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EFFECT OF BIO-ACTIVATORS ON THE TUBER YIELD AND TUBER SIZE OF POTATOES

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ABSTRACT

Two bio-activators, the Crop-set and the ISR-2000 were sprayed on the potato plants before flowering in order to increase tuber set and tuber size in a field trial conducted at Bornova, Izmir-Turkey in 2009 and 2010. The Crop-set increased the number of tubers per plants, plot yield, tuber width over the control in 2009 and 2010. The ISR-2000 had the highest single tuber weight such as 36.7 g in 2009 and 35.9 g in 2010. It could be concluded that bio-activators could be used in the minituber propagation stage in order to increase tuber number and tuber size in a seed potato program.

Key words: Bio-activator, number of tubers, potato, tuber size, tuber yield

INTRODUCTION

In the seed potato production technology, increasing minitubers in the field is an important stage. In this practice, micro and minitubers obtained from the micropropagation of meristem plantlets are grown in the greenhouse in small pots. Then minitubers obtained are grown under the field conditions in order to obtain large amount of tuber to distribute to the seed potato growers. There are several difficulties during this stage. One of the main constraints is the size and amount of minitubers produced in the greenhouse as well as in the field (Struik, 2007). Minitubers produced in the pots under the greenhouse conditions are not uniform in size so they are classified in two classes such as suitable and not suitable to field production (Struik and Lommen,1999). As a result, significant amount of the minitubers should be discarded (Melching et al., 1993).

In Turkey, seed potato technology has been developing slowly and supported by the government in order to establish a dependable seed production and distribution system. Therefore a national research project has been completed by the Ministry of Food, Agriculture and Livestock in cooperation with the research institutions and the universities and the productions of virus free seed stocks were accomplished (Yildirim, et al., 2009). Minituber production in the field is the first stage of certified seed potato production, since the minitubers are advanced to the potato seed growers. But there were some difficulties and deficiencies in the field propagation stage of minitubers, such as the size and amount of minitubers produced in the field (Lommen, 1994).

Bio-activators have been proposed and used in plant production for a long time and their positive effects on increasing yield and yield components have been reported (Plissey, 2003). On the other hand bio-activators have also been proposed to enhance the induced systemic resistance (ISR) in plant protection. Tosun (2003) gave information about the ISR-2000^{TM} and the Crop-set^{TM} and reported the effects of ISR-2000 on the control of late blight in tomatoes and potatoes in the western Turkey. Since they have organic ingredients in nature bio-activators have been accepted to use in plant production (Karavas, 2000; Ozturk et al., 2006; Akbudak and Tezcan, 2006; Unlu et. al., 2010). Turkan et al., (2004) speculated that plant activators could enhance plant growth and development so yield and quality might increase. Bower (2004), stressed the importance of the Crop-set and the ISR-2000 to enhance growth and yield in plant production. Koca, (2003) reported the positive effect of bio-activators on tuber set and tuber size in potato production. Koca and Yildirim, (2003) discussed the effects of the Crop-set and the ISR-2000 on tuber numberper plant, plot yield, single tuber weight and tuber size in potatoes. The positive effects of bio-activators on yield and tuber size of the minitubers were reported so the seed tuber producing farmers have used them in practice (Plissey, 2003). Therefore the purpose of this study was to test the effect of two bio-activators, the Crop-set and the ISR-2000, on the yield and tuber size of minitubers grown under the field conditions in the western Turkey.

MATERIALS AND METHODS

This study was carried out in the tissue culture laboratory, greenhouse, and the experimental field of the Department of the Field Crops of the Agricultural Faculty of the Ege University located at Bornova, Izmir, Turkey during the 2009 and 2010 growing seasons.

The potato plantlets originated from the seed stocks were planted in the plastic containers (19cm x 12cm x 9 cm in size) in the greenhouse and the minitubers obtained were selected for suitable size to increase in the field. The remaining minitubers, 20-30 mm in size, were used as starting material of this study. The potato cultivars grown, were Hermes, Agria and Granola. The characteristics of these cultivars could be found in Ozturk and Yildirim, (2010). The minitubers obtained for these genotypes in the greenhouse in October, 2008 were stored in the storage room at +4 ^{0}C. They were planted in the field in 2009 and the minitubers obtained in the field trial run in 2009 were planted in the field trial of 2010.

Production of Minitubers in the Greenhouse

The starting materials of the research were from the meristem cultures of 3 potato cultivars in the laboratory, *in vitro*, conditions. Micropropagation procedure and nodal cuttings of meristem plantlets were practiced as described by Yildirim, (1995), Ozturk and Yildirim (2011). Virus free *in vitro* plantlets were transferred in to plastics containers (19cm x 12cm x 9 cm in size) having the mixture of 1:2:1 turf, sand and manure. Minitubers not suitable to regular minituber production in the field were used to be grown in the greenhouse. The harvested tubers in 2008 were advanced to the field trial run in 2009.

Field Trial

The minitubers obtained in the greenhouse 20-30 mm in size were grown in the field trial during the 2009 growing season. The tubers obtained in the field trial of 2009 were planted in the field trial of 2010. The meteorological data of two years are given in Table 1.

Table 1. The temperature and the precipitation during the potato growing revised of 2009 and 2010*

Months	Temperature (^{0}C)		Rainfall (kg/m^2)	
	2009	2010	2009	2010
March	11.7	13.3	175.7	16.1
April	16.0	17.4	83.8	20.4
May	21.4	21.8	44.3	27.1
June	26.2	25.5	9.2	76.3
July	29.0	28.8	0	0
August	27.9	30.2	0	0

*: based on the Guzelyali - Izmir Meteorological Station records

The minitubers were grown in the experimental field of the Department of the Field Crops of the Ege University located at Bornova, Izmir-Turkey. The experimental design was the Randomized Complete Block Design arranged in Split Plots with 3 replications. One plot consisted of one single row 1.5 m long and 50 cm apart. Spacing on the row was 30 cm, so each plot had 5 plants. The plantings were done by hand in the second week of March in 2009 and in the first week of April in 2010. Standard agronomical practises were applied during the growing seasons.

The bio-activators, the ISR-2000 (600 ml/ha) and the Crop-Set (300 ml/ha) described by Tosun, (2003), were sprayed before the flowering on 20 May, 2009 and on 4 June, 2010.

The field trials were harvested on 30 July in 2009 and on 9 August in 2010 and the number of tuber per plant and plot yields were recorded and the sizes of tubers were measured.

The data obtained for number of tuber per plant, plot yield, single tuber yield and tuber width and length were analyzed by using the Standard Analysis of Variance techniques. The means were compared by using the Least Significant Difference Test described by Steel et al., (1997).

RESULTS AND DISCUSSION

The F values of the yield characteristics based on the analysis of variance combined over 2009 and 2010 are given in Table 2.

Table 2. The F values of the yield characteristics based on the ANOVA combined over 2009 and 2010.

Source of Variation	F Values				
	Tuber Number Per Plant	Single Tuber Weight(g)	Plot Yield (kg)	Tuber Width (cm)	Tuber Legth (cm)
Bioactivator	13.946*	31.541**	84.800**	9.471*	4.163^{ns}
Genotype	2.269^{ns}	0.232^{ns}	6.399**	0.087^{ns}	1.950^{ns}
Bioactvator x Genotype Year	1.187^{ns}	1.513^{ns}	1.631^{ns}	0.622^{ns}	0.139^{ns}
Bioactivator xYear	23.676**	0.337^{ns}	12.548**	11.193**	5.952*
Genotype x Year	3.748*	0.425^{ns}	2.546^{ns}	0.686^{ns}	1.237^{ns}
Bioactivaor x	2.478^{ns}	0.735^{ns}	0.848^{ns}	0.646^{ns}	0.715^{ns}
Genotype xYear	1.605^{ns}	0.542^{ns}	0.468^{ns}	0.651^{ns}	0.274^{ns}

*: significant at the p≤0.05 level
**: significant at the p≤0.01 level
^{ns}: non significant

It could be seen in Table 2 that bio-activator treatment had significant F values for number of tuber per plant, single tuber weight (g), plot yield (kg), and tuber width (cm). Genotype source of variation had only one

significant F value for plot yield. Years had significant variation for number of tuber per plant, plot yield, tuber width and tuber length. Bio-activator x year interaction was significant for only number of tuber per plant.

The non significant F values for the interactions between bio-activator x genotype, genotype x year and bio-activator x genotype x year indicated that bio-activators could be discussed separately by using the means over the genotypes.

The Effect of Bio-activators

The mean of the yield related traits and tuber size obtained for the bio-activator applications are shown in Table 3.

Table 3. The means of tuber number per plant, single tuber weight (g), plot yield (kg) and tuber size obtained in the field trial run in 2009 and 2010.

Traits	**Year**							
	2009				**2010**			
	Control	Crop-set	ISR-2000	Mean	Control	Crop-set	ISR-2000	Mean
Tuber Number Per Plant	2.7c	**7.5a**	5.6b	**5.26a**	2.2b	**4.4a**	3.6ab	3.4b
Single Tuber Weight(g)	23.8b	**34.2a**	**36.7a**	**31.5a**	24.7b	30.7ab	**35.9a**	**30.4a**
Plot Yield (kg)	0.232b	**1.102a**	**0.896a**	**0.773a**	0.268b	**0.635a**	**0.624a**	0.509b
Tuber Width (cm)	2.9b	**3.5a**	3.2ab	**3.2a**	2.4b	**3.1a**	**3.0a**	2.8b
Tuber Length (cm)	3.5b	**4.5a**	4.0ab	**3.9a**	3.2b	**3.8a**	**3.9a**	3.6b

$LSD(p\leq0.05)_{tuber\ number}$: 1.4 — LSD for means of 2009 and 2010 $(p\leq0.05)_{tuber\ number}$: 0.8
$LSD(p\leq0.05)_{single\ tuber\ weight}$: 6.92 — LSD for means of 2009 and 2010 $(p\leq0.05)_{single\ tuber\ weight}$: 3.9
$LSD(p\leq0.05)_{plot\ yield}$: 0.265 — LSD for means of 2009 and 2010 $(p\leq0.05)_{plot\ yield}$: 0.153
$LSD(p\leq0.05)_{tuber\ width}$: 0.4 — LSD for means of 2009 and 2010 $(p\leq0.05)_{tuber\ width}$: 0.23
$LSD(p\leq0.05)_{tuber\ length}$: 0.5 — LSD for means of 2009 and 2010 $(p\leq0.05)_{tuber\ length}$: 0.3

It could be seen in Table 3 that the Crop-set application increased tuber number per plant (7.5 versus 2.7), plot yield (1.1 kg versus 0.3 kg), tuber width (3.5 cm versus 2.9 cm) over the control in 2009. Although the over all yield was lower as compared to 2009, the same trend could also be observed in 2010. In general, control plots had lower means that those of the two type bio-activators applied. Among the bio-activators, the Crop-set, appeared to have higher means for plot yield (1.102 kg), tuber number per plant (7.5) and tuber width (3.5 cm). The untreated control plot had 0.23 kg and 0.27 kg overall mean in 2009 and in 2010, The Crop-set had 1.1 kg and 0.6 kg plot yield in 2009 and 2010. If the plot yields are converted to t/ha by using the conversion factor 1.3 the control plot had 3.9 t/ha as compared to the Crop-set yield of 13.4 t/ha. The significant point is that the net effects of bio-activator on the increase of tuber number from 2.7 to 7.5 for Crop-set and from 2.7 to 5.6 for the ISR-2000. These result, were in good agreement with the earlier reports (Koca and Yildirim, 2003; Plissey, 2003).

The Crop-set also had higher means for tuber length (control: 3.5 cm Crop-set: 4.5 cm) in 2009. The ISR-2000 had the highest mean for single tuber weight (36.7 g) as compared to 23.8 g for the control and 34.2 g for Crop-set in 2009.

Since there was no significant interaction between the bio-activator and the genotype, it could be concluded that bio-activator had significant effect on the yield related traits of potato. The bio-activators positively increased the tuber number per plant, single tuber weight, plot yield, tuber width of the potato. It could also be observed in Table 3 that the means of the traits studied in 2009 were significantly higher than those of in 2010. One significant result of the trial was the effect of bio-activators on potato yield in two years had the same trend.

Years might have different means due to the adverse weather differences and late planting done in 2010 as compared to early planting done in 2009. Plant development could be fastened due to late planting done in 2010 so the yield related traits could not properly express themselves. On the other hand the effect of bio-activators on the traits expressed a similar trend in two years.

The low yields obtained in 2010 as compared to 2009 might also be due to the usage of harvested field grown seed tubers of 2009. Although the same size tubers were planted in 2010 and they were stored in the storage room until March 2010, the physiological disorders coming from the 2009 harvested could effect the age of tubers. In some minituber propagation practises used in Turkey the tuber harvested are also, used as seed tubers in the coming year, although they have yield losses.

There were statistically significant differences between the means of genotypes tested for plot yield, as shown in Figure 1.

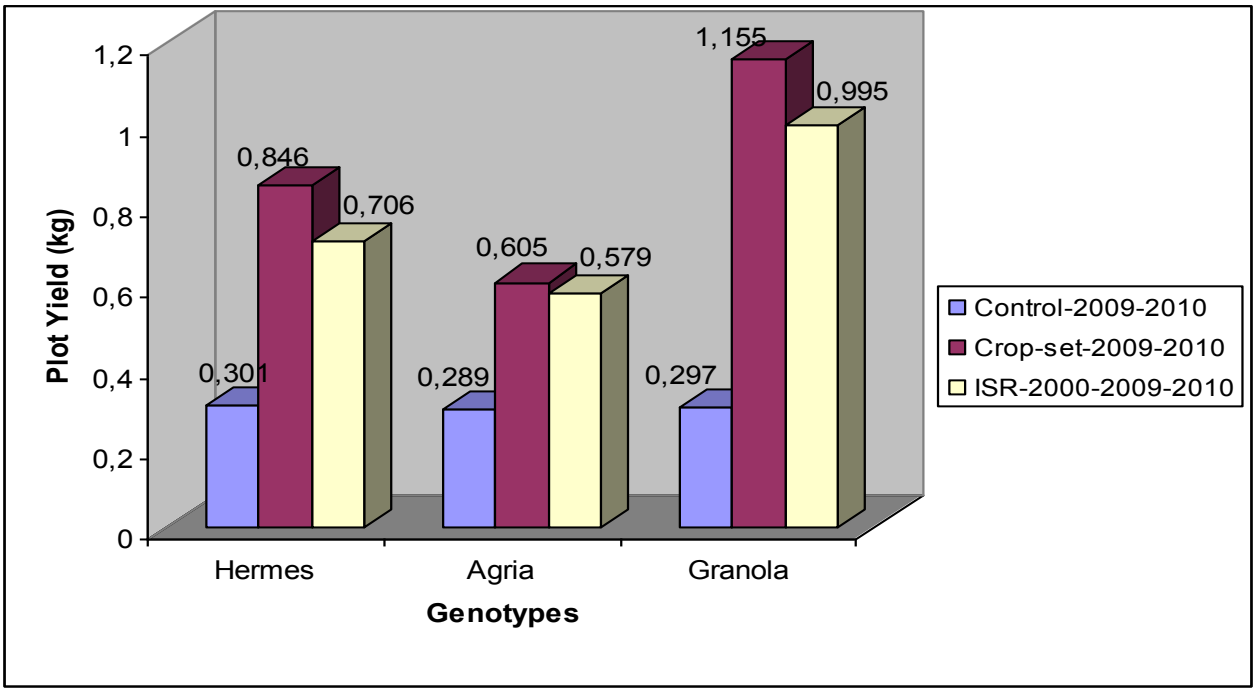

Figure 1. Histogram of the genotypes for plot yield.

The positive effects of the two bio-activators used on the yield related traits were in good agreement with earlier reports given by Koca, (2003); Koca and Yildirim, (2003) and Plissey, (2003).

Based on the results and the discussion given above it could be concluded that the bio-activators could be used to increase tuber set and tuber size in the minituber propagation stage of a seed potato program.

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