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Full Research Article

Effect of Tillage and Organic Manures on Soil Moisture and Performance of Rainfed Groundnut (*Arachis hypogea* L.)

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Abstract

A field experiment was conducted during rainy season of 2000 to 2005 on medium black clay soil at Main Dry Farming Research Station, JAU, Targhadia (Rajkot) to find out suitable tillage practice with organic manure for obtaining higher yield of groundnut. Main plot comprised of three tillage practices viz., every year deep ploughing in set row furrows, alternate year deep ploughing in alternate set row furrows and farmer's practice (opening the set row furrows only) and sub-plot of two organic manures viz., farm yard manure @ 5 t ha^{-1}, farm residues @ 5 t ha^{-1} and control (no organic manure) were evaluated in split plot design with four replications. Significantly higher pod yield were recorded under alternate year deep ploughing in alternate set row furrows and FYM @ 5 t ha^{-1} as compared to farmers practice and farm residues @ 5 t ha^{-1}, respectively. The soil moisture content was found non-significant due to tillage practices, while it was recorded significantly higher under application of FYM @ 5 t ha^{-1} and farm residues @ 5 t ha^{-1} than control. Similarly, significantly higher soil moisture content was also recorded under the combination of every year deep ploughing in set row furrows and FYM @ 5 t ha^{-1}. Alternate year deep ploughing in alternate set row furrows gave the highest net returns of ₹ 13742 ha^{-1} with the B:C ratio of 1.96. While application of FYM @ 5 t ha^{-1} gave the highest net returns of ₹ 13888 ha^{-1} with B:C ratio of 1.89.

1. Introduction

Groundnut is the most important oilseed crop being grown in Saurashtra region under rainfed conditions. Low and unstable crop yields are common phenomena in dry farming area due to low, erratic and uneven distribution of rainfall. Soil-related constraints that exacerbate drought stress include crusting and compaction, low water infiltration rate, low water retention capacity, high surface runoff, and high losses due to soil evaporation (Lal, 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 (Ozpinar and Cay, 2006; Rashidi and Keshavarzpour, 2007). Beside tillage, addition of organic manures helps to bring the soil tilth. They are not only the source of nutrients but also improve the physical properties resulting in better soil structure, increase water holding capacity, hydraulic conductivity in soil and more favourable environment for root growth and better infiltration of water. Since last several years, the problem of moisture conservation is severe and crop suffers due to moisture stress, and ultimately crop yield was reducing drastically in rainfed area of Saurashtra region. Deep tillage with organic manure conserved higher amount of soil water and resulted in increased crop yields (Patil and Sheelavanta, 2006). But there is inadequate information on the effect of deep tillage and organic manures on soil moisture conservation and productivity of groundnut under rainfed farming systems in the North Saurashtra Agro-climatic Zone of Gujarat. Keeping in mind this aspect, a field experiment was undertaken to find out suitable tillage practice with organic manure for obtaining higher yield of groundnut.

2. Materials and Methods

The field experiment was conducted on medium black clay soil (Vertisol) at Main Dry Farming Research Station, Junagadh Agricultural University, Targhadia (Rajkot) during the rainy (*kharif*) season of 2000-01 to 2005-06. The experimental area is located at 20°17′ N. latitude 70°48′ E. longitude and at an altitude of 137.7 m above the mean sea level. The soil was clayey, medium in available nitrogen (285.6 Kg ha^{-1}) and

phosphorus (36.6 kg ha^{-1}) and high in available potassium (418 kg ha^{-1}) with mildly alkaline (7.92 pH) and non-saline (EC 0.34 dS m^{-1}). The experiment was laid out in split-plot design keeping 9 treatment combinations, involving main plot with three tillage practices viz., every year deep ploughing in set row furrows (T_1), alternate year deep ploughing in alternate set row furrows (T_2) and farmer's practices (T_3) and sub plot with three organic manure treatments viz., farm yard manure @ 5 t ha^{-1} (O_1), farm residues @ 5 t ha^{-1} (O_2) and control (no organic manure) (O_3) in four replications. Deep ploughing was carried out by sub-soiler up to 25 cm depth in set row furrows after farmer practice of tillage in summer as per treatments. In farmer practice of tillage, no deep ploughing but only primary and secondary tillage was carried by sweep cultivator and blade harrow and opened the set row furrows at the distance of 60 cm with 10 cm depth. Organic manures were applied in sub-plots as per treatments after main plot treatment imposed and one light blade harrow passed after application of organic manures. Groundnut (GG-20) was sown by tractor drawn seed drill in month of June or July after onset of monsoon with recommended package of practices. The total rainfall received during the crop season (June to November) was 372.5, 411.6, 311.0, 803.2, 878.9 and 1136.2 mm in 18, 33, 11, 41, 35 and 38 rainy days in the year of 2000, 2001, 2002, 2003, 2004 and 2005, respectively. Soil sample (0-20 cm depth) was taken in morning time from each treatment for soil moisture content during dry spells of crop growth period. Soil moisture content was estimated by gravimetric methods. At maturity, pod yields and haulm yields from the net plot in different treatments were recorded after through sun drying and the yields were expressed in kg ha^{-1}. The experimental data were subjected to statistical analysis adopting Fisher's method of analysis of variance as out lined by Gomez and Gomez (1984). The level of significance used in 'F' test was given at 5%. Critical difference (CD) values are given in the Table at 5% level of significance, wherever the 'F' test was significant at 5% level. Productivity of groundnut and moisture content (%) were pooled over four years (2001, 2003, 2004 and 2005) because pod yield of groundnut was recorded below average in remaining years (2000 and 2002). Economics of different treatments was worked out on the basis of pooled results of pod and haulm yield of groundnut in terms of gross and net returns ₹ ha^{-1} and B:C ratio considering the prevailing market price of produce and cost of cultivation.

3. Results and Discussion

3.1. Soil Moisture content (%)

3.1.1. Effect of tillage practices (T)

All eight sampling of soil and in pooled results, the soil moisture content (%) was found to be non-significant due to tillage practices (Table 1). However every year deep ploughing in set row furrows (T_1) and alternate year deep ploughing in alternate set row furrows (T_2) often retained higher moisture content than farmers practice (T_3) in all eight sampling of soil. While on the basis of pooled results, alternate year deep ploughing in alternate set row furrows (T_2) often retained slightly higher moisture content (32.47%) followed by every year deep ploughing in set row furrows (32.39%) than farmers practice (31.52%). This might be due to higher infiltration and lower loss of rain water through runoff in deep ploughing treatments than farmer's practices. Ghosh et al. (2006); Patil and Sheelavantar (2006) also reported higher soil water storage due to deep ploughing.

3.1.2. Effect of organic manures (O)

The soil moisture content (%) was found to be significant in three out of eight sampling of soil and in pooled results

Table 1: Soil moisture content (%) as influenced by tillage and organic manures

Treatments	27.8.01	23.6.03	1.8.03	6.9.03	3.7.04	24.8.04	11.8.05	30.9.05	Pooled
A. Tillage practices (T)									
T_1	25.64	35.80	32.59	32.47	30.68	30.81	35.68	35.42	32.39
T_2	24.76	36.48	32.54	32.19	30.31	31.31	36.35	35.80	32.47
T_3	24.64	34.78	32.21	31.93	29.31	31.09	33.43	34.78	31.52
SEm±	0.72	1.05	0.52	0.50	0.77	0.52	0.85	0.52	0.25
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
B. Organic manures (O)									
O_1	25.46	35.78	31.93	31.59	29.58	31.07	36.69	36.07	32.27
O_2	25.16	37.38	34.18	33.67	31.71	31.88	35.59	35.51	33.16
O_3	24.43	33.89	31.24	31.33	29.02	30.27	33.18	34.42	30.97
SEm±	0.86	0.82	0.64	0.87	0.61	0.81	0.98	0.74	0.28
CD (p=0.05)	NS	2.44	1.90	NS	1.82	NS	NS	NS	0.79
C. Interaction effect (T×O)									
SEm±	1.49	1.42	1.11	1.50	1.06	1.40	1.70	1.29	0.49
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	1.37

(Table 1). Significantly highest soil moisture content was recorded under application of farm residues @ 5 t ha^{-1} (O_2) in all three sampling of soil as compared to application of FYM @ 5 t ha^{-1} (O_1) and control (O_3) except in first sampling in the year of 2001, in this year it was remained at par with application of FYM @ 5 t ha^{-1} (O_1). This may be attributed to decreasing the loss of runoff water and increasing infiltration due to application of farm residues act as vertical mulch in set furrow (Bhatt and Khera, 2006). While on the basis of pooled results, it was recorded significantly higher under application of FYM (32.27%) and farm residues (33.16%) as compared to control (30.97%). This could be attributed to the lower soil temperature, reduce evaporation and improve soil structure resulting in better *in situ* moisture conservation (Patil and Sheelavantar, 2006; Vekariya et al., 2014).

3.1.3. Interaction effect (T×O)

Interaction effect of tillage practices and organic manure was found non-significant during all the eight sampling of soil in respect of soil moisture content (%), but it was turned out significant in pooled results (Table 2). Significantly higher soil moisture content was recorded under the combination of every year deep ploughing in set row furrows and farm residues @ 5 t ha^{-1} (T_1O_2), followed by alternate year deep ploughing in alternate set row furrows and FYM @ 5 t ha^{-1} (T_2O_1) and farmers practice of tillage and farm residues @ 5 t ha^{-1} (T_3O_2), while significantly lower soil moisture content was recorded under the combination of farmers practice of tillage and control (no organic manure). This might be attributed to the improvement of physical properties of soil through deep tillage with organic manures resulting in higher soil moisture conservation (Patil and Sheelavantar, 2006). On the other hand, farmer practice of tillage without organic manure in set raw furrow have no particular advantage because much of rainfall is lost as runoff (Bhan, 2007).

3.2. Pod yield of groundnut

3.2.1. Effect of tillage practices (T)

The pod yield of groundnut was found to be significant in two out of four years of experimentation and in pooled results (Table 3). Significantly highest pod yield was recorded under alternate year deep ploughing in alternate set row furrows (T_2) as compared to every year deep ploughing in set row furrows (T_1) and farmers practice (T_3) in the year of 2001 and 2005, but it was remained at par with every year deep ploughing in set row furrows (T_1) in pooled results. The better results of deep ploughing may be due to the reason that the soil became softer and needles were facilitated for penetration in to soil. While in remaining years, it was found non-significant but recorded maximum pod yield of groundnut under every year deep ploughing in set row furrows (T_1) and alternate year deep ploughing in alternate set row furrows (T_2) as compared farmers practice (T_3) in the year 2003 and 2004, respectively. On the basis of pooled results, pod yield of groundnut was significantly increased in the tune of 14.57 and 7.75% by alternate year deep ploughing in alternate set row furrows over farmers practice and every year deep ploughing in set row furrows, respectively owing to higher moisture content in soil profile. 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 tillage. Similar explanation were given by Akhtar et al. (2005) in groundnut. Jat et al. (2013) also reported that summer deep ploughing alone increased black gram seed yield by 16 to 21% over shallow tillage due to lower runoff and soil loss.

Table 2: Interaction effect of tillage and organic manures on soil moisture content (%) in pooled results

T/O	O_1	O_2	O_3
T_1	31.96	34.17	31.04
T_2	32.83	32.25	32.32
T_3	32.02	33.03	29.56
SEm±0.50		CD (p=0.05) 1.37	

3.2.2. Effect of organic manures (O)

The pod yield of groundnut was found to be significant during all the four years and in pooled results (Table 3). Significantly highest pod yield of groundnut was recorded under application of FYM @ 5 t ha^{-1} (O_1) as compared to farm residues @ 5 t ha^{-1} (O_2) during all the four years and in pooled results, but it was remained at par with control (O_3) in the year of 2001 and 2004 and in pooled results. On the basis of pooled results, pod yield of groundnut was significantly increased in the tune of 27.99 and 13.13% by application of FYM @ 5 t ha^{-1} over farm residues @ 5 t ha^{-1} and control, respectively. The increased in pod yield observed in application of FYM over the control could be partly due to more favourable moisture regime in the root zone and partly due to more efficient utilization of nutrients released from decomposition of the added FYM. While reduction in pod yield due to application of farm residues, nitrogen might have been temporally immobilized and become unavailable for attaining optimum crop yield than control. Similar results were reported by Khan et al. (2009) in maize and Vekariya et al. (2014) in groundnut.

3.2.3. Interaction effect (T×O)

Interaction effect of tillage practices and organic manures was found non-significant during all the four years and in pooled result in respect of pod yield of groundnut.

3.3. Haulm yield of groundnut

3.3.1. Effect of tillage practices (T)

The haulm yield of groundnut was found to be non-significant during all the four years and in pooled results (Table 3). However it was recorded comparatively higher under alternate

Table 3: Pod and haulm yield of groundnut (kg ha^{-1}) as influenced by tillage and organic manures

Treatments	2001		2003		2004		2005		Pooled	
	Pod	Haulm	Pod	Haulm	Pod	Haulm	Pod	Haulm	Pod	Haulm
A. Tillage practices (T)										
T_1	1368	4807	1458	3454	601	2542	804	2838	1058	3410
T_2	1588	4783	1391	3435	672	2576	909	3009	1140	3451
T_3	1276	4915	1313	3285	621	2611	771	2637	995	3362
Mean	1411	4835	1387	3391	631	2576	828	2828	1064	3408
SEm±	47	207	111	97	57	73	27	124	34	67
CD (*p*=0.05)	163	NS	NS	NS	NS	NS	92	NS	99	NS
B. Organic manures (O)										
O_1	1561	4969	1643	3963	692	2625	897	3042	1198	3650
O_2	1288	4738	1103	2823	565	2694	786	2709	936	3241
O_3	1383	4799	1415	3388	637	2410	801	2733	1059	3332
Mean	1411	4835	1387	3391	631	2576	828	2828	1064	3408
SEm±	71	138	63	99	25	39	30	86	51	133
CD (*p*=0.05)	211	NS	188	295	75	115	89	257	177	NS
C. Interaction effect (T×O)										
SEm±	123	239	110	172	43	67	52	150	45	84
CD (*p*=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

year deep ploughing in alternate set row furrows (T_2) than farmers practice (T_3) in the years of 2003, 2005 and in pooled results.

3.3.2. Effect of organic manures (O)

The haulm yield of groundnut was found to be significant in three out of four years, but it was turned out non-significant in pooled results (Table 3). Significantly highest haulm yield of groundnut was recorded under application of FYM @ 5 t ha^{-1} (O_1) as compared to farm residues @ 5 t ha^{-1} (O_2) and control (O_3) in the years 2003 and 2005. Whereas in the year of 2004, it was recorded significantly highest under application of farm residues @ 5 t ha^{-1} (O_2) as compared to control and remained at par with the application of FYM. @ 5 t ha^{-1} (O_1). While in remaining year of 2001 and in pooled results, it was recorded comparatively higher under application of FYM @ 5 t ha^{-1} (O_1) than farm residues @ 5 t ha^{-1} (O_2) and control (O_3).

On the basis of pooled results, haulm yield of groundnut was significantly increased in the tune of 12.62 and 9.54% by application of FYM @ 5 t ha^{-1} over farm residues and control, respectively. Similar finding were also reported by Khan et al. (2009) in maize and Vekariya et al. (2014) in groundnut.

3.3.3. Interaction effect (T×O)

Interaction effect of tillage practices and organic manure was found non-significant during all the four years and in pooled result in respect of haulm yield of groundnut.

3.4. Economics

Economics of groundnut as influenced by tillage practices and organic manures (Table 4) revealed that highest gross returns, net returns and B:C ratio was obtained under alternate year

Table 4: Economics of groundnut as influenced by tillage and organic manures

Treatments	Gross return (₹ ha^{-1})	Cost of cultivation (₹ ha^{-1})	Net return (₹ ha^{-1})	B:C ratio
A. Tillage practices (T)				
T_1-Every year deep ploughing in set row furrows	26393	14850	11543	1.78
T_2-Alternate year deep ploughing in alternate set row furrows	27992	14250	13742	1.96
T_3-Control-farmers practice	25132	13650	11482	1.84
B. Organic manures (O)				
O_1-Farm yard manures @ 5 t ha^{-1}	29463	15575	13888	1.89
O_2-Farm residues @ 5 t ha^{-1}	23790	15300	8490	1.55
O_3-Control	26256	14250	12006	1.84

deep ploughing in alternate set row furrows than every year deep ploughing in set row furrows. While, application of FYM @ 5 t ha^{-1} gave the highest gross and net return and B:C ratio than farm residues @ 5 t ha^{-1}.

4. Conclusion

Alternate year deep ploughing in alternate set row furrows up to 25 cm depth and application of FYM @ 5 t ha^{-1} was found better for obtaining higher yield of groundnut and net returns with B:C ratio as well as conserving maximum soil moisture in root zone in medium black soils under rainfed condition of North Saurashtra Agro-climatic Zone of Gujarat.

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