.228	0.07
N- levels in linseed (Kgha^{1})						
20 kg/ha	129.9	5.6	17.602	39.113	21.511	1.22
40 kg/ha	133.2	6.8	17.826	43.982	26.156	1.46
60 kg/ha	136.7	7.2	18.049	46.313	28.264	1.57
80 kg/ha	140.1	7.3	18.272	47.389	29.096	1.61
S.Em±	-	0.1	-	0.716	0.614	0.04
CD (P=0.05)	-	0.3	-	1.418	1.216	0.08

significantly low in fallow-linseed sequence while net profit was minimum in sorghum (fodder)-linseed sequence might be due to variation in cultivation cost. These results corroborate with the findings of Padhi *et al.* (1993).

Gross as well as net return increased with increasing levels of N up to 60 kg Nha^{-1} might be attributed to increase in seed yield of linseed at increased rates of N application. Dwivedi *et al.* (1994) also reported similar findings. It is evident from Table 3 that income and profit increased significantly with increasing N up to 60 kgha^{-1} in fallow-linseed, sorghum (fodder)-linseed and maize-linseed sequences, but in other sequences of pulses-linseed, increase in income and profit was significant up to 40 kg Nha^{-1}. Sharma *et al.* (1991) also reported similar findings in mustard based crop sequences.

Table 3. Interaction effect of crop sequence x nitrogen on gross income and net profit of linseed based crop sequences (pooled 2 yrs.)

Crop sequence	N- levels (kgha^{1})				Significance
	20	40	60	80	
Gross income (000 Rs ha^{-1})					
Fallow-linseed	22.551	25.225	28.168	30.188	S.Em±
Cowpea-linseed	51.751	57.556	60.255	60.014	N(S) 1.754
Blackgram-linseed	40.982	47.597	49.109	48.908	S(N) 1.554
Greengram-linseed	61.896	69.085	69.421	69.696	CD (P=0.05)
Sorghum (fodder)- linseed	25.995	29.145	32.893	35.306	N(S) 3.472
Maize-linseed	31.501	35.283	38.029	40.224	S(N) 3.159
Net profit (000 Rs ha^{-1})					
Fallow-linseed	13.121	15.571	18.291	20.088	S.Em±
Cowpea-linseed	31.801	37.382	39.858	39.260	N(S) 1.505
Blackgram-linseed	21.912	28.303	29.592	29.168	S(N) 1.351
Greengram-linseed	42.006	48.971	49.084	49.136	CD (P=0.05)
Sorghum (fodder)- linseed	8.715	11.641	15.166	17.356	N(S) 2.980
Maize-linseed	11.511	15.069	17.592	19.564	S(N) 2.747

CONCLUSION

It may be concluded that growing of rainfed linseed in double crop sequences with pulse crops is more productive and remunerative than double cropping with cereals or monocropping of linseed. Among pulses crops sequences greengram-linseed sequence with 40 kg N ha^{-1} to linseed was proved to be the best combination by producing 11.01 qha^{-1} linseed yield and by earning Rs. 48,971 ha^{-1} net profit with highest B: C ratio.

REFERENCES

Chaubey, N. K., Tripathi, V., Shrivastava, G. K., Lakpale, R. and Tripathi, R. S. 2004.
Performance of linseed (*Linum usitatissimum*) under the different crop sequence and fertility levels in rainfed condition of Chhatisgarh. Proceeding of National Symposium on Resource Conservation and Agricultural Productivity held at Ludhiana, Punjab from 22-25 Nov., 2004.

Dubey, M.P., Mishra, P.C. and Purohit, J.P. 1993. Influence of mulching on double cropping of early soybean (*Glycine max*) and linseed (*Linum usitatissimum*) under rainfed conditions. *Indian Journal of Agronomy*, 38 (3): 361-364.

Dutta, H.K., Ram Mohan Rao, D.S. and Singh, H. 1995. Response of linseed (*Linum usitatissimum*) to irrigation and nitrogen. *Indian Journal of Agronomy*, 40 (1): 130-131.

Dwivedi, V.D., Pandey, R.P., Namdeo, K.N. and Sharma, N.K.1994. Response of linseed *(Linum usitatissimum* L.) to nitrogen and phosphorus. *Indian Journal of Agronomy*, 39 (4) : 695-697.

Meena, R.L., Singh, T.K., Kumar, Rakesh, Singh, A.K. and Hari Om. 2011. Production performance of Linseed *(Linum usitatissimum L.)* to fertility levels and seed rates in dryland conditions of eastern Uttar Pradesh. *Indian Journal of Soil Conservation*, 39 (3) : 230-235.

Padhi, A.K., Sahoo, B.K. and Das, K.C.1993. Possibility and prospects of double cropping sequence under rainfed, upland situation. *Indian Journal of Agricultural Sciences*, 63 (10) : 616-620.

Rao, M.V. 2008. Oilseeds: Several constraints in increasing productivity. The Hindu Survey of Indian Agriculture, : pp. 39-41.

Sarkar, R.K., Shit, D. and Chakraborty, A. 1993. Production and economic potential of cropping sequences on uplands of Chotanagpur plateau. *Indian Agriculturist*, 37 (4) : 239-247.

Sharma, H.S., Mali, A.L., Singh, G. and Manohar, S.S. 1991. Comparative economics of various cropping systems under different levels of nitrogen in the semi-arid plains. *Haryana Journal of Agronomy*, 7 (1) : 14-18.

Viets, F.G. Jr. 1962. Fertilizers and the efficient use of water. *Adv. Agronomy*, 14 : 223-364.

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Dry/wet spell analysis and rainwater availability at Durg district of Chhattisgarh state for rice crop planning

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ABSTRACT

Markov chain modeling of wet/dry spells and probability analysis of periodic rainwater availability and crop water requirement at different growth stages of rice crop were made for Durg, Dhamdha and Patan blocks of Durg district in Chhattisgarh. Dry/wet spell analysis by Markov chain model indicated that equal to or greater than 50% initial probability of wet weeks were found during 27th to 35th SMW (Standard Meteorological Week) except 28th SMW at Durg block, during 27th to 35th SMWs except 33rd and 34th SMW at Dhamdha block and during 27th to 36th SMWs except 32nd SMW at Patan block, indicating good enough rainfall during seedling and vegetative growth period of rice crop at the three study blocks. Conditional probability of wet weeks also, by and large, indicated good rainfall during this period. Initial and conditional probabilities of dry weeks equal to or greater than 50% were found during nursery (23rd – 26th SMW) and reproductive (37th – 40th SMW) stages of rice crop. Based on probability analysis of rainfall and estimation of ET requirement of rice crop at different growth stages of rice crop, it was found that at later vegetative stage (29-32 SMW), there was surplus rainwater after meeting the water requirement of rice crop at Dhamdha and Patan blocks only. Otherwise all the growth stages of rice crop suffered from rainwater deficits at all the blocks. This indicated that supplemental irrigation will be needed during these stages for good rice yields and water harvesting needs to be done at Dhamdha and Patan blocks for supplemental irrigation at nursery and reproductive stages. Recommendations on growing short to medium duration rice crop varieties were also made.

Key words: Effective monsoon, vegetative growth, Markov chain, Conditional probability, initial probability

INTRODUCTION

Rainfall is one the most important hydrologic variables for which long term historical data are usually available in India. South-west monsoon rainfall in India is the major source of water for most of the regions. In the absence of irrigation facilities in several areas, most of the Indian farmers follow rainfed farming (Patil *et al*., 2013). The different aspects of the rainfall comprise of rainfall intensity, daily, weekly, monthly, seasonal or annual totals, onset and withdrawal of monsoon period, occurrence of dry and wet spells, moisture availability indices and so on. Each of these aspects is relevant to different activities of the agricultural production process, such as sowing, irrigation, drainage etc.

This study deals with the analysis of dry and wet spells and availability of rainfall in the study area. Agnihotri (1993) studied occurrence of wet/dry spells and weather cycles at Chandigarh using daily rainfall data with the help of Markov chain model. Panigrahi and Panda (2002) used 30 years daily rainfall data of Kharagpur (W.B.) for predicting dry spell probability. A prior knowledge of probable dry and wet spells and probable rainwater availability is helpful in planning land preparation and sowing of *kharif* crops (Agnihotri and Murti, 2001). India is a tropical country and its agricultural planning and utilization of water are largely dependent upon monsoon rainfall. About more than 75% of the total annual rainfall of the country is received in monsoon season itself. It is, therefore, rather more important to study the behavior and pattern of Indian monsoon in terms of sequence of dry and wet periods and rainwater availability for analyzing periodic rainwater

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surplus/deficit in order to plan appropriate agricultural strategies for good crop production under rainfed conditions. The analysis of monsoon rainfall not only helps in deciding suitable cropping pattern and crop varieties but also to plan comprehensive activities for proper and efficient management of rainwater for improving agricultural production per unit of available water (Das *et at.*, 1998). Keeping this in mind the present study was undertaken on rainfall analysis for Durg district in Chhattisgarh for assessing the probable occurrence of dry and wet spells and rainfall.

MATERIALS AND METHODS

The study area

Three blocks, namely Durg, Dhamdha and Patan of district Durg in Chhattisgarh were selected for the present study. These blocks represent Chhattisgarh Plains agro-climatic zone of the state as per National Agriculture Research Project (NARP) classification. The geographic locations of Durg, Dhamdha and Patan blocks are 81^0 16′ 58" E and 21^0 11′ 21" N, altitude 299 m above mean sea level, 81^0 19′ 57" E - 21^0 27′ 38" N, altitude 280 m above mean sea level and 81^0 32′ 58" E - 21^0 02′ 06" N, altitude 302 m above mean sea level respectively. The location map showing the three study blocks is depicted in Fig. 1. The study blocks together have a total geographical area of about

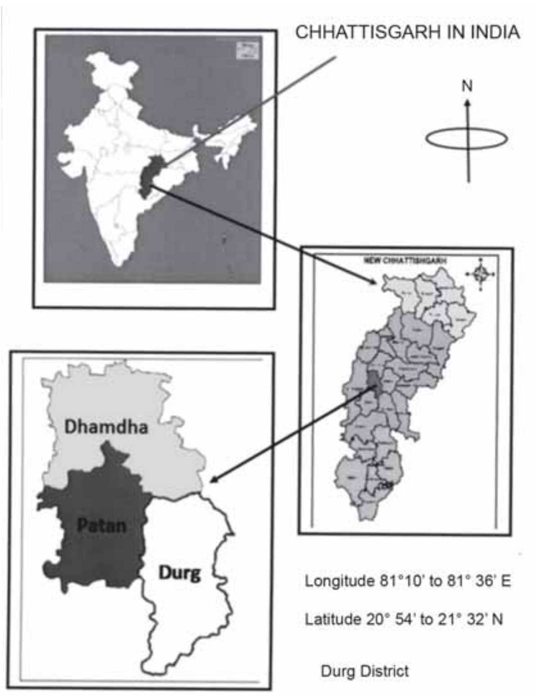

Fig. 1. Location map of the study area

2238 sq. km. The whole study area falls in temperate zone of Indian subcontinent. Rainy season begins from mid June and starts terminating by the end of September. Summer season is hot reaching a peak temperature of 45^0C in second fortnight of May. The month of December in winter usually experiences a minimum temperature of 7-8^0C. The RH is very low (19%) in summer and goes up to 80% during monsoon period. The winds blow with moderate speed of about 5-6 km h^{-1}. The characteristic toposequence has *kanhar* (vertisols) found in the lowest land portion, d*orsa* (alfisols) situated just upstream of *kanhar soils*, *matasi* (inceptisols) found just upstream side of *dorsa* soils and *bhata* (entisols) encountered at the top of the toposequence. The major cultivated area in Durg district is occupied by *matasi* soils. Rice is the main *kharif* crop that covers 80-90% of total cultivated area in monsoon season. Farmers of the area, generally grow long and medium duration photosensitive tall rice varieties, which flower by mid to late September and mature by mid to late November depending upon the duration of the rice varieties grown.

Dry/wet spell computation

Probability analysis of rainfall for dry and wet weeks was carried out by applying Markov chain model. For considering a week as dry or wet, the criteria given by Raj (1979) were applied. Dash and Senapati (1992) and Pandarinath (1991) used 30 mm or more rainfall in 10 days period for a wet spell and below 30 mm rainfall in 10 days for a dry spell. Dash and Senapati (1992) assumed 20 mm or more rainfall in a week as wet week and weekly rainfall below 20 mm as dry week. In the present study, however, the above criteria were not considered appropriate but a minimum of 50 mm or more weekly rainfall was taken as a wet week and below 50 mm as a dry week as suggested by Choudhary (1998) because for effective growth of rice crop, a minimum weekly rainfall amount of 50 mm is necessary. This is because of the fact that on daily basis, 3-4 mm of ET loss takes place. In early crop stages, percolation losses are found to be high as compared to later stages. On the contrary, the ET requirement is less at early stages and increases in later stages. This amounts to 7 mm of water loss per day or approximately 50 mm of water loss per week. Thus, a week receiving equal to or more than 50 mm rainfall was assumed a wet week and a week receiving less than 50 mm rainfall was considered a dry week. Probability analysis of dry and wet weeks was also made using Markov chain process.

Markov chain model is applicable, when dependence exists between sequential events in a random process and the dependence is such that the next step depends only on the present state and not on the preceding past states. In general, a Markov process describes only step-by-step dependence, called a first order process. The probability relationships for a Markov process must provide for the conditional probabilities of the process moving from any state at period (t) to any subsequent state at period (t+1). Two conditions must be defined to describe the Markov process completely. One is the initial state and the other is the complete matrix of transition state. The probabilities can be computed as follows:

Initial probability

$$P(D) = F(D)/n \text{ and } P(W) = F(W)/n$$

Where, P(D) is the probability of occurrence of a dry week.

P(W) is the probability of occurrence of a wet week.

F(D) is the frequency of a dry week.

F(W) is the frequency of a wet week.

n is the number of years of records

Conditional probabilities

$$P(D/D) = \frac{F(D/D)}{F(D/D)+F(W/D)} = \frac{F(D/D)}{F(D)}$$

$$P(D/W) = \frac{F(W/W)}{F(W/W)+F(D/W} = \frac{F(W/W)}{F(W)}$$

$$P(D/W) = \frac{F(D/W)}{F(W)} = 1 - P(W/W)$$

$$P(W/D) = 1 - P(D/D)$$

Where, P(D/D) is the probability of occurrence of a dry week provided the preceding week was a dry week.

P(D/W) is the probability of occurrence of a dry week provided the preceding week was a wet week.

P(W/W) is the probability of occurrence of a wet week provided the preceding week was a wet week.

P(W/D) is the probability of occurrence of a wet week provided the preceding week was a dry week.

The first letter in parentheses for the conditional probability indicates the present week and the second letter indicates the previous week.

Probability of Consecutive Wet and Dry Weeks

Probability of wet run and dry run of two weeks and three weeks can be calculated as:

$$P(2W) = P(W) \cdot P(W/W)_2$$
$$P(2D) = P(D) \cdot P(D/D)_2$$

Where, P(2W) is the probability of two consecutive wet weeks.

P(2D) is the probability of two consecutive dry weeks.

P(W) is the initial probability of wet week.

P(D) is the initial probability of dry week.

The initial and conditional probabilities of dry and wet weeks and the probabilities of consecutive 2 dry and wet weeks are given in Table 1 to 3 for Durg, Dhamdha and Patan blocks, respectively.

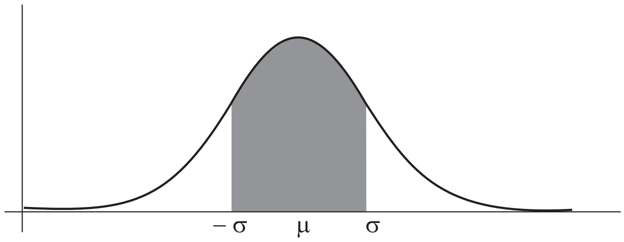

Fig. 2. Normal probability distribution curve

RESULTS AND DISCUSSION

Markov chain modeling of wet/dry spells was and probability analysis of rainwater availability was made in the study for Durg, Dhamdha and Patan blocks of Durg district in Chhattisgarh. Subsequently, analysis of water requirements at the various growth stages of rice crop was performed to determine water surplus/deficit at all the blocks and comprehensive planning of rice crop was suggested.

Dry/Wet Spell Analysis

Dry and wet spell analysis was carried out by Markov chain model using weekly rainfall data of Durg, Dhamdha and Patan blocks and rainwater availability during the corresponding dry and well spells were also worked out. The outcomes of Morkov chain model are given in Table 1, 2 and 3.

Durg Block

Markov chain model returned the initial and conditional probabilities of wet and dry weeks which have been given in Table 1 for Durg block. It is found that that during the period from 29^{th} –

Table 1 Initial and conditional probabilities of dry/wet weeks during monsoon at Durg block

SMW	Initial probability (%)		Conditional probability (%)				Probability of consecutive 2 dry and wet weeks (%)	
	P(W)	P(D)	P(W/W)	P(D/W)	P(D/D)	P(W/D)	P(2W)	P(2D)
23	0	100	0	100	95	5	0	95
24	40 (11.8)	60	50	50	67	33	20	40
25	40	60	50	50	67	33	20	40
26	35	65	28	72	69	31	10	45
27	55	45	45	55	33	67	25	15
28	35	65	0	100	46	54	0	30
29	65	35	69	31	57	43	45	20
30	50	50	50	50	50	50	25	25
31	50	50	40	60	30	70	20	15
32	55	45	54	46	56	44	30	25
33	60	40	58	42	37	63	35	15
34	75	25	67	33	0	100	50	0
35	55	45	63	37	56	44	35	25
36	35	65	14	86	54	46	5	35
37	15	85	33	67	82	18	5	70
38	25	75	20	80	73	27	5	55
39	10	90	0	100	83	17	0	75
40	20	80	0	100	69	31	0	55
41	10	90	0	100	83	17	0	75
42	10	90	0	100	83	17	0	75
43	10	90	0	100	83	17	0	75

Table 2 Initial and conditional probabilities of dry and wet weeks during monsoon at Dhamdha block

SMW	Initial probability (%)		Conditional probability (%)				Probability of consecutive 2 dry and wet weeks (%)	
	P(W)	P(D)	P(W/W)	P(D/W)	P(D/D)	P(W/D)	P(2W)	P(2D)
23	6	94	20	80	88	12	0	83
24	28	72	38	62	77	23	6	56
25	44	56	14	86	50	50	17	28
26	39	61	45	55	45	55	6	28
27	61	39	40	60	29	71	28	11
28	56	44	62	38	25	75	22	11
29	72	28	60	40	0	100	44	0
30	56	44	33	67	50	50	33	22
31	33	67	67	33	58	42	11	39
32	50	50	25	75	67	33	33	33
33	44	56	38	62	50	50	11	28
34	44	56	70	30	40	60	17	22
35	56	44	33	67	50	50	39	22
36	33	67	0	100	67	33	11	44
37	22	78	0	100	71	29	0	56
38	17	83	0	100	80	20	0	67
39	11	89	0	100	81	19	0	72
40	11	89	0	100	88	12	0	78
41	0	100	0	100	94	6	0	94
42	11	89	0	100	81	19	0	72
43	6	94	0	100	88	12	0	83

Table 3. Initial and conditional probabilities of dry and wet weeks during monsoon at Patan block

SMW	Initial probability (%)		Conditional probability (%)				Probability of consecutive 2 dry and wet weeks (%)	
	P(W)	P(D)	P(W/W)	P(D/W)	P(D/D)	P(W/D)	P(2W)	P(2D)
23	22	78	0	100	79	21	0	61
24	33	67	33	67	58	42	11	39
25	39	61	29	71	45	55	11	28
26	3	97	17	83	58	42	6	39
27	56	44	50	50	25	75	28	11
28	61	39	73	27	43	57	44	17
29	67	33	58	42	17	83	39	6
30	78	22	64	36	0	100	50	0
31	78	22	86	14	75	25	67	17
32	44	56	37	63	50	50	17	28
33	61	39	55	45	28	72	33	11
34	61	39	55	45	28	72	33	11
35	50	50	44	56	44	56	22	22
36	50	50	67	33	56	44	33	28
37	22	78	0	100	71	29	0	56
38	17	83	0	100	80	20	0	67
39	11	89	0	100	81	19	0	72
40	0	100	0	100	94	6	0	95
41	6	94	0	100	88	12	0	83
42	17	83	0	100	73	27	0	61
43	11	89	0	100	87	13	0	78

Table 4. Computation of rainwater surplus/deficit at the study blocks

Growth stage	Weeks (mm)	ET_{rice}	Rainwater availability (mm) at 75% probability			Rainwater surplus/deficit (mm)		
			Durg	Dhamdha	Patan	Durg	Dhamdha	Patan
Nursery	22-24	104.6	25.1	31.57	24.5	-79.5	-73.03	-80.1
Seedling	25-26	68.4	26.31	34.6	25.6	-42.1	-33.8	-42.8
Seedling	27-28	63.0	37.4	42.4	41.2	-25.6	-20.6	-21.8
Vegetative	29-30	62.6	55.22	92.5	90.0	-7.38	29.9	27.4
Vegetative	31-32	59.3	37.5	60.5	72.8	-21.8	1.2	13.5
Vegetative	33-34	60.7	58.8	43.7	57.2	-1.9	-17.0	-3.5
Reproductive	35-36	54.9	21.8	40.0	39.6	-33.1	-14.9	-15.3
Reproductive	37-38	67.6	18.2	10.7	19.8	-49.4	-56.9	-47.8
Reproductive	39-40	72.3	9.7	5.8	5.62	-62.6	-66.5	-66.7
Maturity	41-42	66.1	6.3	5.6	8.41	-59.8	-60.5	-57.7
Maturity	43	56.7	2.3	1.8	20.6	-54.4	-54.9	-36.1
Total		736.2	298.6	369.7	405.3	-437.6	-366.5	-330.9

35th SMW, the initial probabilities of getting wet weeks ranged from 50 to 75% and conditional probabilities during the same period ranges from 40 to 63%. Within the span of 29th – 35th SMW, it was observed that 29th, 33rd and 34th SMWs have the highest (>60%) initial probabilities, while conditional probabilities was higher in 29th, 34th and 35th SMWs, ranging from 63 to 69%. This suggests that chances of getting good amounts of rainfall are higher during the period and the vegetative stage of rice crop may not suffer from water deficiency. Any excess water to ET requirement can be harvested in on-farm storages structures for later use during moisture stress period. The probability of getting 2 consecutive wet weeks is 45% in 29th SMW and 50% in 34th week. In other weeks, the chances of 2 consecutive wet weeks are from 0 to 35% only. Therefore, one can expect enough and continuous rainfall in 29th and 34th week, which could be harvested at farm level.

The first week (23rd SMW) of the nursery stage is likely to be surely a dry week as the probability of being dry week is 100%. Therefore, supplemental irrigation is necessary to raise good and healthy nursery. 30th and 31st SMWs that fall in vegetative stage have 50% chance of being dry. Initial and conditional probabilities of getting dry spell during reproductive phase (37th – 40th SMW) were very high (Initial probability: 75-90%; Conditional probability: 69-83%). With regard to probability of being two consecutive dry weeks, it was also observed that 23rd SMW has the probability as high 95%. Similarly, 37th and 39th SMWs exhibited the probability of two consecutive dry weeks as 70% and 75%, respectively indicative no rains during this period.

Dhamdha block

From Table 2, it is evident that during 27th to 30th SMW the initial probabilities of being wet week ranged from 56-72%, indicating a good number of wet spells during vegetative growth period of rice crop. The surplus rainwater may be stored in water harvesting structures for later use during moisture requiring period. During reproductive stage (37th – 40th SMW), the initial probability of getting wet weeks was from 11% to 22% only. The conditional probability of wet weeks was 62% in 28th week and 60% in 29th week during which continuous rains may occur. In 31st and 34th SMWs also, the probability of wet week was high i.e. 67% and 70%, respectively. It means in Dhamdha block also, good amounts of rainfall may be received and thus, the excess rainwater can be harvested in storage structures. The probability of two consecutive weeks to be wet is below 44% throughout the rice crop season.

The 23rd to 26th SMW stage has an initial probability of dry week as high as 56% to 94%, indicating water stress during nursery period at Dhamdha block also and supplemental irrigation will be required. During vegetative growth period (31st – 34th SMW) also, the initial probabilities of dry weeks is high (50-67%). This indicates that during vegetative growth period also, a supplemental irrigation of 5-7 cm might be needed. Conditional probabilities of dry weeks are also higher during the same period. During 23rd – 24th SMW at nursery stage and during 37-40 SMW at reproductive stage, the probabilities of getting two consecutive dry weeks are higher (Nursery: 56-83%; Reproductive phase: 56-78%).

Patan block

From Table 3, it is seen that almost similar situation is observed at Patan block also during nursery and reproductive stages. From 23rd to 25th SMW the probability of getting wet week is below 40%. In other words, the probability of getting dry weeks is above 60% and may reach to 97% in 26th SMW. From 27th – 34th SMW except 32th SMW, the probability of wet weeks is higher (56-78%) and good rain-spells are expected during this period, indicating good possibility of rainwater harvesting. During reproductive phase, continuous dry spells with 78 to 100% probabilities are expected at Patan block, indicating the need for supplemental irrigation from stored rainwater. Probability of getting two consecutive wet weeks is from 50 to 67% in 30th to 31st SMW during vegetative stage. At reproductive phase, higher probabilities (56-95%) of two consecutive dry weeks occur from 37th to 40th SMW.

Crop water requirement and rainwater surplus/deficit

The expected rainfall amounts during different standard meteorological weeks were determined by probability analysis of rainfall and ET requirements of rice crop at different growth stages were also worked out. Based on these two parameters, water requirements of rice crop were computed. The results of this analysis are given in Table 4. It is found that water requirement of rice crop at the study blocks during nursery stage, was found to be 104.6mm but rainwater availability at 75% probability level was 25.1 mm, 31.6 mm and 24.5 mm only at Durg, Dhamdha and Patan blocks respectively. This indicates that at all the blocks, there may be acute shortage of water during nursery stage and supplemental irrigation is a must to raise good rice nursery. At seedling stage of 4 weeks also, the rainwater availability is about 50 to 60% of the total water requirement. It means, the remaining water requirement has to be met by supplemental irrigation for healthy growth of rice seedlings. During vegetative growth stage, the water requirement is 182.6 mm. The rainwater availability at Durg block is 151.5 mm indicating a water deficit of 31.1 mm that has to be provided by supplemental irrigation. But at Dhamdha and Patan blocks, rainwater is in surplus that should be stored in water harvesting structures. Reproductive stage of the crop is the most crucial stage and any shortage of water at this stage may be very detrimental to the rice yield. It is seen that all the study blocks may experience appreciable water deficit at reproductive stage and supplemental irrigation will be very necessary, if potential rice yield has to be realized. At maturity stage, the rainwater availability is almost negligible in comparison to the ET requirement, which is rather beneficial in terms of timely grain maturity and ease in crop harvesting.

CONCLUSION

Prior knowledge of expected amounts of rainwater availability, occurrence of dry and wet spells and consequent water surplus and deficit is crucial in proper rice crop planning. The study reveals that nursery and reproductive stages of rice are likely to experience severe deficit of rainwater at all the blocks and will need supplemental irrigation for good rice yields. At Dhamdha and Patan blocks, rainfall is most likely to be in surplus during 29 to 32 SMW, i.e. about one month of vegetative stage and the excess rainwater should be harnessed in on-farm water harvesting structures for use during reproductive stage when there is large water deficit. At Durg, however, possibility of rainwater harvesting is remote as there is water deficit during entire crop duration and the use of canal water or groundwater is necessary for successful rice crop. The study also suggests that long duration (more than 130 days) rice varieties should not be grown. Under complete rainfed condition, only short duration (up to 110 days) rice should be grown at Durg block and short to medium duration (up to 130 days) may be grown in Dhamdha and Patan blocks.

REFERENCES

Agnihotri, A. 1993. A study on occurrence of wet/dry spells and weather cycles at Chandigarh using Markov chian model, *Indian j. Soil Cons.* 21(1):71-79

Agnihotri, A. and Murti, R. (2001). Relationships between onset of monsoon with sowing weeks and monthly/seasonal rainfall at Chandigarh, *J. Indian Water Resources Society*, 21(2):60-64

Choudhary, J.L. 1998. Storage index as an aid in crop planning and water management- a case study of Bastar district. *Indian J. Agril. Engg. 6(3-4):*119-122.

Das H.P., Abhyankar, R.S., Bhagwal, R.S. and Nair, A.S. (1998). Fifty years of arid zone research in India, CAZRI, Jodhpur, 417-422

Dash, M.K. and Senapati, P.C. 1992. Forecasting of dry and wet spell at Bhubaneshwar for agricultural planning. *Indian* J. Soil Cons. *20(1 & 2)*

Pandarinath, N. 1991. Markov Chain model probability of dry and wet weeks during monsoon period over Andhra Pradesh, *Mausum* 42(4):393-400.

Panigrahi, B. and Panda, S.N. (2002). Dry spell probability by Markov chain model and its application to crop planning in Kharagpur, *Indian J. Soil. Cons.* 24(1):28-36

Patil, J. P., Sarangi, A., Singh, D.K., Chakravarty, D., Rao, M.S. and Dahiya, S. 2013. Rainfall Trend Analysis: A Case Study of Pune District in Western Maharashtra Region J. Soil and Water Cons., 12(1):35-43

Raj, Ashok 1979. Onset of effective monsoon and critical dry spells- A computer based forecasting techniques. *Water Technology Centre*, New Delhi, IARI Research Bulletin No. 11 (New Series):8-12

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Productivity, water use efficiency and economics of Indian mustard (*Brassica juncea* L.) as influenced by various fertility levels and mulching under rainfed condition

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ABSTRACT

A field experiment was carried out on sandy loam soil at Kanpur to study the effect of levels of NP nutrients and mulching on growth, yield attributes, yield, water use efficiency (WUE) and economics of Indian mustard [*Brassica juncea* (L.) Czernj and Cosson]. Twelve treatment combinations consisted of four fertility levels *viz*. control, 40 kg N+20kg P_2O_5/ ha, 60 kg N+30 kg P_2O_5/ ha, 80 kg N+40 kg P_2O_5 / ha and three mulches *viz*. control, dust mulch created by weeding and hoeing at 20 and 30 DAS and organic mulch @ 4 t / ha Paddy straw, 30 DAS, replicated thrice, were arranged in randomized block design. Results showed that application of 80 kg N+40 kg P_2O_5 / ha fertilizer induced significantly higher growth, yield attributes, over other treatment and yielded 64.86%, 29.38% and 9.99 % more seed yield over control, 40 kg N+20kg P_2O_5/ ha, and 60 kg N+30 kg P_2O_5/ ha, respectively. Highest net return (Rs 28,803/ha) and B:C ratio (2.41) were realized with application of 80 kg N+40 kg P_2O_5/ ha. Application of paddy straw mulch @ 4 t / ha gave 14.93 % and 6.45 % higher grain yield as compared with no mulching and dust mulch created by weeding and hoeing at 20 and 30 DAS and raised income to the tune of Rs 32,471/ha with a net B:C ratio (2.64).

Key words: Fertility, mulching, mustard, water use efficiency, yield

INTRODUCTION

Rapeseed-mustard account for 21% (6.51 million ha) of the total oilseed area and 23% (7.67 million tonne) of the total oilseed production next to groundnut and soybean (Anonymous, 2011). Mustard yield can be increased by adopting the improved agronomic practices. Fertilizer management has an important role to play for increasing the productivity of mustard, which can be realised by providing plant nutrient in balanced amount along with suitable agronomic package to the crop. Sowing the crop under rainfed conditions on residual moisture in marginal and sub-marginal land with limited nutrient use rank at the top for low productivity.

Mid- season drought during growing season is one of the main cause of low yield of rainfed mustard. Moisture conservation in soil and reduction of soil erosion can be achieved by the use of organic mulches including paddy straw and weed biomass. Mulching is effective in conserving soil moisture, reducing evaporation and regulating soil temperature (Ratan Lal, 2004). Moisture conservation practices increase infiltration rate, porosity and improve root growth and yield (Gupta, 2007). In the view of the above, the present study was under taken to find out suitable fertilizer dose and mulch materials for higher yields and soil moisture conservation.

MATERIALS AND METHODS

A field experiment was conducted during the (*Rabi*) seasons at the Soil Conservation and Water Management Research Farm of Chandra Shekhar Azad University of Agricultural and Technology, Kanpur (25^0 26′ and 26^0 58′ N and 79^0 3′1 and 80^0 34′ E, at 125.90 m above mean sea - level). The soil of the experimental field was sandy loam, having pH 7.8, bulk density 1.47, particle density 2.8, field capacity 18.35, wilting point 6.2, porosity 42.90, EC 0.36, organic carbon 0.45%, available N, P and K, 205, 16.25, and 154.80 kg / ha, respectively. The

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twelve treatments comprised of 4fertility levels (F_0 Control, F_1 40 kg N + 20 kg P_2O_5/ ha, F_2 60 kg N +30 kg P_2O_5/ ha, F_3 80 kg N + 40 kg P_2O_5/ ha) and 3 Moisture Conservation Practices (M_0 Control, M_1 dust mulch created by weeding and hoeing at 20 and 30 DAS and M_2 organic mulch @ 4t / ha paddy straw, 30 DAS). The experiment was laid out in randomized block design with 3 replications. Mustard 'Vaibhav' was sown in 3rd week of October and harvested in last week of February. The crop was sown in rows 45 cm apart with a seed rate of 6 kg/ha. Nitrogen and phosphorus were applied in the farm of urea of DAP as per the treatment. The water use efficiency (WUE) in kg/ ha-cm was calculated by dividing the seed yield with the respective total consumptive use for the crop period.

RESULTS AND DISCUSSION

Effect of fertility levels

Growth and yield attributes

Growth and yield attributing characters of mustard were influenced significantly with increasing levels of fertility (Table 1).The maximum number of primary and secondary branches per plant, number of siliquae / plant, length of siliquae, 1000 seed weight and seed yield / plant were observed with application of 80 kg N + 40 kg P_2O_5 / ha (F_3), which were significantly higher over other doses.Such improvement in yield component was owing to increased availability of nutrients. Several workers have reported the positive response of fertilizer application on different growth and yield attributes of mustard (Reager *et al.*, 2006).

Yield

Significantly improvement in seed yield as well as in stover yield was observed with successive increase in level of fertility. The mean response due to application of 80 kg N + 40 kg P_2O_5/ ha (F_3) was 64.86, 29.38 and 9.99 % in seed yield and 56.35, 25.04 and 8.92 % in stover yield over control (F_0), 40 kg N + 20 kg P_2O_5 / ha (F_1), 60 kg N + 30 kg P_2O_5 / ha (F_2), respectively. The significant increase in seed and straw yields of mustard were largely a function of improved growth and the consequent increase in different yield components due to adequate supply of major plant nutrients under successive increase in nutrient doses which finally resulted in higher seed yield. Such increased trends were also reported by Roul *et al.* (2006).

CU and WUE

Consumptive use of water and water use efficiency was influenced by fertilizer application in mustard crop (Table 2). The consumptive use of water decreased with increasing level of fertility. Highest (184.17) consumptive use of water was recorded in control plot and lowest (172.7) was recorded with application of 80 kg N+40 kg P_2O_5/ ha (F_3). The highest (8.31 kg/ha-cm) water use efficiency was recorded with application of 80 kg N + 40 kg P_2O_5 / ha (F_3) treatment. The superiority of this treatment over rest of the treatments might be ascribed to higher seed yield coupled with more proportionate increase in seed yield due to higher availability of major nutrients to crop. These results are in consonance with those of Panda *et al.* (2000).

Table 1. Influence of fertility levels and mulching on growth, yield attributes and yield of mustard

Treatment	Plant height (cm)	Primary branches/ plant	Secondary branches/ plant	Siliquae/ plant	Length of siliqua (cm)	1000-seed weight (g)	Grain weight/ plant (g)	Seed yield (q/ha)	Stover yield (q/ha)
Fertility levels (kg/ha)									
F_0	136.86	4.35	14.68	256	3.73	2,97	5.82	8.68	25.84
F_1	143.75	4.72	17.87	277	3.94	3,02	6.09	11.06	32.31
F_2	145.61	5.73	22.83	301	4.06	3.19	7.91	13.01	37.09
F_3	147.19	6.25	25.21	351	4.26	3.53	9.29	14.31	40.40
CD (P=0.05)	2.68	0.32	0.79	22.17	0.07	0.10	0.54	1.09	2.33
Mulching									
M_0	138.67	5.02	19.11	273	3.82	3.06	6.10	10.92	32.09
M_1	143.82	5.24	20.33	299	4.02	3.18	7.19	11.79	34.14
M_2	147.56	5.53	21.01	316	4.16	3.30	9.05	12.55	35.50
CD (P=0.05)	4.05	0.32	0.68	19.20	0.06	0.09	0.47	0.94	2.02

F_0 - Control, F_1 - 40 kg N+20kg P_2O_5, F_2 - 60 kg N+30 kg P_2O_5, F_3 - 80 kg N+40 kg P_2O_5 M_0 – Control, M_1 - Dust Mulch created by weeding and hoeing at 20 and 30 DAS and M_2 - Organic mulch @ 4 t / ha paddy straw, 30 DAS)

Table 2. Effect of fertility levels and mulching on consumptive use of water, water use efficiency and economics of mustard

Treatment	Consumptive use of water	Water use efficiency (kg/ha-cm)	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio
Fertility levels (kg/ha)						
F_0	184.17	4.70	10427	24738	14311	1.37
F_1	180.70	6.10	11199	31416	20217	1.80
F_2	175,98	7,40	11574	37069	25495	2.20
F_3	172.7	8.31	11971	40774	28803	2.41
Mulching						
M_0	172.86	6.10	9865	31115	21249	2.15
M_1	178.48	6.64	11709	33609	21899	1.87
M_2	176,75	7.15	12303	35775	32471	2.64

F_0 - Control, F_1 - 40 kg N+20kg P_2O_5, F_2 - 60 kg N+30 kg P_2O_5, F_3 - 80 kg N+40 kg P_2O_5 M_0 - Control- M_1 Dust Mulch created by weeding and hoeing at 20 and 30 DAS and M_2 - Organic mulch @ 4 t / ha paddy straw, 30 DAS)

Effect of mulching

Growth and yield attributes

Different moisture conservation practices exerted pronounced effect on growth of plants as evidenced by significant variations in various growth epithets, namely plant height, number of primary and secondary branches/plant. Maximum increase in plant height, number of primary and secondary branches/plant was recorded under the application of paddy straw mulch @ 4 t / ha treatment while the lowest was noticed under the control plot. The results were corroborated with the findings of Chiroma *et al*., (2006).

Significant higher values of yield attributes, viz. number of siliquae per plant, length of siliqua, seed weight per plant and 1000 seed weight were observed by the application of different mulches as compared to no mulch. Application of paddy straw mulch @ 4 t / ha (M_2) produced significantly maximum length of siliqua, seed weight per plant and 1000 seed weight than rest of the mulching treatment but at par with application of dust mulch created by weeding and hoeing at 20 and 30 DAS (M_1) in case of number of siliquae / plant.

Application of paddy straw mulch @ 4 t / ha (M_2) gave 14.93 % higher grain yield and 10.63 % higher stover yield as compared with no mulching. This might be due to conservation and availability of higher amount of moisture during reproductive phase resulting in better growth and yield. These findings were in agreement with those reported by Thakur *et al*., (2011).

Consumptive use of water and Water use efficiency were influenced by various mulching treatments. Maximum consumptive use of water (178.48) was recorded with application of dust mulch created by weeding and hoeing at 20 and 30 DAS (M_1), while water use efficiency was recorded with application of paddy straw mulch @ 4 t / ha (M_2). The lowest were recorded with no mulching.

Economics

The net return and benefit: cost ratio were affected by various treatments (Table 2). Highest net return (Rs 28,803/ha) and B:C ratio (2.41) were realized with application of 80 kg N + 40 kg P_2O_5/ ha (F_3). Further, the maximum return and (Rs 32,471/ha) and B:C ratio (2.64) were recorded in use of organic mulch @ 4 t / ha paddy straw, 30 DAS (M_2). This might be due to higher productivity in this treatment.

REFERENCES

Anonymous 2011. www.ends.dacnet.nic.in/At_A_Glance-2011/4.18 (a).xls

Chiroma, A.M., Alhassan, A.B. and Yakubu, H. 2006. Growth, nutrient composition and straw yield of sorghum as affected by land configuration and wood-chips mulch on a sandy loam soil in north-east Nigeria. *International J. Agril. and Bio*. **8** (6): 770-73.

Gupta, A. 2007. Effect of moisture conservation practices on growth and yield of Sorghum (*Sorghum bicolor* L. Moench). M. Sc. (Agriculture) Thesis of Mahatma Phule Krishi Vidyapeeth, Rahuri, India.

Panda, P. K., Sounda, S and Tripathi, S. K. 2000. Effect of irrigation and sulphur on yield, nutrient uptake and quality of mustard. *J. Oilseeds Res*. **17** (1): 122-126.

Ratan Lal. 2004. Effect of mulching on maize (*Zea mays*), higher growth rate and vigour. *J. Plant and Soil*. **40** (1): 129-143.

Reager, M. L., Sharma, S. K. and Yadav, R. S. 2006. Yield attributes, yield and nutrient uptake of Indian mustard (*Brassica juncea*) as influenced by nitrogen levels and its split application in arid Western Rajasthan.*Indian J. Agron*. **51** (3): 213-216.

Roul, P. K., Sarawgl, S.K., Srivastava, G. K. and Kumar, D. 2006. Effect of integrated nutrient management techniques on productivity, nitrogen uptake, N use efficiency, economics and energetics of rice (*Oryza sativa*) – Indian mustard (*Brassica juncea*) sequence. *Indian J. Agron*. **51** (3): 170-173.

Thakur, N. S., Kushwaha, B. B. and Sinha, N. K. 2011. Productivity and water use in *kharif* sorghum (*Sorghum bicolor*) under different land configuration and mulching. *Indian J. Agron*. **56** (1): 47-51.

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Micronutrient status in erosion prone Basmati rice growing soils of Jammu

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ABSTRACT

A study on DTPA-extractable micronutrients (Zn, Cu, Fe and Mn) was undertaken from different Basmati rice growing locations of Jammu district and their relationship with various physiochemical properties of the soils was also studied. The DTPA-extractable available micronutrients in these soils showed wide variation. The DTPA-extractable, zinc, copper iron and manganese in the surface (0-15cm) varied from 0.02-1.18, 0.05-3.67, 2.40-40.76 and 1.14-11.13with mean values of 0.25, 0.82, 21.30 and 4.34 mg kg^{-1} , respectively. The available micronutrient Cu, Zn and Fe showed significant correlation with pH (-0.288**,0.197 and-0.273). The available micronutrient Fe correlated significantly with organic carbon (0.257**) whereas the available Mn showed significant correlation with CEC (0.206*). Other physio-chemical properties of soil showed non-significant correlations with either micronutrients during the study. Zinc deficiency was observed in most of the surface samples (about 96%), whereas 10% soils were found deficient in available copper. However, DTPA-extractable Mn and Fe in the studied soils were above the critical limits.

Keywords: Copper, DTPA extractable, Iron, Manganese, Zinc, Rice

INTRODUCTION

The relatively minor problem of soil micronutrient deficiency at the beginning of the green revolution three decades ago is a factor to reckon with in present times in sustaining the productivity of rice. Proper management of the rice-wheat cropping system is a key to minimize crop yield reduction induced by micronutrient deficiency. There is a general lack of awareness among farmers on micronutrient deficiency problem.

Continued emphasis on maximization of Rice food grain production without appropriate management practices from a shrinking land resource base will result in further depletion of micronutrient reserves. The simplest solution to alleviate micronutrient deficiency is the application of micronutrient fertilizer to the crop. Micronutrient deficiency is considered as one of the major causes of the declining productivity trends observed in rice growing countries. Sodic, upland soils and calcareous coarse-textured soil with low organic matter content suffer from Fe deficiency, besides Zn and Cu deficiency. Studies suggest that rice cultivars usually do not experience deficiency of B and Mo in majority of soils.

Micronutrients play a vital role for the growth and development of crops. Availability of micronutrients is influenced by their distribution in soil and other physico-chemical properties of the soil (Sharma and Chaudhary 2007). Thus, knowledge of status of micronutrient and their interrelationship with soil characteristic is helpful in understanding the inherent capacity of soil to supply these nutrients to plant. Besides, soil characteristics, land use pattern also plays a vital role in governing the nutrient dynamics and fertility of soils (Venkatesh *et al.* 2003).

The total micronutrient content of soils is of limited value to plant growth and responses to their application. To match the levels of micronutrient in soil with plant requirement, their available contents in soils is determined. The available micronutrient status of soils is also highly variable. Soil properties exercise a considerable influence on the availability of micronutrients.

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Therefore, the extent of micronutrient deficiency varies not only in J&K districts but also in different blocks within the same district depending upon the soil characteristics and other management conditions. Since no systematic information is yet available on status of micronutrient in rice growing area soil of Jammu, therefore the present work was conducted to assess the status of micronutrient in rice growing area of Jammu.

MATERIALS AND METHODS

A study on DTPA-extractable micronutrients (Zn, Cu, Fe and Mn) was undertaken by collecting soil samples from 154 different Basmati rice growing locations of Jammu district comprising of six blocks (Khour, Bishnan, Jammu, R. S. Pura, Satwari and Marh,). After harvesting of rice crop, surface (0-15 cm) soil sample from various identified areas were collected and processed. These samples were analyzed for pH, EC,OC,CEC by standard methods (Jackson, 1973). These soil samples were also extracted with solution consisting of 0.005M DTPA, 0.01M $CaCl_2$ and 0.1 M Triethanolamine (pH 7.3) as per the procedure described by (Lindsay and Norvell 1978) for available micronutrient cations. The Zn, Cu, Fe, Mn in extracts were estimated using atomic absorption spectrophotometer Model, Z2300 (Hitachi).

RESULTS AND DISCUSSION

Physico-chemical Properties

The data on some important soil properties are presented in table 1 and 2. The result showed that majority of the soil sites were alkaline and neutral in reaction. Considering textural classes most of the soils varied sandy clay loam to clay loam. The soil pH value (1.25) ranged between 5.91 to 9.94 with overall a mean value of 7.33 whereas electrical conductivity (EC) of these soils varied between 0.11 to 0.45 dSm^{-1} with a mean value of 0.23 dSm^{-1}, respectively. The soil organic carbon content was ranged between 0.31 to 0.78 % with overall mean value of 0.56gkg^{-1}. The values of CEC varied between 3.45 to 24.58 [$cmol(p^+)kg^{-1}$] for these Basmati rice soils.

Micronutrients status of soils

The DTPA-extractable available macronutrient status of the basmati growing soils of the Jammu district is inserted in Table 2.

DTPA-Zn: The DTPA- extractable zinc in the soil ranged from 0.02 to 1.18 mg kg^{-1} with average value of 0.25 mg kg^{-1}. The high amount may have resulted from high organic matter content and more weathered soil conditions. The higher value in Marh soils might be due to higher content of organic carbon as well as finer fraction of soils leading to increase in the surface area for ion exchange and hence contributed to the higher amount of DTPA-Zn in these soils (Sharma *et al*. 2003). Correlation studies (Table 3) revealed that negative relation with EC, organic carbon, CEC, sand, silt and clay (Sharma *et al*. 1996). The available Zn in soil has been found significant and positive relationship with pH of the soil (r = 0.197*), thereby indicating that availability of Zn decreases with increase in soil pH, which is in line with that (Saha *et al*. 1996). These results were also similar to the findings of (Yadav and Meena 2009). On the basis of the critical limits (0.6 $mgkg^{-1}$) suggested by

Table 1. Range and average values of important physico-chemical properties of Basmati growing soils of Jammu district

Block	pH	EC (dSm^{-1})	OC (%)	Sand (%)	Silt (%)	Clay (%)	CEC [$cmol(p^+)kg^{-1}$]
R. S. Pura	6.83-8.68 (7.49)	0.12-0.45 (0.23)	0.40-0.78 (0.61)	22.00-38.08 (29.62)	11.52-43.60 (27.15)	20.32-66.16 (43.22)	6.56-24.22 (13.54)
Marh	6.04-8.67 (7.35)	0.11-0.38 (0.22)	0.32-0.76 (0.56)	20.00-56.70 (37.30)	14.00-43.60 (29.61)	20.32-51.68 (32.68)	3.67-23.45 (12.21)
Jammu	7.72-8.30 (7.94)	0.14-0.28 (0.21)	0.54-0.63 (0.59)	30.16-45.10 (37.49)	24.00-31.90 (28.71)	30.90-39.60 (33.80)	7.81-16.34 (12.91)
Satwari	6.94-7.39 (7.11)	0.11-0.32 (0.18)	0.45-0.61 (0.54)	30.40-45.10 (36.82)	24.00-39.60 (33.28)	26.32-31.80 (29.89)	5.54-19.14 (11.73)
Khour	5.91-7.77 (6.96)	0.11-0.41 (0.24)	0.31-0.72 (0.52)	22.32-46.20 (34.30)	11.52-38.40 (27.25)	27.70-66.16 (37.50)	3.45-24.58 (13.92)
Bishnah	6.60-9.94 (7.59)	0.16-0.37 (0.24)	0.31-0.66 (0.50)	23.20-56.30 (38.89)	14.00-38.40 (27.60)	27.70-48.80 (32.85)	4.57-21.14 (11.06)
Overall Mean	7.33	0.23	0.56	35.04	28.47	36.06	12.76

*Figure in parenthesis indicates mean value

Table 2. Status of DTPA-extractable cationic micronutrients of tested soil samples of district Jammu

Block	Zn	Cu	Fe	Mn
		mg Kg^{-1}		
R. S. Pura	0.14-0.80(0.31)	0.19-1.32(0.68)	13.41-34.46(22.93)	1.45-8.93(4.47)
Marh	0.04-1.18(0.29)	0.21-1.96(0.92)	6.66-40.76(25.79)	1.75-10.22(4.71)
Jammu	0.15-0.30(0.22)	0.26-0.75(0.44)	16.11-20.38(18.93)	1.14-1.96(1.42)
Satwari	0.25-0.76(0.38)	0.52-0.86(0.65)	15.97-29.63(21.59)	1.87-5.76(3.91)
Khour	0.02-0.25(0.06)	0.11-3.67(1.18)	2.86-40.23(18.08)	1.30-10.30(4.14)
Bishnah	0.05-0.54(0.34)	0.05-0.75(0.31)	2.40-29.64(12.12)	2.23-11.13(4.33)
Overall Mean	0.02-1.18 (0.25)	0.05-1.96 (0.82)	2.40-40.76 (21.30)	1.14-11.13 (4.34)

*Figure in parenthesis indicates mean value

Table 3. Correlation coefficients of DTPA-extractable cationic micronutrients with soil properties Basmati rice growing soils

	Zn	Cu	Fe	Mn
pH	0.197*	-0.288**	-0.273**	-0.089
EC (ds/m)	0.008	0.064	0.153	0.148
OC (%)	0.147	-0.076	0.257**	0.044
CEC [cmol (p+)kg^{-1}]	-0.002	0.007	0.126	0.206*
Sand (%)	0.223*	0.082	-0.052	-0.172
Silt (%)	0.112	-0.004	-0.102	0.158
Clay (%)	0.079	-0.056	0.100	0.010

*Significant at 5%level; **Significant at 1% level

(Lindsay and Norvell 1978), 92 percent soil samples were deficient and 8 percent samples sufficient in available Zn in these soils.

DTPA- Cu: The DTPA- Cu ranged from 0.05 to 3.67 mg kg^{-1} with a mean value of 0.82 mg kg^{-1} , respectively. Copper and soil pH was negatively and significantly correlated with r value of -0.288** indicating that a decline in pH of the soil leads to significant increase in copper availability. These results are in concomitant with that of Jalali *et al.* (1989). Copper was also positively and significantly correlated with sand (r = 0.256^{*}). Correlation study indicated a negative relationship with EC, organic carbon, CEC, silt and clay. Similar finding were also reported by Nazil *et al.* (2006). Considering 0.20 mg kg^{-1} as critical limit (Lindsay and Norvell 1978), the studied soils samples were 8 percent deficient and 92 percent sufficient in DTPA-Cu all soil association of Jammu district.

DTPA-Mn: Available manganese content of the soils varied from 1.14 to 11.13 mg kg^{-1} with mean value of 4.34 mg kg^{-1} . This higher value might be due to better supply of manganese to basmati rice soils because Mn is soluble under relatively acidic and reducing conditions. Higher organic carbon may further increase the DTPA extractable Mn content in soil. Besides, (Kirmani *et al.* 2011) also subscribed similar type of results. Manganese had negative correlation with soil pH, EC, organic carbon, sand, silt and clay. The result was positive non-significant. The positive correlation between Mn and CEC of the soils 0.206* might be due to the fact that with increasing clay, organic carbon and CEC, more number of exchange sites would be available for retention of Mn and subsequently more release of Mn into the soil solution from exchange sites (Sharma and Choudhary 2007). Considering 2.0 mg kg^{-1} as a critical limit for Mn deficiency (Lindsay and Norvell 1978), 92 percent of the soils has sufficient amount of available Mn to sustain basmati crop.

DTPA-Fe: Available DTPA-Fe content of the soils under basmati growing areas varied from 2.40 to 40.76 mg kg^{-1} with a mean value of 21.30 mg kg^{1}. These results are in conformity with that of (Kirmani *et al.* 2011). DTPA-Fe bears negative and significant relationship with pH (r = -0.273**). It can be observed that Fe like the other micronutrients i.e, Cu and Mn decreases with the increase in soil pH. These results were supported by earlier workers. DTPA-Fe was positively and significantly correlated with organic carbon content of soil. These might be due to formation of organic chelating agents which could have transformed in soluble phase of Fe into soluble metallic complexes, Patiram *et al.* (2000). The result was positive non significant as have been observed by Sharma *et al.* (1996). Considering critical limits of 4.5 mg kg^{-1} , (Lindsay and Norvell 1978), soil samples were 12 percent deficient and 88 percent samples sufficient in available Fe in these basmati growing soils. Therefore there is urgent need of proper management of available Zn in these basmati growing soils of Jammu for quality and yield.

REFERENCES

Jackson, M. L. 1973. *Soil chemical analysis: Advanced course*. Madison, Wisconsin, USA.

Jalali, V.K. Talib, A. R. and Takkar, P. N. 1989. Distribution of micronutrients in some benchmark soils of Kashmir at different altitudes. *Journal of the Indian Society of Soil Science*. 37: 465-469.

Kirmani, N.A., Sofi, J.A. Bhat, M.A., Bangroo, S.A. and Bhat, S.A. 2011. Soil Micronutrient Status of District Budgam. *Research Journal of Agricultural Sciences*. 2: 30-32.

Lindsay, W. L. and Norvell, W. A. 1978. Development of DTPA soil test for zinc, iron, manganese, and copper. *Soil Science Society*. *America*. *Journal*. 42: 421–428.

Nazif Wajahat, Perveen Sajida and Saleem Ifikhar 2006. Status of micronutrients in soils of district Bhimber (Azad Jammu and Kashmir). *Journal of Agricultural and Biological Science*. 8: 35-40.

Patiram, R., Upadhyaya, C., Singh C. S., Munna R. and Ram, M. 2000. Micronutrient cation status of mandarin (Citrus reticulate Blanco) orchards of Sikkim. *Journal of the Indian Society of Soil Science*, 48: 246-249.

Sharma, B. D., Sidhu, P.S., Singh, G., Mukhopadhyay, S. S. and Singh, G. 1996. Elemental distribution and mineralogy of arid zone soils of Punjab. *Journal of the Indian Society of Soil Science*, 55: 40-44.

Sharma, R. P., Singh, M. and Sharma, J. P. 2003. Correlation studies on micronutrients *vis-à-vis* soil properties in some soils of Nagpur district in semi-arid region of Rajasthan. *Journal of the Indian Society of Soil Science*, 51: 522-527.

Sharma, J. C., and Chaudhary, S. K. 2007. Vertical distribution of micronutrient cations in relation to soil characteristics in lower Shiwaliks of Solan district in North-West Himalayas. *Journal of the Indian Society of Soil Science*, 44(4): 746-752.

Takkar, P.N. and Mann, M. S. 1975. Evaluation of analytical methods of estimation of available Zinc and response of applied zinc in major soil series of Ludhiana, Punjab. *Agrochmica* 19, 420-430.

Venkatesh, M. S., Majumdar, B; Kumar, K. and Patiram 2003. Status of micronutrient cations under various land use systems of Meghalaya. *Journal of the Indian Society of Soil Science*. 51: 60-64.

Yadav, R. L. and Meena, M. C. 2009. Available micronutrients status and their relationship with soil properties of Degana soil series of Rajasthan. *Journal of the Indian Society of Soil Science*. 57: 90-92.

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Agricultural information preservation and dissemination in the e-Environment

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ABSTRACT

E-agriculture is an emerging field focusing on the enhancement of agricultural and rural development through improved information and communication processes. More specifically, e-agriculture involves the conceptualization, design, development, evaluation and application of innovative ways to use these information and communication technologies (ICT) in the rural domain, with a primary focus on agriculture. The Internet is increasing communication and business opportunities within the agricultural community, which previously operated in the relative isolation of rural areas. Farmers, agricultural researchers, cooperatives, suppliers and buyers use the Internet to exchange ideas and information. The work of preservation and documentation of agricultural knowledge were started during Veda period and after the establishments of Indian Council of Agricultural Research, the activity of bringing out Agricultural Information Products are still continue in a organize way by the ICAR and its institutes. The present paper describes the type of print publications, e-product, and web based information retrieval systems developed by the Indian Council of Agricultural Research.

Key words: E-agriculture, ICT, e-product, e-media, Web-mail

INTRODUCTION

Agriculture in India has a significant history. Over 2500 years ago, Indian farmers had discovered and begun farming many spices and sugarcane. Today, India ranks second in world in the farm output. Presently, Agriculture in India employs 53 percent of the total workforce, making it a vital element of inclusive growth of the Indian economy. The work of writing and preserving agricultural knowledge was started in the ancient time and in VEDA, the Aryans, gave a lot of importance to Agriculture. The Vaidic advice is - "Get rid of gambling, and learn the Art of Farming. "Akshairya Divyaha Krushimit Krushaswaha". *(RIGV. 10/347)*. The importance of Indra, the rain god and the large number of prayers addressed to him in the *Rig Veda* proves beyond doubt that the Vedic Aryans were agriculturists'. Krishi-Parashara, an Early Sanskrit Text on Agriculture was associated with the Vedas, Mahabharata, and Artha-sastra, traces back the evolution of the agricultural science through the literary records to the time of Kautilya (c. 400 BC), whose work, the Arthasastra, also imparts prominence to agriculture.

However, agricultural research in India made humble beginning in 1929 when on the recommendation of Royal Commission on Agriculture, the Imperial Council of Agricultural Research was established, which was renamed Indian Council of Agricultural Research in 1947. One of the basic objectives of the ICAR is to act as a clearing-house of information relating to agriculture and allied sciences. The total activity related to Information Management and Communication was very old. Most of what we see today in the field of Information Management and Communication Management and Communication was achieved only after independence.

The Directorate of Knowledge management of Agriculture (DKMA), erstwhile P&I Division, assigned the responsibility to fulfill the objective of the Council. In 1931 the Council started two journals namely 'Livestock in India' and 'Agricultural Journal of India'. Presently, this Directorate is a biggest publisher of agricultural research literature in the country. On an average, it publishes one publication every second day.

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Print and electronic media hold the key in the socio-economic development of the nation. To a large extent, communication in the agriculture, business and private spheres takes place via print and electronic media. Newspapers, magazines, books, and catalogs, in particular, hold the most important share of the market, and advertising packaging, and commercial printed matters make outstanding use of print media. Print media in agriculture sector is usually produced in medium to long print runs by Govt. and private sector. Production technologies enable high quality and economic production. Although the information content of print media (text, images, and graphics) is fixed/static and cannot be quickly changed interactively, new production technologies increasingly enable content to be personalized and prepared according to customers' specifications. This means that the demands of different target groups (the customers and users) can be met to a large extent. Print media's particular strength (when compared to electronic media) is that it is easy to use in many locations and almost every environment – without recourse to any special equipment. Electronic storage and transmission media allow for the integration of audio and video, that is, speech, music, and animations, into the information document (e.g., on CD-ROM) along with text, graphics, and image information (data types). This gives the user many ways of interacting with the information.

During the past decades, the e-product has grown rapidly. Large number of monographs and new publications appear every year. In the era of information explosion, Information and Communication Technology (ICT) is progressively replacing the old methods of information collection, storage and retrieval.

Journey of print to web publishing

Print media

Topical surveys on the significance and use of print media prove that the need for printed publication is growing worldwide. This is indicated by the fact that at the end of the millennium Time Magazine acknowledged the socio-cultural significance of the invention and utilization of book printing and elected Johannes Gutenberg's work as the most crucial event of the millennium. It is true that the age of electronic media has started; however printed information is and remains omnipresent. Usually, printed products are categorized into commercial printing and periodicals. This classification differentiates printed matter with regard to its frequency of publication. Since the production process also depends largely on these basic conditions, printshops usually specialize in one or the other market segment. Commercial printing referes to print products that are produced occasionally (e.g. catalogs, brochure, leaflets, business cards, etc.) Periodicals are printed matter that appears periodically (e.g., newspapers, journals, magazines). Publishing houses and companies are the typical clients for periodicals printing. There are number of agricultural based journals, magazines, periodicals, bulletins, newspapers are being published in India in a dispersed manner by the government and many private publishers and agencies. These are being published in an unorganized manner without considering the demand of the clients which are going to be benefitted from the information published. Another way of categorizing printed products is by splitting them into special product groups. These individual groups are:

Books

Gutenberg's work and his invention, printing with movable lead type, in the middle of the fifteenth century triggered a revolution in book production. A much greater proportion of the population had the chance to acquire education, culture, and information than had ever been possible with hand-written books. Consequently, illiteracy decreased in the following centuries.

Magazines

The range of magazines consists mainly of periodicals, including trade magazines, journals, and illustrated magazines. Trade magazines cover a limited field, thus attracting a limited specialist readership. Unlike books, production costs for magazines are not paid for exclusively by the final consumer. Often more than half of the costs are financed by advertising. Magazines are usually published by publishing houses just like books. Unlike books, magazines usually have a shorter lifespan.

Newspapers

The newspaper is still one of the most significant mass media today. The first newspapers appeared at the start of the seventeenth century. Pamphlets in the sixteenth century were the precursor of the newspaper. Most newspapers are produced daily and have a high circulation. Some daily papers even appear a few times per day, to ensure that their content is very up-to-date. The two most important categories of newspapers are daily papers (dailies) and weekly papers.

Electronic media

Electronic media was developed in the twentieth century and together with print media became important for communicating information in every spheres of life. This trend continues today and is characterized particularly by the use of computers and the Internet. In addition to the latest developments in the Internet and World Wide Web, electronic media also include the more conventional radio and television along with the corresponding forms of storage such as video and audio recordings on CD-ROM and DVD-ROM as well as animations. Electronic media, as is the case with print media, also involve a chain of creation and transmission which depends on the specific form of the media. In some cases, information is converted from one medium to another, such as from conventional film to video. In the case of web pages though, content can also be computer-generated, thus allowing for the use of content from both the real and the virtual worlds. Animations may describe scenes and "tracking shots"; in the end, running an animation results in a chronological sequence of pixel images, that is, almost a video flow.

Print scenario at ICAR

The Directorate of Knowledge Management in Agriculture (DKMA) is the window of the agricultural research in India through which the research and other activities are presented and shown to the world. It brings out a variety of publications in English and Hindi for the use of scientists, researchers, students, policy planners, extension personnel, farmers and the general public. Research journals, popular magazines, scientific monographs, technical and popular books, handbooks, low-priced books, bulletins, reports, proceedings of conferences and a variety of miscellaneous titles are brought out regularly, along with certain special publications from time to time.

Book programme

ICAR brings out regularly a number of books of topical interest for students/ farmers/ extension officers/ research workers. These include monographs, technical books, technical bulletins, low priced publications etc.

Electronic publishing

Considering the growth of information technology and multi-fold options put forward by the e-publications, ICAR publication programme underwent a sea change. The publications programme was restructured during 2000 to reap the rich benefits and enormous advantages offered by the electronic products. May e-publications were brought out and planning to bring art series of e-publication.

E-Publishing and Knowledge System in Agricultural Research: A project on E-Publishing and Knowledge System in Agricultural Research has been launched in 2009 by NAIP, under Directorate of Knowledge management in Agriculture (DKMA). The aim of this project is to develop fully automated on-line publishing system. The ICAR research journals (*The Indian Journal of Agricultural Sciences* and *The Indian Journal of Animal Sciences*) are available in open-access mode and have been downloaded from a knowledge portal developed and hosted by the Directorate of Knowledge Management in Agriculture (DKMA) of the Council.

e-Granth : Strengthening of Digital Library & Information Management under NARS: *e-Granth* was initiated by the council under NAIP project and designed with 'Open Access' as one of its objectives. The consortium, sponsored by NAIP (ICAR), has 12 partner institutions. The local catalogues of 12 partner libraries would be converted into union catalogue which would eventually be uploaded to *WorldCat*. Simultaneously, the library resources (old journals and rare books) of these institutions are digitized and hosted on Eprints based digital repository at Indian Agricultural Research Institute, New Delhi.

Krishiprabha: KrishiPrabha is a full-text electronic database of Indian Agricultural Doctoral Dissertations submitted by research scholars to the 45 State/Deemed Agricultural Universities. This Repository contain full text of about 1000 Ph.D thesis and M.Sc. dissertation created by Nehru Library, Ch. Charan Singh Haryana Agricultural University, Hissar with financial support from Indian Council of Agricultural Research (ICAR)

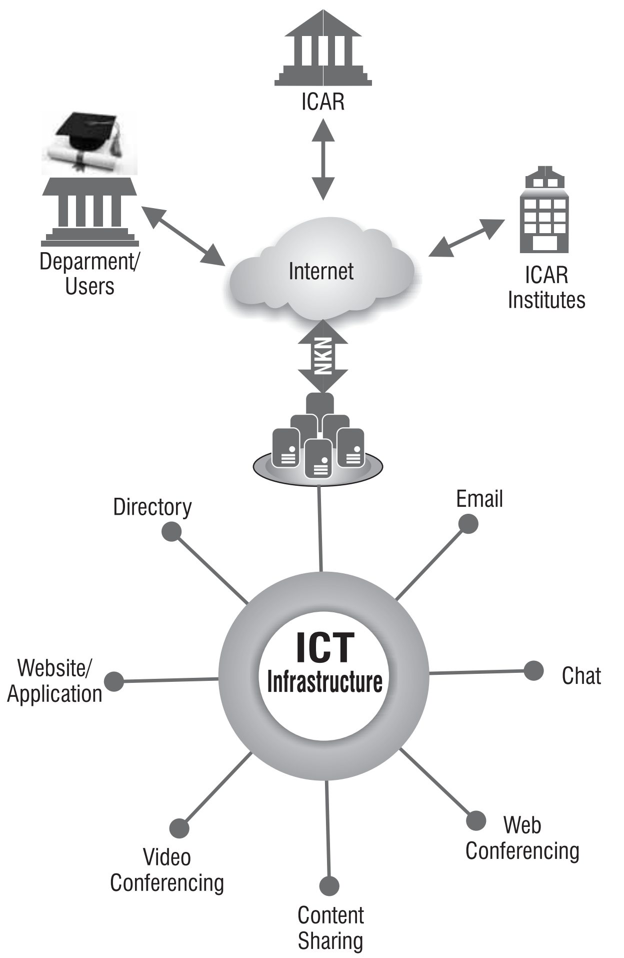
Consortium for e-resources in Agriculture: With the advent of internet facilities and advancement of web technology, almost all reputed international journals are available on-line and can easily be accessed by researchers over the network. Since ICAR is having network connectivity across the institutes and state agricultural universities, select journals could be made available over the network for the use of scientific community. Keeping this broad objective in mind, the National Agricultural Innovation Project (NAIP) has started Consortium for e-Resources in Agriculture (CeRA) in 2008 at the

Indian Agricultural Research Institute (IARI). The access of the CeRA is given to the 126 Institutes through I.P. address. Initially this consortium is entered into agreement for three years under centralized funding and subscription of the NAIP (National Agricultural Innovative Project) by maintaining print subscription of individual libraries which are members of this consortium. The consortium covers the journals of Springer verlag, Annual Reviews, CSIRO Australia and J-gate publishers on Agriculture, Veterinary Sciences, Fisheries, Crop Sciences, Socio-economic, Computer Sciences, Soil Sciences, Animal Sciences etc.

Open access journals: The Council of Scientific and Industrial Research (CSIR), the International Crops Research Institute for Semi-Arid Tropics (ICRISAT) and Consultative Group on International Agricultural Research (CGIAR) have adopted open access policy for their publications. The Eprints@IARI, <http://eprints.iari.res.in> an OAR has been established by IARI to secure agricultural research benefits for all and also to showcase the institute's research output to the world. ICAR has made available their two research journal and some professional society journals on open access. Globally, 229 'Open Access' journals (registered with Directory of Open Access Journals (DOAJ)) are available in the field of Agricultural (79) and related sciences such as Animal Sciences (60); Aquaculture and Fisheries (11); Forestry (24); Nutrition and Food Sciences (20); and Plant Sciences (35). However, agricultural and related science journals published from India are more than thousand. NAAS has prepared the list of agricultural and allied science journal with its impact factor which can be useful for selecting the good rating journal for their library.

Agropedia: It is a state-of-the-art, one stop shop for all knowledge, pedagogic or practical, related to Indian agriculture. It has a variety of content holders like a library (where the content is verified for its correctness), an open wiki, a blog, a forum; all of them semantically tagged using knowledge models. Knowledge models capture semantic relationships that exist between various terms in a domain and are useful search and inference. Agropedia has developed 11 knowledge models and uses them for tagging and searching the repository objects. These knowledge models are universal in the sense they are not restricted to India and can be extended and adopted to any agro-climatic zone. The agropedia website with over 1100 digital documents is being accessed by more than 600 users every day from more than 140 countries.

ICT Infrastructure and Unified Messaging & Web Hosting Solution: ICT Infrastructure and Unified Messaging & Web Hosting Solution has been established by Indian Council of Agriculture Research (ICAR) at Indian Agricultural Statistics Research Institute (IASRI), New Delhi for ICAR Institutes and their regional stations. This solution is one of the components under the project entitled "Implementation of Management Information System (MIS) including Financial Management System (FMS) in ICAR" funded by NAIP. This solution will facilitate ICAR to deliver the unified communication and web hosting services to its stakeholders. It is envisioned to provide services for hosting websites and applications relating to education, research and e-governance of the institutes.



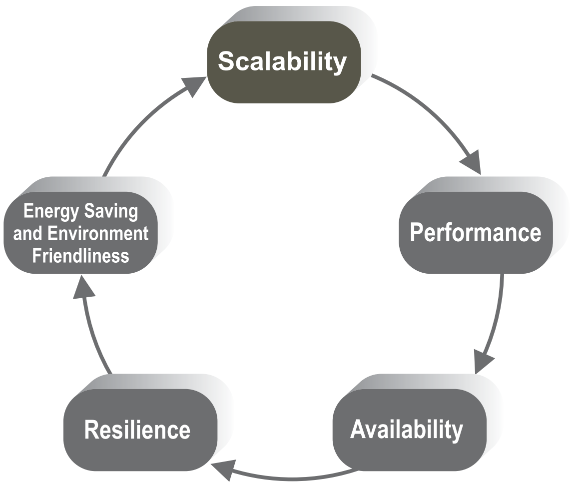
The unified communication system will help to connect the ICAR personnel via instant messaging, e-mail, audio/video, chat rooms, on-line meeting and presentation.

Services offered ICT Infrastructure and Unified Messaging & Web Hosting Solution:

- Unified Communication
  - Messaging (Webmail and POP)
  - Phonebook
  - Calendar
  - Schedule meetings
  - Chat
  - Presence
  - Web Conferencing
  - Video Conferencing
  - Content Sharing
- Virtual Machine & Data Storage
- Web Hosting
- Bring Your Own Device (BYOD) optimized interface for tablets and smart phones as well as desktop and laptop computers

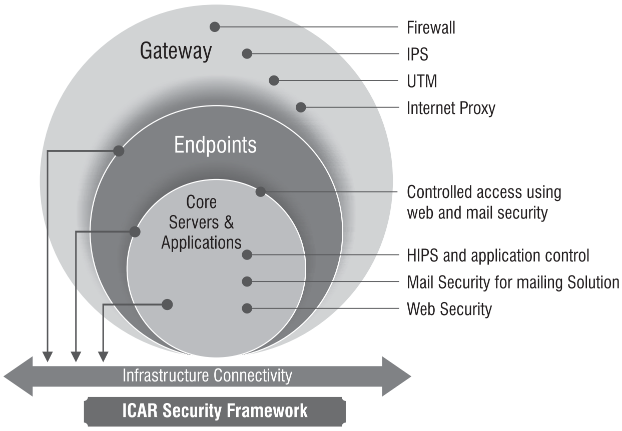
This service has features like;

- Scalability
- 24 X 7 Availability
- Interoperability
- Security
- Manageability
- Integration
- Reliability
- Adherence to ISO 27001, ITIL, TIA 942 standards



The system has the benefits like;

- Uniform Email ID of ICAR & its institutes/ departments under single ICAR domain.
- Effective Communication at desktop.
- Implementation of standardized IT policy and deployment of website/application.
- Secure and reliable IT services and infrastructure on demand.
- Aggregation of IT infrastructure (Hardware, Storage, Networking and Software) and Mgmt. Resources.
- Centralized management of IT infrastructure
- Dynamic Scalability
- Improved Data Quality
- Lower Risk of Data Loss.
- Service Level Agreements



Integration of new media

Beside the classical areas of activity – the production of print media – other services are becoming more important. Hence the design of print media, the creation of multimedia products (CD-ROMs, Internet sites, print media in combination with electronic media, etc.), consulting services, and individual training are being requested more and more by the printing and publishing industry. The increasing power of electronic media (especially CD-ROM, Internet) will increase competitive pressure on the print media and partially replace print products while at the same time creating new print jobs. Despite strong growth in electronic media, the market for print media remains large and attractive since a high proportion of the ever-growing advertising expenditure flows into print media, and the demand for print and electronic media especially worldwide is increasing. As the Internet continues to grow, the sale of goods and services via data networks is increasingly regarded as a new method of generating sales by many businesses. The customer is able to choose from an almost unlimited range of goods 24 hours a day. All that is needed is a PC, which the customer uses to connect via modem to the net. There are large global differences as far as online connections but also use of the Internet is concerned. At the turn of the millennium Internet users are creating great problems for advertising agencies. In about 80% of cases they are male, around thirty years old, educated, and have a passion for computers. Sixty percent of all users visit fewer than ten web sites per month. Hence it is impossible for advertising agencies to reach a particularly differentiated target group, in contrast to the possibility of targeted advertising messages in individual print media. Whether and at what rate the Internet is exploited depends to a considerable extent on the acceptance of the new technologies by a broad population base.

Some areas have been identified for dissemination and popularization of technologies/ process/success stories among various stakeholders through appropriate media mix:

- Releasing news/features/sponsored features and advertisements for print media which includes Newspapers and Magazines in English, Hindi and vernacular languages.
- Dissemination of video and audio clips to electronic media which includes television and radio channels and streaming of audio-visual content on websites.
- Sharing and dissemination of Information through social networking tools such as Facebook, Twitter, YouTube and other online platforms.
- Developing effective contents for website.
- Organization of media visits across India for sharing of agricultural knowledge.
- Bringing publications on Agricultural Technologies, Success Stories, Innovations and their impact for wider circulation among various stakeholders.

CONCLUSION

The Information and Communication Technology (ICT) is playing a key role in agricultural growth and development in the country by providing timely and useful information in a demand-driven mode. As a commitment to deliver cost-effective and production-oriented technologies for the welfare of farming community, the ICAR has adopted ICT based information dissemination system. Apart from increasing trends in e-publishing in agricultural sector in the country, it has been noticed that number of print publication has also been increased. The Indian Council of Agricultural Research is leading the country in the area of agricultural research, education and extension through its wide network of 99 Research Institutes and 637 Krishi Vigyan Kendra. In addition, ICAR supports 59 Agricultural Universities (SAUs) in their region specific research and academic pursuits. The e-connectivity of ICAR institutes Libraries has been strengthened to cater the ICT services and provide connectivity to various stakeholders. The research journals have been made available in open -access mode for the benefit of students, researchers, farmers and various stakeholders belonging to national and global communities. During the 1995-2012, digitization activities have grown rapidly in agriculture sector over the years. In the era of information explosion, Information and Communication Technology is progressively replacing the old methods of information collection, storage and retrieval. The agricultural websites and databases developed by different agricultural institutions, associations, agencies, and publishers provide the latest information.

In order to strengthen the agricultural knowledge, there is a need to work in the area of:

- Information clearing house (ICH) for the benefit of Scientists on emerging trends in integrated management including ecology, adaption and mitigation approaches etc.
- Bring out compendium and interactive facility in Indian successes, desk based intensive research and documentation through field based reality checks.

REFERENCES

Bharti, V.K. and Hans Raj 2009. Technologies for agricultural information management in "Bio-industrial Watershed Development", SCSI, New Delhi, pp. 312-324.

Hans Raj and Mitali Gosh Roy 2006. Scientific Publishing and Open Access in Agricultural Sciences in India; paper presented at 1st AGRIS Conference on Open Access in India, ICRISAT, Patancheru, Hyderabad (A.P.), 06-07 November, 2006.

Trivedi, T. P, Saxena, J. and Hans Raj 2010. Shaping and delivery mechanism of information in agriculture in proceeding of International Conference on Agriculture Education and Knowledge management held at Agartala from 24-26 Aug 2010.

Yaduraju, N.T. (2009). NAIP e-Agriculture Initiatives. Information for Development, 2009. (www.i4donline.net).

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