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Effect of a New Combined Implement for Reducing Secondary Tillage Operation

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ABSTRACT

Primary tillage operation often creates cloddy and un-even soil surface due to limited time and inappropriate moisture content in the most parts of Iran. Farmers therefore use disk harrows several times to overcome this problem, which affect soil properties, time and costs of operation significantly. The aim of this research was to develop a new combined machine for sufficient clod breaking as well as surface uniformity in one pass and the shortest possible time. The machine was combination of a disk harrow and a Cambridge roller. The combined machine was field tested in a research station with loamy soil texture. Treatments of disk harrow once; disk harrow twice and combined machine applied after moldboard plowing. The parameters of bulk density, clod mean weight diameter (MWD), penetration resistance and soil surface profile were determined and analyzed among the treatments. The results indicated that combined machine improved some soil physical properties, which were important for secondary tillage such as clod breaking and surface uniformity. No significant difference was noted between combined machine and disking twice in the most parameters. It can be therefore concluded that new combined machine would be substitute for several disking and allows operation to complete in one pass.

Key Words: Combined machine; Secondary tillage; Clod breaking; Disk; Rollers

INTRODUCTION

Using combined equipment and reducing number of passes is getting popularity due to its effect on time, efficiency and costs. Disk harrow is the most common equipment used for clod breaking rather than weed control or residue mixing after moldboard plow in Iran (Anonymous, 2003). Moldboard plow leaves cloddy and un-even surface, which need to use disk harrow several times in many regions. This operation could affect soil structure, create crust, increase risk of erosion and change cost and time significantly. On the other hand rollers mainly used for surface compression, leveling and clod breaking. It seemed that if clods pushed into soft soil surface by rollers could be loosened by absorbing moisture and broken later.

Design and development of combined machine was considered in both primary and secondary tillage operations from about hundred years ago. The combinations of chisel plow + rotivator, disc harrow + leveler or chisel plow + roller are the examples (Shafee, 1995). Disk harrows were particularly used in combination with equipment, which could break the clods as well as creating uniform surface such as spike harrows (Buckingham, 1984). Rollers were also used and operated successfully in combination behind different equipment including moldboard plow, spike harrows and field cultivators. One cultivator loosened surface shallow soil in front and roller stabilized and leveled loosen soil surface on behind (Behroozilar, 1995). Loghavi and Hosseinpoor (2002) attached a roller behind a moldboard plow to combine primary and secondary tillage operation. It was noted that draft and clod mean weight diameter (MWD) significantly decreased comparing to separate operation. Moreover soil surface was more uniform than using moldboard plow and disk harrow as a common method. Ghazavi (1998) developed a combined machine consisting of disk plow and chisel plow and reported that this could be suitable substitute of moldboard plow for soil conditions in Iran. Chisel plow was used in combination with disk harrows successfully in the past (ASAE, 1999). Combination of different equipment sometimes was more than two machines. It was reported that four machines including tooth roller for clod breaking, cultivator for loosening surface layer, tooth roller again and finally packer roller were combined (CIGR, 1999). Jori (2002) proved that new combined machines such as combination of disk with cultivator, chisel or ripper were needed for sustainable tillage systems. It was indicated that combined machines such as spike harrow + disk harrow; disk harrow + packer roller and cultivator + spiked harrow had positive effect on soil loosening, bulk density and surface clod breaking (Ozturk & Bastaban, 1993). Javadi and Shahidzadeh (2005) developed a combined equipment with chisel plow behind of moldboard plow and indicated that the combined plow enabled to break plow pan during plowing in one pass and would avoid un-necessary sub-soiling in deep soil layers separately.

The objectives of this research were investigation of possibility to use combined machine rather than several

disking in secondary tillage operation and its benefits consisted of reducing the number of pass, increasing the efficiency, saving time and improving soil surface uniformity.

MATERIAL AND METHODS

In this research a conventional offset disk harrow with 140 cm working width and 53 cm disk diameter was used. A Cambridge roller was selected, which was more efficient for clod breaking. An extended chassis was added on disc chassis to attach roller behind of disk. Divisions of roller were attached to each other enabling to cover disk harrow width. Attachment was done in a way to put pulling centre of disk and roller in direction with pulling line of tractor. Fig. 1 shows the developed prototype machine. The combined machine was then evaluated in the field and its effect on some soil physical and mechanical properties was determined. Three treatments compared using Completely Randomize Block Design with three replications after plowing as follows:

1) Disk harrow once
2) Disk harrow twice
3) Combined machine.

Experiments were conducted in a research station located in 3 km south west of the Karaj city with loamy soil texture and 300 mm average rainfall. Details of soil characteristics are given in Table I. Plot dimensions were 20 × 6 m^2 with 5 m spacing between them. Bulk density on dry basis was determined before and after operation. The depth ranges of 0 - 10 and 10 - 20 cm were considered to cover fully working depth of treatments. For this test un-disturbed samples were taken from the plots by core sampler and dried 24 h at 105ºC in an oven. Clod mean weight diameter was determined using different sieve sizes before and after operations in three replications. Penetration resistance was measured by 10 insertions in each plot before and after operations. A penetrometer (SP 1000) was used with 12.83 mm cone diameter and 30 degree angle based on ASAE standard. Soil moisture content was also determined during cone index recording. Soil surface profile measurement was developed to compare surface uniformity left after each treatment. Device consisted series of Aluminum rods that could be placed on plow furrow. The loose rods were tightened by bolts after placement. By transferring and measuring the movement of each rod and calculating standard deviation, the uniformity was determined.

RESULTS AND DISCUSSION

The effect of different treatments was not significant on bulk density at 0 - 10 cm depth (Table II). However it was noted that combined machine had minimum bulk density. The results proved that bulk density generally decreased after operation. This was considered to be due to clod breaking and loosening of soil surface layer. Bulk density at 10 - 20 cm depth was not also showed significant difference among treatments after operation. The reason was due to working depth of implements, which was mostly in 0 - 10 cm. In cases of similar effect, it is clear that combined machine would be preferable as operation could be done in one pass. Time is also a dominant factor for tillage operation and seemed combined machine could save time significantly.

Once disking had almost no effect on clod breaking as no change was recognized in mean weight diameter before and after operation (Table III). Combined machine showed the greatest difference followed by twice disking treatment. This is proved why once disking can not significantly effect or break the clods and more disking is often needed. However statistical analysis presented that there was non-significant difference between treatments after operation with 95% confidence. It can be confirmed that combination of disk harrow with other equipment, which enabled to break the clods and create uniform surface would avoid several disking. Combination of disk harrow and spiked harrows was successfully used in the past (Javadi, 1997).

The results (Fig. 2) showed that combined machine had maximum effect to decrease penetration resistance particularly at 10 - 20 cm depth. There was no significant difference between once and twice disking treatments. Penetration resistance increased in 20 cm depth range, which was due to plow pan in the field. It was reported that field plowed continuously for more than three years and existing of plow pan was expected.

Results revealed that combine machine created maximum uniformity (minimum non-uniformity) followed by disking twice and once (Table IV). This result was fairly close to real condition in the field, where combined machine left more even surface than others (Fig. 3 photo taken in the field). Statistical analysis and Duncan grouping proved significant difference between treatments although there was no significant difference between once and twice disking in terms of surface uniformity. Soil uniformity left by combine machine was thought to be due to right selection of roller, which had both spiked and wedged rings. This type of roller would break the clods as well as creating uniform surface. Loghavi and Hosseinpoor (2002) reported similar result by using such a roller behind of moldboard plow. However it seemed that placing roller behind of disk harrow pushed some clods into subsurface soil layer, which provided appropriate both seed bed and root growth zone in the soil. It can also help for additional cold breaking by absorbing moisture in that layer. Surface uniformity is also important for irrigation efficiency and the other implement works such as planter, sprayer and harvester.

Reducing number of pass by substituting combined machine instead of single operation has been major concern of many studies. Minimum pass in the field particularly for tillage operation was goal to achieve sustainable farming in a research reported by Pietola (2005). It was also demonstrated that increasing number of pass in tillage

Table I. Soil physical and chemical properties

Depth (cm)	Saturation (%)	EC ($\times 10^3$)	O.C. (%)	P (ppm)	K (ppm)	PH	Soil texture		
							Sand (%)	Silt (%)	Clay (%)
0-25	41.17	1.27	0.48	21.3	272.7	7.3	31.94	74.76	24.27
25-50	39.18	1.10	0.35	13.7	213.3	7.5			

Table II. Mean bulk density $\left(g.cm^{-3}\right)$ in two depth range

Depth (cm)	0-10		10-20	
	Before	After	Before	After
Combined machine	1.25	1.12	1.25	1.22
Disk harrowing once	1.24	1.16	1.33	1.22
Disk harrowing twice	1.32	1.17	1.32	1.34

Table III. Clod mean weight diameter (cm) average in different treatments

	Before	After
Combined machine	1.49	1.23
Disk harrowing once	1.39	1.37
Disk harrowing twice	1.28	1.15

Table IV. Surface pan-uniformity comparison among treatments

Treatment	Plot number			Average	Subset
	1	2	3		
Disk harrowing once	2.76	1.89	1.98	2.21	a
Disk harrowing twice	1.68	1.30	2.07	1.69	ab
Combined machine	0.96	1.15	1.31	1.14	b

operation created plow pan and would lead to subsoil hard pan after five years (Birkas *et al.*, 2004). It was confirmed that the new combined machine allows operating secondary tillage in one pass rather than several disking, which could save time and cost with less compaction effect on soil. This can be fairly applicable for similar countries within the region, where clod breaking after plowing and time are major concerns.

CONCLUSIONS

Field experiment presented possibility of using combined machine with acceptable performance compared to common disking methods. The effect of combined machine was similar with twice disking on bulk density. The results of mean weight diameter proved that combine machine was slightly more effective than twice disking in shallow soil layer. Penetration resistance result was also demonstrated higher effect of combine machine, which reduced at 10 - 20 cm depth range. Moreover soil uniformity was significantly improved by using combined machine. It can be concluded that there were some benefits of using new machine in the secondary tillage operation. In case of similar effect, it can be also recommended that combined machine would be preferable reducing the number of pass, time and costs.

Fig. 1. Developed combined machine with a disk harrow and extended chasis attached by a Cambridge roller with both spiked and wedged rings

Fig. 2. Penetration resistance in 0-25 cm depth range after moldboard plwoing and application of different treatments in a loamy soil texture

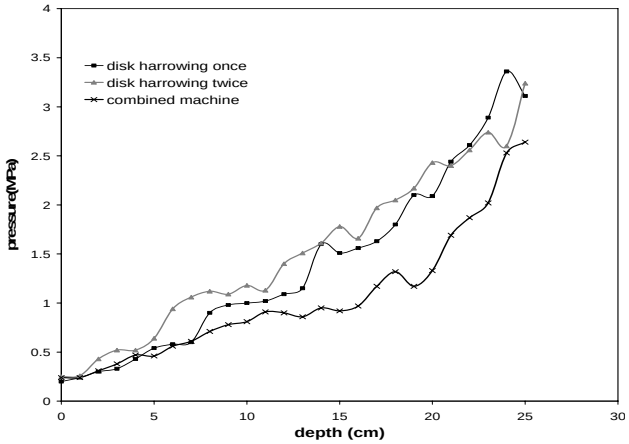
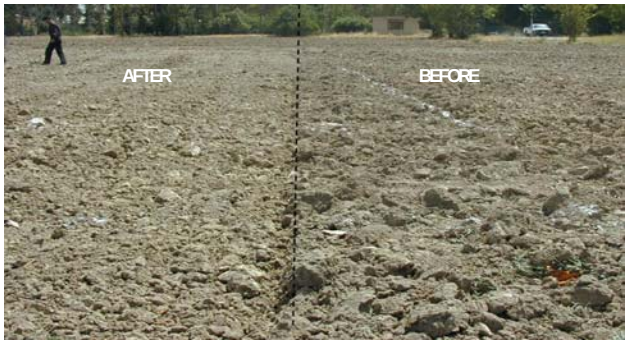


Fig. 3. Soil surface before and after combined machine application in a plowed field



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