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EFFECT OF SOIL TEXTURE AND COMPACTION ON NUTRIENT UPTAKE AND GROWTH OF MAIZE *(Zea mays* L.)

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A pot experiment was conducted to determine the effect of soil texture and compaction on the growth and nutrient absorption by maize. Two soils, clay loam and sandy clay loam, were selected for the study. Fifteen pots were filled with each soil and compaction was accomplished by dropping 5kg weight from two feet height @ 10 beats or 20 beats at field capacity (FC) or 70% of FC. Maize crop (cv, Golden) was sown during summer of the year 1996. Crop was harvested 90 days after sowing and plant height, fresh and dry weights of roots and shoots were measured. Roots and shoots were analyzed for N, P and K contents. Results revealed that more increase in plant height, root and shoot fresh and oven dry weights and N, P and K uptake was observed in the case of sandy clay loam than that of clay loam soil, while soil compaction had no significant effect on these parameters. Interaction between soil texture and compaction was statistically non-significant for all these parameters.

Key words: growth of maize, nutrient uptake, soil texture and compaction

INTRODUCTION

Technological advances in the farm machinery have, in part, increased farm productivity. These implements are often heavier and larger than conventional tillage implements, thus creating the soil compaction by their heavy axle load. Compaction changes the physical properties of soil and creates the environment, not conducive for the good growth of crops, especially those of upland, which require well-aerated soil environment. Soil physical properties and processes affected by soil compaction include mechanical resistance, disruption of pore continuity and altered water and heat flow. These properties are vital for root growth, nutrient movement and uptake, and consequently for plant growth (Logsdon et al., 1987). Large soil pores, which conduct water at lower tension, are more easily affected by soil compaction than smaller pores, conducting water at higher tension. Thus the rate of water movement and uptake is potentially reduced (Ankeny et al., 1990).

In the compacted soil environment, the mechanical impediment to root renders it unable to penetrate deeply and hence the soil compaction reduces the volume of soil explored by roots. A restricted root system may greatly reduce the plant uptake of less mobile nutrients like P. In field studies Dolan et al. (1992) found that subsoil compaction reduced the P uptake by 22% in 1982 and 7% in 1985. Similarly, K uptake was reduced between 8 to 21kg ha^{-1} in the compacted field. Another greenhouse study revealed that soil compaction reduced the uptake and plant tissue concentration of P and K in corn plants and pea seedlings (Castillo et al., 1982; Lowery and Schuler, 1991). Literature indicates that yield of field crops decreases with an increase in soil compaction (Voorhees et al., 1989; Oussible et al., 1992). For example, Dolesh et al. (1987) reported that yield of maize crop decreased up to 61% with soil compaction induced by 20 tonne axle load, compared with control.

Keeping these aspects in mind, a pot study in a wire-house was carried out during the year 1996 to evaluate the effect of soil compaction on growth and nutrient uptake by maize *(Zea mays* L.) plants.

MATERIALS AND METHODS

The study was carried out in a wire-hour in the Department of Soil Science, University of Agriculture, Faisalabad. Two soils having clay loam (moderately fine) and sandy clay loam (medium) textures were collected from the surface layer (0-15 cm), air-dried, ground, passed through 2mm sieve and were filled in pots @ 12kg soil per pot. The pots were then saturated with water and allowed to dry. The cracks/voids thus produced were filled with soil. This process was repeated to achieve natural settling of soil. A basal dose of fertilizers [75mg N, 60mg P_2O_5, 60mg K_2O per kg of soil in the form of urea, single super phosphate (SSP) and sulfate of potash (SOP), respectively] was applied. The water, equal to saturation percentage of soil, was added to each pot. Following treatments pertaining to the clay loam texture were tested: T_1S_1=Control; T_2S_1=10 beats at field capacity (FC); T_3S_1=10 beats at 70 0k of FC; T4SI=20 beats at FC; T"Sl=20 beats at 70 % ofFC.

The same treatment combinations were applied in S2 (sandy clay loam soil).

Compaction was accomplished with the help of 5kg weight, dropping from two feet height on a rounded wooden block placed on soil surface inside the pots 10 or 20 times (beats) at two soil moisture levels (FC or 70% FC). After compacting the soil, upper 2-3 cm soil surface was loosened with spatula and seven seeds of maize (cv. Golden) were sown in each pot and seven days after germination the seedlings were thinned to four. Irrigation and plant protection measures were carried out as and when needed. Plants were harvested 90 days after sowing and growth parameters such as plant height, fresh and oven-dry weight of roots and shoots were measured. Roots and shoots were analyzed for N, P and K concentration and their uptake was determined. Statistical analysis was carried out following 'ANOVA' and DMR test as described by Steel and Torrie (1980).

RESULTS AND DISCUSSION

a) Plant Height: Among the experimental treatments, the highest plants (91.3 cm) were obtained in sandy clay loam soil (Fig. la). Compaction had no significant effect on plant height. However, the highest plants (93.5 cm) were obtained in control while plants remained the lowest (65.3 cm) in T4 (20 beats at FC). The reason might be that the compaction when carried out at higher water content level, has more deleterious effect because soil particles tend to adhere with one another than that when carried out at lower ones. This phenomenon might be responsible for reduced plant height due to restricted aeration and low uptake of water/nutrients. Literature also indicates that compaction reduces *the plant* height, productive tillers and most yield components *(Styk* and Sochaj, 1992).

b) Fresh and Oven - **Dry Weight of Shoot:** Statistically the highest fresh and oven-dry weights (161.7 *g/pot* and 58.4 *g/pot)* were obtained in sandy clay loam soil, respectively as against 95.4 *g/pot* fresh and 36.4 *g/pot* dry weight under clay loam soil (Fig. Ib). Less weight under clay loam texture can be attributed to low nutrient uptake and less root development under finer texture than coarser one, due to less aeration and less mobility of nutrients and water. Compaction had no significant effect on shoot weight. Earlier, Martinez et al. (1992) reported that compaction and texture significantly reduced the fresh and dry matter yield.

c) Fresh and Dry Weight of Root: Coarser texture (sandy clay loam) yielded higher fresh and oven-dry weights (106.3 and 23.2 g/pot), respectively compared to 60.2 and 11.5 *g/pot* for the clay loam soil (Fig. Le). The low values for fresh and oven-dry weights might be due to reduced root growth because of poor aeration and low uptake of water and/or nutrients. Chen and Cheng (1990) also reported that barrier of soil compaction can reduce the yield to 5.6 t ha⁻¹ as compared to 7.9 tonnes at a similar site without compaction.

d) Nitrogen Uptake: Maximum N uptake (967.0 *mg/pot)* was found in the sandy clay loam, which differed significantly from that of clay loam soil i.e. 583.0 mg pot-I (Fig.2a). The low uptake for clay loam soil might be due to less soil exploration because of poor root growth as described by Iijima et al. (1991). Compaction had no significant effect on N uptake by shoot but the highest value was for the control plants and the least being with 20 beats at FC. A similar trend was obtained for N uptake by roots. This may be due to the fact that compaction at high water contents results in reduced pore space and the destroyed structure. Previously, Lowery and Schuler (1991) also noted that compaction reduced the Nand K uptake and consequently the plant height and physiological maturity.

e) Phosphorus Uptake: Statistically more uptake of P was observed with sandy clay loam than with clay loam soil (Fig. 2b). Compaction significantly decreased the P uptake by roots. Low aeration, restricted root development and consequently less soil exploration might have caused the low P uptake. In an earlier study, Dolan et a1. (1992) reported that corn P uptake in surface compacted treatment (16kg ha⁻¹) was 1kg ha⁻¹ lower than that *in the* non-compacted one *(l7kg* ha⁻¹).

f) Potassium Uptake: More K uptake was observed from sandy clay loam soil than that from clay loam soil both by the shoots and roots (Fig. 2c). This might be due to the poor root growth in fine textured soil, which causes low K uptake than that in coarser soil. It was indicated earlier that uptake of essential nutrients like P and K was potentially reduced by soil compaction (Dolan et al., 1992).

Conclusions: Texture affects significantly all the physical parameters and nutrient uptake both by shoots and roots. Compaction had no significant effect on any of these parameters (except P uptake by roots). It might be due to the reason that level of

Table 1. Effect of texture and compaction on physical parameters of maize plants

1-Plant height

	Compaction levels					
	T1 0 beats	T2 la beats (FC)	T3 la beats (70% FC)	T4 20 beats (FC)	Ts 20 beats (70%FC)	Mean
Sl(CL)	87.3	73.3	57.2	41.6	66	65.1b
S2(SCL)	99.7	92.2	92.5	88.9	82.4	91.3a
Mean	93.5	83	74.9	65.3	74.2	

2-Shoot fresh weight

	Compaction levels					
	T1 0 beats	T2 la beats (FC)	T3 la beats (70% FC)	T4 20 beats (FC)	Ts 20 beats (70%FC)	Mean
SI(CL)	151	124.3	75.5	70.1	56.3	95.4b
S2(SCL)	229.7	112	193.3	117	156.2	161.7a
Mean	190.4	118.2	134.4	93.6	106.2	

3-Shoot oven-dry Weight

	Compaction levels					
	Tl 0 beats	T2 la beats (FC)	T3 la beats (70% FC)	T4 20 beats (FC)	Ts 20 beats (70%FC)	Mean
SI(CL)	55.2	45.5	23.3	29.4	28.6	36.4b
S2(SCL)	64.3	44	61.7	49.2	72.8	58.4a
Mean	59.7	44.7	42.5	39.3	50.7	

4-Root fresh weight

	Compaction levels					
	Tl 0 beats	T2 la beats (FC)	T3 la beats (70% FC)	T4 20 beats (FC)	Ts 20 beats (70%FC)	Mean
SJ(CL)	75.7	83.3	54.3	51.5	36.2	60.2b
S2(SCL)	163.4	72.6	28.5	85	82.1	106.3a
Mean	119.6	77.9	91.4	68.2	59.2	

5-Root oven dry weight

	Compaction levels					
	TI 0 beats	T2 la beats (FC)	T3 la beats (70% FC)	T4 20 beats (FC)	Ts 20 beats (70%FC)	Mean
Sl(CL)	19.7	12.4	9.3	10.8	5.3	11.5b
S2(SCL)	30.2	15.2	34.9	16.7	19	23.3a
Mean	24.9	13.8	22.1	13.8	12.1	

Table 2. Effect of texture and compaction on mineral nutrition of maize plants

1N - uptake by shoots

	Compaction levels					
	T1 0 beats	T2 10 beats (FC)	T3 10 beats (70% FC)	T4 20 beats (FC)	T5 20 beats (70%FC)	Mean
S1(CL)	846.8	726.2	381.5	575.9	388	583.7b
S2(SCL)	832.6	815	1095	828.7	1263.9	967a
Mean	839.7	770.6	738.2	702.3	825.9	

2N - Uptake by roots

	Compaction levels					
	T1 0 beats	T2 10 beats (FC)	T3 10 beats (70% FC)	T4 20 beats (FC)	T5 20 beats (70%FC)	Mean
S1(CL)	104.3	93.7	53	55.6	31.1	67.6b
S2(SCL)	206.7	90.5	177.8	119.4	129	144.7a
Mean	155.5	92.1	115.4	87.5	80.1	

3P - uptake by shoots

	Compaction levels					
	T1 0 beats	T2 10 beats (FC)	T3 10 beats (70% FC)	T4 20 beats (FC)	T5 20 beats (70%FC)	Mean
S1(CL)	45.5	38	22	18.5	14.5	27.7b
S2(SCL)	35.1	40.4	48.1	44.3	44.1	42.4a
Mean	40.3	39.2	35	31.4	29.3	

4P - Uptake by roots

	Compaction levels					
	T1 0 beats	T2 10 beats (FC)	T3 10 beats (70% FC)	T4 20 beats (FC)	T5 20 beats (70%FC)	Mean
S1(CL)	15.9	10.9	5.8	8.5	3.4	8.9b
S2(SCL)	26.3	10.4	27.5	13.3	10.6	17.6a
Mean	21.1a	10.6c	16.7b	10.9c	7.0d	

5K - uptake by shoots

	Compaction levels					
	T1 0 beats	T2 10 beats (FC)	T3 10 beats (70% FC)	T4 20 beats (FC)	T5 20 beats (70%FC)	Mean
S1(CL)	1227.3	1007.5	513.3	650.8	630.3	805.8b
S2(SCL)	1418.4	966.2	1350.3	1073.5	1596.6	1281a
Mean	1322.9	986.8	931.8	862.1	1113.4	

6K - Uptake by roots

	Compaction levels					
	T1 0 beats	T2 10 beats (FC)	T3 10 beats (70% FC)	T4 20 beats (FC)	T5 20 beats (70%FC)	Mean
S1(CL)	423.6	265.2	198.6	232.9	114	246.9b
S2(SCL)	644.6	323.5	742.4	350.2	403.5	492.8a
Mean	534.1	294.4	470.5	291.6	258.7	

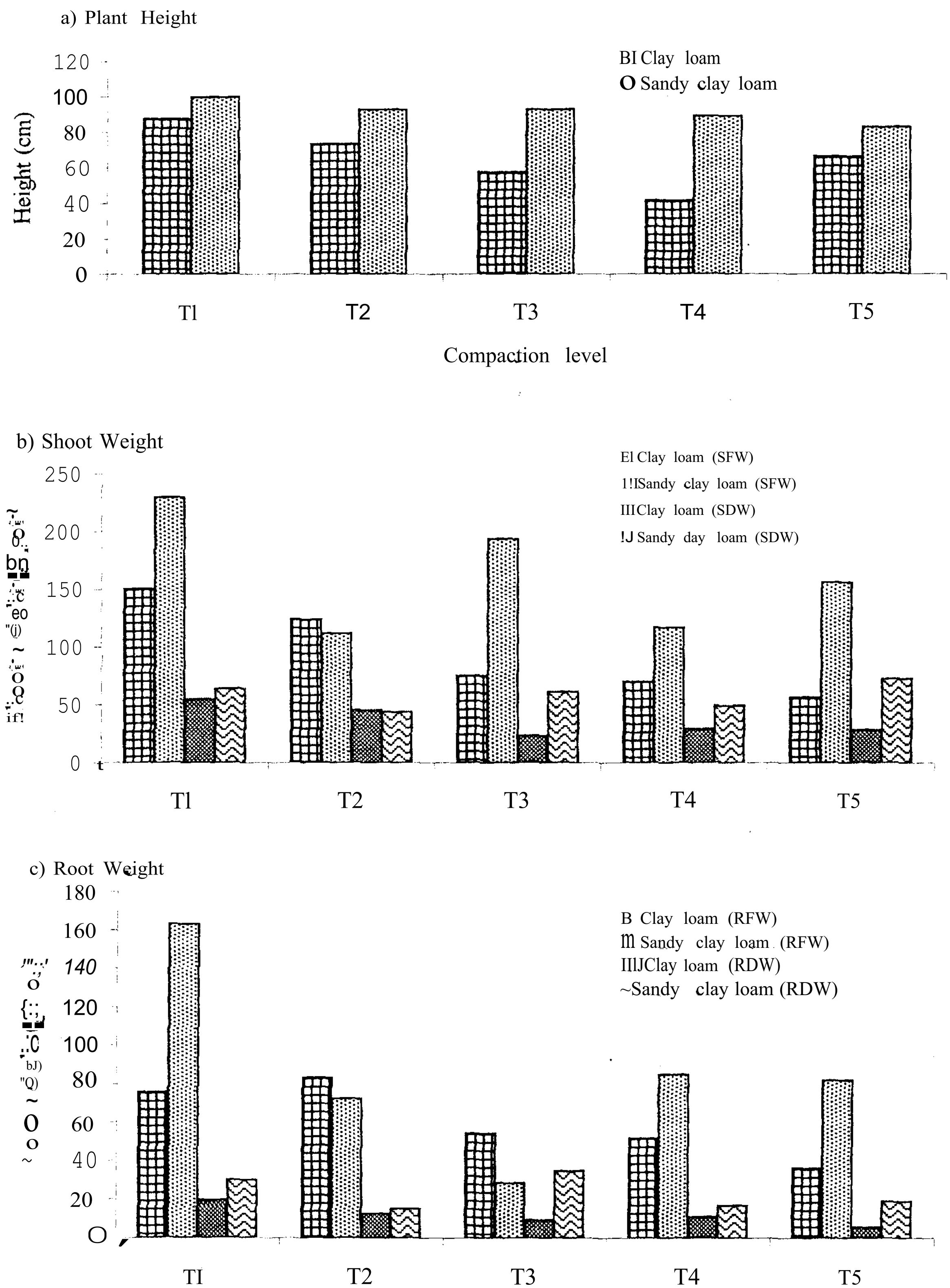

Fig. 1: Effect of soil texture and compaction on maize (*Zea mays* L.) growth

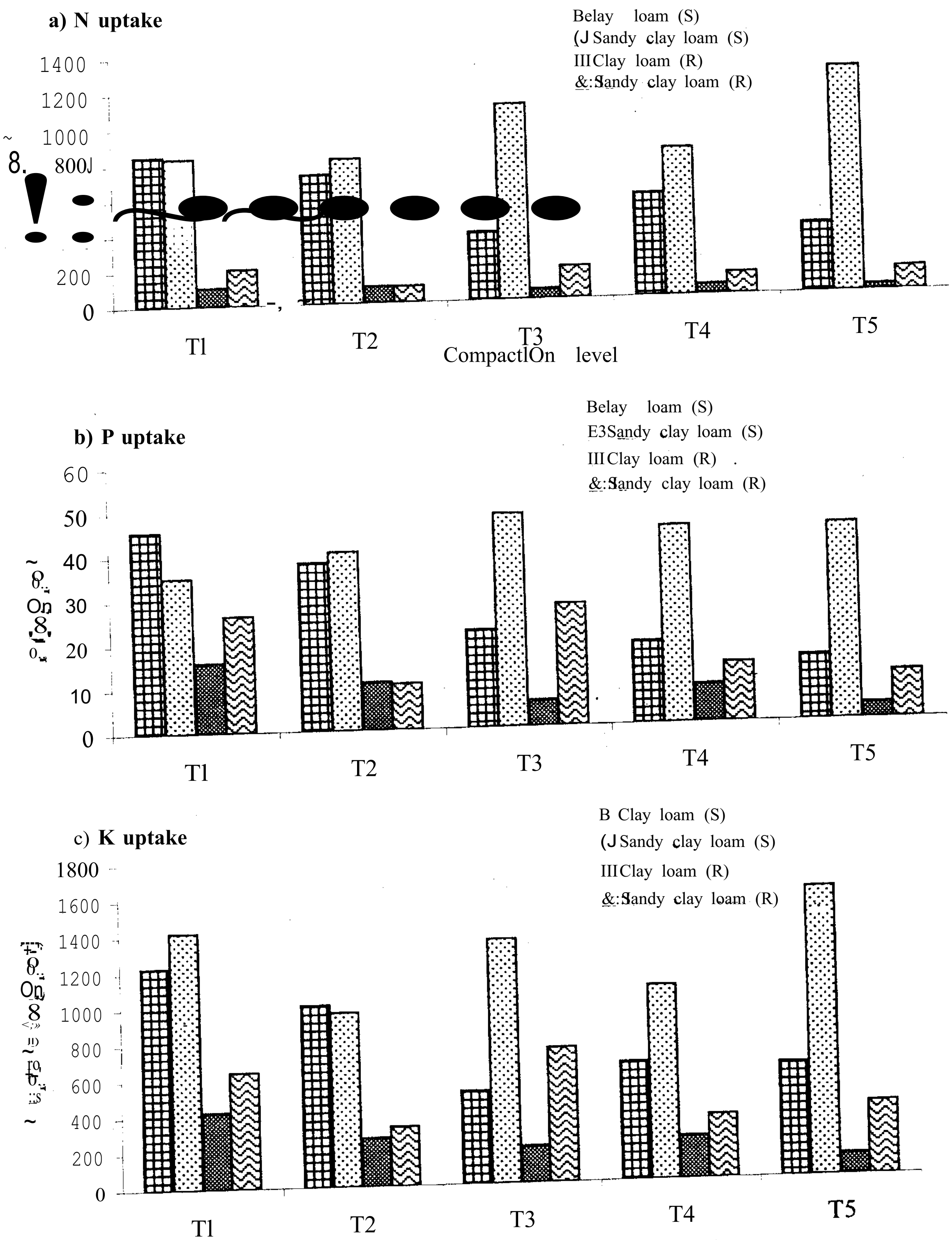

Fig.2 Effect of soil texture and compaction on nutrient uptake by maize (Zea mays L.)

compaetion was not severe enough to cause a significant decrease/increase in these parameters.

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