

The Effect of Fluid Drilling on Seedling Quality of Cucurbit Rootstock Seeds at Low Temperature Sowing

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Abstract

Grafting is used widely in cucurbits, mainly in watermelon transplant production. Seeds are sown in early spring in rootstocks to get seedling for grafting. Even though glasshouse is heated night temperatures may drop down and extends the time of appearance of seedlings on the surface. So early emergers are likely to produce well developed seedlings compared to late emergers. This is an impact on graftable seedling numbers. This work was carried out to test the effect of sowing germinated rootstock cucurbit seeds (fluid-drilling) on seedling emergence and seedling quality at low temperature. Six rootstock cultivars (Domingo, Zorba, Polifemo, Carnivor, Strongtosa and Gürdal) were germinated in laboratory conditions and 2-3 mm radicle protruded seeds were sown in a peat:moss:perlite mixture either with or without gel at 18 °C. Subsequently germinated seeds were stored either at 5 °C over five days and sown with or without gel mixture. Results indicated that sowing germinated seeds in all cultivars significantly increased emergence percentages ($p<0.05$). This was highest in pre-germinated and five-day stored seeds sown with gel at 96.6% and lowest in the control at 73.1%. Storing germinated seeds did not decrease the advantages of pre-germination, and in fact germinated and stored seeds had slightly higher emergence percentages than unstored ones. Seedling quality, as shown by shoot fresh and dry weights and root fresh and dry weights of pre-germinated and sown seeds, were better than the controls in all cultivars. The thickness of the seedlings were also significantly higher than those of the controls sown either with or without gel mixed or stored. The results showed that sowing germinated seeds of rootstocks can be used to enhance graftable seedling size.

Keywords: Germination, seedling emergence, seed treatments, fluid drilling.

Kabakgil Anaçlık Tohumlarında Sıvı Ekim Metodunun Düşük Sıcaklık Ekimlerinde Fide Kalitesine Etkisi

Öz

Karpuz yetiştiriciliğinde aşılınmış fide kullanımı hızla artmaktadır. Yavaş ve düzensiz çıkış aşılı fide üretiminin etkinliğini azaltır. Düşük sıcaklıklar bu düzensiz çıkışın en önemli nedenlerindendir. Aşılı fide üretimi için tohum ekiminin yapıldığı erken ilkbahar periyodunda sera ısıtma sistemi iyi çalışsa bile gece sıcaklıklarının düşük olabilmesi nedeniyle çıkış süresi uzamaktadır. Bu süre çeşitlere göre değişebilir ve dolayısıyla da fide kalitesini belirler. Erken çıkan fideler daha kalın ve gelişmiş, geç çıkanlar ince ve zayıf fideler oluşturur. Bu çalışma çimlenmiş kabakgil anacı tohumlarının düşük sıcaklıkta ekilmesinin fide çıkışı ve kalitesine etkisini test etmek için yürütülmüştür. Altı kabakgil anaçlık tohumu (Domingo, Zorba, Polifemo, Carnivor, Strongtosa and Gürdal) laboratuvar koşullarında elde edilen 2-3 mm uzunluğundaki kökçükleriyle torf ve perlit karışımı ortama jelli ya da jelsiz olarak ekilerek 18 °C 'de çıkış testine tabi tutulmuştur. Çıkış yapan tohumların bir kısmı 5 °C'de 5 gün % 100 oransal nemde depolandıktan sonra jelli veya jelsiz olarak ekilmiştir. Ön çimlendirme yapılmış tohumların ekilmesi tüm çeşitlerde daha yüksek fide çıkış oranı sağlamıştır. Çıkış oranı çimlendirildikten sonra 5 gün depolanıp jel ile ekilenlerde %97 kontrolde ise %73 olarak gerçekleşmiştir. Çimlendirilip depolanmış tohumlar çimlendirilip depolanmayanlardan daha yüksek çıkış göstermiştir. Yaş ve kuru fide ağırlığı, hipokotil kalınlığı çimlendirilerek ekilenlerde kontrolden daha yüksek bulunmuştur. Sonuç olarak düşük sıcaklıklarda kaliteli anaçlık fide üretiminde ön çimlendirme yapmanın fide çıkış ve kalitesinin artırılmasında kullanılabileceği ortaya konulmuştur.

Anahtar Kelimeler: Çimlenme, fide çıkışı, tohum uygulamaları, sıvı ekim yöntemi.

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Geliş Tarihi/Received: 15.10.2018 Kabul Tarihi/Accepted: 17.11.2018

Makalenin Türü: Araştırma
Category: Research

Introduction

Grafting is a technique in vegetable seedling production which aims to obtain the advantages of a rootstock such as resistance to diseases, robust growth, nematode resistance, higher yield

and plant development (Yetisir and Sari, 2003, Lee et al., 2010). Watermelon is a warm climate crop in which grafting is performed intensively for various purposes (Lee et al., 2010). In Turkey, pre-grafting stage rootstock and scion

seeds are sown in late winter into a growing medium in glasshouses. The aim in early season sowing is that making grafting is achievable earlier (i.e. March). Then, watermelon production under tunnels are done in out of season in early summer. Night temperatures may decline this time of the year even heating is on to un-optimum level for timely germination. Late germination causes not well developed seedlings which affect efficiently graftable seedling number. This has an impact on timely grafted seedling production. Watermelon seeds require 27-28 °C for ideal germination. Low temperatures during emergence period cause poor emergence and in turn small sized transplants. Slow and erratic emergence of rootstock seeds results in larger differences in thickness of rootstock, which results in incompatibility, lowers the efficacy of grafting, and non-uniform grafted seedlings. A large number of non-germinated or late germinated seed causes economic loss, since the rootstock seeds are in general high-value hybrid cultivars. Therefore, rapid and synchronous emergence is a necessity for fast and efficient grafted seedling production. Various pre-sowing treatments have been used to enhance seed emergence, including rootstock seeds (Mavi et al., 2006, Jisha et al., 2013). One of these is fluid drilling, sowing pre-germinated seeds, which can help to overcome the uncontrollable effects of the environment on germination through enabling the selection of emerged seeds (Gray, 1978), leaving less time between sowing and emergence of the seeds. This was proven to be effective for increasing stand establishment in various species (Darby, 1980, Pill, 1991). The shorter time period between imbibition and radicle emergence was proven to be related to larger seedling size (Demir et al., 2008). Therefore this work was conducted to test whether sowing germinated cucurbit rootstock seeds will increase the quality of seedlings to be grafted. This will allow the producers, seed companies, to save energy and lead to efficient grafting, use of glasshouse space.

Materials and Methods

Six hybrid cucurbit rootstock cultivar (Domingo, Zorba, Polifemo, Carnivor, Strongtosa and Gürdal) seeds were obtained from seed companies. All varieties were

Cucurbita maxima Duch. x *Cucurbita moschata* Dutch. hybrids. Seed moisture content was determined by the high-temperature oven method (130°C, 1 h) (ISTA, 2005) and was 7.0-8.1%. Six hundred seeds (one hundred seeds/petri dish, 90 mm diameter) were planted on wetted Whatman paper and kept at 25 °C in the dark. Seeds at the 2 mm long radicle stage were separated by hand in frequent counts. They were collected on top of wet Whatman paper, covered by a polyethylene bag and kept at 5 °C. Four hundred germinated seeds were collected in each cultivar. They were divided into four groups of one hundred seeds. Then, seeds were sown immediately (PG) without or with gel mixture (PG+G), and the remaining germinated 200 seeds were stored at 5 °C for five days on top of wet Whatman paper and sown either with gel (PG+5D+G), or without gel PG+5D. Non-treated dry seeds were considered as a control (C). Sowing was done with four replicates of 25 seeds in each cultivar and treatment. Laponite (aluminium silicate 15 g/L) was used as the gel medium. Germinated seeds were added to gel and mixed, and the seed gel mixture was extruded into furrows of a peat moss:perlite mixture (2:1 v/v) on plastic flats. The flats were placed in a randomised block design with four replications on benches in a climatically controlled room in which the temperature was 18°C and the relative humidity was approximately 75%. The light intensity was approximately 72 $\mu\text{Mol m}^{-2}\text{s}^{-1}$. Emergence counts were taken daily until no emergence occurred. The seedlings were then cut at the soil line (shoot), weighed and placed in a drying oven 80 °C for 24 hours. Roots were also washed, weighed and dried in oven. Seedling shoot and root fresh (g/plant) and dry eight (mg/plant) were calculated per plant. The thickness of cotyledons in 20 seedlings in each treatment (5 seedlings x 4 replicates) was measured. Duncan multiple range test was performed using SPSS as randomized complete block design ($P<0.05$) in order to compare the means of the treatments.

Results and Discussion

All treatments had significantly higher ($p<0.05$) seedling emergence than these of the control (Table 1). This went up to 30% in some cases such as Gürdal in PG+5D+G. Control seeds had

a seedling emergence of 69 and 77%, whereas pre-germinated seeds before storage sown either with or without gel had a mean emergence of 95% and 91% respectively. When pre-germinated seeds were stored and sown with or without gel, they had a mean emergence of 96.6% and 92.6% respectively. The highest seedling emergence amongst the rootstocks was observed in Domingo as 93%, and the lowest was in Gürdal as 87%. Storing pre-germinated seeds did not reduce emergence potential in any cultivar. Pre-germinated and stored seeds had emergence percentages and larger seedling sizes as well as non-stored ones either after sown with or without gel (Tables 1 and 3). Seeds which were pre-germinated and stored and sown with gel had the highest value of seedling fresh weight at 3.44 g/plant, while control seedlings had 2.20 g/plant. The same trend was seen in seedling dry weight, in which the maximum seedling dry weight was observed in the PG+5D+G treatment as 172.6 mg/plant. Similarly, pre-germinated and five day stored and sown seeds (PG+5D+G) had higher root fresh weight (582 mg/plant) and dry weight (23.3 mg/plant) in all rootstock cultivars (Tables 4 and 5). Storing pre-germinated seeds for approximately five days did not reduce seedling criteria. Sowing seeds with gel or without gel did not make any significant difference. Pre-germinated and stored and sown seeds had a 4.1 mm width of hypocotyl, which is significantly different from that of the control ($p<0.05$) (Table 6). Our results are in agreement with previous findings in seeds of various crop species (Bussel and Gray, 1976, Gray and Steckel, 1977, Gray, 1978). The use of the fluid drilling technique in rootstock seeds has not been reported. Low temperature is the basic abiotic stress that inhibits emergence in the early sowings (Sarıyıldız et al., 2005) of summer crop seeds which delays the timely emergence of uniform seedlings (Demir and Van De Venter, 1999). This can reduce the number of rootstock seedlings that are graftable, since late emergers and those that need a longer time to emerge have smaller seedlings (Demir et al. 2008). Pre-germinated seed sowing can be an alternative to get thicker seedlings. The advantage of pre-germinated rootstock cultivars over dry seed is greatest early in the season when soil temperatures are about 10 °C (Gray, 1978; Finch-Savage, 1981). This is a valuable asset in

obtaining well-developed transplants in early spring sowings because grafting is used to obtain early maturity for off-season production in watermelons in the southern part of Turkey (Yetişir and Sarı, 2003). Germinated seeds can be stored for a reasonable period with minimum radicle extension (Brocklehurst et al., 1980, Pill, 1991). Gray (1978) reported that the optimum radicle length for fluid-drilled lettuce is 2.0 mm and five days would be the maximum safe storage period for pre-germinated lettuce seed. Our observation indicated that pre-germinated seeds can be stored for five days with no adverse effect on seedling emergence. It must be noted, that the seeds in this study were sown by hand. In commercial operations, seeds having radicles longer than 2.0 mm may be more susceptible to physical damage (Finch-Savage, 1981, Finch-Savage and McKee 1990). The gels, in addition to carrying seeds to the seed bed, can also carry fertilizers, plant growth regulators, pesticides and microorganisms, so that they support the early plant growth in the seed bed and fasten the stand establishment (Darby, 1980; Orzolek, 1983, Pill, 1991). Pre-germinated seeds in our work were sown in peat moss and perlite mixture in our study, and this is the ideal environment for transplant production, as seeds were kept well watering and the temperature remained ideal, so that seeds did not come across any adverse conditions as they might in the field. Rootstock seeds for grafting are grown in glasshouse conditions and in an ideal environment to get maximum emergence and uniformity (Yetişir and Sari, 2003). However, the main abiotic stress factor for late emergence was the low temperature which commonly occurs in glasshouses in early spring sowings. Our results indicate that pre-germination sowing can prevent the adverse effect of low temperature conditions (Tables 1 and 4). This may be due to completion of the seed germination stage in ideal temperature conditions before transferring the seeds to a low temperature sowing environment (Finch-Savage and McKee, 1990). It appears that sowing pre-germinated cucurbit rootstock seeds in low temperature conditions may provide an alternative to improve transplant quality. However, pre-germinated seeds are not easy to sow by machine since the emerged radicle can be broken. Sowing seeds with gel is somewhat protective but a longer radicle is more risky to

sow (Darby, 1980, Finch-Savage, 1981). The cultivars displayed different sensitivities to germination and storage as indicated by differences in emergence. This can be due to the both genetic and environmental factors during growing, and seed harvest practices between the cultivars. Therefore, the low temperature germinability can also be a matter of cultivar response as well as pre-harvest seed growing management.

Conclusion

The fluid drilling method can be a useful tool for obtaining a well-developed rootstock seedling production in low temperature sowing conditions in early spring. However, sowing pre-germinated seeds into modules in an appropriate way is a research line that needs to be explored. For the transplanting companies the suggested method can be used to improve high quality grafted seedling production. While, pre-germinated seeds are not appropriate for machine sowing to the modules. Extra studies may be needed for improving the use of the pre-germinated seeds.

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Table 1. The effect of sowing after pre-germination (PG), pre-germinated and sown with gel (PG+G), pre-germinated 5 days stored at 5 °C and sown without gel (PG+5D), pre-germinated 5 days stored at 5 °C and sown with gel (PG+5D+G) and control (C) on seedling emergence percentages of cucurbit rootstock cultivars at 18 °C. Values are presented with standard error of means ($\pm$)

Cultivars	Treatments					Mean
	PG	PG+G	PG+5D	PG+5D+G	C	
Carnivor	93 $\pm$ 0.6Bab	94 $\pm$ 1.1Bb	93 $\pm$ 0.6Bab	97 $\pm$ 0.6Ab	71 $\pm$ 1.3Cab	90
Domingo	96 $\pm$ 1.1Ba	99 $\pm$ 0.6Aa	95 $\pm$ 1.7Ba	99 $\pm$ 0.6Aa	76 $\pm$ 2.3Ca	93
Gürdal	85 $\pm$ 1.7Bd	93 $\pm$ 0.6Ab	93 $\pm$ 1.3Aab	96 $\pm$ 1.1Abc	69 $\pm$ 0.6Cb	87
Polifemo	92 $\pm$ 0.0BCbc	95 $\pm$ 1.3ABb	91 $\pm$ 0.6Cbc	97 $\pm$ 0.6Aab	77 $\pm$ 0.6Da	90
Strongtosa	89 $\pm$ 0.6Cc	93 $\pm$ 0.6Bb	95 $\pm$ 0.6ABa	97 $\pm$ 0.6Ab	71 $\pm$ 0.6Dab	89
Zorba	88 $\pm$ 1.1Bcd	94 $\pm$ 1.1Ab	89 $\pm$ 0.6Bc	94 $\pm$ 0.0Ac	75 $\pm$ 0.6Cab	89
Mean	91b	95ab	93b	97a	73c	

Capital letters are for comparison between cultivar means while small letters are for treatments in the same cultivar.

Table 2. The effect of sowing after pre-germinated (PG), pre-germinated and sown with gel (PG+G), pre-germinated 5 days stored at 5 °C and sown (PG+5D), pre-germinated 5 days stored and sown with gel (PG+5D+G) and control (C) seeds on seedling shoot fresh weight (g/plant) of cucurbit rootstock cultivars at 18 °C. Values are presented with standard error of means ($\pm$)

Cultivars	Treatments				
	PG	PG+G	PG+5D	PG+5D+G	C
Carnivor	2.24 $\pm$ 0.0Ce	2.81 $\pm$ 0.0Bde	2.83 $\pm$ 0.0Bc	2.91 $\pm$ 0.0Ad	1.83 $\pm$ 0.0De
Domingo	3.08 $\pm$ 0.0Db	3.51 $\pm$ 0.0Bb	3.43 $\pm$ 0.0Cb	3.56 $\pm$ 0.0Ab	2.44 $\pm$ 0.0Eb
Gürdal	2.24 $\pm$ 0.0Ce	2.78 $\pm$ 0.0Be	2.76 $\pm$ 0.0Bd	2.91 $\pm$ 0.0Ad	1.71 $\pm$ 0.0Df
Polifemo	2.51 $\pm$ 0.0Cd	2.83 $\pm$ 0.0Bd	2.43 $\pm$ 0.0De	3.55 $\pm$ 0.0Ab	2.23 $\pm$ 0.0Ec
Strongtosa	2.57 $\pm$ 0.0Dc	2.91 $\pm$ 0.0Bc	2.81 $\pm$ 0.0Cc	3.33 $\pm$ 0.0Ac	2.12 $\pm$ 0.0Ed
Zorba	3.51 $\pm$ 0.0Ca	4.01 $\pm$ 0.0Ba	3.51 $\pm$ 0.0Ca	4.39 $\pm$ 0.0Aa	2.85 $\pm$ 0.0Da
Mean	2.26b	3.14a	2.96a	3.44a	2.20b

Capital letters are for comparison between cultivar means while small letters are for treatments in the same cultivar.

Table 3. The effect of sowing after pre-germinated (PG), pre-germinated and sown with gel (PG+G), pre-germinated 5 days stored at 5 °C and sown (PG+5D), pre-germinated 5 days stored and sown with gel (PG+5D+G) and control (C) on seedling shoot dry weight (mg/plant) at 18 °C in 6 cucurbit rootstock cultivars. Values are presented with standard error of means ($\pm$)

Cultivars	Treatments				
	PG	PG+G	PG+5D	PG+5D+G	C
Carnivor	165 $\pm$ 1.7Ac	167 $\pm$ 2.6Ab	143 $\pm$ 1.6Bc	140 $\pm$ 2.2Bc	128 $\pm$ 2.3Cb
Domingo	202 $\pm$ 1.2 Aa	181 $\pm$ 2.8Ba	172 $\pm$ 1.0Ca	202 $\pm$ 2.2Aa	152 $\pm$ 1.7Da
Gürdal	153 $\pm$ 1.6Ad	159 $\pm$ 0.9Ac	141 $\pm$ 0.3Bc	145 $\pm$ 1.6Bc	129 $\pm$ 3.2 Cb
Polifemo	167 $\pm$ 2.0Ac	167 $\pm$ 5.3Ab	159 $\pm$ 1.6Bb	171 $\pm$ 4.9Ab	152 $\pm$ 2.1 Ca
Strongtosa	150 $\pm$ 1.7 Cd	157 $\pm$ 0.4Bc	142 $\pm$ 0.7Dc	171 $\pm$ 3.8Ab	149 $\pm$ 0.8Ca
Zorba	186 $\pm$ 1.5Bb	176 $\pm$ 1.1Ca	176 $\pm$ 1.0Ca	207 $\pm$ 0.8Aa	155 $\pm$ 2.0Da
Mean	170.5a	167.8ab	155.5c	172.6a	144.1d

Capital letters are for comparison between cultivar means while small letters are for treatments in the same cultivar.

Table 4. The effect of sowing after pre-germinated (PG), pre-germinated and sown with gel (PG+G), pre-germinated 5 days stored at 5 °C and sown (PG+5D), pre-germinated 5 days stored and sown with gel (PG+5D+G) and control (C) seeds on seedling root fresh weight (mg/plant) at 18 °C in 6 cucurbit rootstock cultivars. Values are presented with standard error of means ($\pm$)

Cultivars	Treatments				
	PG	PG+G	PG+5D	PG+5D+G	C
Carnivor	480 $\pm$ 6.6Cb	530 $\pm$ 4.4Bc	535 $\pm$ 6.3Bc	557 $\pm$ 5.2Ad	446 $\pm$ 5.8Db
Domingo	537 $\pm$ 3.2 Ca	592 $\pm$ 2.1Ba	635 $\pm$ 7.5Aa	641 $\pm$ 5.9Aa	482 $\pm$ 3.0Da
Gürdal	533 $\pm$ 5.7Ba	546 $\pm$ 3.2 Bb	538 $\pm$ 8.6Bc	565 $\pm$ 2.6Acd	445 $\pm$ 4.5Cb
Polifemo	433 $\pm$ 3.3Cc	530 $\pm$ 3.3Bc	533 $\pm$ 3.2Bc	572 $\pm$ 5.3Ac	436 $\pm$ 1.4 Cb
Strongtosa	425 $\pm$ 3.0Dc	525 $\pm$ 2.8Bc	482 $\pm$ 2.8Cd	554 $\pm$ 4.2Ad	330 $\pm$ 9.3Ec
Zorba	437 $\pm$ 0.3Dc	482 $\pm$ 6.9Cd	573 $\pm$ 4.0Bb	603 $\pm$ 7.7Ab	476 $\pm$ 2.6Ca
Mean	474.1b	534.1ab	549.3ab	582a	435.8c

Capital letters are for comparison means between cultivars while small letters are for treatments in the same cultivar.

Table 5. The effect of sowing after pre-germinated (PG), pre-germinated and sown with gel (PG+G), pre-germinated 5 days stored at 5 °C and sown (PG+5D), pre-germinated 5 days stored and sown with gel (PG+5D+G) and control (C) seeds on seedling root dry weight (mg/plant) at 18 °C in 6 cucurbit rootstock cultivars. Values are presented with standard error of means ($\pm$)

Cultivars	Treatments				
	PG	PG+G	PG+5D	PG+5D+G	C
Carnivor	21.2 $\pm$ 0.7Ab	21.9 $\pm$ 0.6Ab	21.0 $\pm$ 0.5Ab	22.0 $\pm$ 0.2Acd	18.0 $\pm$ 0.3Bbc
Domingo	23.8 $\pm$ 0.4Ba	24.5 $\pm$ 0.2Ba	25.3 $\pm$ 0.4Ba	28.3 $\pm$ 0.9Aa	17.0 $\pm$ 0.0Cc
Gürdal	18.4 $\pm$ 0.1Cc	20.0 $\pm$ 0.3ABcd	18.7 $\pm$ 0.0BCc	20.7 $\pm$ 0.5Ade	19.3 $\pm$ 0.5ABCab
Polifemo	17.6 $\pm$ 0.8Dc	21.1 $\pm$ 0.1BCbc	22.0 $\pm$ 0.6Abb	23.3 $\pm$ 0.1Ac	20.1 $\pm$ 0.0Ca
Strongtosa	15.8 $\pm$ 0.1Cd	18.9 $\pm$ 0.4Bd	18.7 $\pm$ 0.0Bc	20.3 $\pm$ 0.4Ae	15.5 $\pm$ 0.6Cd
Zorba	22.2 $\pm$ 1.1Bb	22.2 $\pm$ 0.2Bb	21.8 $\pm$ 0.4BCb	25.3 $\pm$ 0.5Ab	20.3 $\pm$ 0.5Ca
Mean	19.8b	21.4ab	21.2ab	23.3a	18.3c

Capital letters are for comparison between cultivar means while small letters are for treatments in the same cultivar.

Table 6. The effect of sowing after pre-germinated (PG), pre-germinated and sown with gel (PG+G), pre-germinated 5 days stored at 5 °C and sown (PG+5D), pre-germinated 5 days stored and sown with gel (PG+5D+G) and control (C) seeds on seedling hypocotyl width (mm/plant) at 18 °C in cucurbit rootstock cultivars. Values are presented with standard error of means ($\pm$)

Cultivars	Treatments				
	PG	PG+G	PG+5D	PG+5D+G	C
Carnivor	3.6 $\pm$ 0.0Bb	3.7 $\pm$ 0.0Bbc	4.1 $\pm$ 0.0 Aa	4.0 $\pm$ 0.0Ab	3.1 $\pm$ 0.1Cab
Domingo	3.9 $\pm$ 0.0Ba	4.1 $\pm$ 0.0 Ba	4.2 $\pm$ 0.1Ba	4.5 $\pm$ 0.0Aa	3.3 $\pm$ 0.0Ca
Gürdal	3.2 $\pm$ 0.0Bc	3.7 $\pm$ 0.0Abc	3.7 $\pm$ 0.0 Ab	3.8 $\pm$ 0.1Ab	2.9 $\pm$ 0.0Cb
Polifemo	3.3 $\pm$ 0.0Cc	3.5 $\pm$ 0.0Bc	3.6 $\pm$ 0.1Bbc	4.0 $\pm$ 0.2Ab	3.2 $\pm$ 0.0Ca
Strongtosa	3.8 $\pm$ 0.0Aab	3.8 $\pm$ 0.0Aab	3.4 $\pm$ 0.0Bc	3.9 $\pm$ 0.1Ab	2.9 $\pm$ 0.0Cb
Zorba	3.9 $\pm$ 0.0 Ba	3.9 $\pm$ 0.0 Bab	3.8 $\pm$ 0.0Bb	4.5 $\pm$ 0.1Aa	3.2 $\pm$ 0.0Ca
Mean	3.6b	3.8ab	3.8ab	4.1a	3.1c

Capital letters are for comparison between cultivar means while small letters are for treatments in the same cultivar.