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Research Article

ASSESSING THE EFFECT OF SOIL CHEMICAL AND PHYSICAL STRUCTURE MODIFICATION ON THE QUANTITATIVE AND QUALITATIVE TRAITS OF POTATOES

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ABSTRACT
To determine the effect of improving soil physical and chemical properties with use of subsoiling and animal manure on improved quantitative and qualitative traits of potato, an experiment was done in the Agricultural Research Station of Ardebil. To perform the experiment, the statistical factorial design based on completely randomized blocks design was used with 4 replications. In this experiment, the plowing operation in horizontal plots was applied with and without subsoiling. The animal manure factor was applied at four levels of controls as zero ton per hectare, 15 tons per hectare, 30 tons per hectare and 45 tons per hectare of animal manure at vertical and main plots. The effect of subsoiling on studied traits was not significant. The mutual effect of animal manure in the subsoiling on studied traits was not also significant. The animal manure impact on the traits of plant height, stem diameter, yield per plant, and number of nodes per plant, starch percentage, dry matter percentage and dry matter yield was significant, while showed no significant difference influencing the traits, including number of days to node-producing, number of stems, tuber mean weight per plant and the tuber size. In conjunction with quantitative traits, the manure treatment of 45 tons per hectare was the best, and the highest values of qualitative traits were also obtained in the control treatment.

Keywords: *Subsoiling; Potatoes; Quantitative Traits, Qualitative Traits; Animal Manure*

INTRODUCTION
Potato is one of the most important and strategic products that like wheat, rice and maize plays an important role in supplying hydrocarbons needed in the human body as well as providing other human needs such as proteins, amino acids, vitamins and minerals. Regarding the area under cultivation and production, potato is in the fourth rank in the world after wheat, rice and maize, and most of the countries in the world cultivate and produce potatoes (Rezaei and Soltani, 1997). Among the factors directly affecting the potato production is its tuber producing environment or the soil. A good soil with a high cultivation depth and rich nutrients potential can give the greatest help to the costly production of potatoes (Salardini, 1996). Whereas the area of cultivation of potatoes in Ardabil is over 22,000 acres, and most of potatoes crop in the country is produced in the province, the necessity of performing such study in the province appeared essential more than ever. The soils in Ardebil region are poor in organic food materials and rich in limestone and clay tiny particles, which give them non-favorable physical properties; they also have impenetrable layers in underground parts, all of which make the potato tuber to remain small, and thus, lead to reduced quantity and quality of the product. In some experiments, the impact of animal manure on water-holding capacity and structure of the soil and increasing the potato crop were tested simultaneously. The increased water-holding capacity rates were as 31.5% in the control treatment, and respectively as 33.5%, 34.4%, 35.3% and 35.8% in treatments of 10, 20, 30 and 40 t per ha of animal manure (Barca). Subsoiling was useful to break the under the earth layers, and its effects would be considerable for 2-3 years, and when the underlying layers are quite hard, its effects would be longer. It also increases the depth of rooting, and raises the volume of usable water supply (Holmstrum and Carter, 2000). In addition, if the roots occur in a proper place regarding the availability of chemicals due to fertilization, the positive impacts of manure plus subsoiling would be more. Although the importance of organic fertilizers is reduced with increased consumption of mineral fertilizers, but based on experiences obtained, organic fertilizers that animal manure is one of its kinds play a tremendous role not only as a

food source but also in improving the soil physical properties and chemical (Mina). It is believed that the usefulness of organic fertilizers is due to their physical properties rather than their nutrient properties. In experiments conducted by Nitson and Zout (1989), the optimum amount of nitrogen reduced by using animal manure as 15-50 Kg per ha. It was proven that subsoiling facilitates the availability of food material, and finally would have a positive impact on the performance (Harris, 1991). Hassandoukht (1997) achieved the maximum number of tubers with a diameter of 28-35mm in 20 tons of animal manure and tubers with a diameter of 35-45 mm in 30 tons of manure per hectare. He also found the negative impact of increased manure on the dry matter. Walter *et al.*, (1990) in his experiments found a reverse relationship between high yield and dry matter content; Lams and Gilbert (1988) saw that the use of animal manure meanwhile increasing the yield will have a negative effect on tubers dry matter content (Mina and Gupta). Given that modification of physical and chemical properties of soil has a considerable impact on increasing the tuber products, thus, this study was carried out to investigate the effects of improved physical and chemical properties of soil on potato yield in the region.

MATERIALS AND METHODS

This research was conducted in Ardabil Agricultural Research Station that some of its geographical and climate features are presented in Table (1).

Table 1: Some geographical and climatic characteristics of the test site

Elevation above sea level	Latitude (eastern)	Longitude (northern)	Mean annual precipitation	Mean maximum temperature	Mean minimum temperature
1305 m	1.98	15.8	310.9mm	38	20

Before onset the planting, sampling was performed from the soil at the test site in the fall before planting from three different depths, which were analyzed and evaluated and the results are given in Table 2.

Table 2: Some soil properties at the test site in three different depths

Depth **cm**	Soil texture	%Silt	%Sand	%Clay	**%**Organic matter	Ec Mmoh/cm	Ph
0-30	Clay-Silt	30		32	1.3	0.8	8.2
30-60	Clay	40	38	40	0.7	0.9	8
60-90	Clay	40	20	45	0.5	0.9	8

The potato tuber of DRAGA variety was prepared in the research station weighing approximately 50 g. Tillage operation was performed on the studied land in the fall before planting. The experiment was performed as factorial based on completely randomized blocks with four replications and 8 treatments. Two factors were studied. Tillage operation was done in two levels with and without of subsoiling in horizontal and sub-plots, and animal manure was used on four levels of 0, 15, 30 and 45 ton per ha in vertical and main plots. The area of each plot or experimental unit was 18 square meters. Each plot contained four lines 6 meters in length at row plant spacing distance of 75 cm and the plant distance on the lines as 25 cm. The planting operation was implemented on June 22. Half of the urea fertilizer simultaneously with planting, and the other half after 50 days were given to the tested field. During the

planting season, all planting operations, including three times weed control, 6 times of irrigation, and 3 times of plant soil replacement were carried out without any fighting against the Colorado beetle due to lack of threats. About 140 days after planting, harvesting operation was performed and 10 plants were randomly selected. In the selected plants, the following traits were evaluated based on common practices: Number of days to tuber forming of plants up to 75%, yield per hectare, the main stems number, stem diameter, plants height, dry matter percentage and the percentage of starch, dry matter yield and tubers size in 5 seed groups (tubers with a diameter less than 28 mm were placed in the non-cultivable group with a smaller diameter than the seed group; tubers with a diameter between 28-35 mm: small seed group; tubers with a diameter between 35-45mm: average seed group; tubers with a diameter between 45- 55 mm: large seed group; and the tubers with a diameter larger than 55 mm: large non-cultivable seed group). For analysis of variance of the measured traits, the data mean values obtained from each plot were used, and comparison of means was performed on treatments with significant differences, and finally, the correlation between the traits was calculated. After collecting the necessary data, analysis was done using SPSS software, and comparison of data was performed by Duncan's multi-range test. Drawing the charts and graphs was conducted using Excel software.

RESULTS AND DISCUSSION

Number of Days from Planting to 75% of Plant Tuber-Producing

Based on the results obtained (Table 3), no significant difference was found in this regard.

Stem Diameter

According to analysis of variance (Table 3) for stem diameter, it can be seen that subsoiling and the mutual effect of farmyard manure × subsoiling show no significant differences; however, farmyard manure indicates a significant difference at 1% probability level, so that the farmyard manure has increased the stem diameter. The maximum and minimum stem diameters as 10.70 mm and 9.11 mm were measured in the animal manure treatment of 45 tons per hectare and in the controls, respectively (Figure 1).

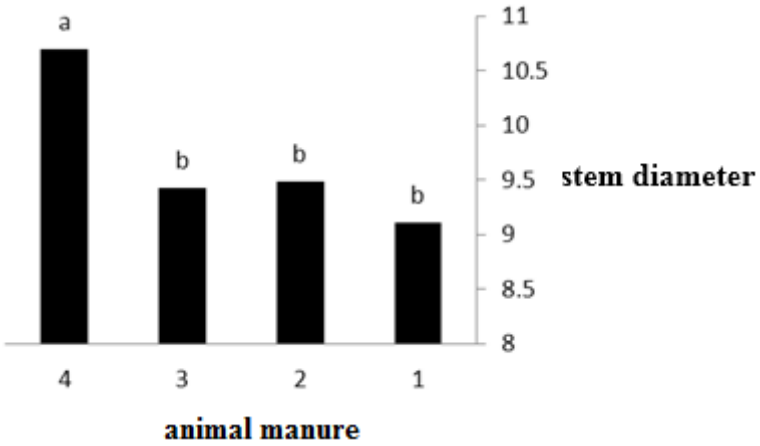

Figure 1: Effect of different levels of manure on potato stem diameter

Plant Height

According to the analysis of variance table (Table 3), it is concluded that subsoiling and the interaction effect of FYM × subsoiling have no influence on the studied trait, but animal manure has been effective at probability level of 5%, and with increased animal manure, the plant height has increased. Based on this, the highest plant height was seen in the manure treatment of 45 tons as 40.99 cm, while the lowest value was found in the controls as 34.42cm (Figure 2).

Table 3: Mean squares for evaluated traits of the potatoes

Mean of Square								
Tuber average weight per plant	Tubers per plant	Number of stem	Plant height	Stem diameter	Days to tuber producing	Days to greening	df	S.O.V
1388.572**	15.545**	0.644ns	11.853ns	0.36ns	6.369ns	3.917ns	3	Rep
216.804ns	1.403ns	0.578ns	2.94ns	0.72ns	0.281ns	0.5ns	1	Subsoiling
287.88ns	3.498*	0.299ns	58.727*	3.905**	7.615ns	4.75*	3	Animal manure
224.197ns	0.571ns	0.024ns	11.21ns	0.173ns	2.365ns	0.75ns	3	Subsoiling + Animal manure
254.55	1.43	0.28	18.13	0.7	3.6	1.29	21	Error
20.47	15.03	13.48	11.38		2.38	2.7	-	C.V. (%)

** And **: Respectively, significant at probability level of 5% and 1%; and ns = not significant*

Table Continued 3-

Mean of Square								S.O.V
Tuber size 45-55 mm	Tuber size 35-45 mm	Tuber size 28-35 mm	Starch %	Dry matter yield	Dry matter %	Yield per plant	df	
0.168ns	1.525**	0.664ns	0.111ns	0.193ns	0.253ns	1088.221ns	3	Rep
0.001ns	0.5ns	0.578ns	0.011ns	0.001ns	0.061ns	8984.70ns	1	Subsoiling
0.037ns	0.18ns	0.299ns	1.432*	0.26ns	0.782*	22080.1*	3	Animal manure
0.24ns	0.136ns	0.026ns	0.118ns	0.203ns	0.335ns	3279.7ns	3	Subsoiling + Animal manure
0.148	0.221	0.28	0.392	0.203	0.291	4700.9	21	Error
23.01	19.86	13.48	7.78	13.97	3.33	13.72	-	C.V. (%)

** And **: Respectively, significant at probability level of 5% and 1%; and ns = not significant*

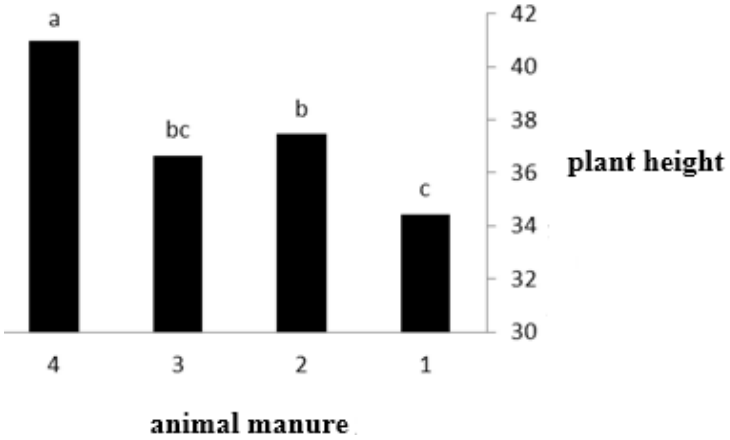

Figure 2: Effect of different levels of animal manure on potatoes plant height

Number of Main Stems

According to the results obtained, animal manure, sub-soiling, and their interactions had no effect on the number of potato stems.

Number of Tubers per Plant

The results indicated a significant effect of animal manure at probability level of 5% on this trait, and accordingly, the highest number of tubers as 9 tubers were obtained in the manure treatment of 45 tons per hectare, and the minimum quantity of 7 tubers were obtained in the manure treatment of 15 tons per hectare, while the subsoiling and its interaction with animal manure were not significant (Figure 3).

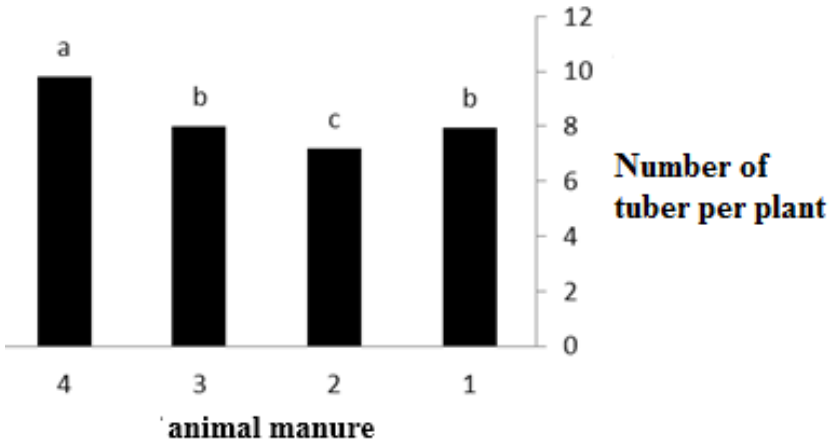

Figure 3: Effect of different levels of animal manure on the number of tubers per potato plant

Tuber Average Weight per Plant

Review of the analysis of variance table (Table 3), lack of significant differences between the treatments was found.

Plant Yield

Referring to the analysis of variance (Table 3), it can be seen that there are no significant differences in subsoiling and the mutual effect of FYM * subsoiling between the treatments; however, the animal manure showed significant differences between the treatments at probability level of 5%. With the increasing amount of manure from zero to 45 tons per acre, the value of crop per plant was increased so that its value in the control has increased from 455.8 g to 574.4 g in the 45 tons per hectare animal manure (Figure 4), while the total yield was also affected by the animal manure proportional to the plant yield.

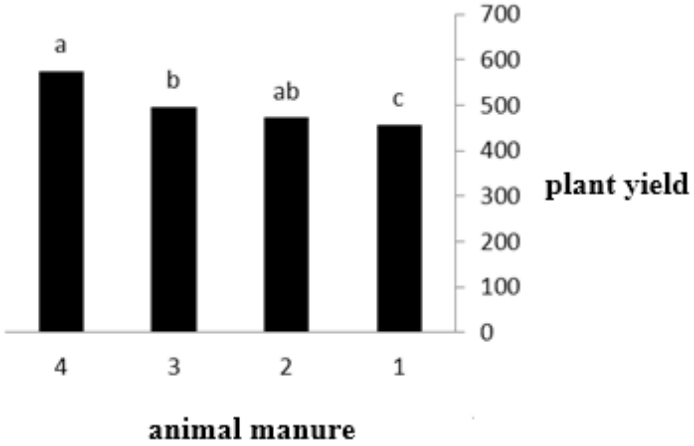

Figure 3: Effect of different levels of animal manure on potato plant yield

Size of Tubers

Based on analysis of variance table (Table 3), it can be realized that subsoiling, animal manure and their mutual effects lacked significant differences among the treatments. However, based on the results, there was a positive and significant correlation between the number of tubers per plant and the percentage of small tubers at probability level of 1% so that the number of small tubers with a diameter of 28-35 mm was the greatest.

Dry Matter Percentage

According to analysis of variance table (Table 3), subsoiling and the interaction between animal manure and subsoiling indicated no significant differences between the treatments; however, significant

differences were seen between treatments regarding the farmyard manure at the 5% level. Based on the results, the highest value of dry matter in the control was equal to 16.68%, while its minimum value was obtained in the manure treatment of 30 tons per hectare as 15.92%, which again with increasing amounts of FYM to 45 tons per hectare, the percentage of dry matter increased. Also, there are significant difference and positive correlation between the dry matter yield and the total yield at probability level of 5% (Figure 4).

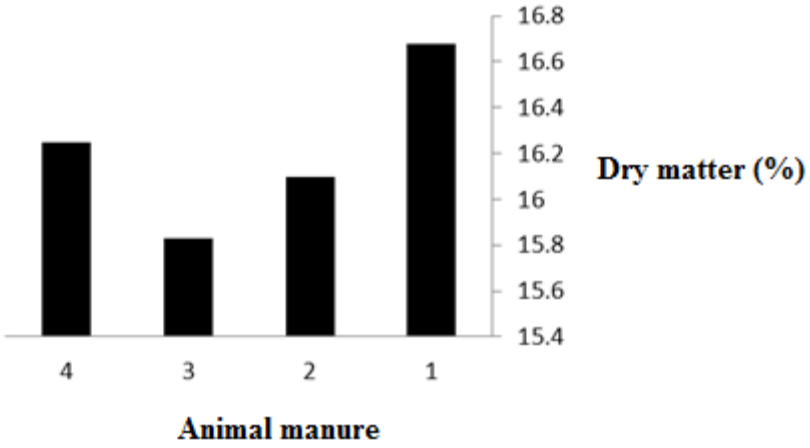

Figure 4: Effect of different levels of animal manure on dry matter content of potato

Starch Content (Percentage)

Like other traits, no significant differences were seen between treatments due to subsoiling and interaction of farmyard manure in subsoiling; however, the farmyard manure was effective on treatments at probability level of 5%. The maximum amount of starch was seen in the control treatment as 8.625%, while its lowest value was found in the manure treatment of 30 tons per hectare as 7.625%; then, the amount of starch again increased and reached to 8.05%. The table of correlation coefficients shows a positive correlation between the percentage of starch and dry matter content at probability level of 5%; since starch is one of the dry matter components, and with increasing of dry matter content, the starch rate will also increase (Figure 5).

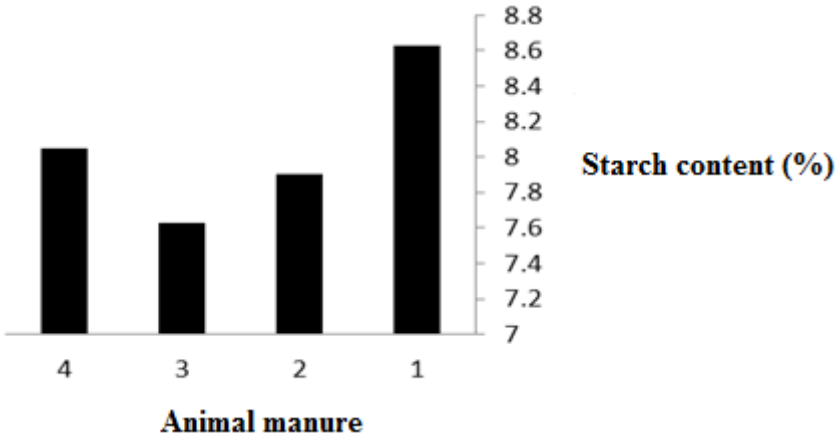

Figure 5: Effect of different levels of manure on potato starch content

Conclusion

Considering that in this experiment, two factors of subsoiling and animal manure have been investigated given the soil condition in the region, the results show that the subsoiling factor had no significant effect

on the traits, which confirms the results obtained by Holmstrum and Carter (2000) suggesting the improved soil physical conditions that would soften the hard and compact layers under the ground. Based on studies, the reason for ineffectiveness of subsoiling on the traits unlike the crops with deep roots depends on the nature of the potatoes rooting, since the potato roots are shallow and not deep; thus, tuber producing occurs in the soil surface parts, and subsoiling also intensifies this condition. The impact of animal manure on the traits is also due to its physical, chemical and biological properties; since using manure causes the entry of elements into the agricultural soils. Also, the decomposition of organic matter leads to formation of humus colloids in the soil and absorbing of nutrients at exchangers surface, which are of great importance regarding nutrition. The manure improves the root respiration and its growth and development. Due to decomposition of organic matter and humus formation, not only the soil ventilation status, especially in clay and dense soils such as the studied region improves, but also the soil water holding capacity increases. The exchange of nutrients in the soil leads to better performance of the potatoes as well. Meanwhile, the presence of countless numbers of beneficial microorganisms leads to the decomposition of organic materials and consuming the elements in them by the plants.

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