Evaluating Physical Properties of Potato by a Combined Tillage Machine

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Abstract: Potato is a complete and cheap food and can be considered as a source of starch. It medical, industrial and other usages have increased its importance. One the most important things about potato from customer's point of view is it appearance. Because its improper shapes raise problems for re-planting and other uses. One of the most important factors that affect shape and other properties of potato is soil preparation practices prior to seeding. Thus through experiments at educational farm located in Khurasegan Islamic Azad University, in form of complete random tests, four treatments of plows, moldboard, chisel, disk, and a new one made by Iran Plow Tools (a combination of chisel and disk plows), in three repetitions were compared. Parts of harvested products from each device's farm were divided and then tested. Through several experiments, skin area averages, tubers weight, tubers size, tubers quantity, and product performance (output) were measured and by a statistical analysis method were compared. In comparing products from moldboard plow and Iran Plow Tools' plow no significant differences were observed in tubers size and product performance, but for tubers quantity and tubers weight averages, the differences were significant. In comparing the new plow with other tested plows for above mentioned factors, mostly the differences were significant. Briefly, the results show that by means of the new combined plow, more uniform products can be obtained and it is a proper choice to replace moldboard plow nationwide. [Nature and Science 2010;8(11):66-70]. (ISSN: 1545-0740).

Keywords: Potato, tillage, tuber weight, tuber shape, tuber skin area.

Introduction

Among food products around the world, potato is the fourth well-known crop after wheat, rice and corn. It has been estimated that about 307 million tons of potato is produced all over the world (Fennir M.A. 2002). The population growth and limitation of farm lands has forced researchers to concentrate on mechanized production of potato (Rembeza J. 1993). Mechanization is consisted of land preparation, planting, cultivation, harvesting and also post-harvest practices which all have effect on the technical aspects of potato production (Spiess E. 1994).

In fact, every progress in mechanization has an impact on quantity and quality of potato production (Balbach, F, W. et al. 1992).

One of the main objectives of tillage is to keep and maintain a high level of clod in soil, so that the roots could penetrate and develop better, maintain highest amount of water for plants consumption, surface soil particles would have more resistance to rainfall, preventing from soil hardening and allowing maximum moisture penetration, minimizing erosion caused by water-flow, and breakage of nutrients holding clods which are carried around by water. Also to increase the resistance of soil particle clods against compaction caused by wheels of trailers and other farm machineries and tillage practices (Richey C. B. et al. Carl W. Hall. 1961).

There is no standard tillage system for preparing potato field, but low-tillage system which economizes time and energy consumption, and minimizes compaction is useful. The vast range of soils in which potato can grow and different and proper plants remnants should be mixed with soil in order to help the planter work properly. The level of tillage needed depends on the type of soil and how the machinery can operate among plant remnants. Tillage practices should loosen the soil as much as possible so that the planter openers easily penetrate to the preferred depth and listers create a proper ridge using the loosened soil. The most common tillage practice is to put the plants remnants inside the soil by means of a moldboard plow during spring or summer and then breaking large clods by means of a disk harrow during spring. It is normal to use a spring-harrow to mix fertilizers with soil (Skorupinska A. et al. 1991). Field preparation for planting is very important and therefore using a suitable tillage device can play an eminent role to do so. Three different tillage machines have been used in this experiment in order to find out which one is the best for preparing soil for planting potato.

Materials and Methods

In order to perform farm practices, various devices have been designed and developed such as moldboard plow, automatic and semi-automatic planters, different cultivators and harvesting machines like combines for some crops such as potatoes.

In different countries in this field, several experiments have been carried out by researchers and different quantity and quality aspects of mechanization have been evaluated (Fillippini , P. 1994 ;Carter M. R. et al. 2001) and there have been results according to increase in product (Lindsag, G. G. 1985) and improving product quality (Trentni, L. 1995; Feek, W. 1991).

In Iran, mechanization have been introduced for a long time and in order to carrying it out, several various machineries have been imported or been manufactured which are being used in potato fields across the nation and are not faultless. Therefore, in order to better use of these tools and soil preservation and optimized application from land, various experiments should be carried out in different regions of our country appropriate to their climate, geography, and economy. Therefore, according to their results, proper suggestions should be made. The type of tillage practice has influence on shape, dimensions and special weight of tubers (Ekeberg, E. 2002). The special weight is effective in vulnerability and therefore in storage of the tubers (Fennir M.A. 2002).

This experiment was carried out in research station of Khurasegan Islamic Azad University located in Isfahan province (51.41 eastern longitude and 32.42 northern latitude) during 3 planting seasons with 146.6 mm of mean rainfall during these years and temperature around 27°C. The farm's soil had loamy-clay texture which is to some extent proper for planting.

This experiment was analyzed with the statistical method of split blocks with 4 treatments and 3 repetitions which main treatments had to levels (manual planting and machinery planting).

In order to evaluate the effect of tillage device, 4 types of moldboard-chisel plows and combinations of disk and chisel plows (progressive disk plows) were implemented. It is important to mention that the new plow of Iran Plow Tools Company is a combination of disk and chisel plows.

For performing the design, a 2500 m^2 of land was used and according to the number of treatments, 5 ridges with 25 m length were considered for each treatment, the gap between ridges was 75 cm and the distance between each seed on each ridge was 20 cm and planting depth was 10 cm. width of each repetition was 16 m and width of each plot was 3.75 which was considered 4m.

At first, the land was divided into 3 parts. Then each of these parts was divided into 4 equal parts from their width axis. Each part was then randomly allocated to one of treatments and plowing was carried out by the related tillage device. Each of these plots were divided into 2 sections and in one of them planting was carried out manually and in the other section it was carried out by means of semi-automatic potato planter.

Marfona was the potato variety used for this experiment which is highly used in planting in Isfahan province.Data were analyzed by MiniTab and for averages comparisons, MSTATC was used.

Results and Discussion

1) Performance: Tubers performance in land preparation by different mentioned devices was statistically significant in relation to total average. This shows that different tillage machines have influence on crop performance. To clarify each device influence, averages comparison table was used.

Table 1- Variance analysis of different treatments effects on crop performance

Squares averages	Degree of freedom	Source of Changes
6.44^{ns}	2	Repetition
148.84^{**}	3	Main Factor (A)
52.79	6	(A) Error
4.55^{ns}	1	Secondary Factor (B)
21.42	2	(B) Error
26.9^{ns}	3	A*B
13.52	6	Error

*, ** & ns: Significant in 1% and 5% level of probability and non-significant, respectively.

Table 2- Performance averages comparison

	P2	P3	P4
P1	5.41^{ns}	12.66^{*}	10.76^{*}
P2		7.25^{ns}	5.35^{ns}
P3			2.1^{ns}

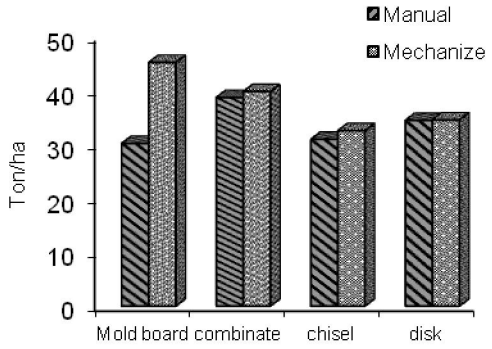

Figure 1 – Product performance with different tillage devices

Table 2 shows that at first year no significant differences were observed in crop performance, but at third year the differences between moldboard plow and chisel and disk plows in 5% level of probability were significant and between moldboard plow with combined plows there was no significant difference. Therefore, it could be suggested that in some cases considering the uniform mixing of plant remnants with soil, this machine can be implemented.

2-4 Quantity of Tubers

From the point of quantity of tubers, there was a significant difference between different treatments ($p < 0.01$). But no significant difference was observed between levels 1 and 2 (manual and machinery planting).

Table 3 – Variance analysis of treatments effect on quantity of tubers

Squares averages	Degree of freedom	Source of Changes
55.4	2	Repetition
1097.15^{**}	3	Main Factor (A)
185.15	6	(A) Error
442.04^{ns}	1	Secondary Factor (B)
502.54	2	(B) Error
793.82	3	A*B
97.32	6	Error

Table 4 – Average comparison of tubers quantity

	P2	P3	P4
P1	10.4^{ns}	42.7^{**}	16.61*
P2		32.6^{**}	5.6^{ns}
P3			27^{*}

According to the results from table 4, there is no significant difference between moldboard plow with combined plow, while the differences between chisel and disk plows with moldboard plow are significant ($p < 0.01$). The lowest amount is for chisel plow and highest is for moldboard plow.

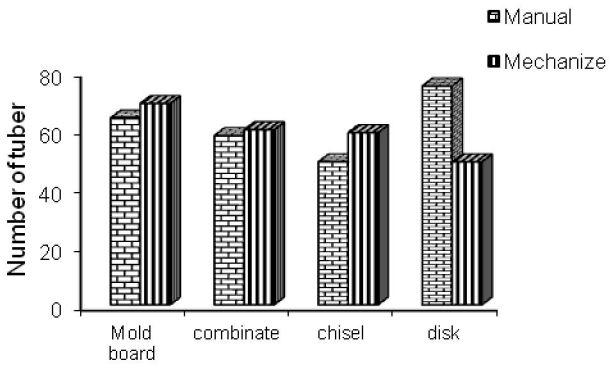

Figure 2 – Tubers quantity in different treatments

3-4 Tubers weight averages

In regards to weight averages of tubers there was a significant difference between treatments at 5% level of probability. But no significant difference was observed for method of planting.

Table 5 – Variance analysis of treatments effect on weight averages of tubers

Squares averages	Degree of freedom	Source of Changes
666.3	2	Repetition
1079.9^{*}	3	Main Factor (A)
382.1	6	(A) Error
245.5^{ns}	1	Secondary Factor (B)
237.7	2	(B) Error
65.4^{ns}	3	A*B
248.3	6	Error

Table 6 – Averages comparison of tubers weight averages

	P2	P3	P4
P1	12.76^{ns}	10.54^{ns}	12.41^{ns}
P2		25.5^{*}	25.17^{*}
P3			1.87^{ns}

There was a significant difference for tubers weight averages between combined treatment with chisel and disk treatments ($p < 0.05$) which according to the averages it could be concluded that using combined plows greatly affect tubers weight averages and it could be used in such soils. Indeed, there was no significant difference between moldboard plow with combined plow.

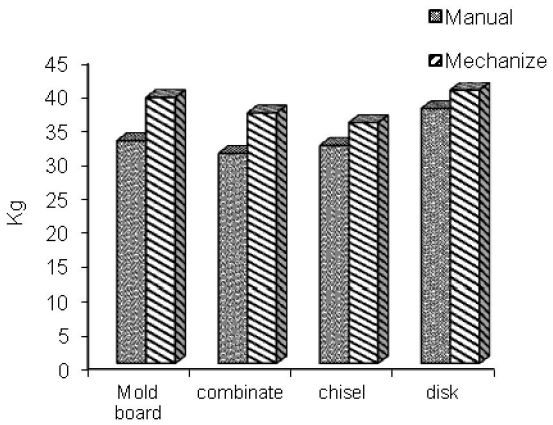

Figure 3 – Tubers weight averages in different treatments

4-4 Deepest tubers depths

According to effect of tubers depth on size and amount of tubers, depth of deepest tubers in each treatment was measured that according to variance analysis table there was significant differences between treatments ($p < 0.01$). For planting method there was a significant difference between manual and mechanized planting. In order to clarify effects of treatments, an averages comparison between treatments was performed and the results are shown in table 8.

Table 7 – Variance analysis of treatments effect on tubers depth at first year

Squares averages	Degree of freedom	Source of Changes
5.371	2	Repetition
21.854^{**}	3	Main Factor (A)
16.507	6	(A) Error
17.493^{**}	1	Secondary Factor (B)
0.189	2	(B) Error
3.954^{ns}	3	A*B
1.011	6	Error

Table 8 – Average comparison of deepest tubers depths at first year

	P2	P3	P4
P1	0.07^{ns}	5.09^{*}	2.58^{ns}
P2		5.16^{*}	2.65^{ns}
P3			2.51^{ns}

Results from averages comparison shows that there is no significant difference between moldboard plow with combined plow, while there are significant differences between moldboard plow with chisel plow and also combined plow with chisel plow ($p < 0.05$).

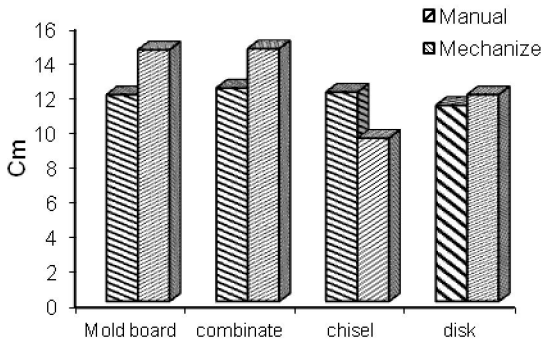

Figure 4 – Depth of deepest tuber

5-4 Tubers size

Potato tubers sizes were measured by means of a caliper for three different diameters and diameter averages was used to evaluate treatments. Results from variance analysis table show that there is significant difference ($p < 0.05$) and also indicate the effect of main factor (tillage device type).

Table 9 – Variance analysis of treatments effect on tubers size at third year

Squares averages	Degree of freedom	Source of Changes
46.51	2	Repetition
94.88^{*}	3	Main Factor (A)
93.07	6	(A) Error
1.47^{ns}	1	Secondary Factor (B)
7.55	2	(B) Error
24.07^{ns}	3	A*B
11.21	6	Error

Table 10 – Averages comparison of tubers sizes at third year

	P2	P3	P4
P1	1^{ns}	11.8**	10.66**
P2		12.8**	11.6**
P3			1.86^{ns}

According to the performed averages comparison, it could be observed that between first and second treatments, moldboard and combined plows, there is no significant difference, while there is a significant difference between moldboard and combined plows with chisel plow ($p < 0.01$). Also no significant difference was observed between chisel plow with disk plow.

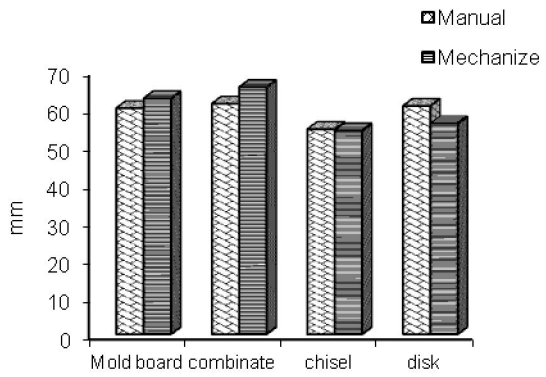

Figure 5 – Tubers size at different treatments

Conclusions

Results show that in relation with discussed special issues, moldboard plow and Iran Plow Tools (combined) had better results, while the plow from Iran Plow Tools does not have any of moldboard plow deficiencies and also favors more benefits than the moldboard plow. Therefore, in future, this plow can be replaced for moldboard plow nationwide. In addition to the results from this paper, this new plow as a fast-moving device has a high field capacity and because of the relative uniformity in mixing soil, moisture and plants remnants, increases the soil fertility (Ghazavi, M. A. et a. 1999).

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