

Modern tillage and integrated nutrient management practices for improving soil fertility and productivity of groundnut (*Arachis hypogaea L.*) under rainfed farming system

S. B. Patil*, B. C. Balakrishna Reddy, S. C. Chitgupekar, B. B. Patil

University of Agricultural Sciences, GKVK, Bangalore 560 065, Karnataka, India

*E-mail address: sbpatil84@gmail.com

ABSTRACT

The field experiment was conducted with four tillage and three nutrient management practices at Agronomy field unit, University of Agricultural Sciences, GKVK, Bangalore, Karnataka, India. The results of the study indicated that, higher groundnut pod yield (1307 and 1282 kg ha⁻¹) and haulm yield (2733 and 2889 kg ha⁻¹) was recorded with mechanical tillage + two intercultivations and integrated application of 50% organics and 50% inorganics, respectively as compared to rest of the treatments. Further, the same treatments noticed higher availability of N, P₂O₅ and K₂O in soil after harvest of groundnut, but greater improvement in soil organic carbon content was observed with conventional tillage + one intercultivation (0.62%) as compared to rest of the tillage practices. The maximum net returns and benefit-cost ratio was recorded with mechanical tillage + two intercultivations (Rs. 11,287 ha⁻¹ and 1.75, respectively) and integrated application of 50% organics + 50% inorganics (Rs. 10,462 ha⁻¹ and 1.69, respectively). However, interaction effect of tillage and nutrient management practices were not influenced significantly on soil fertility and productivity of groundnut under rainfed farming system.

Keywords: groundnut; tillage; soil fertility; economics; intercultivation

1. INTRODUCTION

Groundnut (*Arachis hypogaea L.* Monech), also known as peanut and earthnut, is an important oilseed crop, seed containing 50% oil, 25-30% protein, 20% carbohydrates and 5% fiber and ash (Fageria *et al.*, 1997). Groundnut is ‘king of oilseeds’ belongs to the family Leguminosae. Groundnut is cultivated globally on an area of 24.62 million hectares adding 41.27 million tonnes of grains annually to the world food basket, with an average productivity of 1676 kg ha⁻¹ (FAO, 2013). It is the most important oilseed crop of India, cultivated in an area of 4.77 million hectares and 4.75 million tonnes of total production with an average productivity of 996 kg ha⁻¹ (Anonymous, 2013). A number of factors constrain groundnut

production in Karnataka including declining soil fertility, imbalanced use of chemical fertilizers, poor weed and pest controls, and inappropriate tillage practices.

Groundnut is largely grown by resource poor smallholder farmers under rainfed conditions. These farmers employ different tillage practices in the production of the crop. Many farmers perform tillage operations without being aware of the effect of these operations on soil physical properties and crop responses (Ozpinar and Isik, 2004). Tillage is one of the important processes in agriculture. It is carried out mainly to loosen the upper layer of soil, to mix the soil with fertilizer and organic residues, to control weeds, and to create a suitable seedbed for germination and plant growth (Rasmussen, 1999). According to Srivastava *et al.* (2006), the objectives of tillage are to develop a desirable soil structure or suitable tilth for a seedbed.

Tillage is crucial for crop establishment, growth and ultimately, yield (Atkinson *et al.*, 2007). A good soil management programme protects the soil from water and wind erosion, provides a good, weed-free seedbed for planting, destroys hardpans or compacted layers that may limit root development, and allows maintenance or even an increase of organic matter (Wright *et al.*, 2008). Tillage systems are site specific and depend on crop, soil type and the climate (Rasmussen, 1999). Tillage practices influence soil physical, chemical and biological characteristics, which in turn may alter plant growth and yield (Çarman, 1997; Ozpinar and Cay, 2006; Rashidi and Keshavarzpour, 2009). The role of deep tillage in ameliorating plough pans, hard pans or naturally occurring dense soil layers has been investigated by many workers (Vepraskas *et al.*, 1986; Reddy *et al.*, 1987; Campbell *et al.*, 1994; Rashid *et al.*, 1994; Akhtar *et al.*, 1994).

Reduced tillage is an effective alternative to conventional tillage for groundnut production (Drake *et al.*, 2014). Tripathi *et al.* (2007) have reported that soil tillage has major influence on soil bulk density, penetration resistance, water intake, storage and extraction of water from the soil by the plant roots and on the microbial activity which influences soil aeration, moisture and temperature. Integrated use of both chemical fertilizers and organic manures is needed to check the depletion of soil and enhance the yield levels. The theme of nutrient management in integrated way for increasing the soil fertility is gaining ground throughout the world in recent years due to high cost of fertilizer and reduced availability of organic manures.

Modern tillage and integrated nutrient management practices may affect soil fertility and productivity of groundnut due to different soil conditions created and fulfills the nutrient requirement of crop. But there is inadequate information on the effect of tillage and integrated nutrient management practices on soil fertility and productivity of groundnut under rainfed farming systems in the Karnataka region. The objective of the study was to compare the effect of different tillage and nutrient management practices and on the soil nutrient status, yields and economic returns components of groundnut.

2. MATERIALS AND METHODS

2. 1. Location of the study

A field experiment was conducted at Agronomy field unit, University of Agricultural Sciences, GKVK, Bangalore, Karnataka, India. The test crop sown in the experiment was groundnut (variety TMV-2). The soil of the experimental field was analyzed before experimentation and values are presented in Table 1.

Table 1. Physico-chemical properties of soil in the experimental site.

Particulars	Values	Method followed
I. Physical properties		International pipette method (Piper, 1966)
1. Coarse sand (%)	36.50	
2. Fine sand (%)	34.60	
3. Silt (%)	11.50	
4. Clay (%)	17.40	
5. Textural class	Red sandy loam	
II. Chemical properties		
1. pH	6.6	Buckman's Zero metric pH meter (Piper, 1966)
2. EC (dSm ⁻¹)	0.15	Conductometry (Jackson, 1973)
3. Organic carbon (%)	0.56	Wet oxidation method (Walkley and Black, 1934)
4. Available N (kg ha ⁻¹)	189.6	Alkaline permanganate method (Subbaiah and Asija, 1956)
5. Available P ₂ O ₅ (kg ha ⁻¹)	29.3	Bray's method (Jackson, I973).
6. Available K ₂ O (kg ha ⁻¹)	202.8	Neutral normal ammonium acetate method (Jackson, 1973).

2. 2. Treatmental details and design

The agronomic practices like various tillage and nutrient management practices carried out in present investigation. The experiment was laid out in a split-plot design with three replications. The twelve treatment combinations comprised four tillage practices *viz.*, T₁: Conventional tillage (bullock drawn desi plough twice followed by bullock drawn cultivator twice) + one intercultivation @ 25 days after sowing, T₂: Conventional tillage (bullock drawn desi plough twice followed by bullock drawn cultivator twice) + two intercultivations @ 25 and 40 days after sowing, T₃: Mechanical tillage (tractor drawn disc plough once followed by tractor drawn cultivator twice) + one intercultivation @ 25 days after sowing and T₄: Mechanical tillage (tractor drawn disc plough once followed by tractor drawn cultivator twice) + two intercultivations @ 25 and 40 days after sowing in main plots and three nutrient management practices *viz.*, F₁: 100% organics (FYM @ 25 kg N equivalent), F₂: 100% inorganics (25:50:25 kg N, P₂O₅, K₂O ha⁻¹) and F₃: 50% organics (FYM @ 12.5 kg N equivalent) + 50% inorganics (12.5:25:12.5 kg N, P₂O₅, K₂O ha⁻¹) in sub-plots.

2. 3. Cultural practices

As per treatments, calculated amount of farmyard manures (based on the N requirement) was applied 15 days prior to sowing and mixed well. Nutrient compositions of the farmyard manure (FYM) was analyzed and presented in Table 2. Then land was prepared as per treatment and leveled.

The plots were laid out and leveled within the plots. Each plot was enclosed by bunds of 20 cm width and 15 cm height. Groundnut cultivar TMV-2 was sown on last week of July 2007 by hand dibbling by adopting a spacing of 30 cm x 15 cm. All other agronomic practices were carried out as per schedule to raise the crop. The crop was raised under rainfed conditions.

Table 2. Nutrient composition of farmyard manure (FYM).

Organic source	Nutrient composition (%)		
	Nitrogen	Phosphorus	Potassium
Farmyard manure (FYM)	0.55	0.28	0.52

2. 4. Soil sample collection and analysis

Soil samples were collected after harvest of the crop from 0-15 cm depth, dried under shade, powdered and passed through 2 mm sieve. The samples were analyzed for available nitrogen, phosphorus, potassium and organic carbon content in soil. The available nitrogen (N kg ha^{-1}) in the soil was determined by alkaline potassium permanganate method as outlined by Subbaiah and Asiji (1956).

The available phosphorus ($\text{P}_2\text{O}_5 \text{ kg ha}^{-1}$) in the soil was determined by chlorostannous reduced molybdophosphoric blue colour method in hydrochloric acid system by using Bray-I extractant (Jackson, 1973). The available potassium ($\text{K}_2\text{O kg ha}^{-1}$) in the soil was determined by neutral normal ammonium acetate extractant using a flame photometer (Jackson, 1973). Organic carbon content was analyzed by using wet oxidation method (Walkley and Black, 1934) and expressed in percentage (%).

2. 5. Crop data collection

The data on groundnut haulm and pod yield was calculated after harvest of crop from net plot area in kgs and converted into kg ha^{-1} . The harvest index (HI) was calculated as given by Donald (1962).

$$\text{HI (\%)} = \frac{\text{Kernel yield per ha}}{\text{Biological yield per ha}} \times 100$$

In computing the economics, different variable cost items were considered. The cost includes expenditure on seed, manures, fertilizers and labour charges were calculated at prevailing market prices.

Labour requirement was worked out on the basis of labourers engaged for performing different field operations.

2. 6. Statistical analysis

The experimental data were subjected to statistical analysis adopting Fisher's method of analysis of variance as outlined by Gomez and Gomez (1984). The level of significance used in 'F' test was given at 5 per cent. Critical difference (CD) values are given in the Table at 5 per cent level of significance, wherever the 'F' test was significant at 5 per cent level.

3. RESULTS AND DISCUSSION

3. 1. Weather condition during crop growth period

Environment is foster parent of plants. The fluctuations in weather conditions truly reflect on an expected yield. A rainfall of 682.1 mm was recorded during the period of experimentation (July to November, 2007). There was marginal variation in the rainfall of the experiment period from that of the average of 32 years (Table 3). A look at the maximum and minimum temperature and also at the relative humidity indicates that the experimental locality recorded the maximum temperature of 28.8 °C in July to 26.9 °C in November, minimum temperature of 19.9 °C in July to 15.1 °C in November and relative humidity of 74.5% in September to 70.0% in July. Temperature and relative humidity existing during period of experimentation were conducive to the growth and development of groundnut. The crop did not experience abiotic and biotic stress during any of its growth stages.

Table 3. Weather parameter of experimental site at GKVK, Bangalore during 2007.

Month	Rainfall (mm)			Relative humidity (%)			Maximum temperature (°C)			Minimum temperature (°C)		
	N*	A**	D***	N*	A**	D***	N*	A**	D***	N*	A**	D***
Jan	1.6	0.0	-1.6	64.0	66.0	2.0	27.2	28.1	0.9	14.0	13.8	-0.2
Feb	11.0	0.8	-10.2	57.5	65.0	7.5	29.8	29.8	0.0	15.5	14.8	-0.7
Mar	42.6	0.0	-42.6	52.0	57.5	5.5	32.6	33.2	0.6	17.9	18.4	0.5
April	42.6	109.6	67.0	55.5	58.0	2.5	33.7	33.8	0.1	20.4	20.2	-0.2
May	97.5	85.4	-12.1	60.0	61.5	1.5	33.1	33.2	0.1	20.5	21.2	0.7
June	82.6	60.3	-22.3	69.0	70.0	1.0	29.6	29.6	0.0	19.4	19.7	0.3
July	100.5	149.2	48.7	72.5	70.0	-2.5	28.2	28.4	0.2	18.9	19.9	1.0
Aug	125.5	189.8	64.3	73.5	73.0	-0.5	27.6	27.4	-0.2	18.7	19.5	0.8
Sep	208.4	179.1	-29.3	72.5	74.5	2.0	28.1	27.4	-0.7	18.7	19.1	0.4
Oct	168.1	151.6	-16.5	72.5	70.5	-2.0	27.7	28.2	0.5	18.2	18.0	-0.2
Nov	53.5	12.4	-41.1	71.5	71.0	-0.5	26.6	26.9	0.3	16.6	15.1	-1.5
Dec	13.4	31.2	17.8	68.0	68.5	0.5	26.1	25.5	-0.6	14.4	14.4	0.0
Total	947.3	969.4	22.1	788.5	805.5	17.0	350.3	351.5	1.2	213.2	214.1	0.9

Note: Total rainfall during the crop growing season (July to November) = 656.0 mm (Normal), 682.1 mm (Actual); Total rainfall during the calendar year (January to December) = 947.3mm (Normal), 969.4 mm (Actual).

N*: Normal; A**: Actual; D***: Deviation from normal. Normal values are average of years (Total rainfall-1972-2004; Maximum and Minimum Temperature -1976-2004; Relative humidity - 1976-2004).

3. 2. Soil fertility status

Soil fertility status was accessed by availability of organic carbon (OC), N, P₂O₅ and K₂O content in the soil after harvest of groundnut. The soil fertility status was differed significantly due to tillage and nutrient management practices (Table 4 and 5). Among tillage practices, greater improvement in organic carbon content was recorded with conventional tillage + one intercultivation (0.62%) as compared to rest of the tillage practices. However, lower organic carbon was observed with mechanical tillage + two intercultivations (0.57%). This might be due to deep tillage by tractor drawn disc plough associated with maximum disturbance of soil which enhanced the oxidation processes in soil thereby lower the organic carbon content in soil. However, mechanical tillage + two intercultivations treatment recorded higher availability N, P₂O₅ and K₂O in soil after harvest of groundnut (195.7, 35.88 and 214.8 kg ha⁻¹, respectively) over other tillage practices and which was on par with that of mechanical tillage + one intercultivation except K₂O availability.

These results are in conformity with the findings of Vijay Kumar *et al.* (1999) who reported that the mean pod yield of groundnut was highest with treatment disc plough once + disc harrow once (tractor drawn) closely followed by that of rotavator and lowest was recorded in tillage with country plough. Among nutrient management practices, the increase in organic carbon content of soil was recorded with application of 100% organics (0.65%) followed by integrated application of 50% organics + 50% inorganics (0.59%). However, integrated application of 50% organics + 50% inorganics recorded higher availability N, P₂O₅ and K₂O after harvest of groundnut (195.1, 34.46 and 207.6 kg ha⁻¹, respectively) over rest of the treatments. These results are in conformity with the findings of Tolanur and Badanur (2003) and Bajpai *et al.* (2006). However, the interaction between tillage and nutrient management practices were found to be non-significant with respect to soil fertility status.

Table 4. Soil organic carbon content as influenced by tillage and nutrient management practices.

Tillage practices (T)	Nutrient management practices (F)			
	Organic carbon content (%)			
	F ₁	F ₂	F ₃	Mean
T ₁ = Conventional tillage + one intercultivation	0.67	0.58	0.60	0.62
T ₂ = Conventional tillage + two intercultivations	0.66	0.54	0.60	0.60
T ₃ = Mechanical tillage + one intercultivation	0.63	0.54	0.60	0.59
T ₄ = Mechanical tillage + two intercultivations	0.64	0.52	0.56	0.57
Mean	0.65	0.54	0.59	
For comparison of means	SEm±		CD (p=0.05)	
Tillage (T)	0.005		0.018	
Nutrient management (F)	0.004		0.013	
F at same level of T	0.009		NS	
T at same or different levels of F	0.009		NS	
Initial status	0.56			

NS= non-significant; F₁= 100% organics; F₂= 100 % inorganics; F₃= 50% organics + 50% inorganics

Table 5. Available N, P₂O₅ and K₂O in the soil after the harvest of groundnut as influenced by tillage and nutrient management practices.

Tillage practices (T)	Nutrient management practices (F)											
	N (kg ha ⁻¹)				P ₂ O ₅ (kg ha ⁻¹)				K ₂ O (kg ha ⁻¹)			
	F ₁	F ₂	F ₃	Mean	F ₁	F ₂	F ₃	Mean	F ₁	F ₂	F ₃	Mean
T ₁ = Conventional tillage + one intercultivation	192.1	183.3	188.4	187.9	28.3	27.5	30.9	28.9	195.1	176.2	205.1	192.1
T ₂ = Conventional tillage + two intercultivations	189.6	186.8	192.3	189.6	31.7	30.1	31.8	31.2	195.9	197.3	206.8	200.0
T ₃ = Mechanical tillage + one intercultivation	195.9	187.8	197.4	193.7	35.4	31.4	36.3	34.4	205.8	210.8	208.2	208.3
T ₄ = Mechanical tillage + two intercultivations	196.8	188.2	202.3	195.7	36.0	32.8	38.9	35.9	220.0	213.9	210.6	214.8
Mean	193.6	186.5	195.1		32.9	30.5	34.5		204.2	199.5	207.6	
For comparison of means	SEm ±		CD (p=0.05)		SEm ±		CD (p=0.05)		SEm ±		CD (p=0.05)	
Tillage (T)	0.62		2.16		0.49		1.71		1.13		3.92	
Nutrient management (F)	0.86		2.58		0.41		1.23		1.02		3.07	
F at same level of T	1.72		NS		0.82		NS		2.05		NS	
T at same or different levels of F	1.54		NS		0.83		NS		2.02		NS	
Initial status	189.6				29.3				202.8			

NS= non-significant; F₁= 100% organics; F₂= 100 % inorganics; F₃= 50% organics + 50% inorganics.

3. 3. Pod and haulm yield

The pod and haulm yield of groundnut varied significantly due to various tillage and nutrient management practices but interaction effect was non-significant (Table 6). The results indicated that, significantly higher pod and haulm yield of groundnut was recorded with minimum disturbance of soil with mechanical tillage + two intercultivations (1307 and 2733 kg ha⁻¹, respectively) and was closely followed by mechanical tillage + one intercultivation (1215 and 2693 kg ha⁻¹, respectively). However, lowest value was recorded with conventional tillage + one intercultivation (1081 and 2538 kg ha⁻¹, respectively). Similarly, effect of different tillage on pod and haulm yield was also reported by Sutaria *et al.* (2010). Rabo and Ahmed (2013) reported that decreased of pod yield from 200.38 kg ha⁻¹ to 110.25 kg ha⁻¹ as the tillage practices are increased from zero tillage to maximum tillage, respectively.

The increase in yields of groundnut under tractor drawn tillage treatment was mainly due deep ploughing with tractor drawn implements may be due to the reason that the soil became softer and needles were facilitated for penetration in to the soil. Deep ploughing might be resulted in better conservation of soil moisture, which ultimately was used more efficiently by the crop for longer periods as compared with shallow ploughing. Similar explanations were given by Akhtar *et al.* (2005) and Anonymous (2006). Howell (2011) further noticed that deep tillage in the seed furrow may have allowed more water to be held when rainfall occurred than in the conventional tilled plots.

Table 6. Haulm yield of groundnut as influenced by tillage and nutrient management practices.

Tillage practices	Nutrient management practices											
	Haulm yield (kg ha^{-1})				Pod yield (kg ha^{-1})				Harvest index			
	F ₁	F ₂	F ₃	Mean	F ₁	F ₂	F ₃	Mean	F ₁	F ₂	F ₃	Mean
T ₁ = Conventional tillage + one intercultivation	2203	2809	2604	2538	996	1082	1164	1081	0.311	0.278	0.309	0.300
T ₂ = Conventional tillage + two intercultivations	2247	2814	2722	2594	1029	1176	1254	1153	0.314	0.295	0.315	0.308
T ₃ = Mechanical tillage + one intercultivation	2343	2946	2789	2693	1114	1215	1316	1215	0.322	0.292	0.321	0.312
T ₄ = Mechanical tillage + two intercultivations	2410	2985	2803	2733	1217	1312	1393	1307	0.335	0.305	0.332	0.324
Mean	2301	2889	2729		1089	1196	1282		0.321	0.293	0.319	
For comparison of means	SEm±		CD ($p=0.05$)		SEm±		CD ($p=0.05$)		SEm±		CD ($p=0.05$)	
Tillage (T)	20.1		69.7		6.9		23.9		6.9		23.9	
Nutrient management (F)	13.0		39.0		7.0		21.0		7.0		21.0	
F at same level of T	26.001		NS		14.0		NS		14.0		NS	
T at same or different levels of F	29.256		NS		13.4		NS		13.4		NS	

NS= non-significant; F₁= 100% organics; F₂= 100 % inorganics; F₃= 50% organics + 50% inorganics

The integrated use of organic and inorganic nutrient sources (50% organics + 50% inorganics) produced significantly higher pod yield of groundnut (1282 kg ha^{-1}) than 100% inorganics (1196 kg ha^{-1}) and 100% organics (1089 kg ha^{-1}). However, haulm yield was significantly higher in application of 100% inorganics (2889 kg ha^{-1}) compared to application of 50% organics + 50% inorganics (2729 kg ha^{-1}) and 100% organics (2301 kg ha^{-1}). It may be due to application inorganic N fertilizer with organic sources is known to reduce the C:N ratio and stimulate the mineralization of organic N that intern resulted in higher yields (Malligawad *et al.* 2000).

3. 4. Harvest index

Harvest index of groundnut differed significantly due to various tillage practices and nutrient management practices, but not due to their interactions effect (Table 6). Mechanical

tillage + two intercultivations treatment noticed maximum harvest index (0.324) as compared to rest of the treatments. It was closely followed by mechanical tillage + one intercultivation (0.312). Application of 100% organics recorded significantly maximum harvest index of groundnut (0.321) and which was on par with that of 50% organics + 50% inorganics (0.319).

3. 5. Economics

The gross returns, net returns and benefit-cost ratio of groundnut were presented in Table 7. Among the tillage practices, mechanical tillage + two intercultivations recorded higher net returns (Rs. 11,287 ha⁻¹) and was closely followed by mechanical tillage + one intercultivation (Rs. 9,308 ha⁻¹). The higher net returns in mechanical tillage + two intercultivations was attributed to maximum gross returns (Rs. 26,243 ha⁻¹) realized with relatively lower cost of cultivation. The highest benefit-cost ratio of 1.75 was obtained with the same treatment *i.e.*, mechanical tillage + two intercultivations, closely followed by mechanical tillage + one intercultivation (1.61). However, the lowest net returns and benefit-cost ratio was realized with conventional tillage + one intercultivation (Rs. 6,297 ha⁻¹ and 1.41, respectively). This was due to lower pod and haulm yield of groundnut (1081 and 2538 kg ha⁻¹, respectively) compared to rest of the tillage practices. Integrated application of 50% organics + 50% inorganics recorded higher gross and net returns (Rs. 25,771 and 10,462 ha⁻¹) and also higher benefit-cost ratio (1.69) as compared to either 100% organics and inorganics. However, lower gross returns, net returns and benefit-cost ratio were noticed with application of 100% organics (Rs. 21,873 ha⁻¹, 7,185 ha⁻¹ and 1.49, respectively). This might be due to lower pod and haulm yield (1089 and 2301 kg ha⁻¹, respectively). Application of 50% N through urea + 50% N through FYM recorded higher net return and BC ratio (Sutaria *et al.*, 2010). Similarly, Godsey *et al.* (2011) noticed that the reduced tillage system saved \$93 ha⁻¹ and generated \$179 ha⁻¹ more revenue compared to the conventional tillage system. Reduced tillage practices, especially no-till, seem to be a good fit for Southwestern US peanut production areas.

Table 7. Cost of cultivation, gross returns, net returns and benefit cost ratio as influenced by tillage and nutrient management practice in groundnut.

Treatment combinations	Cost of cultivation (Rs. ha ⁻¹)	Gross returns (Rs. ha ⁻¹)	Net returns (Rs. ha ⁻¹)	Benefit-cost ratio
T ₁ F ₁	15,010	20,082	5,072	1.34
T ₁ F ₂	16,225	22,152	5,927	1.37
T ₁ F ₃	15,617	23,508	7,891	1.51
T ₂ F ₁	14,815	20,723	5,908	1.40
T ₂ F ₂	16,030	23,883	7,853	1.49
T ₂ F ₃	15,377	25,255	9,878	1.64
T ₃ F ₁	14,560	22,370	7,810	1.54
T ₃ F ₂	15,775	24,712	8,937	1.57
T ₃ F ₃	15,267	26,444	11,177	1.73

T ₄ F ₁	14,365	24,315	9,950	1.69
T ₄ F ₂	15,530	26,538	11,008	1.71
T ₄ F ₃	14,972	27,875	12,903	1.86

NS= non-significant; T₁= Conventional tillage + one intercultivation; T₂= Conventional tillage + two intercultivations; T₃= Mechanical tillage + one intercultivation; T₄= Mechanical tillage + two intercultivations; F₁= 100% organics; F₂= 100 % inorganics; F₃= 50% organics + 50% inorganics

4. CONCLUSION

The study indicated that mechanical tillage followed by intercultivations was helps in improving the soil fertility status as well as productivity of groundnut. But, deep tillage with tractor drawn implement associated with maximum disturbance of soil which enhanced the oxidation processes in soil thereby which resulted lower organic carbon status in soil. Farmyard manure is one of the important organic source of nutrient that improves the soil properties and use efficiency of applied chemical fertilizers. The supplementary and complementary use of organic manures along with chemical fertilizers, besides improving soil fertility also improves the productivity of groundnut under rainfed conditions. Integrated application of organic and inorganic sources of nutrient found to be improvement in soil fertility and productivity of groundnut, but increase in organic carbon content of soil was recorded with application of organics source of nutrients alone.

References

- [1] Akhtar J., Mehdi S. M., Obaid-ur-Rehman, Mahmood, K., Sarfraz, M., *Journal of Agriculture and Social Sciences* 1(2) (2005) 98-101.
- [2] Akhtar M. E., Campbell J. A., Arain M. Y. (1994). Impact of different tillage implements on wheat crop under barani conditions. In: *Proc. Efficient Use of Plant Nutrients*, pp. 419-422. 4th Natl. Cong. Soil Sci. May 24-26, 1992 at Islamabad.
- [3] Anonymous (2006) *Annual Progressive Report*, 2005-06, NRCG, Junagadh, pp.1-4.
- [4] Anonymous (2013). Directorate of Economics and Statistics, Department of Agriculture and Cooperation, India.
- [5] Atkinson H. S., Sparkes D. L., Mooney S. J., *Soil and Tillage Research* 97(2) (2007) 218-228.
- [6] Bajpai R. K., Chitale S., Upadhyay S. K., Urkurkar J. S., *Journal of Indian Society of Soil Science* 54 (2006) 24-29.
- [7] Campbell J. A., Akhtar M. E., Robertson G. W. (1994). Water balance and deep tillage in rainfed agriculture of the potowar plateau of Pakistan. In: *Proc. Efficient Use of Plant Nutrients* pp. 439-450. 4th Natl. Cong. Soil Sci. May 24-26, 1992 at Islamabad.
- [8] Carman K., *Soil and Tillage Research* 40(3-4) (1997) 201-207.
- [9] Chad B., Godsey, Jeffrey Vitale, Phil G., Mulder, Jon-Joseph Q., Armstrong, John P., Damiconi, Ken Jackson, Kelly Suehs, *Peanut Science* 38(1) (2011) 41-47.

- [10] Donald C. M., *Journal of Australian Institute of Agricultural Science* 28 (1962) 171-178.
- [11] Drake W. L., Jordan D. L., Johnson, Shew, B. B., Brandenburg R. L., Corbett T., *Agronomy Journal* 106(2) (2014) 486-490.
- [12] Fageria N. K., Baligar V. C., Jones C. A. (1997). *Growth and Mineral Nutrition of Field Crops*. p. 494. Marcel Dekker, Inc., NY, USA.
- [13] FAO (2013). Regional office for Asia and the Pacific, Bangkok.
- [14] Gomez K. A., Gomez A. A. (1984). John Wiley and Sons. New York, pp. 1-680.
- [15] Howell, M. (2011). Evaluation of Tillage Systems as Related to Peanut Yield. Extending Agricultural Information, Mississippi Crop Situation.
<http://www.mississippi-crops.com/2011/01/24/160/#sthash.EB7K5CtV.dpuf>
- [16] Jackson M. K. (1973). Prentice-Hall. Nc. Engle wood cliffs, New Jersey.
- [17] Malligawad L. H., Patil P. K., Vidhyadhar K., Giriraj K., *Karnataka Journal of Agricultural Science* 13 (2000) 299-305.
- [18] Ozpinar S., Cay A., *Soil and Tillage Research* 88(1-2) (2006) 95-106.
- [19] Ozpinar S., Isik A., *Soil and Tillage Research* 75(1) (2004) 19-26.
- [20] Piper C. S. (1966) *International Science Publications*, Inc. New York.
- [21] Rabo A. S., Ahmed H. G., *International Journal of Scientific and Technology Research* 2(7) (2013) 204-206.
- [22] Rashid A., Gill K.H., Nawaz S., Hussain B., Niazi N.K. (1994). Conservation Farming: A concept for sustainable crop production in Punjab rainfed area. In: *Proc. Efficient Use of Plant Nutrients* pp. 523-533. 4th Natl. Cong. Soil Sci. May 24-26, 1992 at Islamabad.
- [23] Rashidi M., Keshavarzpour F., *International Journal of Agriculture and Biology* 9(2) (2009) 274-277.
- [24] Rasmussen K. J., *Soil and Tillage Research* 53(1) (1999) 3-14.
- [25] Reddy D. S., Reddy D. R., Chary G. V., *Annals of Arid Zone* 16 (1987) 149-52.
- [26] Srivastava A. K., Goering C. E., Rohrbach R. P., Buckmaster D. R. (2006). *Engineering Principles of Agricultural Machines*. 2nd Edition, American Society of Agricultural Biological Engineers, Michigan.
- [27] Subbaiah B. V., Asija G. L., *Current Science* 31 (1956) 196.
- [28] Sutaria G. S., Ramdevputra M. V., Akbari K. N., Vora V. D., Padmani D. R., *Legume Research - An International Journal* 33(2) (2010) 131-133.
- [29] Tolanur S. I., Badanur V. P., *Journal of Indian Society of Soil Science* 51 (2003) 41-44.
- [30] Tripathi R. P., Sharma P., Singh S., *Soil and Tillage Research* 92 (2007) 221-226.
- [31] Vepraskas M. J., Mirer G.S., Peeding G.F. *Soil Science Society of America Journal* 50 (1986) 1541-1546.
- [32] Vijay Kumar C., Rama Rao S. M., Singa Rao, Prabhu Prasadini R., *Journal of Oilseeds Research* 16 (1999) 362-366.

- [33] Walkley A. J., Black C. A., *Soil Science* 37 (1934) 28-29.
- [34] Wright D., Marois J., Rich J., Sprenkel R., (2008). Field Corn Production Guide - SS-AGR-85. Available online: <http://edis.ifas.ufl.edu/pdffiles/AG/AG20200.pdf>.

(Received 23 October 2014; accepted 31 October 2014)