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PARTICLE SIZE AND COMPACTION PRESSURE OF SOIL AS IMPORTANT PARAMETERS IN THE SELECTION OF TRACTORS AND EQUIPMENT

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The application of tractors and equipment may produce compaction and particle size of soil of such values that may greatly affect the emergence pressure and growth of seedlings. This study was accordingly undertaken to investigate the effects of such parameters under varying conditions of soil moisture. On the basis of relevant investigations, it was recommended that the use of heavy tractors and equipment be avoided so as to achieve a happy balance between the air, water and solid components of soil.

INTRODUCTION

The importance of design, construction and operation of tillage and traction equipment in creating soil conditions conducive to plant growth, has long been recognised by agricultural engineers. The application of such an equipment may produce the particle size of soil and compaction pressure of such values which are likely to upset the balance between air, soil and water components. The coarseness or fineness of the soil in the vicinity of seeds, and the level of its compaction alongwith moisture will affect the emergence pressure of seedlings and the final yield of crops. This study was accordingly undertaken to investigate the effect of size of soil particle, compaction pressure and moisture on the emergence pressure and growth of seedlings with a view to select a suitable size of tractor and allied equipment.

MATERIALS AND METHODS

An instrument was developed for measuring the force or pressure exerted by a mechanical seedling having a diameter equal to the diameter of alfalfa seedling (0.12 cm) and was forced to move through the soil in a manner similar to that of an emerging seedling. A cantilever beam attached to a rectangular plate was constrained to move up and down on the two guide rods of the instrument at the rate of 20 cm per minute. An SR-4 strain gauge bridge, fixed at the end of cantilever beam, was employed for sensing the force exerted by the mechanical seedling.

ii. An Offner Dynograph was used to amplify and record the force of pressure, on a two channel oscillograph.

iii. A hydraulic press fitted with a pressure gauge was employed for packing the soil to a desired compaction pressure.

iv. An electric sprayer was used for spraying water on the soil to increase the moisture content of the soil.

v. A rotary sieve was used for separating various grain sizes of soil.

Three grain sizes i.e. 0.32 and 0.21 cm and a standard mixture were chosen in this experiment. The standard mixture with a

weighted mean size of 0.18 cm consisted of the following percentages of different sizes:

0.16 cm grain size	-	50%
0.21 cm grain size	-	30%
0.25 cm grain size	-	20%

Three boxes of each aggregate size were planted with alfalfa seeds at a depth of 2.54 cm from the top surface. Compaction pressure was applied both at the seed level and top surface. The boxes were placed at a constant room temperature of 25 ° C. Final emergences were converted into percentages of emergence. The experiment was repeated for different moisture contents and compaction pressures.

RESULTS AND DISCUSSION

Table 1 shows the results of emergence pressure and percentage emergence of alfalfa seedlings for the various sizes of soil at different compaction pressures and moistures. The relevant regression equations have been mentioned in the last column of the table.

The multiple linear regression analysis of the entire data mentioned in Table 1 yielded the following equations:

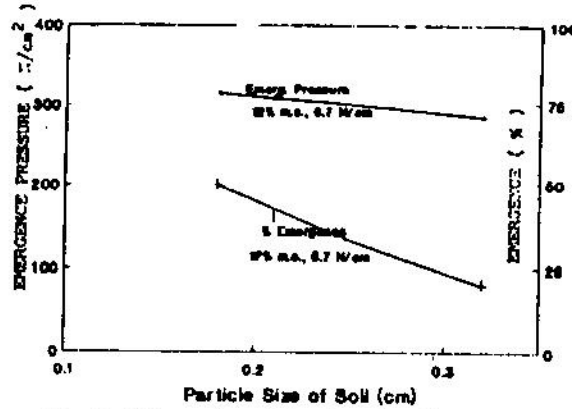

Fig. 1. Effect of particle size of soil at 12% moisture on emergence pressure and percentage emergence (medium compaction pressure)

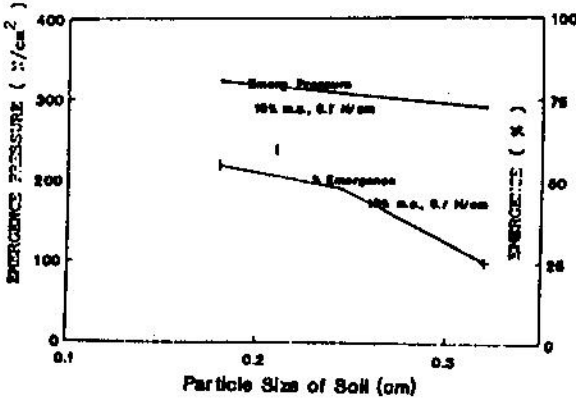

Fig. 2. Effect at a higher moisture content (16%) and medium compaction.

$$Y_1 = 73.26 + 424\,X_1 - 5.26\,X_2 - 468\,X_3 + 7.03\,X_1X_2 - 354\,X_1X_3 + 31.5\,X_2X_3 \quad (R = 0.99)$$

$$Y_2 = 61.1 - 25.7\,X_1 + 5.82\,X_2 - 225\,X_3 - 4.46\,X_1X_2 + 115\,X_1X_3 - 3.7\,X_2X_3 \quad (R = 0.97)$$

where:

Y_1 = emergence pressure of seedling in Newton/cm² (N/cm²),

Y_2 = emergence of seedling in percentage,

X_1 = compaction pressure of soil in N/cm²,

X_2 = moisture of soil in percentage,

X_3 = grain size of soil in cm, and

R = multiple correlation coefficient.

It may be noted from Table 1 that the pressure exerted by the alfalfa seedling during emergence varies from 118 Newtons/cm² to 511 Newtons/cm² for different compactions, moistures and grain sizes of soil. Equations (1) and (2) indicate that the emergence pressure and percentage emergence of seedlings are not only the functions of compaction pressure, moisture

Table 1. Emergence force/pressure and percentage emergence of seedlings

X_1 Compaction pressure	X_2 Soil moisture	X_3 Grain size	Y_1 Emergence pressure	Y_2 Seedling emergence	Equations (Y_1 in N/cm^2, Y_2 in % and X_3 in cm)
0.35	12	0.18	149	65	$Y_1 = 182 - 205\ X3,\ r = 0.95$
0.35	12	0.21	133	50	$Y_2 = 105 - 239\ X3,\ r = 0.97$
0.35	12	0.32	118	30	
0.35	16	0.18	157	70	$Y_1 = 194 - 189\ X3,\ r = 0.98$
0.35	16	0.21	157	60	$Y_2 = 107 - 212\ X3,\ r = 0.99$
0.35	16	0.32	133	40	
0.35	20	0.18	173	90	$Y_1 = 194 - 116\ X3,\ r = 0.99$
0.35	20	0.21	169	80	$Y_2 = 127 - 212\ X3,\ r = 0.99$
0.35	20	0.32	157	60	
0.70	12	0.18	314	50	$Y_1 = 358 - 235\ X3,\ r = 0.99$
0.70	12	0.21	310	40	$Y_2 = 87 - 212\ X3,\ r = 0.99$
0.70	12	0.32	283	20	
0.70	16	0.18	322	55	$Y_1 = 366 - 235\ X3,\ r = 0.99$
0.70	16	0.21	318	60	$Y_2 = 200\ e^{-6.44}\ X3,\ r = 0.95$
0.70	16	0.32	291	25	
0.70	20	0.18	354	60	$Y_1 = 291 - 324\ X3,\ r = 0.98$
0.70	20	0.21	354	65	$Y_2 = 248\ \ e^{-7.1}\ X3,\ r = 0.96$
0.70	20	0.32	395	25	
1.05	12	0.18	452	15	$Y_1 = 524 - 416\ x3,\ R = 0.99$
1.05	12	0.21	432	15	$Y_2 = 38 - 118\ x3,\ R = 0.98$
1.05	12	0.32	393	0	
1.05	16	0.18	503	20	$Y_1 = 601 - 504\ X3,\ r = 0.99$
1.05	16	0.21	491	15	$Y_2 = 46 - 146\ X3,\ r = 0.99$
1.05	16	0.32	432	0	
1.05	20	1.18	511	20	$Y_1 = 571 - 308\ X3,\ r = 0.99$
1.05	20	0.21	511	20	$Y_2 = 51 - 158\ X3,\ r = 0.99$
1.05	20	0.32	472	0	

and grain size of soil, but also of the interaction between such variables.

Some of the observations recorded in Table 1 have been depicted graphically in Figures 1 and 2. It may be observed from the graphs that the percentage emergence drops suddenly, while the decrease in emergence pressure is gradual.

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions may be drawn from the above figures and mathematical equations as mentioned in the last column of Table 1:

i. The percentage emergence of seedlings decreases suddenly with the grain size of soil, generally, observing a linear relationship.
ii. The emergence pressure of seedlings decreases gradually with the grain size following a linear pattern.
iii. The effect of compaction pressure is quite pronounced in suddenly dropping the percentage emergence when the grain size increases.
iv. The compaction pressure suddenly increases the emergence pressure of seedlings.
v. The increase in moisture content of soil suddenly increases the emergence of seedlings when the size increases. On the other hand, the emergence pressure decreases gradually with the moisture content.
vi. The emergence pressure and percentage emergence of seedlings are functions of soil particle size, moisture, compaction and interaction between them.
vii. The effect of compaction pressure of soil appears to be dominant as compared to other variables in increasing the emergence pressure and decreasing the emergence of seedlings.
viii. The effect of particle size is pertinent in decreasing the emergence of seedlings.
ix. Moisture is a prominent variable in increasing the percentage emergence of seedling. It also improves the emergence pressure of the seedlings.
x. The grain size does not drastically reduce the emergence pressure of seedlings. It is rather a gradual effect.

Keeping the above conclusions in view, it is recommended that the application of tillage equipment may be carried out to produce soil of such a particle size that will not hinder the growth of seedlings. Higher compaction pressures may also be avoided, thus discouraging the use of heavy tractors and implements.

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