Deep Tillage and Gypsum Response on Yield Attributes and Yield of Mustard (*Brassica juncea*)

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Abstract: ***In order to evaluate the response of deep tillage and gypsum application on yield attributes and yield of mustard a field experiment was conducted at Soil Research Farm of CCS Haryana Agricultural University, Hisar, Haryana, during the rabi season of 2000-01. The experiment was consisted of two tillage treatments i.e. conventional tillage (CT) comprising of one disc harrowing at 10 cm depth and one run of cultivator followed by planking and deep tillage with disc plough comprising 20-25 cm sub-soiling followed by CT and the gypsum treatments (control and gypsum @ 250 Kg/ha). The study clearly illustrates that a plough sole in a sandy loam soil can be alleviated by deep ploughing with disc plough and deep tillage & gypsum application increase stem & root diameter, fresh & dry weight, primary & secondary branches significantly. The grain yield of mustard can be increased by 26.41 % over conventional tillage and further increased by 32.07 % with the addition of gypsum.***

Keywords: deep tillage, gypsum, stems & root diameter, grain & straw yield

1. Introduction

Increasing mechanization trends towards the use of large and more efficient farm machinery (tractors and other tillage and harvesting equipments/implements) and intensive cropping practices had lead to a gradual densification of soils and a corresponding reduction in soil productivity (Gamoda *et al*., 1987). Compaction of soil has, thus, become a problem of worldwide concern. Current research has shown that with large and heavier field equipments/implements, compaction of soil has increased at depth below the usual tilled zone of approximately 20 cm (subsoil compaction). Raghvan *et al*., (1990) reported in their review article on soil compaction in agriculture that coarser textured soil tend to compact maximum at lower moisture content than finer textured soils and also tend to have lower soil moisture retention capacities.

Among tap rooted crops, mustard is a major oil seed crop grown extensively in Haryana. It is grown under wide range of soils varying from sandy loan to clay loan in texture, but thrive best on the light loam soils that are more sensitive to compaction. Being a tap rooted crop, its production is severely affected if sub-soil is compacted or has developed a plough sole (hard pan). Deep tillage enhanced crop yield by encouraging vertical and horizontal proliferation of roots through reduction in soil strength in the sub-soil and have greater influence on root growth and crop yields.

Oil seed and pulses are well known to respond to sulphur. Majority soils in Haryana are reported to be deficient in available sulphur. Although a number of sources supplying sulphur are available in the market but gypsum is relatively good source of sulphur fertilization as it is inexpensive and more effective. Therefore the present investigation was undertaken to find out the effect of deep tillage and gypsum application on yield and yield attributes of mustard.

2. Material and method

The experiment was undertaken at Soil Research Farm of CCS Haryana Agricultural University, Hisar, Haryana, during the rabi season of 2000-01. Soil of the experimental field was (Typic Ustocrept) sandy loam in texture, slightly alkaline in soil reaction. Low in available-N: 114 kg ha^{-1} (Alkaline permanganate method), available phosphorus: 15 kg P_2O_5 ha^{-1}(Olsen's P method), Sulphur: 18 Kg ha^{-1} (Colorimetrically) and rich in Potassium: 396 kg K_2O ha^{-1}(Flame photometry) with pH: 7.9 (Glass electrode pH method) and electrical conductivity: 1.31 dS m^{-1} (Conductivity meter bridge). The experiment was laid out in randomized block design (RBD) with four (4) treatments and three replications, tested with mustard crop var. RH-30. Plot of the experimental field was of area 75m x 75m, with a spacing of 30cm row to row. The experiment was consisted of two tillage treatments i.e. conventional tillage (CT) comprising of one dicing at 10 cm depth and one run of cultivator followed by planking and deep tillage with disc plough comprising 20-25 cm sub-soiling followed by CT and the gypsum treatments (control and gypsum @ 250 Kg ha^{-1}) with recommended doses of N, P, K and Zn were applied as per University package and practices at the time of sowing. At 50 days after sowing yield attributes plant height & root length (cm) by scale, stem & root diameter (cm) by vernier caliper, fresh & dry weight (g/plant) and at harvest number of primary & secondary branches per plant were observed and the yield parameters recorded were grain yield (t ha^{-1}) and straw yield (t ha^{-1}). Statistical analysis of the yield and yield attributes data of mustard was subjected to randomized block design model.

3. Result and Discussion

The bulk density of the experimental field is measured initially (up to 60 cm) from four different locations (Table 1). A gradual increase in soil bulk density to a certain depth (15-20 cm) and then decrease in the lower depths clearly indicate that the repeated ploughing with heavy machinery continuously for a long time resulted in the development of a plough sole or a plough pan in the sandy loam soil of the University Farm at a depth of about 15-20 cm. Gemeda *et al.* (1985) and Raghavan *et al.* (1990) also reported such type of compacted layer in sub-soil due to continuous ploughing with different sized tractors. This compacted layer may restrict the penetration of plant roots to lower layer for their requirement of nutrients and water (Raghavan *et al.*, 1979).

Table 1: Bulk density (Mg m^{-3}) profile of experimental field

Depth (cm)	Initial	At the time of sowing Conventional Tillage	At the time of sowing Deep Tillage	At the time of harvest Conventional Tillage	At the time of harvest Deep Tillage
00-05	1.50	1.35	1.31	1.40	1.34
05-10	1.59	1.42	1.44	1.47	1.43
10-15	1.65	1.62	1.54	1.65	1.56
15-20	1.70	1.66	1.56	1.69	1.58
20-25	1.68	1.66	1.58	1.68	1.61
25-30	1.63	1.63	1.61	1.60	1.61
30-45	1.60	1.61	1.59	1.62	1.61
45-60	1.61	1.62	1.61	1.61	1.62
CD @ 5%		Tillage = 0.011, Depth = 0.181		Tillage = 0.009, Depth = 0.019	

Deep ploughing with disc plough thus loosened the soil of the plough sole formed at the depth of 15-20 cm as the bulk density of this layer reduced from 1.70 Mg m^{-3} to 1.56 Mg m^{-3} (Table 1). The conventional tillage could not loosen the soil of this layer as the bulk density of the layer was found to be 1.66 Mg m-3. Similar observations were made by Chaudhary *et al.* (1985), Chambers *et al.* (1990), Gajri et al. (1997) and Diaz-Zorita (1999).

The tillage and gypsum treatments did not affect the plant height found significantly, but deep ploughing resulted in significantly large stem diameter, more number of primary and secondary branches, root length and root diameter, fresh and dry weight of plants over conventionally tilled plots (Table-2) recorded at 50 days after sowing. Deep tillage increased the stem diameter significantly from 1.12 cm to 1.55 cm in the field where no gypsum was applied. Gypsum application further increased the stem diameter to 1.81 cm. The increase in stem diameter upon deep tillage and gypsum application may be due to greater adsorption of nutrients and water from lower depth of the soil.

Table 2: Plant height, stem diameter, root length and root diameter at 50 days after sowing in different treatments

Treatment	Plant Height (cm) CT	Plant Height (cm) DT	Plant Height (cm) Mean	Stem Diameter (cm) CT	Stem Diameter (cm) DT	Stem Diameter (cm) Mean	Root Length (cm) CT	Root Length (cm) DT	Root Length (cm) Mean	Root Diameter (cm) CT	Root Diameter (cm) DT	Root Diameter (cm) Mean
Control	124	129	126.5	1.12	1.55	1.33	13.70	18.36	16.03	0.82	1.32	1.07
Gypsum	136	117	126.5	1.23	1.81	1.52	13.75	15.50	14.63	0.98	1.44	1.21
Mean	130	123		1.17	1.68		13.72	16.93		0.90	1.38	
CD (5%)	Tillage (T) = NS, Gypsum (G) = NS, TxG = 11.2			Tillage (T) = 0.131, Gypsum (G) = 0.131, TxG = NS			Tillage (T) = 1.432, Gypsum (G) = NS, TxG = 2.03			Tillage (T) = 0.138, Gypsum (G) = 0.138, TxG = NS		

The increased root length was undoubtedly because of the fact that deep ploughing loosens the plough sole existed at a depth of 15-20 cm depth and roots penetrated through this layer Deep tillage has been reported to enhance root elongation of crops by reducing bulk density and soil strength by Bennie and Botha (1986) and Gajri *et al. (1991).* The interactive effect of deep tillage and gypsum on root length was also therefore, found significant. Root diameter behaved similar to the stem diameter in all the treatments. Deep tillage increased the root diameter significantly from 0.82 cm to 1.32 cm in the field where no gypsum was applied. Gypsum application further increased the root diameter to 1.44 cm. The fresh weights of mustard plants recorded at 50 days after sowing in different tillage and gypsum treatments are presented in Table-3. Both the deep tillage and the gypsum application increased the fresh weight of mustard significantly.

Table 3: Fresh and dry weight, primary and secondary branches at 50 days after sowing in different treatments

Treatment	Fresh Weight (g) CT	Fresh Weight (g) DT	Fresh Weight (g) Mean	Dry Weight (g) CT	Dry Weight (g) DT	Dry Weight (g) Mean	Primary Branches (Nos.) CT	Primary Branches (Nos.) DT	Primary Branches (Nos.) Mean	Secondary Branches (Nos.) CT	Secondary Branches (Nos.) DT	Secondary Branches (Nos.) Mean
Control	187.8	302.8	245.3	26.6	34.8	30.7	5.25	6.50	5.87	8.50	24.75	16.62
Gypsum	270.0	401.8	320.9	31.8	40.6	36.2	6.25	8.25	7.25	23.50	41.50	32.50
Mean	213.9	352.3		29.2	37.7		5.75	7.37		16.00	33.12	
CD (5%)	Tillage (T) = 30.02, Gypsum (G) = 30.02, TxG = NS			Tillage (T) = 3.84, Gypsum (G) = 3.84, TxG = NS			Tillage (T) = 1.03, Gypsum (G)= 1.03, TxG = NS			Tillage (T) = 5.03, Gypsum (G) = 5.03, TxG = NS		

The deep ploughing of the field increased fresh weight from 187.8 g to 302.8g over conventional tillage and application of gypsum further increased it to 401.8g and in conventional tillage from 187.8g to 240g. This was due to the extraction of more nutrients and water from the larger volume of the soil in deep tillage treatment and higher amounts of nutrient applied through gypsum. The dry weight of plants recorded in the early stage behaved exactly in the same manner with tillage and gypsum treatments as of fresh weight. The primary and secondary branches per plant increased significantly with deep ploughing and gypsum application (Table 4). Deep ploughing increased the primary branches from 5.25 to 6.50, which were further increased to 8.25 upon application of gypsum. The corresponding counts obtained for secondary branches were 8.50, 24.75 and 41.50. These results clearly illustrate the role of deep tillage and gypsum application in increasing the vegetative growth of mustard in soil having plough sole at shallow depth.

Deep tillage resulted in significantly higher above ground dry matter accumulation (straw yield) compared with conventional tillage with and without the application of gypsum (Table 4). The straw yield increased from 34.8 to 45.2 q/ha upon deep tillage.

Table 4: Straw and grain yields of mustard (q/ha) in different treatments

Treatment	CT	DT	Mean	CT	DT	Mean
	Straw Yield (q/ha)			Grain Yield (q/ha)		
Control	32.6	44.0	38.3	9.8	12.6	11.2
Gypsum	37.0	46.4	41.7	11.4	16.0	13.7
Mean	34.8	45.2		10.6	14.3	
CD (5%)	Tillage (T) = 8.23, Gypsum (G) = NS, TxG = NS			Tillage (T) = 1.19, Gypsum (G) = 1.19, TxG = NS		

The increase in straw yield of mustard upon deep ploughing of coarse textured soil has also reported by Arora et al. (1993). Kumar et al. (1994) reported an increase in dry matter content of peas with decrease in hulk density (soil loosening) of silt loam soil. The straw yield increased from 32.6 to 44.0 q/ha and from 37.0 to 46.4 q/ha when no gypsum and gypsum @ 250 kg/ha was applied. Deep ploughing increased this yield by 3.7 q/ha. Similar effects in the sandy loam soil have also been observed for corn (Arora et al., 1991), wheat (Gajri et al., 1991) and mustard (Arora et al., 1993). The average grain yield increased upon gypsum application from 11.2 to 13.7 q/ha. It is evident from the yield data that when a sandy loam soil having plough sole at 15-20 cm depth was deep ploughed with disc plough, the grain yield of mustard is increased 2.8 q/ha. When this deeply ploughed field was applied with 250 Kg/ha of gypsum, the grain yield was further increased by 3.4q/ha. In conventional tillage the application of gypsum found to increase the yield only 1.6 q/ha. Thus, in the present problematic soil, deep ploughing and gypsum application can increase the yield of mustard up to 6.2 q/ha over conventional tillage practices adopted by farmers.

4. Conclusion

Deep ploughing with disc plough found to loosen the plough sole as the bulk density of the 15-20 cm deep layer decreased by 0.1 Mg/m-3 at this depth. The root of mustard penetrated deeper in the deep tillage treatment and extracted more nutrients and moisture as compared to conventional tillage. As a result the stem & root diameter, fresh & dry weight of mustard was found to increase at 50 DAS. The number of primary & secondary branches was also found more in deep tillage as compared to conventional tillage. The deep tillage significantly increased the yield (straw & grain) of mustard as compared to conventional tillage. The yield of mustard, which is a tap rooted crop, may be increased by 28 % over the conventional tillage practices and addition of gypsum in such conditions found to increase further the yield by 27 percent.

References

[1] Arora, V.K. Gajri. P.R. and Prihar, S.S. 1991. Tillage effects on corn in sandy soils in relation to water retentively, nutrient and water management and season evaporativity. *Soil Tillage Res.* **21** : 1-21.

[2] Arora V.K., Gajri. P.R. and Chaudhary, M.R. 1993. Effects of conventional and deep tillage on mustard for efficient water and nitrogen use in coarse textured soils. *Soil Tillage Res.* **26** : 327-340.

[3] Bennie, A.T.P. and Botha, F.J.P. 1986. Effect of deep tillage and controlled traffic on root growth, water-use efficiency and yield of irrigated maize and wheat. *Soil & Tillage Research*, **7**, 85– 95.

[4] Chambers. R., Natho-Jina, S., Weil. C. and Mckeys. E. 1990. Crop rotation **and** sub- soiling on compacted clay soils. *Am. Soc. Agril. Eng.* **90** : 1102-12.

[5] Chaudhary. M.R., Gajri, P.R., Prihar, S.S, and Khera. R. 1985. Effect of deep tillage on soil physical properties and maize yields on coarse textured soils. *Soil Tillage Res.* **6** : 31-44.

[6] Diaz-Zorita. M. 1999. Effect of six years of tillage systems in a Hapludoll from the northwest part of Buenos Aires, Argentina. *Ciencia del Suelo* **17** : 31-36.

[7] Gajri, P. R., Gill, K.S., Chaudhary, M.R, and Singh, R., 1997, Irriation of sunflower *(Helianthus annuus)* in relation to tillage and mulching. *Agril. Water Mgt.* **34** : 149-1()O.

[8] Gajri, P. R., Prihar, S .S., Cheema H.S. and Kapoor, A., 1991, Irrigation and tillage effect on root development, water use and yield wheat in textured soils. *Irrig. Sci.* **12** : 161-168.

[9] Gameda, S. Raghavan, G.S.V. Mckyes, E. and Theriault, R. 1985. A review of sub-soil compaction, *Int. Conf. Soil Dynamics Proc.* **5** : 970-978,

[10] Gameda, S., Raghavan, G.V.S. McKyes, E. and Theriault, R. 1987b. Sub-soil compaction in a clay soil. II. Natural alleviation. *Soil Tillage Res*, **10** : I 23-130.

[11] Kumar, K.: Malik, R.S. and Bhandari, A.R. 1994. Effect of soil compaction on root growth and yield of peas. *J. Indian Soc, Soil Sci.* **42** : 132-134.

[12] Raghvan, G.V.S. Mckyes, E. Taylor, F. Richard, P. and Watson, A. 1979. The relationship between machinery traffic and corn yield reactions in successive years. *Trans. ASAE*. **22** : 1256-1259.

[13] Raghvan, G.V.S. 1990. Soil compaction in agriculture: Aview towards managing the problem. *Adv. Soil Sci.* **6** : 65-100.