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The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(5): 1679-1682

www.thepharmajournal.com
Received: 18-02-2022
Accepted: 24-03-2022

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Effect of tractor forward speed and depth on physical parameters of some tillage implements

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Abstract
Tillage practices affect the physical properties of soil that are crucial for better crop production. The study was carried out to compare the efficiency of some tillage implements and their effect on some soil physical properties. The tillage implements included are tractor drawn MB plough (T1), tractor drawn cultivator (T2) was selected as front passive tool and tractor drawn cultivator (T3) and disc harrow (T4). The soil properties *viz*., soil pulverization, soil Cone Index and soil bulk density were determined after the tillage practices. However, the efficiency of tillage operation including operating speed and operating depth were taken during the tillage operation. The comparative analysis showed that the T1 was better in good pulverization, cone Index and reducing mean soil bulk density among selected tillage implements.

Keywords: Tillage implements, soil physical properties

Introduction

Indian agriculture account for nearly 14.2 per cent of the gross domestic product and involves over 58.2 per cent of population. As per the land use statistics 2016-17, the total geographical area of the country is 328.7 million hectares, of which 139.4 million hectares is the reported net sown area and 200.2 million hectares is the gross cropped area with a cropping intensity of 143.6 per cent. The net sown area works out to be 42.4 per cent of the total geographical area (Anonymus, 2020-21) [2].

Rajasthan is the largest state covering 10.5 per cent of geographical area and about 14 per cent of the total India's Agriculture land. Out of total India's population, 5.5 per cent population lies in the state and which about 2/3 population depends on agriculture. Since the cultivated area has remained nearly constant (142 Mha) over the years, the total geographical area of Rajasthan is 34.2 million hectare and the area under forest is 2.651 million hectares. The cultivable area is 25.633 million hectare (74.9% of total geographical area) and the net sown area is 17.096 million hectares (66.7% of cultivable area). The total number of land holdings are 58.19 lakh out of which 18.49 lakh (31.78%) are marginal farmers, 12.10 lakh (20.79%) small farmers and 27.60 lakh (47.43%) farmers hold land above 2 hectares. Udaipur District is one of the 33 districts of Rajasthan state in western India. Udaipur District bounded on the northwest by the Aravalli Range. The biggest challenge before the agricultural sector of India is to meet the growing demands of food for its increasing population from 1.21 billion in the year 2011 to 1.6 billion by the year 2050.

The mechanization level in India is quite low. The application of machines to agricultural production has been one of the outstanding developments in Indian agriculture. The efficient utilization of available resources and timeliness of agricultural operation are the major factors influencing the productivity level of agricultural commodities.

In India cultivator can be used as versatile implement i.e. it can be used as secondary as well as primary tillage tool in case of soft soil condition and it requires relatively low power per meter of width, (Kepner *et al*., 1987) [5]. So, in this study cultivator will be operated as both primary and secondary tillage tool.

Review of Literature

Singh and Panesar (1991) [7] conducted experiments to obtain optimum combination of tillage tool for seed bed preparation of wheat after paddy harvest and the average clod size was used as indirect index for soil tilth. The minimum average clod size was obtained for control 12.1 mm and maximum was 29.3 mm found that when pulverizing roller was combined which resulting into decrease average clod size from 29 to 14 mm.

Kailappan *et al*., (2001) [4] stated that the combination tillage tool reduces bigger size clods in the soil and improves aeration and moisture holding capacity and medium uniformity of soil and finer pulverization modulus obtained by using combination tillage and also added that maximum loosening of the soil was obtained by the combination tool as reflected by the low soil bulk density range of 1.15±0.05 g/cm3 as against the normal 1.4±0.20 g/cm3 encountered in the conventional implements operated field. Saving of 44 to 55 per cent in cost and 50 to 55 per cent in time are possible using combination tillage tool for seed bed preparation.

Maheshwari *et al*., (2004) [6] conducted comparative performance of spiked clod crusher and planker as combination tillage tools with tractor drawn cultivator under different soil conditions. By using cultivator with spiked tooth roller the soil parameters measured in the range of 12 to14 mm, 1.21 to 1.36 g/cc and 0.568 to 1.5 kg/cm2 in case of clod MMD, dry bulk density, and clod index of soil respectively.

Materials and Methods

All the selected tillage implements were operated at Instructional farm of College of Engineering and Technology, MPUAT, Udaipur.

Soil Pulverization

Soil pulverization is the process of breaking of soil into small aggregates resulting from the action of tillage forces. The mass mean diameter of the soil aggregated was considered as index of soil pulverization and was determined by the sieve analysis of the soil sample through a set of standard test sieves (IS: 460- 1982). Sieving provides a simple means for measuring the range of clod size and relative amount of soil in each size class.

Soil sample was collected in the experimental area of 150×150 mm and to the depth of operation of the implement. Samples were weighed accurately and it was passed through a set of sieves with aperture size of 100, 70, 50, 30, 10, 5 and 2 mm. Soil pulverization index was calculated from the following equation.

$$PI = \frac{\sum_{i=1}^{n} WI \times \bar{d}i}{W_{total}}$$

Where, PI = Pulverization Index (mm)

Wi = The mass of the soil obtained between two sieve openings di and di+1 Wtotal = weight of total mass

n = Number of sieves

$$\bar{d}i = \frac{1}{2}(di + di+1)$$

Cone Index

Soil cone index is used as a measure of soil strength (Swarnkar, 2006) [8]. Soil compaction can be described by cone index which is resistance (force per unit area) offered by soil against deformation or disruption, and measured with cone penetrometer (ASAE standards, 1998). It is the force per unit base area required to force a cone shaped probe into the soil at a steady rate. A field scout digital cone penetrometer was used to measure the soil cone index from 0 to 100 mm depth from the surface of soil. Cone penetrometer consisted of 30^0 cone with a diameter of 12.62 mm and 706.25 mm long circular shaft of 10 mm diameter attached to compaction meter. The cone shaped probe was pushed slowly into the soil so as to reduce the side stress on the shaft. The cone index readings given by the compaction meter were recorded in kPa and depth in cm.

Bulk Density

The soil bulk density was determined using standard technique of core sampling method. The cylindrical core sampler of 100 mm diameter and125 mm length was selected for the study. The core sampler was placed in field before and after each experimental run and it was hammered gently into the soil and samples were selected randomly from three locations in the field. The weight of the soil sample was recorded before drying using electrical balance. Later selected samples were oven dried at 105 ^{0}C for the duration of 24 hours and weight of the core sample after drying was recorded using electrical balance. It is the mass of soil of a unit volume and was calculated on the basis of following formula (Swarnkar, 2006) [8].

$$BD\ (g/cc) = \frac{M}{V}$$

Where, BD = Bulk density, g/cc

M = Mass of soil sample contained in the core sample, g V = Volume of core sample, cm^3

Results and Discussion

Effect of operating depth and forward speed of individual and combination tillage implements on soil pulverization

The Fig. 1 clearly shows that mean soil pulverization of various selected individual tillage implements tested in the field varied from 9 mm to 52 mm and increased with increase in tractor forward speed, whereas soil pulverization decreased with increase in implement working depth. The mean soil pulverization of tillage implements T_1, T_2, T_3 and T_4 were 52 mm, 29 mm, 27 mm and 25 mm, respectively with respect to operating speed of 2 km/h. The obtained results trend may be due to increase in speed enhanced the impact force on soil aggregates giving rise to reduced clod size. Whereas, decrease in soil pulverization with increase in depth was due to deeper working of implements causing a greater part of the soil to be pulverized. Similar result trends were also recorded by Dhakane *et al*. 2010 [3].

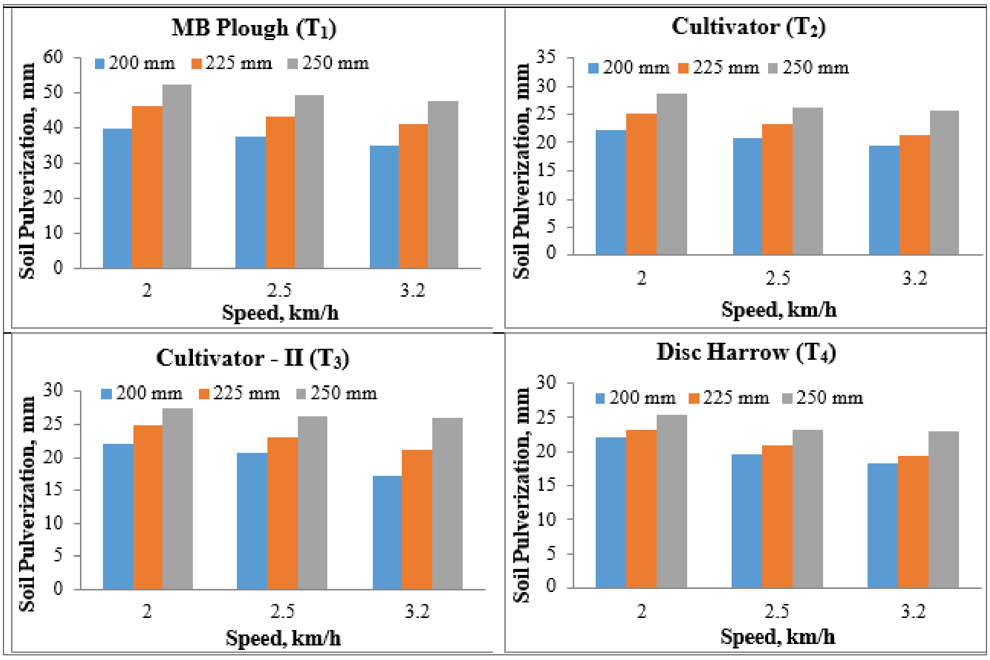

Fig 1: Effect of operating depth and forward speed of individual and combination tillage implements on soil pulverization

Effect of operating depth and forward speed of individual and combination tillage implements on cone index

It is evident from Fig. 2 that the mean soil cone Index after tillage operation of various selected individual tillage implements tested in the field ranged from 115 kPa to 132 kPa. The mean soil cone index of tillage implements T_1, T_2, T_3 and T_4 were 132 kPa, 120 kPa, 115 kPa and 124 kPa, respectively with respect to operating speed of 2 km/h. Similar result trend also reported by Anazodo *et al*., 1991) [1]. This may be attributed in a compartmented soil structure within the tilled profile, with a loose upper layer and a dense lower layer.

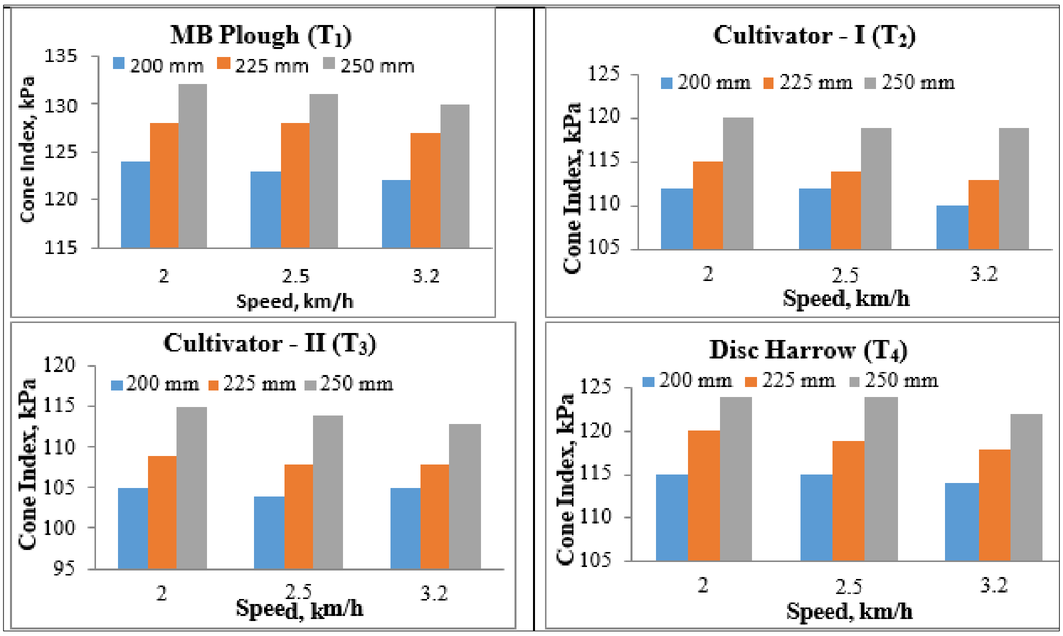

Fig 2: Effect of operating depth and forward speed of individual and combination tillage implements on cone index

Effect of operating depth and forward speed of individual and combination tillage implements on bulk density

Fig 3 shows that the mean bulk density of soil after tillage operation of selected individual tillage implements decreased with increase in working depth. The mean soil bulk density after tillage operation of various selected individual tillage implements tested in the field ranged from 1.69 g/cc to 1.74 g/cc. The mean soil bulk density of tillage implements T_1, T_2, T_3 and T_4 were 1.74 g/cc, 1.70 g/cc, 1.69 g/cc and 1.69 g/cc, respectively with respect to operating speed of 3.2 km/h and 2 km/h, respectively. Similarly, mean bulk density decreased with increase in tractor forward speed but up to some critical depth, beyond which speed had no influence in bulk density reduction. This is attributable to the fact that at higher speeds of operation, the tractor tractive efficiency became very low leading to skidding. The ultimate effect was the pulverization of the top layer of soil by the tillage implement while compacting the lower horizons. These results generally agree with earlier findings of Thakur *et al*., 1988 [9].

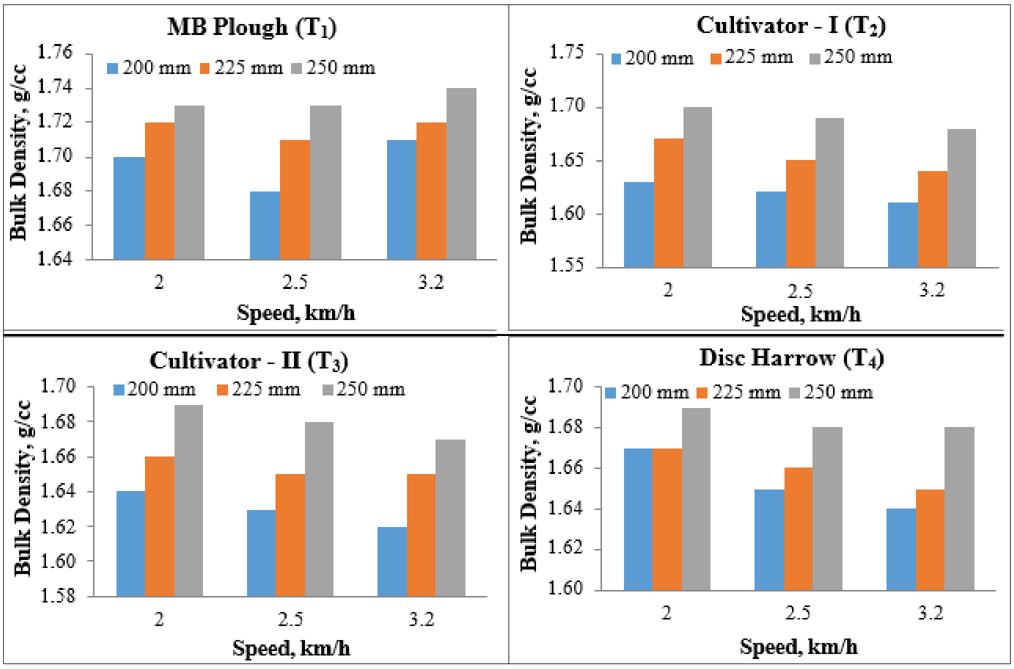

Fig 3: Effect of operating depth and forward speed of individual and combination tillage implements on bulk density

Conclusions

The maximum mean soil pulverization, maximum soil cone Index and maximum soil bulk density was obtained for T_1 tillage implement as 52 mm, 132 kPa and 1.74 g/cc, respectively. Similarly, the minimum mean soil pulverization and minimum soil cone Index was obtained for T_3 tillage implement as 17 mm and 104 kPa respectively and minimum soil bulk density was obtained for T_2 tillage implement as 1.61 g/cc.

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