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A COMPARISON OF FIELD PERFORMANCES OF MINITUBERS AND MICROTUBERS USED IN SEED POTATO PRODUCTION

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ABSTRACT

Field performances of minitubers obtained from *in vitro* plantlets and tubers obtained from microtubers from 6 potato genotypes (Nif, Clone 122, Agria, Resy, Marfona and Granola) were compared. *In vitro* plantlets and microtubers were obtained by using meristem culture technics in the laboratory and at seedbeds. Initially, *in vitro* plantlets (IP) and microtubers (MT) were grown at seedbeds and they were evaluated for morphological and yield characteristics. The IP and the MT plants were not significantly different for plant height, stem number, branch number and leaf number. The high means were obtained from the IP plants such as leaf area, tuber number, single tuber weight, tuber yield, tuber width and length. Genotype Nif had the highest means for the majority of characteristics. In the first and second years of field production, the MT group were found to have higher means for plant height, stem number, branch number and leaf number. But the IP and MT tubers were not significantly different in terms of yield characteristics except tuber number. The high values for yield and related traits were obtained for Clone 122 and Nif.

Key Words: Potato, meristem culture, node culture, *in vitro* plantlets, microtuber, minituber, field multiplication

INTRODUCTION

Health and quality of potato seeds are important in the potato seed technology (Yıldırım, 1995). Moreover, the basic seed materials must be free of many pathogens. Therefore tissue culture technics are used at this stage in the laboratory to produce disease free seeds**.** First, clean stocks are obtained by meristem culture *in vitro.* Then, the multiplication of clean materials are achieved by node cuttings. Then these plantlets are transferred to seedbeds to produce minitubers (Novak, 1980; Yıldırım and Yıldırım, 1984; Yıldırım 1987; Yıldırım et al., 1995; Ritter et al., 2001; Farran and Mingo-Castel, 2006). Minitubers are commonly used in seed potato production in order to increase seed tubers. Recently, an alternative to minitubers in seed potato production is the microtuber that is directly produced in the laboratory (Wang and Hu, 1982; Tovar et al., 1985; Harvey et al., 1991; Dodds et al., 1992; Harvey et al, 1992; Bizarri et al., 1995; Naik et al., 1998; Gopal et al., 1998; Altındal and Karadoğan, 2010). This method could be considered as an alternative to minitubers although their field performances are not studied well. Since, there are many studies in order to produce microtubers *in vitro*, there is little information on their field multiplication. Until now, several field studies have been reported by many researchers (Wiersema et al., 1987; Haverkort et al., 1991; Marinus, 1993; Ranalli et al., 1994; Lommen and Struik, 1994; Lommen and Struik, 1995; Ahloowalia, 1999; Tadesse et al., 2001).

The purpose of this study was to compare field performances of minitubers and microtubers. Therefore, *in vitro* plantlets (IP) and microtubers (MT) produced in the laboratory were multiplied by growing them in seedbeds. Minitubers originated from *in vitro* plantlet (IP) and from microtubers (MT) were tested in a field trial in order to compare their growth and yield performances.

MATERIALS AND METHODS

This study has been conducted in the Tissue Culture Laboratory, in the seedbeds and at the field of the Field Crops Department of the Agricultural Faculty of the Ege University, Izmir, Turkey from 2005 to 2008. The genotypes used are Nif, Clone 122, Agria, Resy, Marfona and Granola. Some characteristics of the genotypes are shown in Table 1. Plantlets were obtained by meristem cuttings grown in Murashige and Skoog (1962) medium enriched by salt and vitamin solution containing 0.1 mg/l Indole-asetic acid (IAA), 0.1 mg/l Gibberelline (GA_3), 0.1 mg/l Benzylaminopurine (BAP) and 3 % sucrose, pH 5.7 under the 16 h light period at 24±2 ^{0}C *in vitro* . Multiplication of plantlets was done by using nod culture grown, in the MS medium enriched by 2 mg/l Indole-butric acid (IBA) as described by Yıldırım, (1995). The plantlets were separated in two parts to obtain *in vitro* plants (IP) and microtubers (MT). One part of the IP was maintained in sub-cultures (Pruski, 2007). The other part was kept *in vitro* in the MS medium fortified by salt, vitamin including 3 mg/l Benzylaminopurine (BAP) and 6 % sucrose for *in vitro* tuberization (Öztürk, 2003). All media were sterilized by autoclaving at 121 ^{0}C for 20 minutes. The IP plantlets and MT tubers were transferred to mixture of soil:turf (1:1) in pots. Following acclimatization they were transferred to seedbeds in 2 rows of 2 m long, 50 cm apart between row

and 30 cm in row spacing in a Randomized Complete Block Design with three replications in April, 2006.

Table 1. Potato genotypes used in the study

Genotype	Main chacteristics	Origin
Nif	CosimaxR.143 hybrid, medium early, round-oval tuber shape, yellow flesh, dry matter 23.4%, starch content 16.8%	Released by the Agricultural Faculty of Ege University (1998), Turkey
Clone 122	Early, oval-long tuber shape, creamy flesh, dry matter 19.6% starch content 13.3%	Promising line selected in the Department of Field Crops of the Ege University (1998), Turkey
Agria	Intermediate to late, oval/oval to long tuber shape, yellow/deep yellow flesh color, dry matter 18.9 % starch content 12.2 %	Germany
Resy	Early, oval to round/oval shape, light yellow flesh, dry matter 19.6% starch content 13.5%	Holland
Marfona	Intermediate/early to intermediate short-round, skin-deep, dry matter 17.5% starch content 16.2%	Holland
Granola	Intermediate to late/ intermediate, oval to round/oval, much skin-deep, dry matter 19.6% starch content 13.5%	Germany

Table 2. The meteorological data of 2006, 2007 and 2008*

Months	Temperature (^{0}C)	Rainfall (mm)	Humidity (%)
2006			
February	9.6	93.4	66.8
March	12.1	180.9	68
April	17.4	29.4	62.7
May	21.1	0.2	61.5
June	25.7	10.0	59.3
July	28.1	-	53.5
2007			
February	10.6	22.6	66.9
March	13.4	29.7	59.8
April	16.2	19.3	48.8
May	22.4	44.1	52.2
June	27.5	0.3	44.7
2008			
February	9.3	9.0	60.0
March	15.2	60.0	73.0
April	18.0	62.3	56.0
May	21.0	4.9	50.0
June	26.9	0.4	44.0

*: based on the Izmir Meteorological Station records

After flowering, plant height, stem number, branch number, leaf number and leaf length and width were measured. Leaf Area was calculated based on the formula given by Simmonds (1964). At the end of the growing period, the tubers of the IP and the MT groups were harvested in August, 2006. The following yield components such as tuber number, single tuber weight, tuber yield, tuber width and length were measured. Minitubers of the IP and the MT groups were planted by hand in the field trial in a Split-Plot Design arrangement with three replications in the following two years (2007 and 2008). Field multiplication trial was arranged in one row plots 3.0 m long and 50 cm apart and 10 tubers were planted on each row with 30 cm spacing. The field experiment was planted on February 25, 2007 and on February 15, 2008 and harvested on July 2, 2007 and on June 22, 2008. During the growing of trial standart agronomical practices were applied. The morphological characteristics and yield were recorded. The data obtained at seedbeds and in the field trial were analyzed by applying the standard ANOVA test. The means were compared by applying the LSD test as given by Steel and Torrie (1980).

Meteorological data of 2006, 2007 and 2008 recorded by the Izmir Meteorological Station are given in Table 2.

RESULTS AND DISCUSSION

Morphological and yield characteristics of in vitro plantlets and microtubers grown in the seedbeds in 2006

In vitro plantlets (IP) and microtubers (MT) of potato genotypes produced in the greenhouse were grown in the seedbeds in 2006. The morphological and yield characteristics measured on their plantlets and harvested tubers were compared. The minitubers obtained from the IP and the MT groups were tested in a field trial for 2 years during 2007 and 2008. The morphological and yield traits measured in two seed groups were compared. The results and their discussion will be given in the following sections.

Morphological and yield characteristics of potato genotypes grown in the seedbeds in 2006.

The F values of measured traits on the plants and tubers of *in vitro* plants and microtuber groups are given in Table 3.

Table 3. The F values of morphological and yield characteristics of the IP and the MT groups belong to 6 potato genotypes grown in the seedbeds in 2006

Characteristic	Genotype	Seed Source[1]	Gen.x Seed Source Interaction
Morphological			
Plant Height	3.484^{*}	0.008^{ns}	0.074^{ns}
Stem Number	1.013^{ns}	0.010^{ns}	0.236^{ns}
Branch Number	5.103^{**}	0.134^{ns}	0.746^{ns}
Leaf Area	3.119^{*}	15.413^{**}	0.842^{ns}
Leaf Number	6.990^{*}	1.709^{ns}	0.315^{ns}
Yield			
Tuber Number	5.233^{**}	109.431^{**}	1.628^{ns}
Single Tubers Weight	5.820^{**}	37.003^{**}	0.819^{ns}
Tuber Yield	11.808^{**}	18.472^{**}	1.414^{ns}
Tuber Width	5.016^{*}	79.251^{**}	1.933^{ns}
Tuber Length	3.743^{*}	73.214^{**}	1.929^{ns}

*: significant at the $p \leq 0.05$ level
**: significant at the $p \leq 0.01$ level
ns: non-significant
[1]: plants from *in vitro* plantlets (IP) and microtubers (MT)

The F values shown in Table 3, indicates that genotypes had significant variation for plant height, branch number, leaf area and leaf number. The F values of seed source (IP and MT) were non significant except leaf area. The F value

indicates significant variation between genotypes for yield traits such as tuber number, single tuber weight, tuber yield, tuber width and length. The seed source had also significant F values for the yield characteristics. The genotype x seed source interaction had F values for the traits measured. Since the genotype x seed source interaction was not significant genotype and seed source could be discussed independently.

The means of the IP and the MT groups for 6 genotypes are shown in Table 4. On the average, the plant height (cm), the stem number, the branch number, the leaf number for the IP and the MT groups were not significantly different. Among the morphological characteristics only leaf area (2.5 cm^2 and 1.6 cm^2) had significant difference in favor of the IP group. These results agree with Tadesse et al. (2001). In general, Nif had the high means for these characteristics since it is a Andigena and Tuberosa hybrid. Its vegetation period is faster than other genotypes in the early growing period. Therefore, Nif could grow fast and had vigorous vegetation as compared to other cultivars, so it has higher means.

Table 4. The means of morphological characteristics measured in the IP and the MT groups of the six potato genotypes grown in the seedbeds in 2006

Traits	Seed Source[1]	Genotype						Mean*
		Nif	Clone 122	Agria	Resy	Marfona	Granola	
Plant Height (cm)	IP	120.5	116.9	94.2	91.8	85.5	84.3	**98.9a**
	MT	128.4	107.4	85.9	90.2	97.4	92.3	**100.3a**
	Mean*	**124.4a**	112.2b	90.1b	91.0b	91.4b	88.3b	
Stem Number	IP	1.3	1.2	1.2	1.2	1.2	1.2	**1.2a**
	MT	1.4	1.4	1.3	1.0	1.0	1.2	**1.2a**
	Mean*	**1.4a**	**1.3a**	**1.2a**	**1.2a**	**1.1a**	**1.2a**	
Branch Number	IP	14.5	14.7	14.9	13.3	6.3	7.8	**11.9a**
	MT	15.7	12.1	19.6	9.3	7.7	10.3	**12.4a**
	Mean*	15.1b	13.5c	**17.2a**	11.2d	**7.0d**	9.1d	
Leaf Area ($cm^{2)}$	IP	2.4	2.3	2.2	2.4	3.7	1.8	**2.5a**
	MT	1.9	1.3	1.5	1.8	1.9	1.3	1.6b
	Mean*	**2.2a**	1.8b	1.8b	**2.1a**	**2.8a**	**1.5b**	
Leaf Number	IP	206.7	138.1	125.1	108.5	76.0	68.8	**120.5a**
	MT	263.0	148.0	167.0	89.7	101.5	108.9	**146.4a**
	Mean*	**234.9a**	143.0b	146.0b	**99.1b**	**88.8b**	**88.9b**	

*: different letters indicate significant means at the p≤ 0.05 level
[1]: IP: plants grown up from *in vitro* plantlets
MT: plants grown from micotubers

It could be seen in Table 5 that, the number of tubers, single tubers weight (g), tuber yield (g), tuber width (cm) and length (cm) of the IP group (7.7 tuber; 19.3 g; 159.7 g; 2.5 cm and 3.2 cm respectively) were higher than those of the MT group. The tuber yield of the IP group was significantly greater (159.7 g) than that of (107.5 g) the MT. The high values of tuber diameter were also obtained for the IP group.

Table 5. The means of yield characteristics measured in the IP and MT groups of the six potato genotypes grown in the seedbeds in 2006

Trait	Seed Source[1]	Genotype						Mean*
		Nif	Clone 122	Agria	Resy	Marfona	Granola	
Tuber number (number)	IP	10.2	7.4	6.7	7.8	7.2	7.1	**7.7a**
	MT	5.9	5.0	3.3	4.4	5.3	2.9	4.4b
	Mean*	**8.0a**	6.2b	5.0b	6.1b	6.2b	**5.0b**	
Single tubers weight (g)	IP	29.8	18.4	14.7	18.3	25.6	9.4	**19.3a**
	MT	19.1	10.1	8.5	15.2	17.7	4.1	12.4b
	Mean*	**24.4a**	14.2b	11.6c	**16.8a**	**21.6a**	**6.7d**	
Tuber yield (g)	IP	273.1	168.2	106.0	156.3	178.6	75.8	**159.7a**
	MT	173.0	106.3	74.0	84.7	181.8	25.2	107.5b
	Mean*	**223.1a**	137.3c	90.0d	120.5c	180.2b	**50.5d**	
Tuber width (cm)	IP	3.3	2.3	2.0	2.4	2.9	2.0	**2.5a**
	MT	2.1	1.4	1.2	2.1	1.7	1.1	1.6b
	Mean*	**2.7a**	1.9c	1.6c	2.3b	2.3b	**1.5c**	
Tuber length (cm)	IP	3.7	2.8	2.9	3.5	4.0	2.4	**3.2a**
	MT	2.4	1.8	1.5	3.0	2.2	1.5	2.1b
	Mean*	**3.0a**	2.3b	2.2b	**3.2a**	**3.1a**	**1.9b**	

*: different letters indicate significant means differed at the p≤ 0.05 level
[1]:IP: tubers of plants from *in vitro* plantlets
MT: tubers of plants from microtubers

The IP group plantlets and the MT group microtubers were transplanted and planted at the same time in the seedbeds. But the IP group plantlets were already rooted and ready to development contrary to the microtubers of the MT group. Therefore they had different physiological at planting, so the IP plants transferred to the seedbeds, the development of plants started earlier than the microtubers. Thus the IP group had long time for tuber development and bulking so the IP group had high means for yield related traits than those of the MT group. Moreover, Nif had also the highest means in morphological characteristics (shown Table 4). We could observe the positive effect of early plant development on tuber yields. The results related to the tuber number and the tuber yields are in agreement with earlier reports (Wiersema et al., 1987; Haverkort et al., 1991; Yıldırım et al., 2003).

Field performances of the IP and the MT groups of minitubers belong to 6 potato genotypes

The F values of the variation sources obtained from the combined analyses of variance over two years are shown in Table 6.

Table 6. The F values of the morphological and yield characteristics measured in the field trial grown in 2007 and 2008

Characteristic	Genotype	Seed Source[1]	Genotype x Seed Source Interaction	Year	Genotype x Year Interaction	Seed Source x Year	Genotype x Seed Source Interaction x Year Int.
Morphological							
Plant Height	203.661**	45.130**	0.980ns	13.189**	5.030**	4.986*	2.769*
Stem Number	10.734**	1.662ns	1.044ns	89.903**	1.295ns	6.864*	1.09ns
Branch Number	22.676**	19.486**	1.152ns	1.853ns	4.268**	2.381ns	0.959ns
Leaf Area	7.692**	7.807**	0.979ns	13.582**	3.853**	1.653ns	1.111ns
Leaf Number	31.011*	12.861**	0.474ns	55.164**	3.489*	2.017ns	0.545ns
Yield							
Tuber Number	3.621*	1.837ns	1.733ns	4.321*	3.440*	3.721ns	0.437ns
Single Tubers Wegh.	10.674**	0.048ns	0.612ns	2.825ns	3.262*	0.269ns	1.045ns
Tuber Yield	24.370**	2.962ns	1.318ns	1.058ns	0.568**	12.267**	5.244**
Tuber Width	22.273**	0.056ns	0.997ns	22.092**	4.543**	0.010ns	0.584ns
Tuber Length	33.607**	0.001ns	1.228ns	17.455**	7.841**	0.153ns	0.153ns

*: significant at the $p \leq 0.05$ level
**: significant at the $p \leq 0.01$ level
ns: non-significant
1: plants grown from *in vitro* plantlets (IP) and microtubers (MT)

It can be seen in Table 6 that from the F values pertinent to morphological and yield characteristics:

(1) Genotypes are significantly different since all the traits had significant F values

(2) The seed source had significant variation for plant height, branch number, leaf area and leaf number.

(3) There were no significant F values for genotype x seed source interaction.

(4) Years could be significantly different for plant height, stem number, leaf area, leaf number, tuber number, tuber width and tuber length.

(5) Genotype x year interaction had significant F values for the traits studied except stem number.

(6) Seed source x year interaction had significant F values for plant height, stem number and tuber yield.

(7) Genotype x seed source x year interaction had significant F values for plant height and tuber yield.

The significant F values indicated that main effects which are genotype, seed source and years, were significant for the traits as expected. The interaction between main effects had significant variation for certain traits. Genotypes studied had significant variation for all the traits. Although seed source had significant variation for the morphological traits, seed source did not have significant variation for yield characteristics contrary to expectation. The minitubers obtained from *in vitro* plantlets and from microtubers were not significantly different from each other for their yield performances. These results will be kept in mind in discussion the means of the traits.

Morphological characteristics measured in the field trial run in 2007 and 2008

The means of the morphological characteristics measured in the field trial run in 2007 and 2008 are shown in Table 7.

In 2007, the MT group had high means for the plant height (40.8 cm), the branch number (13.4) as compared to *in vitro* plant group. In 2008 the MT group had also the high means for the traits such as plant height (39.6 vs 31.7), stem number (4.0 vs 3.5), branch number (11.5 vs 9.5), leaf area (3.8 vs 3.5) and leaf number (101.4 vs 82.5). The plant height and the leaf number were higher in 2007 in comparision to 2008. The IP and the MT groups had high means for stem

number, the leaf area in 2008 in contrast to 2007. No significant differences were found between two groups for

Table 7. The means of morphological characteristics measured in the field trial in 2007 and 2008

Characteristic	Seed Source[1]	Year	Genotype						Mean*
			Nif	Clone 122	Agria	Resy	Marfona	Granola	
Plant Height (cm)	IP	2007	40.8	38.9	41.0	30.2	26.8	43.5	36.9b
	MT		45.7	45.0	41.7	34.4	31.2	46.9	**40.8a**
	IP	2008	32.8	44.7	24.9	24.6	29.5	33.9	31.7b
	MT		43.4	46.8	41.7	32.3	31.5	41.7	**39.6a**
	Mean*	Mean*	40.7b	**43.8a**	37.3c	**30.4d**	**29.7d**	**41.5a**	
Stem Number	IP	2007	3.0	3.3	3.0	2.7	1.6	1.9	2.6b
	MT		2.4	3.0	3.5	2.1	2.2	2.2	2.4b
	IP	2008	3.4	4.0	3.2	3.6	3.7	3.2	**3.5a**
	MT		4.0	4.6	4.2	3.4	3.9	4.1	**4.0a**
	Mean*	Mean*	3.2b	**3.7a**	3.2b	**2.9c**	**2.9c**	**2.8c**	
Branch Number	IP	2007	8.8	12.9	12.9	8.9	4.4	8.7	9.4b
	MT		16.0	18.8	16.8	11.8	4.9	12.3	**13.4a**
	IP	2008	11.0	13.4	6.7	8.0	7.3	11.1	9.5b
	MT		13.6	12.0	11.3	9.2	7.2	15.5	**11.5a**
	Mean*	Mean*	12.3b	**14.3a**	11.9b	9.5c	**5.9d**	11.9b	
Leaf Area (cm^2)	IP	2007	3.1	2.9	3.3	2.3	2.4	2.5	2.7c
	MT		3.3	3.2	4.0	2.6	4.0	3.3	3.4b
	IP	2008	3.6	2.9	2.8	2.8	4.6	4.5	**3.5a**
	MT		3.0	4.0	3.7	3.0	4.6	4.6	**3.8a**
	Mean*	Mean*	3.2b	3.2b	3.4b	**2.7**	**3.9a**	**4.6a**	
Leaf Number	IP	2007	158.3	147.0	188.8	127.2	54.3	135.2	**135.1a**
	MT		225.1	230.7	213.7	156.0	72.7	176.5	**179.1a**
	IP	2008	101.1	114.3	60.3	65.1	61.3	91.9	82.3b
	MT		115.0	127.0	98.9	72.8	62.2	132.4	101.4b
	Mean*	Mean*	**149.9a**	**154.7a**	**140.4a**	105.3c	**62.8d**	134.0b	

*: different letters indicate significant difference at the $p \leq 0.05$ level
[1]: IP: plant grown from IP groups tubers
MT: plant grown from MT groups tubers

branch number in 2007 and in 2008. High rainfall particularly in May, 2007 and in March and April in 2008 (Table 2) could cause differences observed for the morphological traits. Mean temperatures were also different between two years.

The MT group had higher means for leaf area, stem number in 2008 as well as for plant height and the leaf number in 2007. The IP group had lower means than the MT, in both years. The high means for the plant height and the leaf number were obtained in 2007, and for the stem number, the leaf area and the branch number in 2008. These results were in good agreement with Wiersema et al.(1987). Clone 122 and Nif had high means for all the morphological traits for the IP and MT groups. Marfona had the lowest means.

Contrary to the result of seedbeds the MT group had high means for plant height (cm), branch number, leaf area (cm^2) and leaf number in the field trial. This could be the result of increasing microtubers in the seedbeds so microtubers will be in good condition as compared to the IP group. The tuber size and physiological conditions of the tubers would be favourable for the MT group. Therefore they could develop earlier than the IP group.

Yield characteristics measured in the field trial run in 2007 and 2008

The means of the yield characteristics measured in the field trial run in 2007 and 2008 are shown in Table 8.

As expected from the non-significant F values given in Table 6, yield characteristics were not significantly different for the MT and the IP groups. The means for tuber number of the MT and the IP groups were significantly different for years. The IP group had higher tuber number (9.9) than the MT group (9.5) in 2007 but had lower mean in 2008. In spite of this difference the means indicated a similarity between two groups under field conditions during the two growing seasons. This result is partly in agreement with Wattimena et al. (1983). For the yield characteristics cultivars Nif and Clone 122 had significantly high means as compared to remaining genotypes.

To recapitulate, there was no difference between the IP and the MT seed source at seedbeds in term of morphological traits except leaf area. For yield characteristics the IP group had higher means than those of the MT group. This superiority could be due to the longer growing time at the IP group plants after the transfer to seedbeds. Therefore the IP group plantlets had early rooting and leaf development as compared to the MT group tubers. Thus the IP group had longer period for tuber bulking so heavier tubers were produced.

Table 8. The means of the yield characteristics measured in the field trial run in 2007 and 2008

Characteristic	Seed[1] Source	Year	Genotype						Mean*
			Nif	Clone 122	Agria	Resy	Marfona	Granola	
Tuber number	IP	2007	12.4	8.8	15.6	8.4	8.0	6.4	9.9b
	MT		10.9	10.1	10.3	7.7	9.7	8.5	9.5b
	IP	2008	14.1	6.8	10.8	8.0	8.7	11.7	10.0b
	MT		13.7	9.4	11.4	11.6	10.8	16.4	**12.2a**
	Mean*	Mean*	**12.8a**	**8.8b**	**12.0a**	**8.9b**	**9.3a**	**10.7a**	
Single tubers weight (g)	IP	2007	27.7	37.5	31.3	29.3	30.4	22.1	**31.4a**
	MT		34.4	40.2	30.8	30.6	33.6	27.8	**32.9a**
	IP	2008	43.9	57.6	30.3	30.4	19.6	33.6	**35.9a**
	MT		43.8	43.9	39.2	31.8	17.3	31.6	**35.3a**
	Mean*	Mean*	**39.9a**	**44.8a**	32.9b	30.5c	**25.2d**	28.8c	
Tuber yield (g)	IP	2007	557.6	395.6	284.8	216.2	150.3	389.2	**332.1a**
	MT		365.5	377.5	275.1	239.4	295.9	195.0	**291.4a**
	IP	2008	422.6	294.8	348.6	242.1	210.5	137.0	275.9b
	MT		493.7	553.3	349.7	338.5	159.7	467.1	**393.7a**
	Mean*	Mean*	**459.8a**	**405.3a**	314.5b	259.0b	**204.1c**	297.1b	
Tuber width (cm)	IP	2007	3.5	3.6	3.3	3.2	3.2	3.0	**3.3a**
	MT		3.5	3.7	3.4	3.2	3.3	2.6	**3.3a**
	IP	2008	3.8	4.6	3.4	3.4	3.2	3.7	**3.7a**
	MT		3.8	4.7	3.9	3.3	2.8	3.5	**3.7a**
	Mean*	Mean*	3.7b	**4.1a**	3.5b	**3.3c**	**3.1c**	**3.2c**	
Tuber length (cm)	IP	2007	3.9	4.0	4.5	4.2	4.0	3.6	**4.0a**
	MT		4.0	4.2	4.3	4.3	4.1	3.1	**4.0a**
	IP	2008	4.4	5.1	4.4	4.3	3.5	4.6	**4.4a**
	MT		4.5	5.4	4.6	4.4	3.4	4.2	**4.4a**
	Mean*	Mean*	4.2b	**4.7a**	4.4b	4.3b	**3.7d**	3.9c	

*: different letters indicate significant at the p≤ 0.05 level

[1]: IP: tubers grown from the IP groups tubers
MT: tubers grown from the MT groups tubers

Based on the two year field testing trial it could be concluded that normal minitubers (here the IP group) had no advantage over to the newly proposed and used microtuber production. Therefore, the microtubers could be used in the field reproduction stage in a certified seed potato production program.

Further, the high tuber yields for the MT group were obtained in 2008 as compared to the IP group. This might be due to lower temperatures occurred during the growing period as compared to 2007. Potatoes might have been influenced from the climatical conditions. High temperature could affect potato yield by reducing photosynthesis and increasing respiration. Precipitation was also different between 2007 and 2008. Relatively high precipitation in March and April in 2008 could have positively affected plant growth and tuber number. Moreover the low temperatures as compared to 2007 could cause high level of tuber bulking in 2008.

In conclusion: There were no significant differences between the IP and the MT groups for yield characteristics in the field reproduction stage. Altındal and Karadoğan (2010) proposed that microtubers should be tested in the greenhouse and in the field before using commercially. Based on the 2 years of field testing, the microtubers could also be used in the field reproduction stage as well as the standard minitubers. The economical advantages of using microtubers should be considered in deciding their usage in the seed potato production program.

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