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Full Length Research Paper

Assesment of soil fertilty at different working depths of moldboard plow under silty loam soil

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A field experiment was conducted to determine the soil fertility influenced by moldboard plow. The composite soil samples were drawn from the depths of 0 to 5, 5 to 10, 10 to 15, 15 to 20 and 20 to 25 cm respectively, in order to ascertain the physiochemical properties of soil. Results obtained from the present experiment are summarized as; the total soluble salts in the experimental area showed that the soil was not saline. The soil pH remained almost consistent before and after plowing. The total calcium carbonate clearly showed that the soils were calcareous in nature that was more in the top layers. The organic matter in the top layers was more than that of the lower layers. Moreover, significant increase in the organic matter was observed after plowing the soil to the depth of 0 to 15 cm only. Furthermore, the total nitrogen was more in surface layers as compared to lower layers and also turning the soil with moldboard plow did not change total nitrogen.

Key words: Organic matter, soil fertility, soil reaction, working depths and moldboard plow.

INTRODUCTION

Tillage method is the mechanical manipulation of the soil to improve soil conditions for crop production (Olatunji, 2007). Agricultural tillage implements are extensively used to enhance agricultural production, for example, increasing infiltration rate, soil fertility, improving plant rooting and controlling the erosion (Ellison, 1947; Lindstrom et al., 1990). Most common tillage implements are; disc plows, moldboard plow and chisel plow etc.

The Government of Pakistan is endeavoring to provide the best facilities to increase agricultural production, keeping in view achieving self sufficiency in food and fiber. Among these measures, soil fertility is most important where considerable attention is being paid in respect of the basics as well as, the applied research. Besides this, the mechanized cultivation is being emphasized throughout Pakistan to boost up agricultural production. The farmers are being trained to use primary tillage equipments such as mould board plough, disc plough and sub-soilor etc, to break down many types of soils, prepare seed bed and incorporate crop residues etc. With the use of mould board plough basic problems of mechanized farming to soil characteristics need necessary attention, because of the fact that there is a fairly good relationship with the touch of the mouldboard on the soil and its physiochemical characteristics. The impact of the moldboard plowing on the chances of the soil characteristics is more important in soil types having finer particles than sands.

Today, agriculture should maintain itself by sustaining

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Abbreviations: D, depth of plow; **B,** before plowing; **A,** after plowing; **S.L,** silty loam; **S.E,** standard error; **D,** cumulative distribution; ***,** significant; ****,** highly significant.

Table 1. Experiment details of Latif farm.

S/no.	Activity	Particulars
1	Working depths of the moldboard plow	0-10, 0-15, 0-20 and 0-25 cm
2	Replications	3
3	Number of Plots	12 Plot size (5 × 30 m)

Table 2. Procedures for the determination of soil physical and chemical properties.

S/no.	Determinations	Methods
1	Mechanical analysis (texture)	Bouyoucos hydrometer method (Kanwar and Chopra,1969)
2	Water holding capacity	Gravimetric method (Black,1965)
3	Total soluble salts	TDS portable digital meter method
4	Soil reaction (pH)	pH portable digital meter method
5	Total calcium carbonate	Acid neutralization (Kanwer and Chopra,1969)
6	Organic matter	Walkley black method Walkey,1947)
7	Total nitrogen	Kkjeldhal method (Rowell,1994a)
8	Available phosphorous	Spectrophotometer (Rowell,1994b)
9	Available potassium	Flame Photometer (Singh et al., 1999)

soil fertility, protecting groundwater, developing renewable energies, and adapting farming systems to climate change (Lichtfouse et al., 2009). The application of new technological principles in tillage and the use of economically more efficient but heavier tractors and agricultural machinery raise higher requirements for soil physical properties. Soil physical properties are linked mainly with organic constituents that are often considered to be the main indicator of soil fertility (Pernes–Debuyser and Tessier, 2004).

The major objective of this study was to evaluate the performance of a medium sized moldboard plow with three bottoms to investigate the effects of plowing depths on the changes in soil fertility.

MATERIALS AND METHODS

The study was conducted from 2008 to 2009 at Latif Experimental Farm, Sindh Agriculture University, Tandojam, Sindh, Pakistan (Table 1). Mould plough was hitched behind the Massey Ferguson Tractor. The four soil cutting depths adjustments were evaluated in completely randomized block design. The experimental soil was silty loam in condition and was fallow and dry at the time of the plowing. The details of the experiment are as follows (Benton, 2001):

Soil sampling

Pre and post composite soil samples were collected at 0 to 10, 0 to 15, 0 to 20 and 0 to 25 cm depths for the determination of soil physical and chemical properties. The following procedures were adopted for the analysis of each parameter (Table 2). All experimental data were subjected to analysis of statistical procedures as outlined by Fred (2001).

RESULTS AND DISCUSSION

It is usually customary to use a mould board plough for turning the soil. Such type of plowing is more useful in the loam to silt loam soils rather than sandy soils or heavy clays. In the present investigation, a mould board plough was used on apparently silty loam soil of Tandojam farm and some physiochemical characteristics were studied in order to find out its impact on soil fertility. The results obtained are presented in Table 3 to 11.

Soil texture

The mean of the mechanical composition before and after plowing is presented in Table 3. Before plowing, samples at all the depths showed that the soils were silty loam in texture. Plowing to various depths did not show any change. The results clearly showed that up to the maximum depth of 25 cm of plowing the soils profile did not vary texturally. Therefore, there was no variation in the results observed before plowing and after plowing (Tagar and Bhatti, 2001).

Water holding capacity values

The mean of the water holding capacity of the samples drawn at various depths at D1 :(0 to 5), D2: (5 to 10), D3: (10 to 15), D4: (15 to 20) and D5: (20 to 25 cm). D_1 to D_5 under four treatments irrespective of plowing and sampling depths, before and after plowing and their interactions statistically analyzed are presented in Table 4.

Table 3. Mechanical analysis texture.

0 - 10 cm		0 - 15 cm		0 - 20 cm		0 - 25 cm	
Treatments	**Mean**	**Treatments**	**Mean**	**Treatments**	**Mean**	**Treatments**	**Mean**
D_1	Silty loam	D_1	Silty loam	D_1	Silty loam	D_1	Silty loam
D_2	Silty loam	D_2	Silty loam	D_2	Silty loam	D_2	Silty loam
		D_3	Silty loam	D_3	Silty loam	D_3	Silty loam
				D_4	Silty loam	D_4	Silty loam
						D_5	Silty loam
B	Silty loam	B	Silty loam	B	Silty loam	B	Silty loam
A	Silty loam	A	Silty loam	A	Silty loam	A	Silty loam

Table 4. Water holding capacity.

0-10 cm		0-15 cm		0-20 cm		0-25 cm	
Treatments	**Mean**	**Treatments**	**Mean**	**Treatments**	**Mean**	**Treatments**	**Mean**
D_2	42.540**	D_2	42.42**	D_3	42.465	D_1	42.67
D_1	42.450	D_3	42.38	D_2	42.423	D_2	42.56
		D_1	42.36	D_1	42.422	D_3	42.36
				D_4	42.394	D_5	42.31
						D_4	42.29
D_i = 0.04		D_i = 0.03		Standard error = 0.024		Standard error = 0.102	
D_{ii} = 0.06		D_{ii} = 0.05					
B	42.650	A	42.466**	B	42.456*	B	42.490**
A	42.340	B	42.306	A	42.396	A	42.38
Standard error = 0.093		D_i = 0.05		D_i = 0.04		D_i = 0.21	
		D_{ii} = 0.062				D_{ii} = 0.28	
D_1B	42.66	D_3A	42.52**	D_3B	42.58**	D_1B	42.68**
D_2B	42.64	D_1A	42.48	D_1A	42.514	D_1A	42.66
D_2A	42.44	D_2B	42.44	D_4B	42.508	D_2A	42.60
D_1A	42.24	D_2A	42.40	D_2A	42.44	D_2B	42.52
		D_3B	42.24	D_2B	42.406	D_5A	42.48
		D_1B	42.24	D_3A	42.35	D_3A	42.60
				D_1B	42.33	D_4A	42.32
				D_4A	42.28	D_3B	42.32
						D_4B	42.26
						D_5B	42.14
Standard error = 0.208		D_i = 0.07		D_i = 0.10		D_i = 0.42	
		D_{ii} = 0.08		D_{ii} = 0.13		D_{ii} = 0.56	

Data are means of 3 times replicate.

It is seen from the analysis of variance that the data are highly significant in case of 0 to 10 cm and 0 to 15 cm treatments. However, 0 to 20 cm and 0 to 25 cm plowing treatments did not produce any significant variations. In case of 0 to 10 cm and 0 to 15 cm plowing depth of sampling, 0 to 10 cm gave the highest water holding capacity of 42.50 and 42.40% respectively and was significantly more than 0 to 5 cm and 10 to 15 cm depths. Analysis of the water holding capacity of samples before and after plowing did not follow a consistent trend.

However, the analysis of variance showed that in case of 0 to 10 cm, the variation was not significant. In case of 0 to 15 cm, plowing the data was highly significant producing more water holding capacity after plowing than before. In case of 0 to 20 cm, the results were significant at 5% level only indicating higher values before plowing

Table 5. Total soluble salts.

0-10 cm		0-15 cm		0-20 cm		0-25 cm	
Treatments	**Mean**	**Treatments**	**Mean**	**Treatments**	**Mean**	**Treatments**	**Mean**
D_2	0.0473	D_3	0.542**	D_4	0.0734	D_3	0.0632**
D_1	0.0353	D_1	0.0463	D_3	0.0582	D_2	0.0588
		D_2	0.0452	D_2	0.0439	D_4	0.0537
				D_1	0.0354	D_5	0.0531
						D_1	0.0350
Standard error = 0.013		D_i = 0.002		Standard error = 0.0125		D_i = 0.0004	
		D_{ii} = 0.002				$D_{i\,i}$= 0.0006	
A	0.0426	B	0.0486	B	0.05445	A	0.052*
B	0.0400	A	0.0485	A	0.051	B	0.050
S.E.= 0.013		Standard error = 0.00016		S.E.=0.008		Cd_i = 0.001	
D_2A	0.050	D_3B	0.0552**	D_4B	0.0748	D_3A	0.0668**
D_2B	0.0546	D_3A	0.053	D_4A	0.072	D_3B	0.0616
D_1B	0.0354	D_1A	0.0472	D_3B	0.00621	D_4B	0.054
D_1A	0.0352	D_2B	0.0452	D_3A	0.054	D_2B	0.054
		D_1B	0.0452	D_2B	0.0456	D_5B	0.0536
		D_2A	0.0452	D_2A	0.0421	D_4A	0.0534
				D_1A	0.0358	D_5A	0.0526
				D_1B	0.035	D_2A	0.0524
						D_1B	0.0352
						D_1A	0.0348
Standard error = 0.059		D_i = 0.002		Standard error = 0.018		D_i = 0.002	
		D_{ii} = 0.003				D_{ii} = 0.003	

Data are means of 3 times replicate.

and also showed more value before plowing than after at 1% level of significance. The interactions between the depths of sampling and the plowing did not show any significant variations with 0 to 10 cm plowing. However, 0 to 5 cm and 0 to 10 cm samples before plowing indicated higher values than after plowing. In case of the remaining of the plowing depths, highly significant variations on the interactions were observed. In case of 0 to 15 cm plowing, 10 to 15 cm sample produced significantly higher values than the others. In case of 0 to 20 cm, the reverse was true. In case of 0 to 25 cm plowing, 0 to 5 cm samples before plowing gave the highest values than the others.

As earlier stated, the variable trend and inconsistency in the water holding capacity may be because of improper mixing or turning over the soil separates. This may be because the plowing was carried out only once at different depths. However, the variable trend of data showed that water holding capacity changes with the plowing as well as, at the different depths of samplings.

Lebert and horn (1991) had indicated that mould board plough increases loss of moisture, and soil erosion.

Total soluble salts (TDS)

The mean of the total soluble salts of the samples drawn at various depths of D1 to D5 irrespective of plowing and sampling depths before and after plowing and their interactions statistically analyzed are presented in Table 5. The analysis of variance showed that the data was highly significant only in case of 0 to 15 cm treatment and 0 to 25 cm treatment. In both cases, 10 to 15 cm plowing showed higher values than the others. This is further confirmed by the samples drawn before and after plowing which showed that in case of 0 to 25 cm plowing, the samples after plowing produced significantly higher mean values for total soluble salts than the samples drawn before, whereas, the remaining plowing depths did not show any significant variation.

The interactions between the depths of sampling and the samples drawn before and after plowing did not show any significant variation in case of 0 to 10 cm plowing and 0 to 20 cm plowing but 0 to 15 cm plowing showed that the samples drawn from 10 to 15 cm depth possessed significantly more salts than the others. At 0 to 25 cm

Table 6. Soil reaction (pH).

0 - 10 cm		0 - 15 cm		0 - 20 cm		0 - 25 cm	
Treatments	**Mean**	**Treatments**	**Mean**	**Treatments**	**Mean**	**Treatments**	**Mean**
D_2	7.910	D_3	7.940	D_4	7.980	D_4	7.980
D_1	7.860	D_2	7.910	D_3	7.900	D_1	7.930
		D_1	7.820	D_2	7.890	D_2	7.80
				D_1	7.820	D_3	7.80
						D_5	7.61
Standard error = 0.041		Standard error = 0.037		Standard error = 0.44		Standard error = 0.103	
B	7.910	A	7.90	A	7.900	B	7.845
A	7.860	B	7.88	B	7.895	A	7.804
Standard error = 0.041		Standard error = 0.029		Standard error = 0.31		Standard error = 0.65	
D_1B	8.00**	D_2A	8.00**	D_3A	8.00	D_1B	8.00
D_2A	8.00	D_3B	8.00	D_4A	7.98	D_4B	7.98
D_2B	7.82	D_3A	7.88	D_4B	7.98	D_4A	7.98
D_1A	7.72	D_1A	7.82	D_2B	7.96	D_1A	7.86
		D_2B	7.82	D_1B	7.84	D_2A	7.82
		D_1B	7.82	D_2A	7.82	D_3B	7.82
				D_1A	7.80	D_2B	7.78
				D_3B	7.80	D_3A	7.78
						D_5B	7.64
						D_5A	7.58
D_i = 0.24		D_i = 0.15		Standard error = 0.62		Standard error = 0.15	
D_{ii} = 0.25		D_{ii} = 0.21					

Data are means of 3 times replicate.

depth of plowing, the sample drawn at 10 to 15 cm depth possessed significantly more salts than the others. At 0 to 25 cm depth of plowing, the sample drawn at 10 to 15 cm after plowing were significantly more in salts than the samples drawn from the same depths before plowing. The 0 to 5 cm samples before and after plowing showed comparatively lower values of total soluble salts in all the treatments of plowing depths. The results showed that the deep plowing could only mix the salts or turn the salts to the depth of 10 to 15 cm.

However, since the quantity of salts was so low, the variations produced due to plowing may not be of much economic value but the data indicated that due to plowing, the salts from the surface layer may be turned to the depth of 10 to 15 cm in case of soil under study. Further, the data showed that plowing to the depth of 0 to 25 cm was rather more effective than plowing to the lesser depths. The variation observed in the present investigation may be related to the moisture content of the soil samples at the time of sampling.

Soil reaction (pH)

The mean pH value of the samples before plowing, after plowing as well as, the samples drawn at different depths irrespective of plowing and their interactions statistically analyzed are presented in Table 6.

The mean pH values range was 7.6 to 8.0. The statistical analysis did not show any significant variation either at different depths of sampling or in samples drawn before and after plowing. The interaction between the depth of sampling before and after plowing at 0 to 10 cm and 0 to 15 cm however, showed significant variation. Whereas, deeper plowing did not show any significant variation. Scrutinizing the statistical analysis, it is seen that samples to the depth of 15 to 20 cm showed comparatively high pH than the lower depth samples. The pH range is also in agreement with the findings by Meng et al. (1996).

Total calcium carbonate ($CaCO_3$)

The mean value of the total calcium carbonate content in the soil samples analyzed from different depths and those from before plowing and after plowing and their interactions are presented in Table 7. From the results obtained, it was evident that the soils were calcareous in nature. It was seen from the analysis of variance that unlike potassium, calcium carbonate was significantly more in the top layers rather than lower layers. It was

Table 7. Total calcium carbonate.

0-10 cm		0 - 15 cm		0 - 20 cm		0 - 25 cm	
Treatments	**Mean**	**Treatments**	**Mean**	**Treatments**	**Mean**	**Treatments**	**Mean**
D_1	6.43**	D_2	6.640**	D_3	6.36**	D_1	5.89**
D_2	6.32	D_1	6.610	D_2	6.30	D_2	5.82
		D_3	6.250	D_1	5.90	D_3	5.74
				D_4	5.90	D_4	5.73
						D_5	5.73
D_i = 0.04		D_i = 0.02		D_i = 0.12		D_i = 0.08	
D_{ii} = 0.05		D_{ii} = 0.03		D_{ii} = 0.17		D_{ii} = 0.11	
B	6.390	B	6.5133**	B	6.17*	B	5.852**
A	6.360	A	6.5	A	6.06	A	5.712
Standard error = 0.013		D_i = 0.005		D_i=0.008		D_i = 0.05	
		D_{ii} = 0.006				D_{ii} = 0.07	
D_1B	6.48**	D_2B	6.76**	D_2B	6.40**	D_1B	6.10**
D_1A	6.38	D_1B	6.70	D_3A	6.40	D_2B	6.04
D_2A	6.34	D_1A	6.52	D_3B	6.32	D_3B	5.84
D_2B	6.30	D_2A	6.52	D_2A	6.20	D_5B	5.82
		D_3A	6.50	D_1B	6.18	D_4A	5.82
		D_3B	6.00	D_4A	6.02	D_1A	5.68
				D_4B	5.78	D_4B	5.64
				D_1A	5.62	D_5B	5.64
						D_3A	5.64
						D_4A	5.60
D_i = 0.05		D_i = 0.03		D_i = 0.18		D_i = 0.11	
D_{ii} = 0.07		D_{ii} = 0.04		D_{ii} = 0.24		D_{ii} = 0.15	

Data are means of 3 times replicate.

also significantly more in samples before plowing than after plowing except in case of 0 to 10 cm plowing depth where the values did not differ significantly. The interactions between the plowing depths and the sample depths were highly significant. Although, definite trend could not be drawn from the interactions, yet, it could be said that 0 to 5 cm samples and 5 to 10 cm samples before plowing gave significantly higher values of total calcium carbonate. The calcareous nature of the soils analyzed was in conformity with the findings of Gardner et al. (1985).

Organic matter

The mean values of the organic matter content of the soil samples drawn at different depths irrespective of plowing or no plowing and samples drawn before and after plowing and their interactions for the organic matter percentage are presented in Table 8.

It was evident from the statistical analysis of the data that it significantly decreased with the depth increased. With regard to the effect of the depth of plowing, significant increase in the organic matter was observed after plowing the soil to the depth of 0 to 15 cm only. In the case of the remaining treatments before plowing, samples gave significantly higher values except in case of 0 to 10 cm plough depth, where the values did not vary significantly. The results indicated that the turning over of the organic matter did not take place beyond 15 cm depth which is consistent with the results obtained from the samples drawn at the different depth. Such a trend remaining in the surface layer even after deeper plowing may be due to the dry conditions of the soils. Such a trend may change under moist conditions.

The interactions between the plowing and the depth of sampling were highly significant except in case of plowing depth of 0 to 20 cm and 0 to 25 cm where the values were significant at 5% only. 0 to 5 cm samples before plowing gave highest values of organic matter than the others, whereas, in the case of 0 to 15 cm after plowing, gave the highest mean value (Zhang, 1994).

Total nitrogen

Mean total nitrogen percentages of soil samples analyzed irrespective of the plowing depths and the soil samples

Table 8. Organic matter.

0 - 10 cm		0 - 15 cm		0 - 20 cm		0 - 25 cm	
Treatments	**Mean**	**Treatments**	**Mean**	**Treatments**	**Mean**	**Treatments**	**Mean**
D_1	0.974**	D_2	0.969	D_1	0.899*	D_1	0.874*
D_2	0.821	D_1	0.968	D_3	0.791	D_2	0.833
		D_3	0.878	D_4	0.762	D_4	0.788
				D_2	0.745	D_3	0.771
						D_5	0.677
D_i = 0.05		Standard error = 0.036		D_i = 0.12		D_i = 0.10	
D_{ii} = 0.07							
B	0.9	A	0.9906*	B	0.8300*	B	0.854*
A	0.895	B	0.886	A	0.7663	A	0.7192
Standard error = 0.017		D_i=0.08		D_i=0.06		D_i = 0.06	
D_1B	1.064**	D_3A	1.136**	D_1B	1.06*	D_1B	1.074*
D_2A	0.912	D_1B	1.028	D_4A	0.87	D_2B	0.904
D_1A	0.884	D_2B	1.010	D_3A	0.85	D_3A	0.806
D_2B	0.736	D_2A	0.928	D_2B	0.76	D_5B	0.798
		D_1A	0.908	D_1A	0.742	D_4A	0.798
		D_3B	0.620	D_3B	0.732	D_2A	0.762
				D_2A	0.730	D_4B	0.758
				D_4B	0.654	D_3B	0.736
						D_1A	0.674
						D_5A	0.556
D_i = 0.10		D_i = 0.23		D_i = 0.18		D_i = 0.14	
D_{ii} = 0.14		D_{ii} = 0.32					

Data are means of 3 times replicate.

before and after plowing and their interactions statistically analyzed are presented in Table 9.

The results showed that the total nitrogen was more in the surface layers than the lower layers. The depths of sampling were highly significant at the plowing depth of 0 to 20.30 and 0 to 25.40 cm. The layer 0 to 5 cm gave the highest total nitrogen and 20 to 25 cm layer gave the lowest. The analysis of the before and after plowing samples showed that nitrogen was more, in before plowing treatment than after. However, the results were significantly only at the plowing depth of 0 to 15 cm and 0 to 25 cm. The interactions revealed that they were not significant at plowing depth of 0 to 15 cm, but were highly significant at the remaining plowing depths. The interactions revealed that 0 to 5 cm samples before plowing gave significantly higher nitrogen than the remaining of the interactions. The total nitrogen was more or less in line with the organic matter content of the soil. Similar views have been put forward by various workers like Karal et al. (2001).

Available phosphorus ($NaHCo_3$ extractable)

The sodium bicarbonate extractable mean values of the phosphorous of the soil samples drawn at the different depths irrespective of the plowing treatment and those of the samples before plowing and after plowing and their respective interactions are presented in Table 10. The data revealed that available phosphorus in the soils analyzed was low. There was significant variation in the samples drawn from different depths. Samples drawn before plowing and after plowing were not significant. The segregation of the data in the statistical analysis indicated comparatively more available phosphorous in the 0 to 10 cm layer followed by 0 to 5 cm, 0 to 15 cm, 0 to 20 cm, and 0 to 25 cm layers respectively. Samples before plowing indicated slightly higher values than after plowing except in case of 0 to 25 cm plowing where the indication was reversed.

The interactions between the depth of sampling and the plowing were highly significant. Values in 0 to 10 cm layer

Table 9. Total nitrogen.

0 - 10 cm		0 - 15 cm		0 - 20 cm		0 - 25 cm	
Treatments	**Mean**	**Treatments**	**Mean**	**Treatments**	**Mean**	**Treatments**	**Mean**
D_1	0.0470	D_1	0.0466	D_1	0.0464**	D_1	0.0442**
D_2	0.0435	D_3	0.0458	D_3	0.0409	D_2	0.0431
		D_2	0.0453	D_2	0.0400	D_4	0.0409
				D_4	0.0368	D_3	0.0380
						D_5	0.0357
Standard error = 0.0018		Standard error = 0.0007		D_i = 0.004		D_i = 0.002	
				D_{ii} = 0.006		D_{ii} = 0.003	
B	0.0475	B	0.0473*	B	0.0414	B	0.0414*
A	0.0430	A	0.0444	A	0.041	A	0.0393
Standard error = 0.00018		Cd_i = 0.002		Standard error = 0.0002		Cd_i = 0.001	
D_1B	0.054	D_1B	0.052**	D_1B	0.0524**	D_1B	0.0514**
D_2A	0.046	D_3A	0.0504	D_4A	0.0426	D_2B	0.0458
D_2B	0.041	D_2B	0.0488	D_3A	0.041	D_4A	0.0418
D_1A	0.0402	D_2A	0.0418	D_3B	0.0408	D_2A	0.0404
		D_1A	0.0412	D_1A	0.0404	D_4B	0.0400
		D_3B	0.0412	D_2A	0.0400	D_5A	0.0398
				D_2B	0.0400	D_3B	0.0382
				D_4B	0.031	D_3A	0.0378
						D_1A	0.037
						D_5B	0.0316
Standard error = 0.0026		D_i = 0.003		D_i = 0.001		D_i = 0.003	
		D_{ii} = 0.004		D_{ii} = 0.002		D_{ii} = 0.004	

Data are means of 3 times replicate.

before plowing were significantly higher than the remaining of the treatments except in case of 0 to 25 cm plowing depth where 0 to 5 cm was more. The significant variation in the available phosphorous content may be due to turning over of the organic matter. The phosphorous values were within the range as reported by Isaac and Johnson (1995).

Available potassium

The mean value of available potassium of the soil samples at the different depths and the samples before plowing and after plowing and their interactions statistically analyzed are presented in Table 11.

The results evidently showed that the samples analyzed were adequate in available potassium. The statistical analysis of the samples drawn from different depths evidently showed that the potassium increased was highly significant with increase in depth of sampling. The mean values of the samples drawn before plowing and after plowing at 0 to 15 cm and 0 to 20 cm showed that available potassium was significantly more in the samples analyzed before plowing than after. In case of 0 to 10 cm and 0 to 25 cm plowing depths, no significant variation was observed. The interactions also revealed that lower depth samples before plowing were significantly more than the others. In the case of 0 to 10 cm plowing, the statistical analysis of the interactions however, was not significant. The results apparently suggested that the plowing up to the depth of 0 to 20 cm did not affect the potassium inversion. However, plowing to the depth of 0 to 25 cm indicated increased trend of available potassium after plowing than before. These results confirmed the findings of Isaac et al. (1995) and Wiedenhoefi (1980).

Conclusion

The following conclusions were drawn from the study:

1. The results indicated that plowing moved salts from upper to lower layers.
2. The pH of soil ranged from 7.6 to 8.0 and did not vary with respect to depths of sampling and plowing. The total calcium carbonate clearly showed that the soils were calcareous in nature that was more in the top layers.
3. The organic matter in the top layers was more than

Table 10. Available phosphorous ($NaHCo_3$ extractable).

0 - 10 cm		0-15 cm		0-20 cm		0-25 cm	
Treatments	**Mean**	**Treatments**	**Mean**	**Treatments**	**Mean**	**Treatments**	**Mean**
D_2	11.680*	D_2	11.010**	D_2	11.360**	D_2	10.250**
D_1	11.566	D_1	10.720	D_1	10.195	D_1	9.910
		D_3	8.580	D_3	8.780	D_3	8.575
				D_4	7.410	D_4	8.125
						D_5	8.050
D_i=0.08		D_i = 0.05		D_i = 0.07		D_i=0.10	
		D_{ii} = 0.07		D_{ii} = 0.10		D_{ii}=0.14	
B	11.664	B	10.146	B	9.4525	A	8.982
A	11.582	A	10.06	A	9.42	B	8.97
Standard error = 0.028		Standard error = 0.044		Standard error = 0.056		Standard error = 0.025	
D_2B	11.80**	D_2B	11.28**	D_2B	11.96**	D_1B	12.02*
D_1A	11.604	D_1B	11.08	D_1B	11.31	D_2B	11.8
D_2A	11.56	D_2A	10.74	D_2A	10.76	D_5A	9.88
D_1B	11.528	D_1A	10.36	D_3A	9.22	D_4A	9.70
		D_3A	9.08	D_1A	9.08	D_3A	8.89
		D_3B	8.08	D_4A	8.62	D_2A	8.70
				D_3B	8.34	D_3B	8.26
				D_4B	6.20	D_1A	7.80
						D_4B	6.55
						D_5B	6.22
D_i = 0.12		D_i = 0.22		D_i = 0.08		D_i = 0.15	
D_{ii} = 0.16		D_{ii} = 0.30		D_{ii} = 0.14		D_{ii} = 0.19	

Data are means of 3 times replicate.

Table 11. Available potassium**.**

0 - 10 cm		0 - 15 cm		0 - 20 cm		0-25 cm	
Treatments	**Mean**	**Treatments**	**Mean**	**Treatments**	**Mean**	**Treatments**	**Mean**
D_1	340.1	D_3	345.10**	D_4	351.0**	D_5	354.00**
D_2	340.1	D_1	341.60	D_3	346.9	D_4	350.20
		D_2	341.20	D_2	341.4	D_3	349.90
				D_1	340.3	D_2	347.00
						D_1	345.60
Standard error = 0.07		D_i = 0.05		D_i = 0.55		D_i = 0.45	
		D_{ii} = 0.75		D_{ii} = 0.75		D_{ii} = 0.61	
A	340.1	B	342.866*	B	345.25**	A	349.36
B	340.1	A	342.4	A	344.55	B	349.32
Standard error = 0.07		D_i = 0.44		D_i=0.49		Standard error = 0.101	
				D_{ii}=0.66			
D_1A	340.2	D_3B	344.60**	D_4B	353.40**	D_5B	357.8**
D_2B	340.2	D_3A	343.60	D_4A	348.60	D_4B	352.40
D_2A	340.0	D_1A	343.20	D_3B	348.20	D_3B	352.20
D_1B	340.0	D_2B	342.00	D_3A	345.60	D_1A	351.2
		D_2A	340.40	D_2A	342.20	D_5A	350.2
		D_1B	340.00	D_1A	341.86	D_2A	349.8
				D_2B	340.60	D_3A	348.0

Table 11. Cont'd

		D_1B	338.80	D_3A	347.6
				D_2B	344.2
				D_1B	340.0
Standard error = 0.10	D_i = 0.79	D_i = 0.81		D_i = 0.66	
	D_{ii} = 1.07	D_{ii} = 1.08		D_{ii} = 0.86	

Data are means of 3 times replicate.

that of lower layers. Moreover significant increase in the organic matter was observed after plowing the soil to the depth of 0 to 15 cm.

4. The total nitrogen was more in surface layers as compared to lower layers also turning the soil with mould board plough did not change total nitrogen.

5. The available phosphorus was comparatively more in depth of 0 to 10 cm than subsequent depth.

6. The results showed that the plowing up to the depth of 0 to 20 cm did not affect available potassium. However, plowing to the depth of 0 to 25 cm showed increasing trend of available potassium after plowing than before plowing.

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REFERENCES

Benton J (2001). Laboratory guide for conducting soil tests and plant analysis.

Black CA (1965). "Methods of Soil Analysis: Part I Physical and mineralogical properties". American Society of Agronomy, Madison, Wisconsin, USA.

Gardner FP, Pearce RB, Mitchell RL (1985). Physiology of Crop Plants [M]. Ch, 8: 2002-2004.

Isaac RA, Johnson WC (1995). Collaborative study of wet and dry ashing techniques for elemental analysis of plant tissue. J. AOAC, 58: 436-440.

Kanwar JS, Chopra SS (1962). Effect of continuous application of FYM and inorganic fertilizers on crop yield and properties of soil. J. Indian Soc. Soil Sci., 10: 109-120.

Karal V, Juan VG, Marc VM (2001). Soil water holding capacity assessment in terms of the average annual water balance in southern spain. Vadose zone J., 2: 42.

Lebert M, horn R (1991). A method to predict the mechanical strength of agricultural soils (J). Soil till. Res., 19: 275-286.

Meng K, Yan CQ, Wang JG (1996). Study on laws of water consumption for main crops in black soil: 115-123, in JG wag (ed.) agricultural ecosystem research of Song-Nen plain. (in Chinese) Harbin Engineering Univ. Press, Harbin.

Olatunji OM (2007). Modeling the effect of weight,draught and speed on the depth of cut of disc plough during ploughing. M. Tech. Thesis, Department of Agricultural and Environmental Engineering, Rivers State University of Science and Technology, Port Harcourt, Nigeria, p.102.

Rowell DL (1994a). Phosphorus and Sulphur. In Soil Science: Material and Applications. Longman Scientific and Technical, UK., pp. 200-217.

Rowell DL (1994b). Organic materials-alive and dead. In Soil Science: Material and Applications. Longman Scientific and Technical, UK., 38-59.

Singh D, Chopra PK, Pandey RN (1999). Soil testing. In Soil, plant, water analysis: A methods manual. Indian Agricultural Research Institute. New Delhi, pp. 1-56.

Tagar S, Bhatti A (2001). Physical properties of Soil. In "Soil science" [M [. (2nd Ed.). N.B.F, Islamabad, pp. 130-134.

Walkley A (1947). A critical examination of a rapid method for determining organic carbon in soils. Effects of variations in digestion conditions and inorganic soil constituents. Soil Sci., 63: 251-263.

Wiedenhoefi MH (1980). Management and environment effects on organic matter yields of three species (J). Agronomy J., 55: 549-553.

Zhang H (1994). Organic matter incorporation affects mechanical properties of soil. Soil Tillage Res., 31(2-3): 263-275.