FUEL CONSUMPTION AND OPERATIONAL COST OF VARIOUS TILLAGE IMPLEMENTS

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ABSTRACT: *This study evaluated the effects of different tillage implements on soil physical properties and operational cost under clay loam soil. Different tillage implements were used in a field under separate plots. The fuel consumed by the tractor during different tillage operations was measured in the field to determine the cost of different tillage operations. The plots were irrigated after tillage, soil samples were taken from different plots and were analyzed for soil physical properties. Results showed that the soil moisture content (MC) was higher ($p>0.05$), while soil bulk density (BD) and soil compaction were lower ($p<0.05$) under the plot (field) tilled with cultivator followed by disc harrow (C.V+D.H) compared to that tilled with disc harrow (D.H) only. The fuel consumed by the tractor during different tillage operations was 17.66 and 17.79 lit/ha for C.V+D.H and D.H, respectively. It is concluded that C.V+D.H can prepare better seedbed under clay loam soil as compared to D.H only at almost same operational cost.*

Key Words: cultivator, disk harrow, soil compaction, fuel consumption, operational cost

INTRODUCTION

Tillage is a mechanical action on the soil to prepare for agricultural cultivation purpose with different tillage implements to produce favorable environment for plant growth. The capacity of soil to sustain the nutrient cycles, energy flows through soil aggregates and ability to recover from degradation or deterioration after intensive exploitation depends on tillage techniques [1]. There are numerous tillage implements which are used for creating desired soil condition. Tillage has both direct and indirect effects on crop stand establishment and residue decomposition. Tillage directly affects residues fragmentation and distribution as well as facilitates seed placement within the seedbed. Tillage indirectly affects environmental condition which affects residue decomposition, seed germination and seedling emergence [2].

No doubt the rate of root growth depends on the temperature, water and air supply in the soil, roots performs better and develop faster in porous soils but also the type of tillage system adopted for soil manipulation prior to planting does affect the geometry of the root systems, nutrient [3]. Soil physical properties i.e. structures; texture, MC, BD and strength play an important role in soil preparation and crop cultivation to obtain the optimum yield [2, 4].

The present work was initiated for comparison of different tillage implements and their effects on fuel consumption, operational cost and time required. The proper use of implements for primary and secondary soil preparations can resolve problems related to water, air, temperature regime, mobilization of nutrients and cost. As deep tillage increases the cost of farm operations which require powerful tractors with high fuel consumptions. Keeping in view the above stated points a comparative study was conducted to evaluate the soil physical properties, fuel consumption and also operational cost. The MC, BD, soil compaction, effective plowing depth and width, and soil aggregation of each treatment were recorded.

MATERIAL AND METHODS

Experimental site

The experiment was laid down on nine fields each of 25-m x 9-m with randomized complete block design (RCBD). Different tillage treatments T1 D.H (three passes), T2 C.V (one pass) + D.H (two passes) were used respectively. The study was designed to identify suitable tillage system which should be better in performance and also cost effective. A 75 hp tractor was used for plowing. The experimental farm of Sindh Agriculture University Tando Jam Pakistan is located about 20-km away from Hyderabad Sindh. Different implements were used in field experiments of tillage at various plowing depth. The soil at experimental site was clay loam in texture, during 2009. Soil samples were taken at 0-10 , 10-20,and 20-30-cm depths for measurment of BD and soil MC. During the soil analysis, the temperature was observed in the range of 28 to 34 ºC.

Soil analysis

Measurement of soil physical properties

Soil texture was observed by Bouycous hydrometer method (Bouyoucos, 1927), cone index was recorded by CN-973 cone penetrometer, soil MC and dry BD were obtained by gravimetric method [5, 6].

$$MC = \left(\frac{W_w}{W_d}\right) x100$$

Where;

MC = soil moisture content on dry weight basis (%)

W_w = Weight of water

W_d = Weight of dry soil

$$Bulk\ density = \left(\frac{W_d}{V}\right) = \frac{4W_d}{3.14d^2L}$$

Where;

V = Volume, cm3

D = Diameter of core sampler, cm

L = Length of core sampler, cm

Soil aggregation/soil pulverization

Soil aggregation and pulverization were evaluated by using a set of ten sieves which were of mesh (75 mm, 63 mm, 50 mm, 37.5 mm, 31.5 mm, 25 mm, 15.60 mm, 12.50 mm, 8 mm, 2.36 mm). Twelve soil samples l were taken randomly for determination of soil aggregation on the basis of mean

soil clod diameter (MSCD or m.s.c.d). The m.s.c.d was calculated using the formula decribed in RNAM [6].

$$MSCD = \frac{\sum WD}{\sum W}$$

Where;

$\sum w$ = Sum of weight of soil clods

D = Size of sieve.

Fuel consumption

The fuel tank of the tractor was filled with diesel before using disk harrow and cultivator + disk harrow in all fields. After plowing a 25-mx 9-m field, the fuel tank of the tractor was refilled up to previous level with 1000 millimeter graduated cylinder. The total quantity of fuel needed to refill the fuel tank up to the same mark. The data of fuel consumption in liters per hour and liters per hectare were calculated.

Cost of operation: Fuel consumed by each implement, cost per liter of diesel, cost per hour and cost per hectare were recorded.

RESULTS AND DISCUSSION

The study was conducted to evaluate the impact of different tillage implements on moisture content, bulk density, soil compaction, soil aggregation, fuel consumption, and cost of operation. The MC and BD of plowed and un-plowed soil are given in table1. The average moisture content for disk harrow was 20.64% and 20.95% for cultivator followed by disk harrow and bulk density for disk harrow was 1.13 gm cm^{-3} and 1.08 gm cm^{-3} for cultivator followed by disk harrow, the obtained result show that the moisture was more retained by disk harrow followed by cultivator as compare to disk harrow and bulk density was reduced by cultivator followed by disk harrow as compare to disk harrow. There was no significant difference in the MC of both treatments, whereas significant difference was observed in BD ($p<0.05$).The obtained results are in agreement with Battikhi and Suleiman [7].

Table 1. Soil moisture content before and after operation

Depth (cm)	Before Operation		MC after Operation %		BD after Operation g/cm^3	
	MC (%)	BD (g/cm^3)	D.H	CV + D.H	D.H	CV + D.H
10	15.87	1.45	17.59	17.74	1.01	0.93
20	20.16	1.22	19.57	19.38	1.07	1.04
30	25.63	1.31	24.80	25.67	1.31	1.27
Average	20.55	1.22	20.64a	20.95a	1.13a	1.08b

Soil compaction was observed for untilled, disk harrow, cultivator and disk harrow treated plots. The results on soil compaction under differnt treatmetns are given in Table2. The average soil compaction observed was 522.89 and 504.10 KN/m^2 for D.H and CV+DH, respectively. The significant differnce was observed in soil compaction the less soil compaction observed CV+DH as compare to D.H treateed plots. There was significant difference observed at ($p<0.05$). The practice of using cultivator followed by disk harrow is better for reducing soil compaction the obtained results are in line with Paul [8].

Table 2. Soil compaction before and after operation

Depth (cm)	Soil Compaction before operation (KN/m^2)	Soil Compaction after operations (KN/m^2)	
		D.H	CV + D.H
0-10	795.66	291.33	264.66
10-20	842.33	327.33	297.66
20-30	950.00	950.00	950.00
Average	862.66	522.89	504.10

The results on soil aggregation are given in table-3. The average soil aggregation for D.H was found 16.55 mm, while it was15.41 mm for CV+D.H. The soil aggregation/pulverization was higher in T2 as compared with T1. This data suggested that, the use of C.V +D.H prepare better seed bed as compare to D.H.

Table 3. Soil aggregation in (mm)

Passes	D.H (mm)	CV (1)+ D.H-2 (mm)
1	19.86	18.61
2	16.15	15.21
3	13.63	12.42
Average	16.55	15.41

The results on fuel consumption are given in Table4. The results of fuel consumption, in liters, liters/hours and liters/hectares were (0.48, 5.03 and 17.79) and (0.38, 4.44 and 17.66) for disk harrow and cultivator + disk harrow respectively. The fuel consumption was found less by CV + D.H as compare to D.H. There was no significant difference observed at ($p<0.05$) for both tillage treatments.

Table 4. Fuel consumed by disk harrow and cultivator+disk harrow

Passes	Disk Harrow			Cultivator +Disk Harrow		
	Fuel Consumption			Fuel Consumption		
	lit	Lit/hr	Lit/ha	Lit	Lit/hr	Lit/ha
1	0.60	4.83	22.33	0.45	5.19	22.33
2	0.46	4.66	16.53	0.36	3.74	16.15
3	0.39	5.60	14.53	0.32	4.40	14.50
Average	0.48	5.03	17.79	0.38	4.44	17.66

The results on cost of operation are given in table -5. The cost of operation by each implements per hour and per hectare, total area of 0.023 hectare area were tilled. The total cost were Rs. 979.13/ha and Rs. 949.396/ha for D.H (3 passes) and CV (1 pass) + D.H (2 passes) respectively. The overall cost of operation was found less by CV + D.H as compare to

D.H. There was no significant difference observed at ($p<0.05$).

Table 6. Cost of operation by each implement per hour and per hectare

Implement	Area Tilled (ha)	Cost of Fuel/Lit Rs.	Fuel Consumed lit/hr	Total Cost Rs./hr	Fuel Consumed lit/ha	Total Cost Rs./ha
D.H (3passes)	0.023	57.00	5.03	286.71	17.78	979.13
CV (1pass)+D.H (2passes)	0.023	57.00	4.44	253.08	16.67	949.96

*the fuel price at the time of tillage operation

CONCLUSION

Higher soil moisture was observed in the filed/plot under T1/CV+D.H treatment/operation as compared to the D.H only. Meanwhile, the soilBD and soil compaction was reduced under CV+D.H as compare to D.H. The overall performance of CV + D.H is satisfactory and can be more effective for tillage operations in clay loam soils. However, more fuel was consumed by D.H as compared to the CV + DH. The study reveals that fuel consumption and cost of operation was found more by disk harrow as compare to cultivator + disk harrow. In the light of above findings it is suggested that the use of C.V followed by D.H can prepare better seedbed in clay loam soil.

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