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Effect of Sub-surface Compaction and Sulphur Levels on the Performance of Barley Grown under Typicustipsamments

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ABSTRACT

Field experiment was conducted in typicustipsamments in split plot design consisting of four levels of compaction (i.e. 0, 2, 4 and 8 passes of 500 kg manaually driven iron roller at proctor moisture) in main plots and four levels of sulphur (i.e. 0, 15, 30 and 45 kg S ha^{-1}) through gypsum in sub plots treatment which were replicated four times. The results indicated that sub-surface compaction with 8 passes of 500 kg manually operated iron roller has increased maximum bulk density and moisture storage capacity besides, decrease in saturated hydraulic conductivity and infiltration rate of soil. Maximum increase in the growth attributes (viz., plant height, leaf area index, root weight density and root length density at flowering stage), yield (grain and straw), test weight and harvest index was recorded under the treatment 8 passes of 500 kg iron roller and 45 kg S ha^{-1} application, however 4 passes of 500 kg iron roller and 45 kg S ha^{-1} application was statistically at par with 8 passes of 500 kg iron rolelre and 45 kg S ha^{-1} application with respect to above parameters. Thus the above findings indicates that one can achieve highest return with the low levels of compaction and sulphur application as compared to higher levels of compaction and sulphur application.

Key words : Saturated hydraulic conductivity, bulk density, moisture content, root weight density, root length density.

Barley crop from sulphur deficient fields are occurring with greater frequency at various location in India. Leaching and depletion of soil sulphur due to maximum cultivation of cereal crops in cropping sequence, created a gap between supply and removal of sulphur. Use of sulphur free fertilizer in intensively cropped areas, depletion of organic matter in soil which is supposed to be a reservoir of sulphur are also important causes for sulphur deficiency. Loamy sand soils of Rajasthan are highly permeable and loss of water and soluble nutrients especially sulphur is quite high from these soil. Sub surface compaction improves the retention of these inputs, hence looking to the interest of grower and the constraints associated with hihgly permeable soils of Rajasthan, experiments on barley crop was conducted so, as to evaluate improvement in the production potential of this crop.

Materials and Methods

Field experiment was conducted on Chomu series, loamy sand, classified as hypothermic family of Typic Ustipsamment Geographically it is situated 45 km west of Jaipur at 26° 06' North latitude and 75° 28' East longitudes at an altitude of 427 meters above the mean sea level. Experiment on barley was taken in a split-plot design. The treatment consists of four levels of compaction i.e. no compaction (C_0), two passing (C_2) and four passing (C_4) and 8 passing (C_8) of 500 kg iron roller at proctor moisture in main plot, whereas four levels of sulphur i.e. no sulphur (S_0), 15 (S_{15}), 30(S_{30}) and 45 (S_{15}) kg sulphur ha^{-1} and were replicated four times.

Barley seed (RD-2552) was sown with the help of plough at a depth 4-5 cm with row to row distance of 22.5 cm. Uniform basal dose of nitrogen @ 80 kg ha^{-1} through urea, phosphorus @ 40 kg ha^{-1} through DAP in all the plots were applied, where as sulphur was applied through gypsum as per treatment 21 days before sowing and incorporated in the soil. Various physical properties were determined by usual analytical procedures as described by Majumdar and Singh, 2000.

The height of five randomly selected plants in each plot was measured from base to the top of the plant at harvest stage of barley. The leaf area index was measured with the help of leaf area meter. Root weight density and root length density at flowering were collected from0-15 cm depth in all replication with help of three soil cores (7.0 cm in diameter, 8.0 cm length) in the middle row and between two adjacent rows. The sample was washed with water and made free from organic debris and soil particles on 35 mesh screen. Root dry weight was divided by the volume of soil cores from which roots were extracted to obtain root weight density; the length of fresh root was measured by the line-intercept technique.

Result and Discussion

The soils of experimental site were loamy sand in texture, with clay 6.2 and sand content as high as 85.7 per cent. Bulk density, hydraulic conductivity and moisture content at field capacity were around 1.49 Mgm^{-3}, 10.2 cm hr^{-1} and 11.0 per cent in 0-15 cm soil laryer, respectively. Soil reaction was slightly alkaline with pH 8.0 and cation exchange capacity ranging from 5.0 to 5.3 cmol (p^+) kg^{-1} soil experiment site were poor in organic carbon content available nitrogen and sulphur whereas phosphorus content was moderate and potassium content in soil was some wheat low (Table 1).

After sub-surface compaction observation on bulk density, saturated hydraulic conductivity and moisture content (weight basis) in Typic Ustipsamment were recorded. The data revealed that (Table 2) maximum bulk density and moisture content of soil were obtained by 8 passing of 500 kg iron roller in 15-30 cm soil layer during just after compaction. Similarly higher decrease in hydraulic conductivity was obtained under 8 passing of 500 kg iron roller in all the layers (i.e. 0-15, 15-30 and 30-45 cm depth) at just after compaction as compared to that of no passing, two and four passing of 500 kg iron roller, Hirekurabar *etr al.* (1991) and Majumdar (1994) reported that decrease in hydraulic conductivity due to compaction could be attributed to increase in bulk density and re-arrangement of soil particle leading to increase fractional capillary porosity

Table 1. Physiochemical properties of experimental site

Soil properties	Soil depth (0-15 cm)
Coarse sand (%)	26.8
Fine sand (%)	58.9
Silt (%)	7.6
Clay (%)	6.2
Texture class	Loamy sand
Bulk density (Mg m^{-3})	1.49
Saturated hydraulic conductivity (cm hr^{-1})	10.2
Moisture content at 1/3 bar (%)	11.0
pH (1:2 soil water suspension)	8.0
ECe (dSm^{-1} at 25°C)	1.28
Organic carbon (%)	0.15
CEC [cmol (p^+) kg^{-1}]	5.2
Available N (kg ha^{-1})	128.2
Available P_2O_5 (kg ha^{-1})	16.8
Available K_2O (kg ha^{-1})	187.1
Available sulphur (mg kg^{-1} soil)	9.00

Majumdar *et al.* (2000) also reported after an exhaustive study on highly permeable soils that, crop raised after the compaction have shown remarkable increase in moisture content of soil as compared to uncompacted fields.

Growth attributes

Compaction

Compaction significantly increased the growth attributes of barley crop (Table 3). The maximum plant height (97.17 cm), leaf area index (3.76), root length density (1.58 cm cm^{-3}) and root weight density (37.3 µg cm^{-3}) were recorded under C_8 (i.e. compaction by 8 passes of 500 kg iron roller) and minimum plant height (79.65 cm), leaf area index (3.06), root length density (1.21 cm^{-3}) and root weight density (274 µg cm^{-3}) were observed under C_0 (i.e. no compaction) treatment respectively. The percent increase in the plant height, leaf area index, root length density and

Table 2. Effect of compaction on the average bulk density, saturated hydraulic conductivity and moisture content at the just after compaction

Soil properties	Depth (cm)	Treatment (compaction)			
		C_0	C_2	C_4	C_8
Bulk density (Mg m^{-3})	0-15	1.48 ± 0.018	1.53 ± 0.009	1.56 ± 0.031	1.57 ± 0.018
	15-30	1.51 ± 0.025	1.57 ± 0.024	1.61 ± 0.018	1.63 ± 0.029
	30-45	1.53 ± 0.012	1.56 ± 0.025	1.50 ± 0.018	1.59 ± 0.027
Saturated hydraulic conductivity (cm hr^{-1})	0-15	10.85 ± 0.021	9.40 ± 0.018	8.70 ± 0.011	8.16 ± 0.018
	15-30	9.20 ± 0.018	8.10 ± 0.036	7.20 ± 0.025	6.60 ± 0.021
	30-45	8.75 ± 0.014	8.22 ± 0.036	7.42 ± 0.025	6.80 ± 0.008
Moisture content (%)	0-15	8.11 ± 0.018	10.92 ± 0.018	12.40 ± 0.025	13.09 ± 0.018
	15-30	8.61 ± 0.006	11.77 ± 0.029	13.09 ± 0.011	13.79 ± 0.008
	30-45	8.96 ± 0.040	11.35 ± 0.024	12.96 ± 0.023	13.66 ± 0.008

Table 3. Effect of compaction and sulphur levels on growth attributes of barley crop

Treatments	Plant height at harvest stage	Leaf area index at flowing stage	Root weight density at flowing	Root length density at flowing
Compaction levels				
C_0	79.65	3.06	274	1.21
C_2	87.65	3.42	308	1.38
C_4	93.75	3.65	346	1.51
C_8	97.17	3.76	373	1.58
SEm±	1.76	0.07	5.31	0.03
CD (P-0.05)	5.63	0.22	17.00	0.12
Sulphur levels				
S_0	81.45	3.01	293	1.26
S_{15}	87.83	3.40	319	1.38
S_{30}	93.46	3.64	337	1.48
S_{45}	95.48	3.84	352	1.56
SEm±	1.63	0.07	5.27	0.016
CD (P=0.05)	4.67	0.19	15.08	0.083

root weight density by 8, 4 and 2 passing of 500 kg iron roller were of in order of 21.99, 17.70 and 14.05; 22.87, 17.28 and 11.76; 30.79, 24.79 and 14.05 and 36.13, 26.18 and 12.41 respectively over that of control. Data further reveals that the treatment C_4 was found to be statistically at par with that of C_8 treatment with respect to plant height, leaf area index and root length density.

The above observation indicate that the compaction treatment has improved the physical condition of soil that led the better availability of moisture (Singh *et al.*, 1991) increase in nutrient content per unit volume of soil due to increase in bulk density (Ogunreni *et al.*, 1986) and more contact between the root and soil particle consequently higher availability of nutrients (Kar *et al.*, 1976).

Sulphur

Increasing levels of sulphur significantly infleunced the growth attributes (Table 3) of barley crop. The maximum plant height (95.48 cm), leaf area index (3.84) root weight density (352 μg cm^{-3}) and root length densityh (1.56) were observed under 45 kg S ha^{-1} treatment, where as minimum plant height (81.45) leaf area index (3.01), root weight density (293 μg cm^{-3}) and root length densithy (1.28 cm cm^{-3}) were recorded under no sulphur treatment. Application of sulphur @ 45, 30 and 15 kg ha^{-1} produced 17.22, 14.75 and 7.83; 27.57, 20.93 and 12.96; 20.14, 15.02 and 8.87 and 24.75, 17.69 and 9.94 per cent more plant height, leaf area index, root weight density and root length density respectively over that of control (S_0)

treatment. Perusal of data further indicate that increase in plant height, leaf area index, root weight density and root length density observed under S_{30} (i.e. S @ 30 kg ha^{-1}) was found to be statistically at par with that of S_{45} (i.e. S @ 45 kg ha^{-1}) treatment.

The above observation indicates that increasing levels of sulphur significantly increased the growth attributing character. This is probably due to better nutrientional enviroment for plant growth. Increase content of sulphur in plant also helped in better development and thickening of xylem, sulphur helped in better uptake of nutrients, the results so obtained get support from findings by Wani and Refique (2000). Sulphur is required for essential function of plant life especially in chlorophyll formation. Sulphur being a constitutent of succnly COA which involves in chlorophyll formation (Pirson, 1965) and by creating a balanced nutritional environment in the plant system in keeping the micro-nutrient physically active has been very instrumental in increased chlorophyll synthesis in plant leaves. Sulphur application to crops improve nutritional environment for root growth as well as plant system and ultimately enhanced the plant metabolism and photosynthetic activity resulting into better growth and development of plant root.

Yield attributes

Compaction

A perusal of data given in Table 4 indicate that the yield attributes of barley crop have been significantly affected by the compaction levels. The maximum number of ears per plant (3.47), length of ears per plant (7.30 cm) and effective tillers per meter row length (69.85) were obtained under C_8 (i.e. compaction by 8 passes of 500 kg iron roller) and minimum number of ears per plant (2.37), length of ears per plant (5.00 cm) and effective tillers per meter row length (47.89) were observed under C_0 (i.e. no compaction) treatment respectively. The percent increase in number of ears per plant, length of ears per plant and effective tillers per meter row length under C_8, C_4 and C_2 were of in order of 46.41, 39.24 and 18.14; 46.00, 40.00 and 22.00 and 45.85, 38.53 and 12.67, respectively over that of control. Data further reveal that the treatment C_4 was found to be statistically at par with that of C_8 treatment with respect to number of ears per plant, length of ears per plant and effective tillers per meter row length.

Table 4. Effect of compaction and sulphur levels on yield attributing characters of barley crop

Treatments	No. of ears per plant	Length of ears per plant	Effective tillers per meter row length
Compaction levels			
C_0	2.37	5.00	47.89
C_2	2.80	6.10	53.96
C_4	3.30	7.00	66.35
C_8	3.47	7.30	69.85
SEm±	0.07	0.12	1.11
CD (P=0.05)	0.23	0.40	3.56
Sulphur levels			
S_0	2.44	5.20	50.21
S_{15}	2.85	6.20	57.88
S_{30}	3.24	6.90	64.22
S_{45}	3.41	7.10	65.75
SEm±	0.07	0.11	0.91
CD (P=0.05)	0.19	0.31	2.60

The results so obtained clearly indicate that the compaction treatment has improved the physical condition of soil that led the better availability and uptake of nutrient and ultimately enhance the yield attributing character of barley crop. Increase in numbner of ears per plant, length of ears per plant and effective tillers per meter row length of crop due to compaction treatment have been reported by Majumdar *et al.* (2000) and Singh and Verma (2001).

Sulphur

Increasing levels of sulphur significantly influenced the yield attributing characters of barley crop. An application of 45 kg S ha^{-1} resulted in higher number of ears per plant (3.41), length of ears per plant (7.10 cm) and effective tillers per meter row length (65.75) whereas the lower ears per plant (2.44), length of ears per plant (5.20 cm) and effective tillers per meter row length (50.21) were observed under no sulphur treatment. Application of sulphur @ 45, 30 and 15 kg ha^{-1} produced 39.75, 32.79 and 16.80; 36.54, 32.69 and 19.23 and 30.95, 27.89 and 15.27 per cent more number of ears per plant, length of ears per plant and effective tillers per plant row length respectively over that of control (S_0) treatment. Perusal of data further indicate that increase in yield attributing characters obtained under S_{30} (i.e. S @ 30 kg ha^{-1}) were found to be statistically at par with that of S_{45} (i.e. S @ 45 kg ha^{-1}) treatment.

The data clearly show that yield attributing characters were affected by sulphur application. Sulphur application to crop improve nutritional environmental for root growth as well as that plant system and ultimately the plant metabolism and photosynthetic activity resulting into better growth and development of plant. These results also get support from findings made by Mahaptra *et al.* (2000) and Singh and Verma (2001).

Yield

Compaction

Compaction sigificantly increased the grain, straw yield and test weight whereas harvest index could not show any significantly effect (Table 5) maximum grain (41.61 q ha^{-1}), straw yield (63.77 q ha^{-1}) and test weight (38.29 gm) were obtained under C_8 (i.e. compaction by 8 passes of 500 kg iron roller), whereas minimum grain (28.40 q ha^{-1}) straw yield (44.01 q ha^{-1}) and test weight (36.50 gm) was observed under C_0 (i.e. no compaction) treatment respectively. The percent increase in grain, straw yield and test weight under C_8, C_4 and C_2 were of in order of 46.57, 40.04 and 18.42; 44.90, 37.92 and 15.86 and 4.90, 3.78 and 2.49 respectively over that of control. Data further reveal that the treatment C_4 was found to be statistically at par with that of C_8 treatment with respect to grain, straw yield and test weight.

The above observation indicate that compaction treatment has improved the physical condition of soil that led the better availability and uptake of nutrient and ultimately enhanced the growth and yield attributing character of barley crop. Increase in grain, straw yield and test weight of crop due to compaction treatments have been reported by Majumdar *et al.* (2000) and Yadav and Jakhar (2001).

Table 5. Effect of compaction and sulphur levels on yield, test weight, and harvest index of barley crop

Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Test weight (gm)	Harvest index (per cent)
Compaction levels				
C_0	28.40	44.01	36.50	39.18
C_2	33.63	50.99	37.41	39.72
C_4	39.77	60.70	37.88	39.62
C_8	41.61	63.77	38.29	39.53
SEm±	0.68	1.39	0.15	0.278
CD (P=0.05)	2.16	4.44	0.49	NS
Sulphur levels				
S_0	29.92	46.02	36.61	39.36
S_{15}	34.72	52.85	37.46	39.62
S_{30}	38.81	58.94	37.96	39.66
S_{45}	39.96	61.66	38.05	39.42
SEm±	0.54	1.01	0.13	0.327
CD (P=0.05)	1.55	2.86	0.38	NS

NS : Non significant

Sulphur

Examination of data given in Table 5 revealed that grain, straw yield and test weight of barley were increased significantly due to sulphur application. An application of 45 kg S ha^{-1} resulted higher grain (39.96 q ha^{-1}), straw yield (61.66 q ha^{-1}) and test weight (38.05 gm), whereas minimum grain (29.92 q ha^{-1}), straw yield (46.02 q ha^{-1}) and test weight (36.61 gm) were observed under no sulphur treatment. Application of sulphur @ 45, 30 and 15 kg ha^{-1} produced 33.56, 29.71 and 16.04; 33.99, 28.67 and 14.84; 3.93, 3.69 and 2.32 per cent more grain, straw yield and test weight respectively over that of control (S_0) treatment. Perusal of data further indicate that increased grain, straw yield and test weight obtained under S_{30} (i.e. S @ 30 kg ha^{-1}) was found to be statistically at par with that of S_{45} (i.e. S @ 45 kg ha^{-1}) treatment.

The above observation indicates that increasing levels of sulphur significantly increased the grain, straw yield and test weight. Sulphur is also essential for chlorophyll formation. Supply of sulphur in adequate and appropriate amounts helps in flower primordial initiation for its reproductive parts. It is established fact that grain, straw yield and test weight of crop is a function of yield attributes. The increase in yield attributes due to sulphur application have increased grain, straw yield and test weight of barley crop as evidenced by significant relation between yield attributes and yield. Similar, results were advocated by Singh and Singh (2001), and Dwivedi *et al.* (2002).

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