IJTA
© Serials Publications
National Academy of Agricultural Science (NAAS) Rating : 3. 03

Effect of Tillage and Nutrient Management on Soil Properties, Growth and Seed Cotton Yield

N.S. Wagh[1], *R.N. Katkar*[2] *and V.K. Kharche*[3]

Abstract: *The field experiment was conducted to study the "Effect of Integrated Nutrient Management on Soil Quality and Cotton Productivity under Different Tillage Practices in Vertisol" at the Research farm, Department of Soil Science and Agricultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The treatments thus involved two main treatments and eight sub treatments. The experiment main plot comprises of two treatments i.e. conservation tillage (CNS) and (CNV). Bulk density was slightly reduced in conservation (1.34 Mg m^{-3}) as compared to conventional tillage (1.35 Mg m^{-3}). MWD was found to slightly improve under conservation (0.67 mm) than conventional tillage (0.66 mm).The hydraulic conductivity showed slight improvement under treatments of INM comprising use of FYM, wheat straw and green leaf manuring in combination with 50% RDF as compared to the only chemical fertilizers under conservation tillage. Hydraulic conductivity registered highest (0.73 cm h^{-1}) in 50% RDF + 50% N (FYM) while lowest (0.67 cm h^{-1}) in 100% RDF (60:30:30 NPK kg ha^{-1}). The mean available soil moisture content was found to enhanced significantly due to integrated use of FYM, wheat straw and glyricidia green leaf manure as compared to only chemical fertilizers. Slight decrease in pH and electrical conductivity of soil was registered under FYM and fertilizers, while no specific trend was observed due to various treatments.The higher organic carbon was found (5.76 g kg^{-1}) under conservation tillage as compared to conventional tillage (5.71 g kg^{-1}). Organic carbon ranged from (5.89 g kg^{-1}) in 50% RDF + 50% N (FYM) and lowest (5.55 g kg^{-1}) in 100% RDF (60:30:30 NPK kg ha^{-1}).The significantly highest available soil N was recorded in the treatment of integration with FYM wheat straw and GLM in combination with 50% RDF through chemical fertilizers. Under conservation tillage highest available nitrogen was recorded (226.7 kg ha^{-1}) in comparison with conventional tillage (216.5 kg ha^{-1}) while it was recorded highest in 223.2 kg ha^{-1} in 50% RDF + 50% N (FYM) and lowest (219.5 kg ha^{-1}) in 100% RDF (60:30:30 NPK kg ha^{-1}).The highest available soil phosphorus was recorded in conservation tillage (17.10 kg ha^{-1}) as compared to conventional tillage (15.17 kg ha^{-1}) whereas under nutrient management significantly highest and lowest in 50% RDF + 50% N (FYM) (17.67 kg ha^{-1}) and lowest in 100% RDF (60:30:30 NPK kg ha^{-1}) (14.03 kg ha^{-1}). The significantly highest available potassium was noticed in conservation tillage (411 kg ha^{-1}) than in conventional tillage (406 kg ha^{-1}) while in 50% RDF + 50% N (FYM) (419.2 kg ha^{-1}) followed by (390.4 kg ha^{-1}) in 100% RDF (60:30:30 NPK kg ha^{-1}).The seed cotton yield was slightly higher under conservation tillage as compared to conventional tillage Highest seed cotton yield was recorded in the treatment receiving 100% RDF (60:30:30 NPK kg ha^{-1}(15.57 q ha^{-1}) followed by 50% RDF + 50% N (FYM) (14.84 q ha^{-1}).*

Keywords: *Tillage, nutrient management, soil properties and yield.*

INTRODUCTION

Cotton is one of the important cash as well as fibre crop and play vital role in the history and civilization of mankind, with enormous potential in textile industries and is a means of livelihood for millions of farmers and those concerned with its trade, processing, manufacturing and other allied industries. No agricultural commodity in the world exercised a profound influence on economy as cotton had done from the time immemorial.

[1] Ph.D Student, Dept. SSAC, Dr. PDKV Akola.
[2] Assoc. Professor, Dept. SSAC, Dr. PDKV Akola and Officer In-charge AICRPO Micronutrients.
[3] Head, Dept SSAC and Assoc. Dean PGI Dr. PDKV Akola.

Therefore, it is popularly known as white gold. Cotton seed contains about 15-20 per cent oil and is used as vegetable oil and soap industries. After extraction of oil, the left over cake is proteinous and used as cattle feed. It is the king among the fibre crops, taking into consideration the economic impact it generates. Besides its vital role in national economy, its contribution in the foreign exchange is tremendous. Nearly one third of India's export earnings are from textile sectors of which cotton alone constitutes nearly 70 per cent of raw material. Cotton contributes 29.8 per cent of the Indian agricultural gross domestic product (Barwale *et. al.*, 2004). Still there exits large potential for export of raw cotton and value added products.

India ranks first in the world having an area of 11,619 lack ha with the cotton production of 36,610 lack bales. Maharashtra is one of the leading cotton growing state in India having 38.72 lakh ha area under cotton cultivation which is one third of country's area of cotton cultivation with the production of 81.00 lakh bales. The productivity of cotton in Maharashtra is 365 kg lint per ha (Anonymous, 2013). Within Maharashtra state, Vidarbha is the largest cotton growing region of Maharashtra accounting for 12.37 lakh ha with production of 35 lakh bales.In Vidarbha, cotton is grown predominantly as a rainfed crop. In Vidarbha region about 89 per cent cultivable land is under rainfed farming and rainfed cotton crop production has direct bearing on the agrarian economy of the region.

Vertisols are an important soil order in semi-arid dryland agriculture because in this environment they are amongst the most productive soils. The major factor contributing to the productivity of Vertisols in semi-arid environments is their high-water holding capacity. However, low organic matter has been always the constraint in these soils.

The systematic study of soil physical, chemical and biological properties of soil under different tillage practices and integrated nutrient management system is necessary to create an evidence for evaluating the impact of these management measures on soil quality. For enhancement in soil quality and restoration of soil organic carbon is of paramount importance and therefore it becomes necessary to identify the management practices causing preservation of organic carbon in soil. The maintenance of soil organic carbon in agricultural soils is primarily governed by climate, particularly precipitation and temperature and cropping systems. Although the amount of SOC in soils of India is relatively low, ranging from 0.1 to 1 per cent and typically less than 0.5 per cent, its influence on soil fertility and physical condition is of great significance. Intensive cropping and tillage systems have led to substantial decreases in the SOC through enhanced microbial decomposition and through wind and water erosion of inadequately protected soils which is often accompanied by a decline in soil productivity. Carbon loss by tillage is caused by greater oxidation of SOC and it ranges from 20 to 50 per cent in soil dominating the semi-arid regions of India.

Conservation tillage is generic term encompassing many different soil management practices. It is generally defined as "any tillage system that reduces loss of soil or water relative to conventional tillage", mostly a form of non inversion tillage, allows protective amount of residue mulch on the surface. Conservation tillage allows crop residues as surface mulch, is effective in conserving soil and water and maintains good soil structure, organic matter contents and maintains desirably high and economic level of productivity (Lal, 1989). Conservation tillage can rebuild organic carbon levels in soil and increases the carbon sequestration in soil (Novak *et. al.*, 2009).

Cotton is the major crop grown in the Vertisols of central India occupying about 5.0-106 ha. Poor soil fertility is a major cause of the low crop productivity. High risk associated with this rainfed agriculture is the major cause for the non-investment in fertilizer and or/manure. Importance of fertilizer N on the growth and yield of cotton is well known (Prasad and Prasad, 1998). Potassium is considered abundant in the cotton growing Vertisols (Pasricha and Bansal, 2002) and most often is not included in the fertilizer recommendations (Tandon, 1993). Response to P has also not been consistent (Kairon *et. al.*, 2002). The cotton-growing farmers, therefore, generally apply only nitrogenous fertilizers. However, application of K (Shanmugham and Bhatt, 1991) has been observed to improve fibre quality. On the contrary, Jambunathan *et. al.* (1986)

observed no significant influence of fertilizers on fibre quality whereas Singh *et. al.* (1989) reported fibre quality tended to deteriorate when the crop was over fertilized with N. Information on the effects of fertilizer and manure on fibre quality of cotton grown under rainfed conditions is generally limited of late integrated nutrient management involving organic manure and chemical fertilizer has received considerable attention (Swarup *et. al.*, 1998).

Integrated plant nutrient management is an intelligent use of optimum combination of organic, inorganic and biological nutrient sources so as to achieve and sustain optimum crop yield and improve soil physical, chemical and biological properties. Adoption of integrated plant nutrient supply and management strategies for enhancing soil quality, input use efficiency and crop productivity is extremely important for food and nutritional security in Indian agriculture.

MATERIAL AND METHODS

The field experiment was carried out to study the "Effect of integrated nutrient management on soil quality and cotton productivity under different tillage practices in Vertisol" on the Research Farm of Department of Soil Science and Agricultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. Akola is situated in between 22° 41′N latitude and 77° 02′ longitudes at an altitude of 307.4 m above mean sea level and has a subtropical climate. The climate is characterized by three distinct seasons*viz.,* summer becoming hot and dry from March to May. Monsoon characterized as warm and rainy from June to October and winter with dry mild cold from November to February. Most of the rainfall is received from South West monsoon. The soil of experimental site was Vertisol belonging to fine, smectitic, hyperthermic, Typic Haplusterts. It was calcareous in nature and moderately alkaline in reaction. The fertility status of the soil indicates that the soil was moderate in organic carbon, available nitrogen and phosphorus and very high in available potassium. The two seperate experiment each in conservation and conventional tillage were conducted on same site and hencer and omization with similar set of nutrient management treatments.In conservation tillage one harrowing and two weeding operations were carried every year. In conventional tillage one ploughing, one harrowing, two hoeing and two hand weeding operations were carried out every year.

Nutrient Management Treatments

T_1 : 100% RDF (60:30:30 NPK kg ha^{-1})

T_2 : 50% RDF + In situ green manuring (sunhemp)

T_3 : 50% RDF + 50% N (FYM)

T_4 : 50% RDF + 50% N (wheatstraw)

T_5 : 50% RDF + 50% N (GLM)

T_6 : 50% RDF + 25% N (FYM) + 25%N (wheat straw)

T_7 : 50% RDF + 25% N (FYM) + 25%N (GLM)

T_8 : 50% RDF + 25% N (wheat straw) + 25%N (GLM)

Different treatments consists balance use of chemical fertilizer along with organic source of nutrient in which 50 per cent N applied through chemical fertilizer and remaining N was applied through various sources like FYM, crop residues (wheat straw) and green manuring (sunhemp). The quantity of P and K supplied through different organics, green manuring and crop residues, the compensation remaining P and K compensated through chemical fertilizers.

RESULTS AND DISCUSSION

Effect of Tillage

The lower values of bulk density (1.34 Mg m^{-3}) were noticed in conservation tillage as compared to conventional tillage (1.35 Mg m^{-3}). Lal (1989) reported that tillage system did not have a significant effect on bulk density. Bauer and Black (1981) reported little differences in soil structural characteristics among tillage systems in arid and semi arid regions due to low precipitation and high temperature while Bruce *et. al.* (1990) reported that the bulk density of Vertisol reduced significantly in conventional tillage than in minimum tillage and conservation tillage. Acharya and Sharma (1994) reported that no tillage showed a significant decrease in the bulk density as compared to conventional tillage system. Similar results were

Table 1
Effect of tillage and nutrient management on soil physical properties

Treatments	*Bulk density (Mg m^{-3})*	*MWD (mm)*	*AWC (%)*	*Hydraulic conductivity*
	2012-13			
(a) Tillage				
Set I : Conservation tillage	1.34	0.67	23.94	0.70
Set II : Conventional tillage	1.35	0.66	21.72	0.71
SE (m) ±	0.005	0.002	0.17	0.003
CD at 5 %	NS	0.006	0.50	0.009
(b) Nutrient management				
T_1 : 100% RDF (60:30:30 NPK kg ha^{-1})	1.39	0.64	20.83	0.67
T_2 : 50% RDF + *In situ* GM (sunhemp)	1.36	0.65	21.09	0.69
T_3 : 50% RDF + 50% N (FYM)	1.29	0.70	24.47	0.73
T_4 : 50% RDF + 50% N (WS)	1.37	0.66	23.32	0.70
T_5 : 50% RDF + 50% N (GLM)	1.31	0.66	22.95	0.69
T_6 :50% RDF + 25%N (FYM) + 25% N (WS)	1.37	0.69	23.25	0.72
T_7 : 50% RDF + 25% N (FYM) + 25% N (GLM)	1.32	0.67	23.50	0.70
T_8 : 50% RDF + 25% N (WS) + 25% N (GLM)	1.37	0.65	23.24	0.68
SE (m) ±	0.022	0.005	0.28	0.006
CD at 5 %	NS	0.015	0.78	0.018
(c) Interaction effect	*NS*	*NS*	*Sig*	*NS*

also recorded by Salinas-Garcia *et. al.* (1990). Conservation tillage helps to conserve moisture which reduces bulk density. The reduced tillage practices improves the bulk density to a remarkable extent, as the soil become porous thus helping to conserve more moisture as compared to soil mass. Acharya *et. al.* (1994), and Arun Kumar (2000) reported that no tillage showed a significant increase in the bulk density as compared to conventional tillage.

Effect of Nutrient Management

The bulk density as influenced by different treatments of nutrient management varied from 1.29 to 1.39 Mg m^{-3} respectively after harvest of cotton. The bulk density of soil was significantly influenced by nutrient management but the decrease was found slight as compared to only recommended dose of fertilizers. The significantly lower bulk density (1.35 Mg m^{3}) was recorded in the treatment 50% N through FYM + compensation of RDF (T_3) followed by 50% RDF + 50% N (GLM) (1.36 Mg m^{3}) (T_5) which were found to be on par with each other. In the second year, the bulk density of soil was significantly influenced by nutrient management. The significantly lower bulk density (1.29 Mg m^{3}) was recorded in the treatment 50% N through FYM + compensation of RDF followed by 50% RDF + 50% N (GLM) (1.31 Mg m^{3}) which were found to be on par with each other. The decrease in bulk density might be due to higher organic carbon content of soil; better aggregation and increased root growth in the FYM and fertilizers treatment (Sonune *et. al.*, 2012).

The highest bulk density (1.39 Mg m^{3}) was recorded in 100% RDF. Decrease in the bulk density in organic manure applied plots might be due to higher organic carbon, higher pore space and good soil aggregation. Similar observations were also reported by Ghuman *et. al.* (1997) with green manuring of sunhemp. They reported that the bulk density was decreased with increasing depth. The bulk density values that increasedwith soil depth was attributed to greater pre-dominance of smectite expanding type of clay mineral in black soils.

Effect of Tillage

The higher values of MWD were recorded in conservation tillage (0.67 mm) as compared to conventional tillage (0.66 mm). Increased intensity of tillage due higher input of energy decreased mean weight diameter. These results are in confirmity with the findings reported by Arun Kumar (2000) and Mohanty *et. al.* (2003). Lal *et. al.* (1989) observed that the higher organic matter content and lack of mechanical disturbance in no-tillage may be responsible for relatively higher aggregation. These findings are in accordance with Mohanty and Painuli (2003) who reported that the tillage practices decreases the mean weight diameter of the soil.

Effect of Nutrient Management

The MWD in different treatments ranged from 0.64to 0.70 mm. The significantly higher value of MWD (0.70 mm) was recorded in the treatment 50% N through FYM + compensation of RDF (T_3) followed by 50% RDF + 25%N (FYM) + 25% N (WS) (0.69 mm) which were found to be on par with each other. The treatment involving inorganic fertilizers 100% recommended dose of fertilizer showed significantly lower MWD (0.64 mm). Bellaki and Badanur (1997) also observed higher water stable aggregates in treatment receiving FYM or green manuring along with 50% RDF over control. Most of the heavy black soils are becoming deficient in organic matter levels and consequently the physical properties like structure are hampered resulting in to deterioration in soil quality.

Effect of Tillage

The AWC (23.94%) was observed significantly higher in conservation tillage as compared to conventional tillage (21.72%). The available water capacity was recorded consistently higher as against the lower bulk density and lower values of available water may be ascribed to the reduction in available water capacity in treatment of conventional tillage. Similar results were recorded by Gurumurthy and Singa Rao (2006) reported that deep tillage caused increase in water retention upto 30 cm soil layer; however tillage with bullock drawn *desi* plough influenced water retention in surface soil. Secondary tillage with rotavator formed fine tilth with more number of capillary pores in surface soil layer by breaking hard-compacted massive soil structure that might be due to high water retention under such tillage practices.

Effect of Nutrient Management

The available water capacity (AWC) of the soil varied from 20.83 to 24.47 cm m^{-1}during experimentation respectively and was significantly improved due to various treatments of organic manures at harvest of cotton crop during both the years of experimentation. 50% RDF + 50% N (FYM) (24.47 cm m^{-1}) recorded significantly highest AWC followed by 50% RDF + 25% N (FYM) + 25% N (GLM) (23.50 cm m^{-1}), and 50% RDF + 50% N (WS) (23.32 cm m^{-1}). The lowest AWC observed in 100% RDF (60:30:30 NPK kg ha^{-1}) (20.83 cm m^{-1}). Bharambe *et. al.* (2004) and Badanur (1990) reported that available soil water in surface layer (0-30 cm) depth was highest in treatments receiving FYM and NPK as compared to control. The treatments $T_{3,}$ T_4 and T_7 were found at par with each other and showed lower AWC as compared to treatments receiving organics.

Thus, indicating the significance of organics in improving available water capacity, which can be attributed to the rise in organic carbon content, better soil structure and higher porosity in the soil.Bharadwaj and Omanwar (1992) also reported higher AWC in FYM treated plots than those of fertilizer treated plots. While studying on sugarcane trash in relation to physical condition of the soil.Jadhao (2005) reported that application of sugarcane trash and wheat straw in combination with chemical fertilizers was found to be beneficial in increasing AWC as compared to chemical fertilizers alone and control. Thus, in general, it could be revealed that, the application of crop residues along with 50 per cent recommended dose of fertilizers benefited in enhancement of available water capacity which might be due to improvement in physical properties of the soil. Biswas and Khosla (1971) reported that cumulative effect of manures caused improvement in available water and the improvement being relatively more marked in coarse textured soil than in the fine ones. Vittal*et. al.* (1983) were reported that, higher soil moisture content with deep tillage under rainfed conditions owing to higher water storage capacity of soil profile.The beneficial effect in AWC might be ascribed to higher organic carbon and better soil structure. Halemani *et. al.* (2004[a]) also found that the application of FYM, crop residues, green manure and vermicompost was superior over inorganic fertilizers in increasing the soil moisture availability.

Effect of Tillage

The hydraulic conductivity (0.70 cm h^{-1}) were observed in conventional tillage as compared to conservation tillage (0.71 cm h^{-1}). This might be due to the ploughing and harrowing in conventional tillage because of which the soil become loose and porous which may result into downward movement of water thereby increasing the hydraulic conductivity of soil. The movement of water through soil profile is largely dependent on the change in soil volume which ultimately depends upon the reorientation of soil particles and displacement of molecules between particles.

The structural arrangement of particles is highly influenced by soil manipulation practices. The higher degree of soil manipulation changes the state of soil compaction by rearrangement of the particles and changing the volume of soil voids. Hence, in case of conventional tillage treatment, the higher soil porosity and lower soil density might have caused a marked increase in the hydraulic conductivity. Due to reduced tillage and this causes minimum change in the volume of voids resulting in increased soil compaction and decreased hydraulic conductivity. Similar findings was observed by Hirekurbar *et. al.* (1991), he studied the effect of soil compaction on hydraulic conductivity of Vertisol and observed that the bulk density increased with decrease in hydraulic conductivity (1.25 Mg m^{-3} and 1.35 Mg m^{-3}) bulk density the hydraulic conductivity was 11.0 m/s × 10^6, 4.33 m/s × 10^6, respectively.

Effect of Nutrient Management

The hydraulic conductivity of soil was significantly influenced by nutrient management. The significantly higher value of hydraulic conductivity (0.74 cm h^{-1}) was recorded in the treatment 50% N through FYM + compensation of RDF followed by 50% RDF + 25%N (FYM) + 25% N (WS) (0.73 cm h^{-1}) which were found to be on par with each other. The significant decrease in bulk density resulted into increase in hydraulic conductivity of soil due to integrated use of FYM and chemical fertilizers Belekar (1995) reported that saturated hydraulic conductivity were significantly higher under the use of FYM, green manure and wheat straw over 100% NPK through fertilizer. The treatment consisting combination of FYM/wheat straw/green leaf manuring (25% N through each) + compensation of RDF recorded higher values of hydraulic conductivity. Application of FYM and fertilizers had favourable effect on hydraulic conductivity of soil.

Effect of Tillage

The pH of soil was significantly influenced by tillage treatments. The significantly lower pH was observed in conservation tillage (8.19) as compared to conventional tillage (8.24). Organics and crop residues contain a large amount of organic nitrogen such as proteins and amino acids, which mineralizes to nitrate in soil producing protons during nitrification and hence acidifying the soils (Kumar and Goh, 2000). Similar results were reported byDalal (1989) they observed that soil pH was lowered in conservation tillage as compared with conventional tillage treatment.

Effect of Nutrient Management

The effect of nutrient management on pH was found to be significant. The significantly lowest pH (8.13) was observed with the application of 50% N through FYM + 50% RDF followed by 50% RDF + 50% N (GLM) (8.17), 50% RDF + 25% N (FYM) + 25% N (GLM) (8.17) and 50% RDF + 50% N (GLM) (8.21) which were found to be at par with each other. The reduction in pH was also observed by Tyagi and Bharadwaj (1994) due to continous use of manures and fertilizer. There was a slight decrease in soil pH in the treatments where crop residues were incorporated in combination with 50 per cent inorganic fertilizers. Application of 50% RDF + 50% N (FYM) (T_3) recorded numerically lowest values of pH followed by T_5 (50% RDF + 50% N (GLM) and T_6 (50% RDF + 25%N (FYM) + 25% N (WS)) and highest value was recorded in 100 per cent RDF (T_1).

Table 2
Effect of tillage and nutrient management on soil chemical properties

Treatments	*pH (1:2.5)*	*EC (dS m^{-1})*	*OC (gkg^{-1})*	*$CaCO_3$ (%)*
		2012-13		
(a) Tillage				
Set I : Conservation tillage	8.19	0.23	5.76	8.15
Set II : Conventional tillage	8.24	0.24	5.71	8.13
SE (m) ±	0.01	0.01	0.03	0.003
CD at 5%	0.04	0.01	0.08	0.010
(b) Nutrient management				
T_1 : 100% RDF (60:30:30 NPK kg ha^{-1})	8.27	0.26	5.55	8.19
T_2 : 50% RDF + *In situ* GM (sunhemp)	8.31	0.24	5.75	8.17
T_3 : 50% RDF + 50% N (FYM)	8.13	0.21	5.89	8.09
T_4 : 50% RDF + 50% N (WS)	8.24	0.23	5.71	8.15
T_5 : 50% RDF + 50% N (GLM)	8.16	0.22	5.65	8.17
T_6 : 50% RDF + 25%N (FYM) + 25% N (WS)	8.22	0.24	5.76	8.12
T_7 : 50% RDF + 25% N (FYM) + 25% N (GLM)	8.17	0.22	5.75	8.12
T_8 : 50% RDF + 25% N (WS) + 25% N (GLM)	8.21	0.25	5.70	8.13
SE (m) ±	0.01	0.01	0.04	0.007
CD at 5%	0.03	0.02	0.11	0.021
(c) Interaction effect	*NS*	*NS*	*NS*	*NS*

Similar observations were also reported earlier by Prasad and Power (1991). They observed that leaving crop residues on the soil surface reduced the soil pH. Organics and crop residue or plant parts contain large amount of organic nitrogen such as proteins and amino acids, which mineralizes to nitrate in soil producing protons during nitrification and hence acidifying the soils (Kumar and Goh, 2000).

Effect of Tillage

The significantly lower EC was observed in conservation tillage (0.23 dSm^{-1}) as compared to conventional tillage (0.24 dSm^{-1}). Organics and crop residues contain a large amount of organic nitrogen such as proteins and amino acids, which mineralizes to nitrate in soil producing protons during nitrification and hence acidifying the soils (Kumar and Goh, 2000).

Effect of Nutrient Management

The effect of nutrient management on EC was found to be significant. The significantly lowest EC (0.21 dSm^{-1}) was observed with the application of 50% N through FYM + 50% RDF followed by 50% RDF + 50% N (GLM) (0.22 dSm^{-1}), 50% RDF + 25% N (FYM) + 25% N (GLM) (0.22 dSm^{-1}) and 50% RDF + 50% N (GLM) (0.24 dSm^{-1}) which were found to be at par with each other. Similar reduction in EC was also observed by Tyagi and Bharadwaj (1994) due to continous use of manures and fertilizer. Application of 50% RDF + 50% N (FYM) (T_3) recorded lowest values of EC followed by T_5 (50% RDF + 50% N (GLM) and T_6 (50% RDF + 25%N (FYM) + 25% N (WS)) and highest EC was recorded in 100 per cent RDF (T_1).

Similar observations were also reported earlier by Prasad and Power (1991). They observed that leaving crop residues on the soil surface reduced the soil EC. Organics and crop residue or plant parts contain large amount of organic nitrogen such as proteins and amino acids, which mineralizes to nitrate in soil producing protons during nitrification and hence acidifying the soils (Kumar and Goh, 2000).

Effect of Tillage

Higher values of organic carbon (5.76 g kg^{-1}) were observed in conservation tillage as compared to conventional tillage (5.71 g kg^{-1}) in the second year. Conservation tillage helps in leaving crop residues to accumulate on the soil surface and increase carbon sequestration by reducing oxidation of SOC in soil as compared to conventional tillage. Khiani and More (1984) also reported the increase in organic carbon content under conservation tillage as compared with conventional tillage. The only small or no differences in organic carbon between tillage methods in three years were also reported by Aon *et. al.*, (2001) and Andrade *et. al.*, (2003). Conservation tillage plots received 0.87 and 0.86 percent higher organic carbon as compared to conventional tillage during first and second year respectively. The significant increase organic carbon content under conservation tillage can be attributed to less disturbance of the soil which might have helped in preservation of more carbon in soil reducing oxidation of carbon. Novak *et. al.* (2009) noticed conservation tillage increases the soil organic carbon as compared to disc tillage system. Dick (1993) also reported higher amount of organic carbon in minimum tillage as compared to conventional tillage. Sainju *et. al.* (2009) concluded that no tillage increases organic carbon in soil as compared to tilled plot.

Effect of Nutrient Management

The application of 50% RDF + 50% N (FYM) (T_3) recorded significantly more organic carbon content in soil compared to first year followed by T_6 (50% RDF + 25%N (FYM) + 25% N (WS) and T_7 (50% RDF + 25% N (FYM) + 25% N (GLM) which were found to be on par with each other. Crop residues and green leaf manuring in conservation tillage decompose slowly because mixing with the soil was inadequate for complete microbial decomposition (Prasad and Power, 1991).

The addition of crop residues and green leaf manuring encouraged the proliferation in soil microbial environment and biomass of the root system. It was observed that, the organic carbon did not show much more increase after continuous manuring and fertilization over two years. This can be attributed to oxidation of organic matter in soil owing to prevailing high temperature in semi arid climatic areas. However, the conjoint use of chemical fertilizers with organics like FYM, phosphocompost, cotton stalk, soybean straw or neem cake were found beneficial for maintaining organic carbon content compared to the use of only chemical fertilizers.

Effect of Tillage

The higher values of calcium carbonate (8.15%) were observed in conservation tillage as compared to conventional tillage (8.13%).

Effect of Nutrient Management

The lower calcium carbonate was notced in treatment 50% RDF + 50% N through FYM (8.09%), 50% RDF + 25%N (FYM) + 25% N (WS) (8.12%), 50% RDF + 25% N (FYM) + 25% N (GLM) (8.12%) which were found to be at par with each other and higher value of calcium carbonate was obtained in treatment 100% RDF (8.19%). The results are in consonance with the findings of Bellakki and Badanur (1997) and Nehra and Hooda (2002), Katkar (2008) reported slight reduction in calcium carbonate content of Vertisol with organic manure in combination with inorganic fertilizer.

Table 3
Effect of tillage and nutrient management on available macro nutrients

	Available nutrients (kg ha^{-1})		
Treatments	*N*	*P*	*K*
(a) Tillage			
Set I : Conservation tillage	226.7	17.10	411.0
Set II : Conventional tillage	216.5	15.17	406.5
SE (m) ±	0.61	0.21	2.16
CD at 5%	1.83	0.62	NS
(b) Nutrient management			
T_1 : 100% RDF (60:30:30 NPK kg ha^{-1})	219.5	14.03	390.4
T_2 : 50% RDF + *In situ* GM (sunhemp)	220.3	14.79	411.7
T_3 : 50% RDF + 50% N (FYM)	223.2	17.67	419.2
T_4 : 50% RDF + 50% N (WS)	221.8	16.35	409.0
T_5 : 50% RDF + 50% N (GLM)	221.6	16.15	404.6
T_6 :50% RDF + 25%N (FYM) + 25% N (WS)	222.4	16.94	411.1
T_7 : 50% RDF + 25% N (FYM) + 25% N (GLM)	222.2	16.70	414.5
T_8 : 50% RDF + 25% N (WS) + 25% N (GLM)	221.9	16.46	409.7
SE (m) ±	1.52	0.41	4.33
CD at 5%	4.56	1.22	12.99
(c) Interaction effect	*Sig*	*Sig*	*Sig*

Effect of Tillage

The available nitrogen was also found significantly higher in conservation tillage (226.7 kg ha^{-1}) as compared to conventional tillage (216.5 kg ha^{-1}).

Similar observation were recorded by Dick (1983). The higher availability of nitrogen was recorded by Khiani and More (1984), due to harrowing than ploughing in Vertisol due to enhanced, decomposition process and mineralization of the nutrients in the soil. Further, the decreasing trend in available nitrogen was noticed as the soil depth increases. Improved nitrogen status after harvest of crop was due to addition of biomass which was stayed large period under conservation tillage.

Effect of Nutrient Management

50% RDF + 50% N (FYM) (223.2 kg ha^{-1}) recorded significantly highest values followed by 50% RDF + 25%N (FYM) + 25% N (WS) (222.4 kg ha^{-1}), 50% RDF + 25% N (FYM) + 25% N (GLM) (222.2 kg ha^{-1}) and 50% RDF + 25% N (WS) + 25% N (GLM) (221.9 kg ha^{-1}) which were found at par with each other. The lowest values observed in 100% RDF (60:30:30 NPK kg ha^{-1}) (219.5 kg ha^{-1}).

All the treatments of crop residues + 50% RDF significantly improved the availability of N in soil over inorganic fertilizers. Such a response can be ascribed to direct addition of nitrogen through the organics or inorganics backed up by greater soil microbial activity, which converted immobilized organically bound nitrogen into an inorganic form. Similar improvement in available nitrogen with continuous application of FYM and inorganic fertilizer was also reported by Malewar and Hasnabade (1995). Katkar *et. al.* (2005) also reported that application of FYM @ 5 t ha^{-1} significantly increased available nitrogen in the soil as compared to no FYM. This increase in available N might be due to the direct addition of the N through FYM, green manuring to the available pool of soil. Increase in available N due to organic material application could also be attributed to the greater multiplication of soil microbes which could convert organically bound N to inorganic (Katkar *et. al.*, 2002). It was observed that considerable improvement in available N status was observed in all the treatments which involved combined application of crop residues and inorganic fertilizers over initial values. This might be attributed to improved physical properties of the soil coupled with enhanced microbial population. The microbial activity further increased due to availability of organic matter along with readily available N from inorganic fertilizers. Several earlier studies also showed an increase in available N with application of FYM + inorganic fertilizers (Bellakki and Badanur, 1997; Babhulkar *et. al.*, 2000; Katkar *et. al.*, 2002 and Surekha and Rao, 2009).

Effect of Tillage

The significantly higher available phosphorus was observed in conservation tillage (17.10 kg ha^{-1}) as compared to conventional tillage (15.17 kg ha^{-1}). Conservation tillage involves minimum surface tillage, leaving crop residue to accumulate at the soil surface and increase in organic matter ultimately enhance availability of nutrient like phosphorus. Similar observation were also recorded by Dick (1983). Gaikwad and Khupse (1976) observed that available P was higher due to harrowing than ploughing in black soil. Sonune *et. al.* (2012) also observed higher available P in black cotton soils and minimum tillage compared to conventional tillage. Significant variation was observed in available phosphorus due to the tillage practices. This implies that high organic carbon in soil due to conservation tillage reduces phosphorus fixation due to release of various organic acids as a results of which more phosphorus becomes readily available to plant roots in the soil.

Effect of Nutrient Management

The available phosphorous (17.67 kg ha^{-1}) was found significantly higher in the treatment of 50% N through FYM + 50% RDF followed by 50%RDF + 25%N (FYM)+ 25% N (WS) (16.94 kg ha^{-1}) and 50%RDF + 25% N (FYM) + 25% N (GLM) (16.67 kg ha^{-1}) and these treatments were found to be at par with each others. The lowest available phosphorus (14.03 kg ha^{-1}) was recorded in treatment 100% RDF (60:30:30 NPK kg ha^{-1}). This could be attributed to the effect of applied fertilizer and mineralization of organic sources or through solubilization of the nutrients from the native sources during the process of decomposition. Similar observation recorded by Bhriguvanshi (1988), Bellakki *et. al.* (1998), More and Hangarge (2003).

Effect of Tillage

The slightly higher available potassium was observed in conservation tillage (411.0 kg ha^{-1}) as compared to conventional tillage (406.5 kg ha^{-1})

results were non significant. This might be due to conservation tillage, conserve organic carbon in soil and increase availability nutrient like potassium. Similar observation recorded by Gaikwad and Khuspe (1978) in Vertisol and reported that available potassium was higher due to harrowing than ploughing in black soil.

Effect of Nutrient Management

Available potassium (419.2 kg ha^{-1}) was found significantly higher in the treatment of 50% N through FYM + 50% RDF followed by 50%RDF + 25% N (FYM) + 25% N (GLM) (414.5 kg ha^{-1}), T_2 :50% RDF + *In situ* GM (sunhemp) (411.7 kg ha^{-1}), 50% RDF + 25%N (FYM)+ 25% N (WS) (411.1 kg ha^{-1}) and T_8 : 50% RDF + 25% N (WS) + 25% N (GLM) (409.7 kg ha^{-1}) these treatment were found to be at par with each others. The lowest available potassium (390.4 kg ha^{-1}) was recorded in treatment 100% RDF (60:30:30 NPK kg ha^{-1}) and treatment T_5. This could be attributed to the effect of applied fertilizer and mineralization of organic sources or through solubilization of the nutrients from the native sources during the process of decomposition. Similar observation recorded by Bhriguvanshi (1988), Bellakki *et. al.* (1998).

Effect of Tillage

The seed cotton yield (15.00 q ha^{-1}) were observed in conservation tillage as compared to conventional tillage (13.07 q ha^{-1}). In pooled mean analysis higher values of seed cotton yield (14.63 q ha^{-1}) were observed in conservation tillage as compared to conventional tillage (12.73 q ha^{-1}). In Vertisols, the RT systems have been reported to yield equal to or better than the CT systems (Blaise *et. al.*, 2005; Constable *et. al.*, 1992).

Effect of Nutrient Management

The seed cotton yield (15.57 q ha^{-1}) was found significantly higher in the treatment of 100% RDF (60:30:30 NPK kg ha^{-1}) followed by, 50% N through FYM + 50% RDF(14.84 q ha^{-1}), 50% RDF + 25% N (WS) + 25% N (GLM) (14.60 q ha^{-1}), which were found to be at par with each others. The lowest seed cotton yield (11.93 q ha^{-1}) was recorded in treatment 50% RDF + In situ GM (sunhemp).This could be ascribed to the effect of applied fertilizer and mineralization of organic sources or through solublization of the nutrients from the native sources during the process of decomposition. The interaction of conservation tillage with FYM was found most beneficial and recorded highest yield of cotton. This can be attributed to the combined effect of conservation tillage in improving soil properties along with FYM resulting into highest yield of cotton.

The conservation tillage along with glyricidia green leaf manuring also recorded yields which whereat par with FYM which also signifies the importance of conservation tillage with organics.This could be attributed to the intercrop competition with the cotton crop for moisture and nutrients availability throughout the crop growing period. Similar results were observed by Sethi (1988).

Table 4
Effect of tillage and nutrient management on seed cotton yield

	Seed cotton yield (q ha^{-1})
Treatments	*2012-13*
(a) Tillage	
Set I : Conservation tillage	15.00
Set II : Conventional tillage	13.07
SE (m) ±	0.34
CD at 5%	1.01
(b) Nutrient management	
T_1:100% RDF (60:30:30 NPK kg ha^{-1})	15.57
T_2:50% RDF + *In situ* GM (sunhemp)	11.93
T_3:50% RDF + 50% N (FYM)	14.84
T_4:50% RDF + 50% N (WS)	14.25
T_5:50% RDF + 50% N (GLM)	12.69
T_6 :50% RDF + 25%N (FYM) + 25% N (WS)	14.36
T_7 : 50% RDF + 25% N (FYM) + 25% N (GLM)	14.6
T_8 : 50% RDF + 25% N (WS) + 25% N (GLM)	14.05
SE (m) ±	0.68
CD at 5%	2.02
(c) Interaction effect	*Sig*

References

Acharya, C L. and P.D. Sharma, 1994. Tillage and mulch effect on soil physical environment, root growth, nutrient uptake and yield of maize and wheat on an Alfisols in north-west India. Soil and Tillage Res. 30:291-302.

Andrade, D.S.,A.Colozzi-Filhoand.K.E. Giller ,.2003. The soil microbial community and soil tillage. In: soil Tillage in Agroecosystems (Ed.A.ElTitti), pp.51-81.CRS press LLC ,Bocaration,FL.

Anonymous., 2013. Area, Production and productivity of India and Maharashtra, Director Economics and Statistics Department of Agriculture and Co-operation 2012-13

Aon, M.A., D.E., Sarena, J.L. Burgos, and S.S Cortassa, (2001), Microbiological, chemical and physical properties of soils subjected to conventional or no-till management: an assessment of their quality status. Soiland Tillage Research. 60: 173-186.

Arun Kumar, (2000), Effect of different tillage systems on wheat crop. Indian J. Agrono 45(1): 114-117.

Babhulkar, P.S., R.M. Wandile,W.P. Badole and S.S. Balpande, (2000), Residual effect of long term application of FYM and fertilizers on soil properties (Vertisols) and yield of soybean. J. Indian Soc. Soil Sci., 48(1): 89-92.

Badanur, V.P., C.M. Poleshi and B.K. Naik, (1990), Effect of organic matter on crop yield and physical and chemical properties of Vertisol. J. Indian Soc. Soil Sci., 38: 426-429.

Barwale, R.B., Gadwal, V.R., Zehr, U., and Zehr, B. (2004), Prospects for Bt cotton technology in India. Ag Bio Forum, 7(1&2), 23-26. Available on the World Wide Web: http://www.agbioforum.org.

Bauer, A. and A.L. Black, (1981), Soil carbon, nitrogen, and bulk density comparison in two crop land tillage system after 25 years in virgin grassland. Soil Sci. Soc. of Am. J. 45, 1160-1170.

Belekar, D.C. (1995), Long term effect of fertilizers and manures on physical properties of black soil under sorghum-wheat cropping system M.sc. Thesis Dr. PDKV, Akola

Bellakki, M.A. and V.P. Badanur, (1997), Long term effect of integrated nutrient management on properties of Vertisol under dryland agriculture. J. Indian Soc. Soil Sci., 45(3): 438-442.

Bellakki, M.A., V.P. Badanur and R.A. Setty, (1998), Effect of long term nutrient management on some important properties of Vertisols. J. Indian Soc. Soil Sci., 46(2): 176-180.

Bharadwaj, V. and P.K. Omanwar, (1994), Impact of long-term fertility treatment on bulk density and water content. J. Indian Soc. Soil Sci., 40: 553-55.

Bharambe, P.R., V.V. Patil; D.K. Shelke; S.R. Oza and V.D. Sondge. (2004), Response of rabi groundnut to phosphorus levels under different land layouts and moisture regimes grown on Vertisol. J. Indian Soc. Soil Sci., 52(3): 262-265.

Bhriguvanshi, S.R. (1988), Long term effect of high doses of farm yard manure on soil properties and crop yield. J. Indian Soc. Soil Sci., 36 : 784-86.

Bhriguvanshi, S.R. (1988), Long term effect of high doses of farm yard manure on soil properties and crop yield. J. Indian Soc. Soil Sci., 36: 784-86.

Biswas, T.D. and B.K. Khosala. (1971), Building up of organic matter status of the soil by long term manuring and its relation to soil physical properties. Proc.Interl. Sympo. Soil Fertility Evaluation, New Delhi : 831.

Blaise D, Majumdar G, Tekale K.U. (2005), On-farm evaluation of fertilizer application and conservation tillage on productivity of cotton + pigeonpea strip intercropping on rainfedVertisols of central India Soil Till Res 84: 108-117.

Bruce, R.R., G.W. Langdale and A.L.Dillards, (1990), Tillage and crop rotation effect on characteristics of sandy surface soil. Soil. Soc. Am. J. 54: 1744-1749.

Constable, G.A., I.J. Rochesrer and I.G. Daniells, (1992), Cotton yield and nitrogen requirement as modified by crop rotation and tillage method. Soil and Tillage Res. 23: 41-59.

Dalal, R.C. (1989), Long term effects of no tillage crop residue and nitrogen application on properties of a Vertisol. Soil Sci. Soc. American J. 53: 1511-1515.

Dick, W.A. (1983), Organic carbon, nitrogen and phosphorus and pH in soil profiles as affected by tillage intensity. Soil. Soc. Am. J. 47: 102-107.

Dick, W.A. (1983), Organic carbon, nitrogen and phosphorus and pH in soil profiles as affected by tillage intensity. Soil. Soc. Am. J. 47: 102-107.

Gaikwad, C.B. and V.S. Khuspe, (1976), Long term effect of tillage and manuring on some physical and chemical properties in black soil under rainfed cropping. J. Maharashtra Agric. Univ. 1 (2-6): 145-147.

Ghuman, B.S., N.S. Suri and Kulwantlal. (1997), Effect of green manuring on soil properties and yield of wheat under dryland conditions. J. Indian Soc. Soil Sci., 45(1): 99-103.

Gurumurthy, P. and M. Singa Rao, (2006), Effect of tillage and irrigation regimes on soil physical properties and performance of sunflower in rice fallows II. Water use and crop yield. J. Indian Soc. Soil Sci 54, 18-23.

Halemani, H.L., S.S. Hallikeri, S.S. Nooli, R.A. Nandagavi, and H.S. Harish Kumar, (2004[a]), Effect of organics on cotton productivity and physico-chemical properties of soil. In: International symposium on "Strategies for sustainable cotton production–A global vision" 2. Crop Production, 23-25, Nov. 2004, UAS, Dharwad : 123-129.

Hirekurbar, B.M., V.S. Doddamani and T. Satyanarayana, (1991), Effect of soil compaction on soil physical properties and crop growth. J. Indian Soc. Soil Sci. 39(2): 348-350.

Jadhao, V.O. (2005), Effect of crop residue management on soil productivity, yields and water use efficiency under soybean-chickpea cropping system. Ph. D. (Agri.) Thesis (unpub.), Dr. PDKV, Akola.

Jambunathan, R.L., N.P. Mehta, C.J. Sanandia and Y. Subramanyam. (1986), Study of the effects of the application of nitrogen, phosphorus and potash on the economic and quality characteristics of cotton hybrid-4. J. Indian Soc. Cotton Improv. 11(1) : 26-29.

Kairon, M. S., Blaise, D., Venugopalan, M.V., (2002), Cotton, In: Prasad, R. (Ed,) Text Book of Field Crops Production, Indian Council of Agricultural Research, New Delhi, pp. 646-674.

Katkar, R.N., A.B. Turkhede, V.M. Solanke, S.T. Wankhade and M.R. Patil. (2002), Effect of integrated management of organic manures and fertilizers on soil properties and yield of cotton. J. Cotton Res. Dev. 16(1): 89-92.

Katkar, R.N., S.T. Wankhade, A.B. Turkhede and S.P. Lambe, (2005), Effect of integrated nutrient management in cotton grown on shallow soil on growth, seed cotton yield and physico-chemical properties. PKV Res. J. 29 (2) : 210-211.

Katkar, R.N. (2008), Effect of crop residue management and moisture regimes on soil properties, plant growth, seed cotton yield, water use efficiency and fibre quality (Ph.D thesis unpublished) Dr. Panjabrao Deshmukh Krishi Vidyapeeth Akola.

Khiani, K.N and D.A. More, (1984), Long term effect of tillage operation and farm yard manure application on soil properties and crop yield in Vertisol. J. Indian Soc. Soil Sci., 32: 392-393.

Kumar, K. and K.M. Goh. (2000), Crop residues and management practices: Effects on soil quality, soil nitrogen dynamics, crop yield and nitrogen recovery. Advances in Agronomy, 68: 197-319.

Lal, R., T.J. Logan and N.R. Fausey, (1989), Long term tillage and wheel track effects on a poorly drained mollicochraquatt in North West-Ocjto-1. Soil physical properties, root distribution and grain yield of corn and soybeans. Soil and Tillage Res. 14: 34-58.

Malewar G.U, and A.R. Hasnabade, (1995), Effect of long term application of fertilizer and organic sources on some properties of Vertisol. J. Maharashtra Agric. Univ. 20(2): 285-286.

Mohanty, M. and D. K. Painuly, (2003), Land preparatory tillage effects on soil physical properties and growth and yield of rice in a Vertisol. J. Indian Soc. Soil Sci. 51(3): 217-222.

More, S.D and D.S. Hangarge, (2003), Effect of integrated nutrient supply on crop productivity and soil characteristics with cotton-sorghum cropping sequence in Vertisol. J. Maharashtra Agric. Univ. 28(1): 8-12.

Nehra, A.S. and I.S. Hooda, (2002), Influence of integrated use of organic manures and inorganic fertilizers on wheat yield and soil properties. Res. on Crops, 3(1): 11-16.

Novak, J.M. J.R. Frederick, P.J. Bauer, and D.W. Watts, (2009), Rebuilding organic carbon content in coastal plain soils using conservation tillage systems. Soil. Sci. Soc. Am. J. 73: 622-629.

Pasricha, N. S., Bansal, S. K., (2002), Potassium fertility of Indian benchmark soils. In: Pasricha, N. S., Bansal, S.K., (Eds), Potassium for Sustainable Crop Production. International Potash Institute, Basel, Switzerland and Potash Research Institute of India, Gurgaon, Haryana, India, pp.321-346.

Prasad, M., Prasad, R., (1998), Nutrient management in cotton (*Gossypiumhirsutum*). Indian J. Agron, 43, 162-164.

Sainju, U.M., J.D Jabro and T.C. Tonthat, (2009), Carbon and nitrogen fraction in dryland soil aggregates affected by long-term tillage and cropping sequence. Soil. Sci. Soc. Am. J. 73: 1488-1495.

Salians-Garcia J.R., F.M. Hones and J.E. Matocha, (1997), Long term effect of tillage and fertilization on soil organic matter dynamics. Soil. Sci. Soc. Am. J. 61: 152-159.

Sethi, H.N. (1988), Studies on biomass production and water use efficiency of cotton varieties as influenced by intercrops and irrigation levels. Ph. D. Thesis, (unpub.), Dr. PDKV, Akola.

Shanmugam, K. and J.G. Bhatt. (1991), Effect of potassium on fibre properties of high quality cotton varieties. J. Indian Soc. Cotton Improv., 16: 31-15.

Singh, M. (1991), Microbial activity during decomposition of sugarcane trash. J. Indian Soc. Soil Sci., 39 : 812-813.

Sonune B.A., V.V. Gabhane, S.S. Rewatkar and M.S. Sawangikar, (2012), Productivity of rainfed cotton and soil health as influenced by tillage and integrated nutrient management in Vertisol under semi-arid agro-ecosystem of Maharashtra. Indian J. Dryland Agric. Res.and Dev. 27(1): 10-17.

Surekha K and K.V. Rao, (2009), Direct and residual effects of organic sources on rice productivity and soil quality of Vertisol.J.Indian Soc. Soil. Sci., 57(1): 53-57.

Swarup, A., Reddy, D.D., Prasad, R.N., (1998), Long-term Fertility management through Integrated plant nutrient supply system. Indian Institute of Soil Science, Bhopal.

Tandon, H.L.S. (Ed). (1993), Fertilizer management in Commercial crops, FDCO, New Delhi.

Tyagi, V.V. and V. Bhardwaj. (1994), Effect of continuous cropping and fertilization on the status of available nitrogen, phosphorus, and potassium in Mollisol. J. Pot. Res., 10(4): 384-391.

Vittal. K.P.R., Vijayalakshmi, K. and Rao, U.M.B. (1983), Effect of deep tillage on dry land crop production in red soils of India. *Soil and Tillage Research* 3, 377-384.