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The Effects of Earthing up on the Potato Yield in Dezful (Khouzestan, Iran) Weather Condition

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Abstract: The effects of soil adding influences on yield of four varieties of potato were studied in Dezful (Khouzestan province, Iran). The experimental design was a split plot fitted to randomized complete block with four replications and two factors including adding soil to bush foot and variety. Adding soil had two E_1 and E_0 levels, without adding soil and once soil adding and varieties including four V_1, V_2, V_3 and V_4 levels which were Arinda, Sante, Marafona and Ramus respectively. Quantitative and qualitative characteristics were measured during plan execution. Results showed that treatment of adding soil affected on tuber yield significantly ($P>0.01$). The characteristics of the tuber number and mean tuber weight in the bush had significant ($P>0.05$). The characteristics of tuber number, stem number and mean tuber weight have had significant at different varieties ($P>0.01$). Mutual effect of the varieties and adding soil view, the characteristics of tuber diameter has had significant ($P>0.05$). According to obtained results adding soil increase yield with amount of 43.31 t/ha for Ramos variety.

Key words: Potato · Variety · Earthing up · Yield

INTRODUCTION

The potato (*Solanum tuberosum* L.) is the fourth most important world crop, after rice, wheat and maize [1]. It is a major source of inexpensive energy. It contains high levels of carbohydrate and significant amounts of vitamins B and C and minerals. Its growth and yield affected by the variety and environmental conditions significantly. The potato is a psychrophile product and its best growth is in the areas which their mean temperature of the hottest growth season is about is a 25°C. Bodlender *et al.* [2] reported regardless considering the plant water requirement and high temperature, the potato tubers were led to the second growth in 22-27°C. They explained the varieties have different reactions in various temperatures and some factors such as long day's percent and Nitrogen rate delays the tubers formation will induce growth.

Potatoes will grow very quickly under warm and moist conditions. When they are 10cm tall, the leafy shoots can be mounded around with soil to their full height. This will increase the length of underground stems that will bear potatoes. This mounding can be repeated once or twice more at 2-3 week intervals to ensure the best crop, with the added benefit of smothering any competing weeds.

In a growing cultivation, the tuber must be covered with an appropriate soil layer. This process conducted for the tubers protection from the direct light (which makes the tuber color green), high temperatures (second growth) and the insects injury (e.g. potato moth). The stolons formation take place depends on the maternal tuber situation and the new tuber formation take place depends on the stolons situation and their length. The stolons length is only based on the cultivation or plant type (variety, temperature, day length and etc) and the ridge size. Providing good covering for the new tubers is acquired through the deep planning and great ridge providing. Since very deep planting often delays the sprouting, the planting depth Limitation (provided that appropriate moisture and soil temperature supply) and then the new tubers covering by the soil may be better. Whatever the seed tuber planning is fewer, it is necessary to provide bigger ridge later. The ridge should be long and its upper part should be flat. Ridging time depends on the soil temperature and moisture. Weed control

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technique should be considered too. Babaee and Lack [3] compared the mutual yield of the pollution rate to the potato willow and recognized 15cm planting depth treatment and two times soil adding after the primary vegetative growth and making tuber initiation appropriate and this treatment had the highest yield and the lowest willow pollution rate. Memarzadeh and Bolandandam [4] concluded through the annual variance analysis and the compound variance which soil adding time and times had significant effect on the product yield, moreover the weeds are disappeared by adding soil and the formation and replication space of the new provided tubers was economized the spraying costs. Plants such as potato, the soil should be added to the bushes in order to increase the product and it is important to cover the plant sides equally.

It pointed out that the adding soil can considerably increase the yield, also decrease the greening effect compared with low depth planting [5]. It is reported that the variance analysis of the measured characteristic of the adding soil to bushes and wet weight of the stem was significant ($P>0.01$) [6]. It is reported that the potato tuber yield is because of the tuber number and the mean tuber weight in the bush [7]. Regarding to the variety capability for different tuber number production and in order to decrease the green tubers number, soil adding to the bushes in the varieties which are able to produce more tubers in the bush which can have considerable effect on the yield.

This investigation carried out for determination the effects of soil adding on four potato varieties yield.

MATERIALS AND METHODS

Area of Study: This study was conducted in growing season 2008-2009 in a private farm land located in 5 Km to Dezful (Khouzestan Province, Iran) with the longitude 48° and 23 mm and the latitude 32° and 25min in north and with the 140 min height from sea level. Soil samples were collected prior to planting at 0-30 cm and 30-60 cm depth and their properties were given in Table 1.

Plant Material and Experimental Design: All plots received basic application of 200 kg P as phosphate ammonium and 250 kg K as potassium sulphate (48-50% K_2O. N added twice before planting (100kg urea) and 60 days after planting (75 kg urea). Irrigation, pest and disease management were as for the previous potato crops at this sites and followed normal commercial practice. Potato varieties Arinde, Sante, marafona and Ramous prepared from potato seed production (Freidon Shahr, Isfahan) and disinfected and planted. The plots were kept weed-free by hand weeding during the growing period. Some characteristics of mentioned varieties compared in Table 2.

The experimental design was a split plot fitted to randomized complete block. Treatments included two factors adding soil to the bush and four varieties planting. Adding soil to the bush possessed two E and E_1 levels which were respectively considered without soil adding and once soil adding land. Variety had four treatments including as V_1, V_2, V_3 and V_4 levels which were Arinde, Sante, marafona and Ramous, respectively. Every plot consisted 6 lines as brook and the ridge with 75 cm row distances and the bush distances on every row was considered 30 cm. each plot length was 5m. Two rows of every plot were considered for the sampling (two rows for the final harvesting and two rows as the margin). The adding soil was conducted when the bushes height was 20 cm. various treatments were used to study the stems number per bush and other considered characteristics.

Harvest and Yield Measurement: The harvest date was May 2009. Four bushes were randomly chosen from each treatment. At the time of harvest, the potatoes were graded as unmarketable (diameter <28 mm or malformed) and marketable (diameter >28 mm) tubers and the number and weight of tubers in each grade were recorded. Then the mean number of tubers per plant, the mean tuber weight (g) and total tuber yields (t/ha) were calculated. Plant height was measured in cm in experiments as the distance from the top of the ridge to the highest part of the randomly chosen plant. Samples placed in the oven for 45 hours in 75°C for determining of the bush dry matter. After the samples dry weight record, the bush dry matter weight was calculated. Five tubers was chosen from every treatment in the harvesting time, the considered tubers was firstly washed and weighted. For study the stems number, four bushes were randomly chosen from each treatments and the measurement was taken. Two middle lines with omission of %5 margin from the sides was harvested and weighted and finally the mean tubers weight was generalized to area unit.

Leaf area index measured by plantimeter, then it was estimated by the following formula:

$$LAI = \text{Leaf area}/ SA$$

Where SA is the area covered by the plant.

Table 1: Physicochemical characteristics of soil used in the study

Soil texture	Depth (Cm)	Total nitrogen (%)	Available P (ppm)	Available K (ppm)	Organic carbon (%)	Neutral material (%)	pH	EC dS m^{-1}	Saturated soil (%)
Silt-loam	0-30	0.52%	3.6	340	53	7.5	7.3	1.42	29
	30-60	0.30%	2	220	32	10	7.5	1.21	20

Table 2: Some characteristics of used varities in this investigation

	Variety			
Character	Arinda	Sante	Marfona	Ramos
Maturity	Early maturing	Semi early maturing	Semi early maturing	Semi late maturing
Dry matter	Low	Moderate-good	Low	Moderate-good
Foliage extension	Good-very good	Good-very good	Good	Good
Tuber size	Large	Large	Large	Very large
Yield	High	Very high	Very high	Very high
X virus resistance	Enough good	Enough good	Enough good	Enough good
Leaf blight resistance	Good	Enough good	Enough good	susceptible
Tuber blight resistance	Enough good	Enough good	Enough good	Enough good
Scab resistance	Enough good	Resistant	Enough good	Resistant
Internal disorder resistance	Enough good	Resistant	Resistant	Good
Leaf curling resistance	Good	Enough good	Enough good	Enough good

Statistical Analysis: Statistical analysis of experimental data were conducted using the SPSS 11.5 and MSTATC software package and the means were separated following ANOVA by Duncan's multiple range test with at least $P<0.01$ and $P<0.05$.

RESULTS AND DISCUSSION

Results showed that adding soil did not effect on bush height significantly (Table 3). It is related to growth type of various varieties. It is reported that increase of stem number will lead to increase of bush height due to light availability and its effect on increase of length and number of node [2, 8].

Adding soil had not significant effects on leaf area index and this parameters affected by growth type (Table 3). The maximum LAI recorded in Ramos variety (4.23) which had significant difference with other varieties statistically. Variety and culture pattern were two effective factors on LAI and amount of absorbed light [9]. Similar results were reported by Deroo and Waggoner [10].

Results showed that Bush fresh and dry weight did not affected by adding soil because these parameters related to growth type and vegetal period [9]. The maximum bush fresh and dry weight recorded in Ramos variety 2137.3 and 114.216 g ,respectively with significant difference compared to other varieties (Table 3).

Soil adding to bush could not influence on the stem number in bush but significant difference observed among varieties for this parameter (Table 3). In general, the stem numbers per bush feature were not affected by the soil adding to bush and it further relates to the planting depth and the growth type as the experiment planting depth has been equal among all of the varieties. In fact, the stem numbers are formed after planting and before soil adding stage and can't affect by the soil adding to the bush at all. It is reported that bush intensity had significant effect on stem numbers, stolons numbers and the leaves dry weight ($P<0.01$) and correlation of stem numbers and yield was positively insignificant [11]. It can be mentioned the stem numbers per bush in the different verities is as one of the internal and compatible characteristics in the studied varieties related to weather condition. Ramous potato variety had more compatible than other varieties for weather condition, Producing 5.92 stem per bush, maximum of stem number per bush (Table 3). This variation relates different physiological characteristics among various varieties. Hansen [12] mentioned the produced stem number in bush is determined in the early growth period which is probably affected by the plant environmental condition and the variety regardless the seed. Generally, stem numbers per bush feature did not affected by the soil adding to bush and has further related to cultural practices. Henricksen and Molgaard [9] showed that there is significant difference among the potato varieties in produced stem numbers due to hilum variation on seed potato.

Adding soil could increase tuber numbers per bush and tuber yield significantly compared to non adding soil which led to improvement of total yield in treatment groups (Table 3). Among four varieties Ramos showed the maximum amount for these parameters and Arinda had

Table 3: The effects of adding soil on some characteristics of various potato varieties

	Means								
Treatment	Bush height (Cm)	LAI	Tuber numbers per bush	Mean tuber weight per bush (g)	Tuber yield (t/ha)	Bush dry weight (g/plant)	|Bush fresh weight (g/plant)	Stem numbers per bush	Total yield (t/ha)
Non-adding soil to the bush (E0)	58.17a	3.95a	6.58b	198.73b	33.64b	76.27a	1172.76a	3.48b	3364.6b
Once soil adding to bush (E1)	57.62a	4.13a	8.89a	250.5a	46.35a	92.41a	1433.38a	3.87b	4631.9a
Varieties									
Arinda	54.12b	3.65b	7.17c	181.38b	36.05b	54.78c	592.5c	2.08d	3605.4b
Sante	56.25a	3.98b	8.47b	248.58a	42.36a	85.93b	1035.29b	4.54b	4236.3a
Marfona	54.23b	3.87b	7.54c	199.17b	39.75b	82.51b	923.2bc	3.52c	3975.8b
Ramous	58.22a	4.23a	9.60a	256.38b	43.01a	114.21a	2137.32a	5.92a	4301.7a
Soil adding × variety									
$E0V_1$	50.21c	3.34b	5.83d	177.57cde	31.52e	47.25a	496.28b	1.78e	3152e
$E0V_2$	51.34b	3.43b	7.13dc	231.52bcd	35.06cde	84.26abcde	931.73b	3.75cde	3506cde
$E0V_3$	54.53c	3.41b	6.52de	213.57cde	31.57de	64.21cde	823.75b	3.25de	3157.8de
$E0V_4$	52.24b	3.83a	7.89cd	240bc	36.4cde	114.13ab	2295.45a	4.78abc	3640cde
E_1V_1	50.35c	2.85c	7.71cd	196.52cde	38.29bcde	62.32cde	744.68b	2.71ef	3829bcde
$E1V_2$	50.35bc	3.03bc	8.81bc	281.5ab	49.59a	94.73abcd	1150.11b	5.21ed	4959a
$E1V_3$	54.36ab	3.11ab	7.71cd	233bcde	44.57abc	83.57abcde	839.52b	4.52bcd	4457.9abc
$E1V_4$	56.57a	3.75a	11a	301.52a	50.25a	127.18a	2651.57a	5.68a	5025.8a

Means with the same letter in the columns are not significantly different at P<0.01

Table 4: Squares mean of some studied characteristics of potato

		MS								
S.O.V	d.f	Bush height (Cm)	LAI	Tuber numbers per bush	Mean tuber weight per bush (g)	Tuber yield (t/ha)	Bush dry weight (g/plant)	Bush fresh weight (g/plant)	Stem numbers per bush	Total yield (t/ha)
Replication	3	127.85ns	0.388ns	2.31ns	343.56ns	11.56ns	691.23ns	9511.24ns	0.78ns	11.65ns
Soil adding	1	124.20ns	2.24ns	20.83*	12153.36*	651.45**	783.47ns	208073.82ns	2.59ns	125.97**
Error	9	37.55	0.32	2.82	1503.58	43.50	231.32	121348.03	0.94	43.50
Variety	3	750.46*	0.13*	14.52**	16101.86**	125.97*	6832.12**	6769110.32**	20.70**	651.45**
Variety × Soil adding	3	59.45ns	0.24ns	0.88ns	1057.46ns	45.57ns	394.92ns	140108.56ns	0.474ns	45.57ns
Error	12	17.85	0.04	1.12	1251.09	37.09	785.36	170433.52	0.58	37.09
CV%		18.69	19.23	12.96	17.53	15.08	30.17	32	19.76	15.08

Ns: Non significant*, significant at P<0.05 ** and significant at P<0.01

the minimum amount. Tuber numbers per bush of different varieties is one of the internal and compatible features of varieties which are considerably affected by the planting, therefore Ramous is more compatible to the weather condition comparing to other varieties. Positive results of adding soil on tuber number, its weight and yield reported before [6, 7, 9, 5].

Jalavandi, [6] showed that analysis variance of the measured characteristic of the bush soil adding and the tuber dry weight in the bush was significant (P<0.01) and the leaf dry weight, the tuber numbers and the mean tuber weight per bush were significant (P<0.05).

It is reported that the potato tuber yield is a result of the tuber numbers and the mean tuber weight per bush [7]. Ambura [5] pointed out that the soil adding can considerably increase the yield, also it decreases the greening effect comparing to the low depth of the planning. Henricksen and Molgard [9] described that soil adding to the bush affects on the potato product structure and its output and then can considerably influence the tubers number and the related mass. In this investigation same results with suitable correlation among tuber parameters correspond into attained results of other researcher and regarding to the potato making tuber is

affected by the ridge's appropriate space and its dark one and the variety, Ramous variety associated with adding soil treatment produced the most tuber number in bush (Table 3).

It is reported that plant population affect on tuber size and low population size increase tuber size significantly [13]. It seems that adding soil help to dry matter accumulation in tubers and tuber yields to some extent. It caused little stress to tuber due to regulation drought above layer of soil because stresses impaired dry matter accumulation in tubers and tuber yields. Stress imposed at early stages of tuber growth, when tubers were less than 20 mm in diameter, had little effect on dry matter accumulation, whereas stress imposed later resulted insignificant losses of dry matter in tubers [14].

CONCLUSIONS

Regarding to the condition of the experiment conduction, it seems Ramous is the most appropriate variety and adding soil to the bush is an effective factor to acquire the maximum ideal yield in Dezful weather condition. The mutual effect of the soil adding is significant from the tuber yield characteristic view which it indicates the varieties different reaction toward the appropriate time of the soil adding from the limits of physiological growth stages view.

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