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Effect of soil physical properties on draft of the rotary spider weeder tyne

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Tractor operated weeding implements can save about 75% time and 20% cost as compared to conventional methods. The rotary type weeder stirs the soil more accurately, disturb the weed root and remove them from the soil and pulverize the soil effectively.Soil physical properties are importantin design point of any weeders. The interactions between these parameters directly affect the power requirement to operate the machine.Hence, a study was conducted on effect of soil physical properties on the draft requirement of tyne. Soil moisture content is an independent parameter while, bulk density and soil resistance as dependent parameters were measured at respective soil moisture content. Bulk density and soil resistance decreased with increase in soil moisture content. Draft increased with the increase of forward speed at all levels of soil moisture content.

Key words*: Bulk density, Draft, Spider weeder,tyne, Soil moisture content, Soil resistance.*

In India, farmers mainly follow the hand weeding and chemical weeding in spite of it being costly. Use of herbicides will have residual effect and change the quality of soil. Flaming produces intensive heat and more expensive equipment is needed. Hand weeding requires more labour, consumes more time leading to high cost of weeding. An estimate of 400-600 man hours per hectare is the normal man-hour requirement of hand weeding which amounts to Rs.22,000 per hectare, which also depends upon level of weed infestation (Rao and Nagamani, 2013).Weeding was considered a major constraint in crop production. Most farmers experienced a serious labour bottleneck at weeding time. Extension workers considered that competition from weeds led to major losses and they estimated the yield reduction was over 10 per cent. Any equipment like hand khurpi, animal drawn blade hoe, power weeder, single-multiple row weeders, etc. are certainly possessing some inherent drawbacks which used for weeding operations resulting in unnecessary time consumption, extra labour cost, more power requirement (manually as well as mechanically).

Weeding operation is an important, but, equally labour intensive agricultural operation. Mechanical weed control is very effective as it helps to reduce drudgery involved in manual weeding, it kills the weeds and also keeps the soil surface loose ensuring soil aeration and water intake capacity. There is an increasing interest in the use of mechanical row weeders because of the concern over environmental degradation and a growing demand for organically produced food. Today, the agricultural sector requires non-chemical weed control that ensures food safety. Consumers demand high quality food products and pay special attention to food safety. Through the development of such precise new weeders not only meet the needs of the consumers and environmental demands.

Tractor operated weeding implements can save about 75 per cent time and 20 per cent cost as compared to bullock drawn methods(Rathod *et al.* 2010).Usually tractor mounted cultivators are used for weeding and inter-cultural operations in farm, but, these are not effective for soil pulverization. Rotary type weeder stirs the soil more accurately, disturb the weed root and remove them from the soil and pulverize the soil effectively. In addition, this helps in keeping the soil in loose condition for proper aerationand results in better aeration and runoff water conservation,especially for wide row spaced crops like cotton and maizewhere the tractor can be run. The main objective of this paper is to study of physical and mechanical properties of soil on draft requirement of the spider weedertyne.

MATERIAL AND METHODS

Blades of rotary spider weeder directly interact with soil to uproot the weeds. Hence, soil properties directly affect the weeding performance of weeder need to be studied. Following properties of soil were evaluated before designing the weeder

1. Soil moisture content
2. Bulk density
3. Soil resistance
4. Draft requirement

1. Soil moisture content

To determine the soil moisture content, soil samples were taken up to a depth of 100 mm. The samples were collected randomly from 3 locations before a day of weeding in the field. The samples were weighed and kept in an oven at 105±5 ^{0}C for 24 h. After drying the sample that collected were weighed on electronic balance. The moisture content of the soil was determined on dry weight basis by using the following formula:

$$\text{Moisture Content (MC, dry basis)} = \frac{(W1-W2)}{W2} \quad \text{............1}$$

Where,

MC = Soil moisture content, %
W1 = Initial weight of soil sample, g, and
W2 = Final weight of dry soil sample, g

2. Soil bulk density

Bulk density is the ratio of mass of the sample of the material to its occupied volume. The bulk density of the soil was taken as index of the soil compaction and it was measured before and after the each experiment. In order to ascertain the uniformity in soil condition, the samples of the compacted soils were collected randomly at three different locations in the field by the means of core sampler of 50 mm diameter and 300 mm height marked at 10 mm interval along its length on the outer surface for easy and accurate measuring of the depth driven in to the soil.

The core sampler was driven vertically in to the soil up to a 50 mm by gently hammering on a wooden plank placed over it. The soil around the ring was removed up to the bottom of the sampler and gently removed from the soil. The sample thus collected was kept in the hot air oven at a temperature of 105±5 ^{0}C for 24 h. The experiment was replicated from different locations and the weight of the dry soil was recorded using electronic balance and the average bulk density was determined by using the following formula:

$$\rho = \frac{M}{V} \quad \text{....................... 4.2}$$

Where,

ñ = Bulk density of soil, g cm^{-3}
M = Weight of dry soil, g, and
V = Volume of the core cutter, cm^3

3. Soil resistance

Soil resistance is an indication of soil hardness and is expressed as force per square centimetre required for a cone to penetrate into soil. Soil resistance in the soil varies with cone apex angle and area of cone bottom. A standard cone penetrometer was used to determine the soil resistance.

It consisted of a solid cone with included angle of 60° and 20 mm base diameter. The cone was made to penetrate on to the inclined surface of ridge by dropping the weight of 1 kg through height of 50 cm. The numbers of blows required for cone to penetrate up to 5 cm depth were recorded and exerted force was calculated for each observation. From obtained values of force, soil resistance calculated in terms of N cm^{-2}.

4. Draft requirement

This performance parameter is governed by soil resistance or cone index which depends upon soil moisture content, soil type and bulk density. It was considered that on an average the soil resistance for sandy loam soil at the experimental site as 27 N cm^{-2} at 10 per cent moisture content. Total draft required for operating the equipment at selected moisture content by recording the cross sectional area of cut by each tyne at each speed. It was calculated by the formula:

$$D = SR \times A \times N \quad \text{....................................4.4}$$

Where,
D = Draft requirement of weeder, kg
SR = Soil resistance, N cm^{-2}
A = Cross sectional area of cut, cm^2
N = No. of tynes contacted to soil at a time

RESULTS AND DISCUSSION

Physical and mechanical properties of soil affecting the design of weeder

Table 1. ANOVA for soil moisture content.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	451.481[a]	10	45.148	143.412	0.000
Intercept	5749.481	1	5749.481	1.826E4	0.000
Replications	0.296	2	0.148	0.471	0.633
Time	450.296	2	225.148	715.176	0.000
Place	0.296	2	0.148	0.471	0.633
Place * time	0.593	4	0.148	0.471	0.757
Error	5.037	16	0.315		
Total	6206.000	27			

a. R Squared = 0.989 (Adjusted R Squared = 0.982)

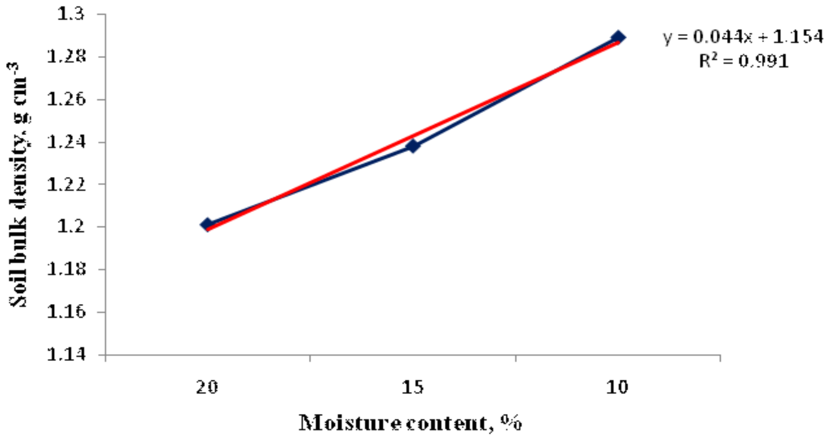

Fig. 1. Soil bulk density at different soil moisture content level.

The soil of the experimental farm was classified as alluvial soil group having sandy loam texture. Soil physical properties in relation with machine parameters are importantfrom design point of any weeding system. Soil moisture content was an independent parameter while bulk density and soil resistance as dependent parameter were measured at respective soil moisture content. The interactions between these parametersdirectly affect the performance of weeding system in terms of weeding efficiencyand power requirement to operate the machine under field conditions.

Soil moisture content

Before conducting the each experiment, soil moisture was observed randomly at 6 locations at different intervals for standardizing the moisture content for studying the effect of soil moisture on different parameters. The observed values were statistically analyzed using SPSS package for its variance and presented in Table 1.

The analysis of variance inferred that there is no significant difference in the soil moisture content throughout the field at a particular soil moisture level, but there is a significant difference among soil moisture levels. Hence, the moisture content was maintained almost same throughout the field.

Effect of soil moisture on soil bulk density

Bulk density is an indicator of soil compaction and soil health. It affects infiltration, rooting depth/restrictions, available water capacity, soil porosity, plant nutrient availability, and soil microorganism activity, which influence key soil processes and productivity.Soil bulkdensity measured under field conditions (sandy loam soil) at respective soil moisture as shown in Table 2 and plotted in Fig. 5.1.

Before conducting the each experiment, bulk density of soil was observed for each experiment randomly at 6 locations at each soil moisture content level for studying the effect of soil bulk density on different parameters. The observed values were statistically analyzed using SPSS package for its variance and presented in Table 5.3.

From the Fig. 1 it was evident that the soil bulk densities measured were 1.282, 1.216 and 1.212 g cm^{-3} at moisture content of 10, 15 and 20 per cent (db) respectively. Soil bulk density decreased with the increase in soil moisture content from 10 to 20 per cent.

The analysis of variance inferred that there is no significant effect of soil moisture content on bulk density throughout the field at a particular soil moisture level, but there is a significant difference among observations at different soil moisture content levels. Hence, the soil bulk density was maintained almost same throughout the field at each soil moisture level.

Effect of Soil moisture on soil resistance

Soil resistance is an indication of soil hardness measured by cone penetrometer and is expressed as force per square centimeter required for a cone to penetrate into soil.Soil resistance measured under field conditions (sandy loam soil) at respective soil moisture as shown in Table 4 and plotted in Fig. 2.

From the Table 5.4, it is evident that the soil resistance measured were 27, 24.8 and 23 N cm^{-2} at moisture content of 10, 15 and 20 per cent (d.b), respectively. Soil resistance decreased about 14.82 per cent with the increase in soil moisture content from 10 to 20 per cent.

Before conducting the each experiment, soil resistance was observed for each experiment randomly at 6 locations at each soil moisture content level for studying the effect of soil resistance on different parameters. The observed values were statistically analyzed using SPSS package for its variance and presented in Table 5.

The analysis of variance inferred that there is no significant effect of soil moisture content on soil resistance throughout the field at a particular soil moisture level, but there is a significant difference among observations at different soil moisture content levels. Hence the soil resistance was maintained almost same throughout the field at each soil moisture level.

Effect of soil and machine operational parameters on draft

The influence of soil and machine operational parameters on draft requirement for 30 and 45 DAS on Cotton, Maize and Chillies was summarized in Table 5.19. The draft for different treatment combinations is shown in Fig. 5.12. It

Table 2. Soil bulk density at different moisture levels.

S.No	Moisture content (%)	Soil bulk density(g cm^{-3})
1	10	1.289
2	15	1.238
3	20	1.201

Table 3. ANOVA for effect of soil moisture on bulk density.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	0.168[a]	7	0.024	47.597	0.000
Intercept	38.787	1	38.787	7.699E4	0.000
Replications	0.003	5	0.001	1.174	0.386
Soil moisture	0.165	2	0.082	163.657	0.000
Error	0.005	10	0.001		
Total	38.960	18			

a. R Squared = 0.971 (Adjusted R Squared = 0.950)

Table 4. Soil resistance at different moisture levels.

S.No	Moisture content (%)	Soil resistance(N cm^{-2})
1	10	27
2	15	24.8
3	20	23

Table 5. ANOVA for effect of soil moisture on soil resistance.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	108.884[a]	7	15.555	15.928	0.000
Intercept	11245.001	1	11245.001	1.151E4	0.000
R	0.883	5	0.177	0.181	0.964
Sm	108.001	2	54.001	55.297	0.000
Error	9.766	10	0.977		
Total	11363.650	18			

a. R Squared = 0.918 (Adjusted R Squared = 0.860)

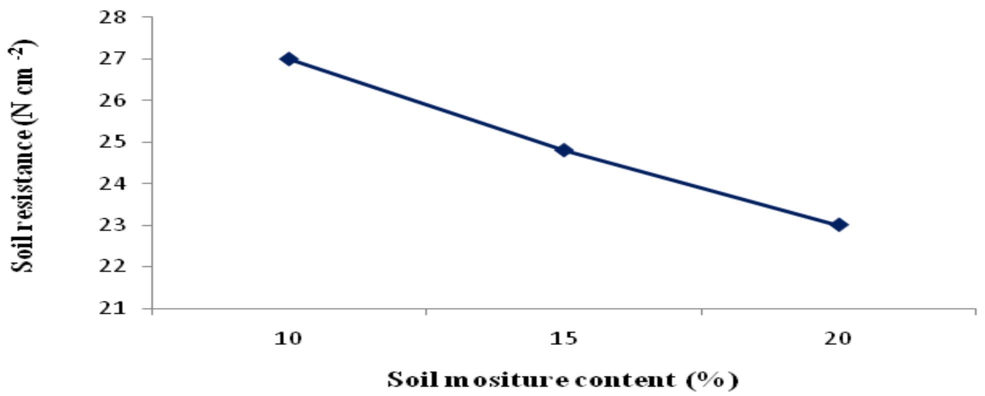

Fig. 2. Soil resistance at different soil moisture content level.

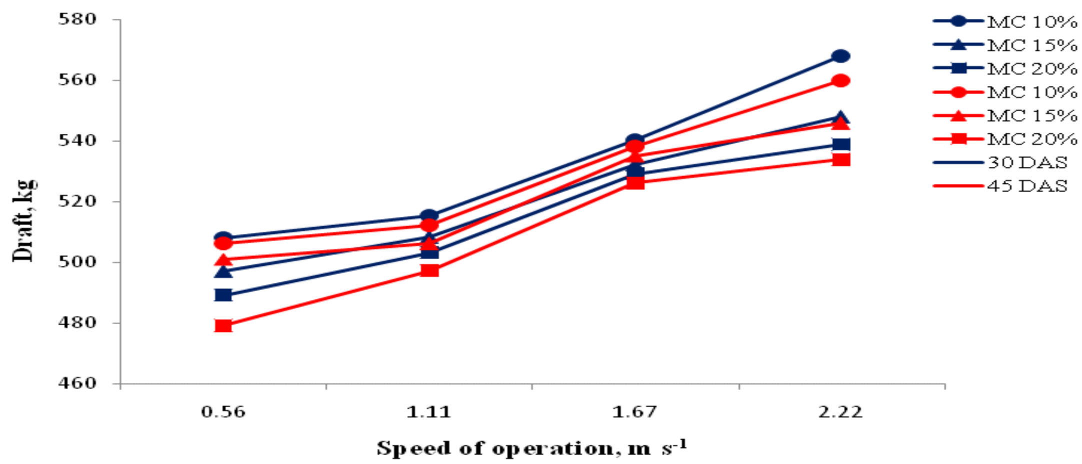

Fig. 3. Effect of soil and machine operational parameters on draft requirement inCotton, Maize and Chillies.

was observed that the draft increased with the increase of forward speed at all levels of soil moisture content. The draft increased with the increase of soil moisture content in all the treatments due to rapid acceleration of soil. The increase of draft is mainly due to increase of normal load and frictional resistance on the soil engaging tool (Kepner *et al.* 1978). The same trend was observed at 45 DAS at all levels of soil moisture content and forward speeds in all the crops.

Conclusions

Soil moisture content is an independent parameter while, bulk density and soil resistance as dependent parameters were measured at respective soil moisture content. The mean bulk density decreased from 1.289 to 1.201 g cm^{-3} when soil moisture increased from 10 to 20 %. Soil resistance is an indication of soil hardness measured by cone penetrometer and is expressed as force per square centimeter required for a cone to penetrate into soil. It decreased from 27 to 23 when increase in soil moisture content from 10 to 20 %. There was no significance difference in the soil moisture content level throughout the field at a particular moisture level. The soil bulk density was maintained constant throughout the field during the field trails at a particular soil moisture level. Draft increased with the increase of forward speed at all levels of soil moisture content.Draft decreased at all the forward speeds and moisture content levels at 45 DAS when compared to 30 DAS.

LITERATURE CITED

Kepner R A, Bainer R and Barger E L 1978 .*Principles of farm machinery*, 3rd edition, AVI publication Co., INC., Westport, Connecticut.

Rao A N and A Nagamani 2013 Eco-efficient weed management approaches for rice in tropical Asia.Proc. 4th Tropical Weed Science Conf. Weed Management and Utilization in the Tropics heldduring January 23-25,2013, The Empress Hotel, Chiang Mai, Thailand.Pp: 78-87.

Rathod R K, Munde P A and Nadre R G 2010 Performance Evaluation Of Tractor Drawn Inter-Raw Rotary Weeder. *International Journal of Agricultural Engineering*, Vol. 3(1): 161-166.

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