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COMPARISON THE GRAFTING METHODS OF CUCUMBER SEEDLINGS (*Cucumis sativum L.*) AND THEIR PERFORMANCE ON DRY MATTER PARTITIONING AND STAND ESTABLISHMENT RATE UNDER NaCl STRESS

Ismet Babaj, Glenda Sallaku, Astrit Balliu

Agricultural University of Tirana, Horticultural Department, Tirana, Albania.

Abstract

Cucumber variety (Ekron F1) was grafted onto a commercial rootstocks (Cucurbita maxima x C. moschata). Splice grafting (SG) and root pruning splice grafting (RPSG) were simultaneously applied. Two weeks after grafting, an equal number of each experimental unit was transplanted in to 200 cm3 plastic pots filled with vermiculite. The plants of each group were split in three equal subgroups and irrigated several times with equal amounts of the same nutrient solution (N 100 mgL^{-1}, P mgL^{-1}, K mgL^{-1}) , but differing by each other by the amount of NaCl added in the nutrient solution (0, 50 and 100 mM). Root, stem and leaf dry matter was weighted, and leaf area of plants was measured. The grafting method showed a significant effect on the dry matter partitioning of grafted seedlings. Compared to splice grafted (SG), the root pruned splice grafted (RPSG) seedlings addressed a much higher amount of dry matter. The dry matter of transplanted seedlings was drastically reduced due to the increase of nutrient solution salinity, but still relatively higher value of dry matter were recorded in case of RPSG. RPSG seedlings showed a significantly higher dry matter partitioning, which was in favour of a quick stand establishment of seedling after transplanting.

Key words: *grafting method, salinity, dry matter, stand establishment rate*

1. INTRODUCTION

Intensive farming practices with limited crop rotations can lead to a buildup of soil-borne pathogens and other deleterious factors, such as increased salinity (King at al., 2010). Salinity in soil or water is one the major abiotic stresses that reduce plant growth and crop productivity worldwide (Arzani, 2008). More than 800 million hectares of land throughout the world are salt affected (including both saline and sodas soils) corresponding to more than 6% of the world total land area (FAO, 2009). Three major factors contribute to secondary salinization in agricultural areas: (i) poor irrigation management and lack of suitable drainage; (ii) irrigation with saline water; and (iii) rising groundwater tables due to vegetation changes (Rewald et al. 2012). Salinity causes several challenges for plants, including water stress, mal-nutrition and accumulation of excess ions to toxic levels (Rewald et al. 2011). Excessive soil salinity reduces productivity of many agricultural crops, including most vegetables which are particularly sensitive throughout the ontogeny of the plant. Plant sensitivity to salt stress is reflected in loss of turgor, growth reduction and potentially death of the plant (Jones 1989; Cheeseman 1988).Cucumber is highly sensitive to salinity (Zhu et al., 2008). Moreover, in protected cultivation, cucumber is the primary vegetable, so the secondary salinization of protected soils has badly influenced the growth, development, and yield of cucumber (Wang, 1998). Grafted vegetable transplants represent a significant component of vegetable industries throughout the world (Aloni at al., 2010). Though the main purpose, still remains the control of soil-borne disease, recently the purpose of grafting has been expanded to obtain increased heat and cold tolerance, to enhance water and nutrient uptake, and to improve plant growth and marketability (Lee, 2007).). In general, vegetable grafting has been motivated by the need to increase plant yields (Kim et al., 1998; Asao et al., 1999).

According to Lee, 1994 and Oda, 1995 the cultivation of grafted fruit-bearing vegetable plants has increased greatly, and grafting is an important technique for the sustainable production of fruit-bearing vegetables in Korea, Japan and some Asian and European countries, where land use is very intensive and continuous cropping is common. There is a common request for the commercial production of vegetable transplants to provide a fast stand establishment coupled with enhancement in one or more attributes of earliness, uniform maturity, and yield quantity and quality (Dufault 1998). The re-establishment of an active root system depends on the rate at which new roots are formed, and how fast root system resumes after transplanting (Wien 1997). The current study was conducted to compare the grafting methods of cucumber seedlings and their performance on dry matter partitioning and stand establishment rate under NaCl stress.

2. MATERIALS AND METHODS

The experiment was conducted in spring 2012 in a polyethylene greenhouse situated in Skenderaj municipality of Kosovo ($42^0$44'52.31" N; $20^0$47'27.03" E; 603m a.s.l.). Graded cucumber (*Cucumis sativus L*,) seeds cultivar Ekron F1 (Enza Zaden, Holland) was used as scion. Nimbus F1 (*Cucurbita maxima x cucurbita muschata*; Nickerson – Zwann, Holland) was used as rootstock. Cucumber seeds were sown in 80 – cell plug trays filled with peat (Klasmann Podgrand H, Rathowen, Ireland) two days prior to sowing of the rootstock seeds. After germination, plants were periodically and equally irrigated, but no additional nutrient elements were supplied during the nursery stage. Grafting was carried out two weeks after sowing. Two different methods, splice grafting (SG) and root pruning splice grafting (RPSG) were applied. Non grafted (NG) seedlings was used as control and were sown at the same time with cucumber plants used as scions. Grafted seedlings were placed in growth room and maintained at 28 ± 2^0C with 95 – 100% relative humidity for healing for five days. Humidity was gradually decreased from 95 – 100% to 75%. Five days after grafting plants were transferred to greenhouse for further growth and adaptation before transplanting in plastic pots. Two weeks after grafting, 10 plants of each experimental unit was randomly selected and harvested. After the harvest above ground, roots was carefully washed out from the substrate by using a soft water jet and 2 mm sieves. Weighed photocopies of the leaves were transformed to leaf areas (LA) by means of the specific area of the copy paper. Afterwards, all leaves and shoots of harvested plants were dried at 70°C for 24 h to determine the dry weight of root (RW), leaf (LA), steam (SW) and plant (W). Two weeks after grafting, an equal number of each experimental unit was transplanted in to 200 cm3 plastic pots filled with vermiculite. The plants of each group were split in three equal subgroups and irrigated several times with equal amounts of the same nutrient solution (N 100 mg/L, P mg/ L, K mg/L and other necessary elements), but differing by each other by the amount of NaCl added in the nutrient solution (0, 50 and 100 mM). The treated plants two weeks after transplanting, 10 plants from each subgroups were randomly selected and harvested. The same methods for washing roots, measuring leaf area and dried harvested plants were used to determine the dry matter weight of root (RW), leaf (LA), steam (SW) and plant (W). Analyses of variance were conducted by MINITAB 15 for each experimental parameter, and respective means were separated by least significant differences test (LSD) at 5% significance level.

3. RESULTS AND DISCUSSION

Two weeks after grafting dry matter partitioning of cucumber seedlings were computed for each experimental units. Statistically significant differences were found between splice grafting (SG) seedlings and root pruned splice grafted (RPSG) with regard to root dry matter (Table 1). The SG seedlings showed higher root dry matter compare to RPSG ones. It is important to note that RPSG seedlings after grafting started with no roots, seedlings reached a near but still slightly less in comparison to SG seedlings dry weight of root system. The findings are in line with those of Sallaku at al. (2012). On the other hand leaf area and leaf dry matter was significantly higher to root pruned splice grafted (RPSG) compare to splice grafted seedlings (Table 1). No significant difference was found between RPSG and SG seedlings regarding steam and plant dry matter (Table 1).

Table 1 Mean values of leaf area (LA), root dry matter (RW), leaf dry matter (LW), steam dry matter (SW) and plant dry matter (W) to grafted and non-grafted cucumber seedlings (mean values, different letters within the same column indicate significant difference at P<0,05).

Grafting methods	Growth parameters two weeks after grafting				
	LA (cm^2 $plant^{-1}$)	RW (gr $plant^{-1}$)	LW (gr $plant^{-1}$)	SW (gr $plant^{-1}$)	W (gr $plant^{-1}$)
NG	15.771^c	0.055^b	0.102^b	0.160^b	0.317^b
SEG	16.112^c	0.042^c	0.056^d	0.134^c	0.233^c
SG	25.338^b	0.069^a	0.081^c	0.213a	0.364^a

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RPSG	37.671[a] 0.359[a]	0.035[c]	0.112[a]	0.211[a]

Two weeks after transplanting cucumber seedlings grown under normal conditions showed significant differences between experimental units. There were significant differences in leaf area, leaf dry matter, steam and plant dry matter between the grafting methods. Root pruning splice grafting (RPSG) seedlings showed significantly higher leaf area, leaf, steam and plant dry matter compare to splice grafting (SG) seedlings (Table 2). No significant difference was found between RPSG and SG seedlings with regard to root dry matter (Table 2). Non grafted plants showed significantly lower performance on plant dry matter partitioning compare to self-grafted one. Generally speaking RPSG seedlings resulted with higher performance on dry matter partitioning compare to splice grafting (SG) seedlings (Table 2).

Table 2 Mean values of leaf area (LA), root dry matter (RW), leaf dry matter (LW), steam dry matter (SW) and plant dry matter (W) to grafted and non-grafted cucumber seedlings grown under normal conditions (0 mM NaCl)

Grafting methods	Growth parameters two weeks after transplanting				
	LA (cm^2 $plant^{-1}$)	RW (gr $plant^{-1}$)	LW (gr $plant^{-1}$)	SW (gr $plant^{-1}$)	W (gr $plant^{-1}$)
NG	148.535[d] 0.838[d]	0.169[b]	0.473[d]	0.196[d]	
SEG	172.950[c] 1.054[c]	0.176[b]	0.579[c]	0.298[c]	
SG	209.150[b] 1.329[b]	0.253[a]	0.706[b]	0.368[b]	
RPSG	275.208[a] 1.716[a]	0.266[a]	0.967[a]	0.482[a]	

*Different letters within the same column indicate significant difference at P<0. 05

The grafting method showed a significant effect on the dry matter partitioning of grafted seedlings under salt growing condition. Table 3 shows a very clear and distinguished trend of a reduction of all growth parameters to all experimental units due to the increase of solution salinity from 0 to 50 and 100 mM NaCl. Reduction of dry matter partitioning due to enhanced salinity was for both types of seedlings grafted and non-grafted but higher reduction was found to NG and SEG compare to SG and RPSG (Table 3). Explanation for those facts was provided by reports of previous studies (Balliu at al., 2012; Babaj at al., 2012). This is a clear evidence of the negative effects the salinity plays to the development of new root system and the stand establishment rate of transplanted plants.

RPSG seedlings demonstrated anyway higher root dry matter under each of salinity levels, which can be interpreted as a better potential to stand under adverse salinity soil conditions (Table 3). Among the grafted seedlings (SG and RPSG) significantly higher leaf area, and dry matter partitioning were found for RPSG seedlings versus the respective SG ones (Table 3). The increase of NaCl concentration in the nutrient solution resulted with reduction of leaf area and dry matter partitioning to all transplanted seedlings, but still significantly higher rates were recorded to RPSG seedlings. In general RPSG seedlings transplanted under salinity soil conditions were characterized by a better performance in terms of leaf area and dry matter partitoning compare with SG once. In practical terms, this mean that stand establishment rate of root pruned seedlings under saline conditions has better performance compare with splice grafting seedlings due to their enhanced physiological efficiency of root pruned seedlings. A possible explanation for that fact was provided by report of previous study (Balliu at al., 2012).

Table 3 Mean values two weeks after transplanting of leaf area (LA), root dry matter (RW), leaf dry matter (LW), steam dry matter (SW) and plant dry matter (W) to grafted and non-grafted cucumber seedlings (mean values, different letters within the same row indicate significant difference at P<0,05).

Growth parameters			Grafting methods		
	NaCl (mM)	NG	SEG	SG	RPSG
LA (cm^2 $plant^{-1}$)	0	148.335^{d}	172.95^{c}	209.151^{b}	275.208^{a}
	50	140.804^{d}	164.972^{c}	198.869^{b}	264.82^{a}
	100	118.061^{d}	131.205^{c}	180.841^{b}	252.281^{a}
	Average	135.733^{d}	156.376^{c}	196.287^{b}	264.103^{a}
RW (gr $plant^{-1}$)	0	0.169^{b}	0.176^{b}	0.253^{a}	0.266^{a}
	50	0.156^{c}	0.158^{c}	0.237^{b}	0.256^{a}
	100	0.114^{d}	0.147^{c}	0.228^{b}	0.246^{a}
	Average	0.146^{d}	0.161^{c}	0.239^{b}	0.256^{a}
LW (gr $plant^{-1}$)	0	0.473^{d}	0.579^{c}	0.706^{b}	0.967^{a}
	50	0.458^{d}	0.565^{c}	0.684^{b}	0.872^{a}
	100	0.406^{c}	0.431^{c}	0.609^{b}	0.763^{a}
	Average	0.446^{d}	0.525^{c}	0.666^{b}	0.867^{a}
SW (gr $plant^{-1}$)	0	0.196^{d}	0.298^{c}	0.368^{b}	0.482^{a}
	50	0.189^{d}	0.266^{c}	0.361^{b}	0.472^{a}
	100	0.181^{d}	0.254^{c}	0.357^{b}	0.441^{a}
	Average	0.188^{d}	0.273^{c}	0.362^{b}	0.465^{a}
W (gr $plant^{-1}$)	0	0.838^{d}	1.054^{c}	1.329^{b}	1.716^{a}
	50	0.804^{d}	0.991^{c}	1.281^{b}	1.601^{a}
	100	0.701^{d}	0.832^{c}	1.196^{b}	1.451^{a}
	Average	0.781^{d}	0.959^{c}	1.269^{b}	1.589^{a}

4. CONCLUSIONS

Grafting methods showed a significant effect on leaf area and dry matter partitioning of cucumber grafted seedlings under saline conditions. Two weeks after grafting SG seedlings showed higher root dry matter compare to RPSG ones. It is important to note that RPSG seedlings after grafting started with no roots, seedlings reached a near but still slightly less in comparison to SG seedlings dry weight of root system. After transplanting in normal growing conditions Root pruning splice grafting (RPSG) seedlings showed significantly higher leaf area, leaf, steam and plant dry matter compare to splice grafting (SG) seedlings. No significant difference was found between RPSG and SG seedlings with regard to root dry matter. The increase of NaCl concentration in the nutrient solutions reduced the leaf area and dry matter partitoning of all seedlings, but still significantly higher rates were recorded for RPSG seedlings. In general root pruning splice grafting (RPSG) seedlings were characterized by a better performance in terms of leaf area, dry matter partitoning and stand establishment compare with splice grafting (SG) once.

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