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Evaluation of some quantitative properties of potato mini-tubers affected by genotype, different planting bed composition and pot size

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Abstract

This experiment is evaluation of genotype effect value and different types of potato mini-tubers planting bed composition on quantitative properties of potato include total number of mini-tubers, number of mini-tubers in standard size, mini-tubers dry matter and root dry matter. This research is a three-factor factorial experiment on based of randomized completely design in four replication at Seed and Plant Certification and Registration Institute (SPCRI) located In Iran in agricultural year of 2010-2011. The first factor (genotype) in three levels (Agria, Sante and Satina), the second factor (planting bed) in six levels (peat moss+sand (1:1by volume) , coco peat+perlite+sand (1:1:1 by volume) , peat moss+perlite (3:1 by volume) , peat moss+sand+perlite (1:1:1 by volume), coco peat+perlite+peat moss (1:1:1 by volume) , coco peat+sand (3:1 by volume)) and the third factor (pot size) in two levels (1.5-liter and 3-liter). results indicated that different genotype and different planting beds lead to create significant differences ($p \leq 0.01$) in all of the four evaluated traits in this research. Existence of these differences verity in the pot size factor, but with this odds that pot size in mini-tuber dry matter trait couldn't result significantly differences. On base of these experiment results it shall be stated that Sante cultivar due to having most optimum values in these experiment traits is known as most suitable genotype rather than the other genotypes. Also peat moss+sand (1:1by volume) planting bed had better properties than the other planting beds.must be noticed that bigger pot size leads to more total mini-tuber, more mini-tuber dry matter, and more root dry matter but produce less number of mini-tuber in standard size.

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Introduction

Potato crop in terms of world ranking is fourth with an annual production of 325 million tons. In fact, potato as most important dicotyledonous plant, has been allocated the largest area under cultivation among the edible plants after plants like wheat, rice and corn (World Book, 2000). Considering the fact that the potato is propagated by tubers and annual invasion of viruses into the produced tubers increases, the number of potato tubers has decreased as a result of viral infection thus after a few years, it greatly decreases the quantity and quality values (Rezaii and Soltani, 1996). Therefore, efforts are made to provide pathogen-free tubers. So that is estimated that the application of healthy potato tubers will increase yield by at least 30 percent (Zarghami, 2001).

The viral and fungal infections can also have tragic effects on product quality and market-friendly set up and can cause deleterious distribution of potato germplasm (Tovar *et al.*, 1985). Pathogen-free seedlings and mini-tubers of potato that have been produced through tissue culture can be used as one of the best methods of certified seeds production program (Pajohandeh, 2001).

Tissue culture as a method, provides the possibility of mass colony reproduction and it has been used in controlled conditions to reproduce and maitain genetic resources of potato and the other tuber plants. At the International Research Center of Potato (CIP, 1993), approximately 5000 clones are maintaining with this method which are used in breeding, reproducing and micro propagation programs and Leads to saving costs of field planting and harvesting and warehousing and avoids from the contamination of samples by pathogen and transmission of disease agent from one country to another simply (Epinoza *et al.*, 1992).

In addition to be cheap and cost-effectiveness, desire planting bed must have good portability, style, and physically, chemically and biologically be desire (Davidson *et al.*, 1998).

Planting bed is one of the factors that is more important in the production of potato mini-tubers. Tukaki and Mahler (1989) reported superiority of sand and perlite planting bed and specified that mixed composition including 80% vermiculite and 20% silica sand leads to produce highest number of tuber under greenhouse conditions. Forti *et al* (1990) and Ranali *et al* (1994) to evaluate the mini tubers applied the Soil, vermiculite and sand planting bed to the ratio of (1: 1: 2).

Also Alan *et al.* (1994) have evaluated the effect of different planting beds such soil, perlite, pit, sand and Pumice in single and different combinations form on tomato quality and quantity and they observed that applied planting beds had significant difference in terms of the effect on the quality and quantity of tomato. Jami Moeini *et al* (2003) and Modarres Sanavi and Jami Moeini (2001) reported that while agricultural soil had not favorable condition to add to the culture medium, planting bed of peat moss and sand to volumetric ratio of 1: 4, was a hotbed for producing mini-tuber.

Vanaei *et al.* (2008) investigated the effect of genotype, planting bed combination and pot size on potato-mini-tuber yield and indicated that there is a significant difference between potato cultivars, substrates and pot size in terms of number and weight of all of the mini-tubers and it was not observed significant mutual effect between pot sizes and planting beds. Marfona cultivar by 9-tuber per plant production and yield of 65 grams per plant had showed better performance rather than Agria cultivar by 7-tuber production per pot and yield of 57 grams per plant. Planting bed peat/perlite in ratio of 1: 1 in large pots (19 cm) showed highest yield (15-mini-tuber per pot and yield of 95 grams per plant).

Ozkanak (2005) among an experiment cultivated three cultivars of potato, Concord, Marabl and Volux, by combination of peat moss and soil in volumetric ratio of 1:1.He reported that a significant difference exists between the varieties in terms of mini-tuber number and yield so that the Marabl cultivar by about

7 mini-tubers and yield of 75 g per plant showed better results in comparison to other cultivars. The experiment was conducted to select the suitable planting bed, cultivars and pot size to achieve the maximum efficiency of under green house condition.

Materials and methods

This study was done in Seed and Plant Certification and Registration research Institute located In Iran at 2010-2011. The research coming into force as three-factor factorial experiment on based of randomized completely design in four replication. The first factor (genotype) in three levels (Agria, Sante and Satina), the second factor (planting bed) in six levels (peat moss+sand (1:1 by volume) , coco peat+perlit+sand (1:1:1 by volume) , peat moss+perlit (3:1 by volume) , peat moss+sand+perlit (1:1:1 by volume), coco peat+perlit+peat moss (1:1:1 by volume) , coco peat+sand (3:1 by volume) and the third factor (pot size) in two levels (1.5-liter and 3-liter).

Plantlets production

Virus-free seedlings were produced using combination method of heat treatment and meristem isolated and cultured in MS liquid medium onto paper bridges and then transferred cultures in suitable growth condition in the growth chamber. Obtained seedlings using single-node cuttings on solidified MS medium multiply with agar and were transmitted to a growth chamber with a temperature of 24 degrees Celsius, light for 16 hours and light intensity of 4500 lux and were kept there about 4 weeks to grow and become the new seedlings(Hasanpanah *et al.*, 2006).

Minituber production in greenhouse

After obtaining the required number of seedlings, seedlings 25-30-day life time having 7 to 9 leaves were selected for transfer to greenhouse.In the greenhouse, seedlings were taken out of the pots and the roots were washed with water to remove medium residual matter. cleaned seedlings were transferred carefully into the bed including a mixture of soil disinfected by fungicides and insecticides (Sevyn and captain) and perlite and peat moss in the ratio of(1: 2: 1)and for a few days aplastic cap was placed on them to adaptingseedlings to greenhouse environment and preventing damage to them.Seedlings were growning in growth chamber with day and night temperatures of 18 and 12 ° Celsius, 12 hours day length and relative humidity of 85 percent.After 100 days, the mini-tubers were harvested (Garmchy, 2010).

Preparing the pots

1.5 and 3-liter pots were filled by prepared beds until half.Selected and considered tubers were placed in the middle of the pots by two tuber per each pot density and the second half of the pots were filled with equal amounts of planting beds and each treatment reagent tags were attached to the pots.After planting, all mini-tubers were irrigated and in terms of pests and diseases control keeping operations were made after emergence to the end of the growing period of plants and also the same feeding were carried out for all the pots.

It is to be noted that all the watering and feeding steps were applied through the drip irrigation system.In the early period of growth applying solution was performed 3 times a week and gradually reduced the number of applying solutions and it was stopped in the late period of vegetative growth.In order to prevent beds salinity through the nutrient solution, irrigation was done after each three times solution application.

Seedling establishment

After mini-tubers planting, the number of days to emergence from the soil surface, number of days to buds emergence (2 leaves), leaf number, plant height and number of subsidiary branches were recorded.All notes were recorded three times a week.During doing these processes the temperature was measured and recorded regularly. Among the growth period was done one time spraying with diazinon 2/1000 to combat aphids.

Harvesting Mini-tubers and Measured Traits after Harvest

Heading operation (removal of shoot) of plant carried out 10 days before harvesting and then mini-tubers were harvested and the traits of total number of mini-tuber, number of mini-tuber in standard size, mini-tuber dry weight and root dry weight were measured.

Statistical analysis

To analyze this study's data were applied ANOVA procedure of SAS software. For mean comparisons Duncan test was used by a probability level of 5%.

Results and discussion

Total number of mini-tuber

Based on the analysis of variance (Table 1), it can be seen that the main effect of three experimental factors had a significant effect (p≤0.01) on the total number of mini-tubers. Also among the interaction effects the interaction between cultivars and planting bed (P≤0.01) and the number and size of the pot (P≤0.05) showed significant differences and the other interactions did not cause significant differences in this trait.

Table 1. Analysis of variance for properties.

Source of Variances	Degree of Freedom	Mini-Tuber Total Number	Mini-Tuber Number in Standard Size	Mini-Tuber Dry Weight	Root Dry Weight
Genotype (A)	2	210.34**	225.81**	1.29**	5.95**
Different Planting Bed Composition (B)	5	15.45**	12.60**	1.03**	1.24**
Pot size (C)	1	59.25**	70.08**	0.16^{ns}	29.03**
A * B	10	11.38**	9.61**	0.60**	0.51**
A * C	2	5.56*	4.11*	1.94**	3.03**
B * C	5	1.21^{ns}	0.90^{ns}	0.52**	0.29**
A * B * C	10	3.12^{ns}	2.22^{ns}	0.89**	0.77**
ErrorE_a (a)	70	1.74	1.18	0.054	0.038
CV		21.28	21.13	12.81	11.44

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

Based on the mean comparison of treatments it can be said that Sante cultivar with average of 8.80 mini-tuber were assigned highest and Agria cultivar with average of 4.02 mini-tuber lowest number of mini-tuber to themselves. The cause of existence significant differences among cultivars in terms of the total number of produced mini-tuber can be stated due to different genetic characteristics and of course environmental adaptability.Also in the other researches it is stated that Agria cultivar has produced fewer mini-tubers than the Sante and Bourne cultivars (Shojaei *et al.*, 2009).

Table 2. Mean comparison of main effects.

Experimental Treatments		Mini-Tuber Total Number		Mini-Tuber Number in Standard Size		Mini-Tuber Dry Weight (g)		Root Dry Weight (g)	
Cultivar	Agria (a_1)	4.02	c	3.22	c	1.96	a	1.33	c
	Sante (a_2)	8.80	a	7.94	a	1.60	b	2.14	a
	Satina (a_3)	5.77	b	4.61	b	1.90	a	1.66	b
Different Planting Bed Composition	Peat Moss-Sand(1: 1) (b_1)	8.00	a	6.72	a	2.04	a	1.95	a
	Cocopeat-Perlite-Sand (1: 1: 1) (b_2)	5.83	b	4.61	c	1.80	b	1.25	c
	Peat Moss- Perlite (3: 1) (b_3)	5.50	b	4.88	c	1.79	b	1.86	a
	Peat Moss-Sand-Perlite (1: 1: 1) (b_4)	5.61	b	4.72	c	1.98	b	1.91	a
	Cocopeat-Perlite-Peat Moss (1: 1: 1) (b_5)	5.94	b	4.94	c	1.94	ab	1.71	b
	Cocopeat-Sand (3: 1) (b_6)	6.33	b	5.66	b	1.38	c	1.60	b
Pot Size	1/5-Liter Pot (c_1)	5.46	b	5.51	a	1.78	a	1.19	b
	3-Liter Pot (c_2)	6.94	a	5.00	b	1.86	a	2.23	a

Mean in each column, followed by similar letter (s) not significantly different at 5% probability level, using LSD test.

In addition to assigning the highest level, it was also observed that peat moss - sand planting bed (1: 1by volume) with an average of 8 mini-tubers were placed in various group compare with the other planting beds which indicates the superiority of this bed than the others. Also Moeini *et al* (2001) declared peat moss - sand planting bed in ratio (1: 4 by volume) is appropriate. Ozkaynak and Samanci(2005) declared planting bed containing peat moss - soil ratio (1: 1) as appropriate form.While some of the other researchers recommended peat - perlite ratio (1: 5) (Regand *et al.*, 1995). In another experiment peat moss -perlite planting bed produced the largest number of mini-tuber(Allen and Wurr, 1992).

Table 3. Mean comparison of interaction effects.

Experimental Treatments		Mini-Tuber Total Number		Mini-Tuber Number in Standard Size		Mini-Tuber Weight (g)		Dry Root Dry Weight (g)	
a_1	b_1	4.33	a	3.16	a	1.97	b	1.15	d
	b_2	4.50	a	3.16	a	1.79	b	0.80	e
	b_3	4.16	a	3.66	a	1.72	bc	1.60	b
	b_4	3.50	a	3.16	a	2.28	a	1.88	a
	b_5	4.16	a	3.16	a	2.41	a	1.40	bc
	b_6	3.50	a	3.00	a	1.58	c	1.20	cd
a_2	b_1	13.33	a	12.00	a	1.74	b	2.31	a
	b_2	7.16	c	6.66	c	1.62	bc	1.60	c
	b_3	8.00	c	7.50	bc	2.04	a	2.45	a
	b_4	7.50	c	6.66	c	1.35	cd	2.20	b
	b_5	7.33	c	6.33	c	1.76	b	2.06	b
	b_6	9.50	b	8.50	b	1.12	d	2.25	ab
a_3	b_1	6.33	a	5.00	a	2.42	a	2.40	a
	b_2	5.83	a	4.00	b	1.99	b	1.35	c
	b_3	4.33	b	3.50	b	1.62	c	1.53	bc
	b_4	5.83	a	4.33	ab	2.30	a	1.65	b
	b_5	6.33	a	5.33	a	1.66	c	1.68	b
	b_6	6.00	a	5.50	a	1.43	c	1.36	c
a_1	c_1	3.50	b	3.27	a	2.12	a	0.52	b
	c_2	4.55	a	3.16	a	1.80	b	2.15	a
a_2	c_1	7.61	b	8.61	a	1.31	b	1.91	b
	c_2	10.00	a	7.27	b	1.90	a	2.37	a
a_3	c_1	5.27	b	4.66	a	1.92	a	1.15	b
	c_2	6.27	a	4.55	a	1.89	a	2.17	a
b_1	c_1	6.88	a	7.33	a	2.02	ab	1.46	a
	c_2	9.11	a	3.88	c	1.57	c	0.90	c
b_2	c_1	5.44	a	5.33	b	1.68	c	1.21	b
	c_2	6.22	a	5.22	b	1.92	b	1.22	b
b_3	c_1	5.00	a	5.33	b	2.22	a	1.25	b
	c_2	6.00	a	6.00	b	1.28	d	1.13	b
b_4	c_1	4.77	a	6.11	a	2.07	a	2.44	a
	c_2	6.44	a	5.33	a	2.03	a	1.60	c
b_5	c_1	5.11	a	4.44	bc	1.91	a	2.51	a
	c_2	6.77	a	4.22	c	2.03	a	2.60	a
b_6	c_1	5.55	a	4.55	b	1.67	b	2.17	b
	c_2	7.11	a	5.33	ab	1.47	b	2.07	b

Mean in each column, followed by similar letter (s) not significantly different at 5% probability level, using LSD test.

Regarding the effect of pot size on the total number of mini-tubers it can be said according to the table of mean comparisons of main effects (Table 2), the larger pot has a greater ability to produce a greater number of mini-tuber that it is due to more root growth space and produce more mini-tuber in larger pots.Similar results with the results of this experiment have been obtained in some other studies that is indicating more mini-tuber production is in larger pots (Vanaei *et al.*, 2008; Bandara and Tanino, 1995; Balali *et al.*, 2008).

Mini-tuber number in standard size

Obtained results also showed that main effect of three experimental factors ($P \leq 0.01$),interaction effect of cultivars and planting bed ($P \leq 0.01$) and interaction effect of cultivars and pot size ($P \leq 0.05$) had significant effect on mini-tuber number in standard size. It should be noted that other interactions were not significant.

Among the experimental cultivars Sante cultivar with average of 7.94 had shown the highest number and Agria cultivar with average of 3. 22 the lowest number of standard mini-tubers.Similar to total number of mini-tuber trait, cause of creating significant difference between the cultivars was due to cultivars genetic and morphological characteristics.

According to the results of mean comparisons, It is noteworthy that the planting bed peat moss - sand (1: 1 by volume) with an average of 6.72 and planting bed Cocopeat - sand (1: 3 by volume) with an average of 5.66 standard size mini tuber, were placed in Separate groups and of course in different groups compare with four other treatments. This arises from the proper planting bed structure in terms of uniform mini-tuber production.

In this study, it was found that pots with lower capacity were produced more mini-tubers in standard-sized than higher capacity pots.So that the 1.5-liter pots with an average of 5.51 and 3-liter pots with an average of 5.00 standard size mini-tuber showed a significant difference.The reason can be explained in this way that due to lack of space, all the mini-tubers continue to growth until they occupy the maximum capacity of the pot and if the pot is larger than a certain capacity some of mini-tubers that have the potential for further growth can continue to grow. Balali *et al* (2008) reported in their research that standard mini-tuber production value is higher in smaller pots.

Mini-tuber dry weight

In this study, the dry weight of mini-tuber trait, except the main effect of pot size get affected of main and interaction effects of the experimental factors($P \leq 0.01$).

Agria and Satina cultivars mini-tubers dry weight had higher values respectively, with an average of 1.96 and 1.90 grams than the average of cv.Sante 1.60 grams and of course were divided into different groups.Dehdar and Masjedloo (2010) in their study reported that Savalan, Agria and Marfuna cultivars, has the highest weight of mini-tubers respectively and also they were showed significant differences. In another report Agria cultivar showed greater mini-tubers dry weight than savalan cultivar (Hassanpanah *et al.*, 2011).

In terms of composition of planting bed was also observed that the peat moss - sand (1: 1 by volume) with an average of 2.04g and cocopeat - sand (1: 3 by volume) with an average of 1.38 g mini-tuber dry weight achieved highest and lowest values respectively.This indicates that peat moss – sand planting bed with a better supply of nutrients and probably having good ventilation is able to help more to increase mini-tuber dry weight than other treatments. In reported results of Hasanpanah *et al* (2011) different planting beds had specified mini-tuber dry weight completely different and also significant.

Root dry weight

Considering achieved results it can be stated that root dry weight get affected by all of main and interaction effects of experimental factors ($P \leq 0.01$).

According to Mean comparison Table of main effects (Table 2), it can be said that Sante cultivar with an average of 2.14g and Agria cultivar with an average of 1.33g had been known as highest and lowest root dry weight values respectively.This event can be due to different genetic characteristics which generate roots with different weights.The report states that the root weight in different potato cultivars can vary due to genetic causes (Ahloowalia, 1994).It should also be noted that the planting bed peat moss - sand (1: 1by volume) with an average of 1.95 g root dry weight was known as well as the highest rate and it was placed along with the planting beds peat moss - sand - perlite (1: 1: 1by volume) and peat moss - perlite (3: 1by volume) in (a) group and also different group by the other groups.The treatment Cocopeat - Perlite - sand (1: 1: 1by volume) showed the lowest value with an average of 1.25 g of root dry weight.Ahloowalia (1994) also reported that planting bed peat moss – Sand (1: 1by volume) and Cocopeat - sand (1:1by volume) had specified highest values of root dry weight to themselves. Results showed that the larger pot has the ability to produce more root dry weight.So that the 3-liter pots with an average of 2.23g produced more root dry weight than 1.5-liter with an average of 1.19g.Cause of this event is due to existence of more space in larger pots to increasing roots volume and producing more dry weight in roots.

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