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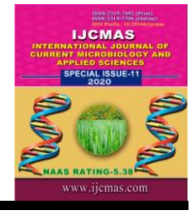

Review Article

Scope of Grafting in Watermelon: A Review

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ABSTRACT

Watermelon is an economically and nutritionally important fruit vegetable grown throughout the world. Grafting vegetable seedlings is a specific horticultural technique that began in Japan and Korea in the early twentieth century with the cultivation of watermelon grafted on gourd. The primary aim of this strategy is to prevent damage caused by various soil-related biotic and abiotic constraints where genetic and chemical approaches are unavailable. In grafting, susceptible watermelon plants grafted on resistance rootstocks to control soil-borne diseases. Although suitable rootstocks offer tolerance to chilling temperature, salinity, minerals toxicity and enhance uptake of nutrition to improved yield as well as fruit quality. Numerous factors influence the survival rate of grafted plants, including scion-rootstock compatibility, seedling age and condition, joint section quality, post-grafting handling, and rootstock resistance to soil-borne diseases.The best performing rootstocks (in terms of size and vigor) provides highest seed yield and quality. In general, grafting with ideal rootstocks causes seed emergence and germination to occur earlier (3 and 4 days respectively); percentage emergence and germination increased by more than 200 percent compared to non-grafted plants. Apart from wild watermelon species, Bottle gourd (*Lagenaria siceraria*) and Interspecific winter squash hybrid (*Cucurbita maxima*x*C. moschata*) are commonly preferred as rootstock in watermelon grafting.Throughout the study, there is no doubts that using appropriate rootstock/scion combinations will promote long-term watermelon production, and that using such strategies is crucial for watermelon farming.

Keywords

Grafting, Watermelon, *Citrullus lanatus*, Abiotic, rootstock, salinity

Introduction

Watermelon [*Citrullus lanatus* (Thunb.) Matsum. and Nakai] is an economically and nutritionally important fruit vegetable grown throughout the world. The species are native of Africa; cultivated from ancient times (Paris *et al.*, 2015). Currently, Asia contributed over 80% of worldwide watermelon production and 67.6% of worldwide production are accounted by China (Dube *et al.,* 2020). Even though the bulk of this production is consumed on the domestic market (Passam, 2003). The crop is cultivated in open fields as well as in low plastic tunnels across different regions (Guler *et al.*, 2014). Out of 71 identified volatile organic compound (VOCs) of watermelon (Yajime *et al.,* 1985); approx. ten VOCs responsible for its distinctive aroma in the fruits (Guler *et al.,* 2014). Grafting of vegetables seedlings is a unique horticultural technique (Fallik and Ilic, 2014); laid in early 20th century (late 1920s) in Japan and Korea with production of watermelon grafted on gourd (Davis *et al.,* 2008) where it was used to control soil-borne diseases such as Fusarium wilt. In East Asia; practiced for more than fifty years to overcome the problems associated with intensive cultivation in arable land. In late 20th century; introduced in Europe and others countries with improved grafting methods for commercial grafted vegetable seedlings production (Fallik and Ilic, 2014) and later on introduced in North America from Europe; and creating interest for both greenhouse growers and organic producers (Kubota 2008). Among cucurbits, grafted watermelon, melon and cucumber are undergoes commercial productions (Kong *et al.,* 2014). Grafting is laborious and time-consuming practices aimed to available scions with higher survival rates of the stocks (Johkan *et al.*, 2008).

The primary goal of this technique is to avoid damage caused by different soil related biotic and abiotic constraints where genetic and chemical approaches are not available (Oda, 2002). A right combination between scion and rootstocks not only develop tolerance/ resistance to biotic (soil borne diseases and pests) and abiotic stresses but also useful in enhancing plant vigour and yield through uptake of plant nutrient.

In grafting, susceptible watermelon plants grafted on resistance rootstocks to control soil-borne diseases (Davis *et al.,* 2008). Although suitable rootstocks offer tolerance to chilling temperature (Gao *et al.,* 2006; Shu *et al.,* 2016); salinity (Colla *et al.,* 2010); minerals toxicity (Gao *et al.,* 2015); and enhance uptake of nutrition (Huang *et al.,* 2016) to improved yield; fruit quality (Kyriacou *et al.,* 2015). However, rootstocks are also associated with negative effect in grafting (Kombo and Sari, 2019). Therefore, grafting with suitable rootstocks would be an efficient tool to counter different biotic and abiotic constraints arose in intensive watermelon farming.

Grafting methods

Hassell and Memmott (2008) in their literature mentioned that there are two grafting techniques; manual grafting and machine (automatic/ robot) grafting are practiced in watermelons. In manual, one cotyledon, tongue approach, and hole insertion grafting are mostly preferred methods by grower which is based on experience of grower, scion and rootstock purpose, and post-grafting management condition. Tongue approach method require space and adequate labors, mostly preferred by farmers who are non-experienced or looking for first time, because have a high survivor rate. Whereas, one cotyledon and hole insertion demands time for learning; and grafts durability require specialized tools and healing chamber. Automated method, is more forgiving and require less labor to operate. In Japan, 40 % watermelon grafts are prepared through this technique (Lee and Oda, 2003; Masanao and Hisaya, 1996; Suzuki *et al.,* 1998). Generally, one cotyledon type of grafting methods is performed by this machine, which is well adapted and has a high rate of success. Two operators with simple grafting machine can produce about 600 grafts per hour as compared with manual grafting produce ~ 1000 grafts by one person per day (Lee and Oda, 2003; Masanao and Hisaya, 1996; Suzuki *et al.,* 1998). Apart from it, uniformity in germination and growth as well as proper development of the rootstock and scion are critical for the machine-driven grafting.

Preparation of rootstock and scion of watermelon

1. Sowing of rootstocks seed just 5-7 days before sowing of scion either in trays or germination beds.
2. At the time scions emerge, the

cotyledon of rootstocks should be fully expanded.

3. In order to minimize pathogen, the scion should keep at low relative humidity conditions before grafting.
4. Scions should harvest just 1-2 days after emergence, followed by rinsed with clean water and treat with some fungicide and disinfectant *viz.* peroxyacetic acid/hydrogen peroxide etc to avoid damaging of grafts.
5. Optimal age of seedling used in grafting may vary with species and methods of grafting applied. Too young seedling results improper handling while too old seedling shows undesirable growth on the rootstock.
6. As per grafting methods is used, proper healing chamber is required for complete union of grafts. In tongue approach, adequate greenhouses with temperature controls are require. However, other methods are requiring a special healing chamber with light, humidity, and temperature controls systems.
7. In order to acclimatize the grafted plants to natural greenhouse conditions, slowing down the relative humidity and increase the light after 6 to 8 days of grafting is desirable.
8. As per Miguel (1996), the best conditions for grafting are 22 to 28 ^{0}C temperature, RH ~ 100%, and very low light intensity for the first 5 to 7 d.

Types of rootstock

Selection of better rootstocks is pre-requisite for successful grafting; it comprises solution from problem specifically related with rootstocks, No significant changes has arisen on other quality traits of scion and a good compatibility formed between scion and rootstock (King *et al.*, 2010; Kong *et al.*, 2014). Therefore, it is essential to test the candidate rootstock at small scale before going to larger level. The best rootstock selection is dependent on the production area, and many different rootstock species and cultivars , used for various conditions (Sakata *et al.*, 2007). Various species and varieties with range of grafting methods served as rootstocks for cucurbits crops (Karaagac and Balkaya, 2013). Several researches have been conducted for rootstock selection. Among these, Bottle gourd (*Lagenaria sinceraria*) and Interspecific winter squash hybrid (*Cucurbita maxima* X *C. moschata*) (Colla *et al.*, 2010; Kong *et al.*, 2014) are the two most commonly used rootstocks in watermelon grafting, as well as wild watermelon species (Davis *et al.*, 2008).

Abundant genetic diversity in *C. moschata*; offers great potential for rootstock breeding (Kong *et al.*, 2014). However, it is not necessary that all *C. maxima* and *C. moschata* germplasms would be a suitable rootstock for cucurbits crops (Kong *et al.*, 2014); it depends upon the genotype compatibility (Karaagac and Balkaya 2013).

Bottleguard was evaluated as suitable rootstock for watermelon grafting, because of its resistance to fusarium wilt, high affinity and stable growth of plant after grafting (Sakata *et al.*, 2007; Ling and Levi, 2007). In general, bottle gourd type rootstocks had a higher survival rate than other rootstocks (Yetisir and Sari; 2003; Sayed *et al.*, 2015).

Lagenaria siceraria (Mol.) Standley is one of the species commonly used as rootstock for watermelon to increase plant growth and enhance water transport and plant nutrition (Oda, 1995). In Japan, Bottle gourd is currently the most commonly used rootstock for watermelon grafting. While in Spain, it is not used because of its susceptibility to monosporascus vine decline (Davis *et al.*, 2008).

Disease management in watermelon

Traditional approaches to deal with problem posed by Fusarium infestation such as crop rotation is limited only for extensive watermelon production. However, in intensive limited availability of soil in off season horticulture forces the farmers to grow same crop almost every year which aggravates the problem caused by Fusarium infestation Miguel *et al.,* 2004**.**

Fusarium Wilt (*Fusarium oxysporum*)

Fusarium Wilt (*Fusarium oxysporum* f. sp. niveum (E.F. Sm.) W.C. Snyder and H.N. Han.) is well established disease in watermelon growing regions throughout the world and frequently is the main factor for limiting production of triploid (seedless) watermelon (Zhou *et al.,* 2010). *F. oxysporum* f. sp. *niveum* is host specific and limited to watermelon production only, with few exception (Martyn *et al.,* 1996; Zhou and Everts, 2007). Three races (0, 1, and 2) of F. oxysporum. f. sp. niveum have been described in watermelon (Martyn *et al.,* 1996; Zhou and Everts, 2010). After 37 years discovery of race 2; a fourth genetic strain (race 3) of *F. oxysporum* f. sp. niveum evaluated in soil of Maryland by Zhou and Everts, 2010.

Traditional approaches to deals Fusarium infestation such as implementation of crop rotation is limited only for extensive watermelon production. However, in intensive limited availability of soil in off season horticulture forces the farmers to grow same crop almost every year which aggravates the problem caused by Fusarium infestation Miguel *et al.,* 2004**.** Once infested in field, then require long term crop rotation (5 to 10 years) and leave soil fallow to reduce the population, but does not exterminate Martyn, 1991. There are numerous factors affecting the survival rate of grafted plant namely compatibility between scion and rootstock, age and quality of seedlings; joint section quality; post-grafting management and resistance of rootstock to soil borne diseases (Sayed *et al.,* 2015). Plant survival and yield were the highest in plants grafted onto several *Cucurbita maxima* × *Cucurbita moschata* hybrids grown in Fusarium-infestated soils Miguel *et al.,* 2004. In late 1920, the first report of vegetable grafting came from Japan and Korea where resistance for Fusarium wilt was conferred in watermelon by used of Pumpkin (*Cucurbita moschata*) as rootstock (Lee *et al.,* 1994; Sakata *et al.,* 2007). Interspecific squash hybrid (C. *maxima* X C. *moschata)* characterized by resistance to Fusarium wilt (caused by *Fusarium oxysporum*) for the production of watermelon (Davis *et al.,* 2008). Paroussi *et al.,* 2007 got more vigorous plants and higher fruit yield in 'Crimson Sweet' (watermelon cv.) for all treatments with or without inoculation by *Fusarium oxysporum* f. sp. niveum and *Verticillium dahlia* pathogen when grafted rootstocks of squash hybrid *viz.* 'Mamouth' (C. *maxima* X C. *moschata*) followed by bottlegourd (*Lagenaria sinceraria*) and the non-grafted plants.

Survival rate of the plants was the main factor in the determination of fruit yield Miguel *et al.,* 2004. During, 1960s in South-Japan, new f. sp. of bottle gourd, *F. oxysporum* Schl. f. sp. *lagenariae* Matsuo et Yamamoto began to occur in bottle gourd-grafted–watermelon and by 1970 disease had spread throught Japan. Kuwata *et al.,* 1981 suggested it was due to complex interaction between scion and rootstock. Resulted, replacement of bottle gourd rootstock by *Cucurbita spp.* that offer resistant to both physiological and pathological causes of the wilting. Due to dissatisfaction of fruit quality with Cucurbita spp., with the successful selection of new resistant accession of bottle gourd by Matsuo *et al.,* (1985) bottle gourd widely used in watermelon cultivation again in Japan (Sakata *et al.,* 2007).

Fruit yield and quality

Although, grafting of watermelon provides better plant growth by the time of transplanting, but the fruit quality mostly depends on scion-rootstock combination (Petropoulos *et al.,* 2012). Shape and other fruit quality attributes of watermelon grafted on bottle gourd, wax gourd, and watermelon grafted watermelon are excellent (Sakata *et al.,* 2007). In contrast, the total sugar content of watermelon grafted onto bottle gourd rootstock was reported to be lower (did not significantly differ) than in self-rooted watermelons (Liu *et al.,* 2006). Fruit shape of watermelon was not significantly affected by a grafting (Alan *et al.,* (2007); Sayed *et al.,* 2015). Interspecific squash hybrid (C. *maxima* X C. *moschata*) rootstocks most consistently increase pulp firmness in both diploid and triploid watermelon scions (Bruton *et al.,* 2009; Soteriou and Kyriacou, 2015). Grafting diploid watermelon hybrid cultivars on *C. maxima* × *C. moschata* rootstocks enhances plant vigor and improves overall fruit quality and storability through sustained higher fruit lycopene content; improved flesh color and limited discoloration during storage (Kyriacou and Soteriou, 2015). Miguel *et al.,* (2004) found no difference in soluble solids concentrations of watermelon fruit from scions grafted onto a squash interspecific hybrid versus control. Kyriacou and Soteriou, 2015 worked on the postharvest performance of diploid watermelon cultivar grafted on three *Cucurbita maxima* × *C. moschata* rootstocks, they found that improvement in fruit quality and storability and there was limited reduction in soluble solids content in response to grafting which is not detrimental to fruit quality. Grafting improved pulp texture, bioactive composition in watermelon fruit and also minimized the suppression of sugar content at full commercial maturity when *Cucurbita maxima* and *Cucurbita moschata* served as rootstocks (Kyriacou *et al.,* 2015). Rind thickness, a morphological trait related with watermelon harvest maturity are responsive to grafting and to cultural practices (Soteriou *et al.,* 2015; Kyriacou *et al.,*2016); thickening of watermelon rind is often observed when grafted on commercial rootstock C. *maxima* × C. *moschata* and L. *siceraria* especially landraces of latter (Yetisir *et al.,* 2003). Grafting increased fruit rindness in watermelon-grafted-'Emphasis' (*Lagenaria sinceraria*) compared to control, but it was not significant.

Plants grafted onto Lagenaria type rootstocks produced larger fruit than control plants and the plants grafted on *Cucurbita* type rootstocks. Fruit weight (5.538 kg) and plant yield (12.129 kg) were significantly increased in watermelon as compared with non-grafted control (3.569 kg and 8.529 kg, respectively) when 'Emphasis' (*Lagenaria sinceraria*) used as rootstocks (Sayed *et al.,* 2015). On comparison with self rooted plants, watermelon cv. Sugar Baby and Crimson Sweet increases vine length, leaf areas, and mean fruit weight at harvest when grafted on rootstock RS 841 F1 (*Cucurbita maxima* × *C. moschata*) or bottlegourd [*Lagenaria siceraria* f. *clavata*] and plus *L. siceraria* f. *pyrotheca*. whereas, sugar content are mostly affected by scion-rootstock combination (Petropoulos *et al.,* 2012).

Plants grafted on Argentario (*Lagenaria siceraria* (Mol.) rootstock were only significantly superior in their vigor than non-grafted ones. This increased vegetative growth may be due to the increasing in the area connection and the speedily differentiation from callus or cambium to vascular tissues (xylem and phloem) in the union area in the scion and rootstock of Argentario as compared with Kazako rootstock. In addition, Argentario rootstock might induce more amounts from gibberellins and auxins (Sayed *et al.*, 2015). Grafting of Watermelon cv. Crimson Sweet upon plus *L. siceraria* f. *pyrotheca* rootstock showed taller plants than other rootstocks (RS 841 F1 (*Cucurbita maxima* × *C. moschata*) or bottlegourd [*Lagenaria siceraria* f. *clavata*]) combination (Petropoulos *et al.*, 2012).

Seed yield and quality

Besides cultural practices and environment situation; the successful yield of crop could be increased upto 15-20 % by use of quality seeds (Ambika *et al.,* 2014). Kombo and Sari, 2019 concluded that the best performing rootstocks (in size and vigourness) provides highest seed yield and quality. Cucurbit rootstock 'NUN - 9075' (*Cucurbita maxima* × *Cucurbita moschata*) showed the highest seed emergence percentage (91.0%); seed germination percentage (97.5%) with watermelon cv. Crimson Sweet (as scion) compared to other rootstocks of 'Argentario' (*Lagenaria siceraria*), citron watermelon cv. PI 296341 (*Citrullus amarus Schard*) and non-grafted plants (Kombo and Sari, 2019).

Generally grafting with suitable rootstocks results earliness in seed emergence and germination (3 and 4 days respectively); percentage emergence and germination increased more than 200% as compare to non-grafted plants (Kombo and Sari, 2019).

Environment tolerance

Temperature

Root is helpful in determining the low temperature stress of plants Shu *et al.*, 2016. Thus, screening of ecologically well adaptable rootstocks is a successful approach to facilitate the cold tolerance and growth of scion Gao *et al.,* 2006; Shu *et al.*, 2016. Petropoulos *et al.,* 2012 studied on post transplantation growth performance and fruit quality at harvest of grafted watermelon cv. Sugar Baby and Crimson Sweet plants by providing 8^{o}C or 16^{o}C (minimum temperature) during the post-grafting phase; observed that plants grown at 16^{o}C were comparable taller and consists higher fresh weight than those at 8^{o}C; that indicates that relatively high temperature is required for healing process. As such demands, earliness in watermelon is desirable, therefore rootstock that exhibits chilling tolerance have great importance (Bletsos and Passam, 2010). Grafting increased chilling tolerance in watermelon; that may related with higher anti-oxidative ability and membrane stability of plants (Liu *et al.,* 2003). Grafting watermelon, melon, cucumber, even summer squash onto low temperature tolerant rootstocks such as interspecific hybrid between *Cucurbita maxima* Duch. × *C. moschata* Duch. or figleaf gourd can greatly reduce the risk of severe growth inhibition caused by low soil temperatures in winter greenhouses (Lee *et al.,* 2010). Compare to wax gourd and pumpkin, the growth of bottle-gourd-grafted watermelon plants during the low-temperature period in spring was faster, as wax gourd requires higher temperatures (Sakata *et al.,* 2007). Storage of grafted watermelon seedlings under low temperature in darkness is comparatively more suitable than non-grafted ones. In addition, it had more soluble sugar and chlorophyll contents, higher activities of antioxidant enzymes, and less malondialdehyde content than the non-grafted ones after 6 days of storage (Ding *et al.,* 2011).

Drought: Grafting for drought resistance consist high yielding genotypes as scion with rootstocks having higher water absorption potential than the roots of scion; improved crop performance under restricted water supply (Proietti *et al.,* 2008).

Salt: Physiological mechanisms such as lowering in water potential of rooting media, toxicity due to Na^+ and Cl^- and nutrient imbalance by depression in uptake and/or shoot transport are arises due to salinity conditions (Lauchli, 1986) that affect the growth, production and quality of plant produce globally (Mizrahp and Pasternak 1985) or in arid and semi arid regions (Parida and Das, 2005) and it become crucial for the future of local agriculture development and farmers income (Zong *et al.,* 2011), they reported decline in fruit number (27.69%), firmness, fresh seed weight per fruit of watermelon. While, Crude protein content got increase (up to 40%), TSS content (27.13% - 42.68%) and soluble carbohydrates (3.64% - 12.73%) under different salt treatments. Salinity causes reduction in fruit mean mass resulting total yield loss, although the number of fruits per plant under treatments was not significant (Colla *et al.,* 2010).

In cucurbits, grafting would be an effective tool that can reduce yield loss cause by salinity stress (El-Eslamboly *et al.,* 2014). Colla *et al.,* 2010 worked watermelon grafting onto two commercial rootstocks of *Lagenaria siceraria* (Mol.) Standl. and *Cucurbita maxima* Duch. × *C. moschata* Duch under two salinity levels (2 and 5.2 dSm^{-1}), there was no salinity x grafting interaction for different traits excepts peel and pulp percentage; highest pulp % were recorded in both grafted combinations receiving a saline nutrient solution. the pulp values decreased whereas peel values increase in response to an increase of nutrient solution salinity for grafted plants. Moreover, leaf Na^+ concentration had reduced in grafted combination but not for Cl^-.

Minerals use efficiency

Availability of mineral nutrients and its utilizations into stem, leaves, and fruits of grafted plants is determined by its rootstocks (Huang *et al.,* 2016) or is related to rootstock and scion combinations (Huang *et al.,* 2013; Yetisir and Erhan, 2013). Watermelon cultivar 'Zaojia 8424' was grafted onto pumpkin 'Qingyanzhen 1' (*Cucurbita maxima* × *C. moschata*) rootstocks exhibited significantly higher root surface area, number of root tips, and volume as compare with non-grafted plants. They reported that the total uptake of minerals nutrient (N, K, Ca, Fe, Mg, and Mn) were increased by 30.41% and 49.14% at fruit development stage and by 21.33% and 47.46% at fruit maturation stage when grafted onto bottle gourd 'Jingxinzhen 1'(*Lagenaria siceraria*) and pumpkin 'Qingyanzhen 1' (*Cucurbita maxima* × *C. moschata*) rootstocks respectively, compared with non-grafted plants, especially for N in the pumpkin rootstock grafted plants, thereby affecting plant growth, fruit yield, and quality. (Pulgar *et al.,* 2000) reported that Pumpkin {*Cucurbita pepo* L. cvs. Brava, Shintoza and Kamel} rootstock showed high Nitrogen uptake and assimilation which results in enhancement in growth of watermelon (*Citrullus lanatus* [Trumb.] Mansfeld cv. Early Star) plant when used as scion.

However, Colla *et al.,* 2010 observed no significant difference in nitrogen status when watermelon cv. 'Ingrid' grafted for alkalinity tolerance (Martínez-Ballesta, 2010).

In conclusion, grafting on disease- resistant rootstocks is a growing practice in watermelon cultivation worldwide. There are numerous factors affecting the survival rate of grafted plant namely compatibility between scion and rootstock, age and quality of seedlings; joint section quality; post-grafting management and resistance of rootstock to soil borne diseases. Apart from wild watermelon species, Bottle gourd (*Lagenaria siceraria*) and Interspecific winter squash hybrid (*Cucurbita maxima* X *C. moschata*) are commonly preferred as rootstock in watermelon grafting. This report gives an overview to how the grafting on watermelon affected its quality including physical properties, flavour, soil related biotic and abiotic constraints, also useful in enhancing plant vigour and yield through uptake of plant nutrients. There are many contradictory findings also available about the advantageous or deleterious effects of grafting on fruit quality.

Despites of disease resistance and vigorousness, more breeding work is needed to select a perfect graft combination having high fruit quality attributes for different climatic and geographic conditions. Throughout the review, there is no doubt that the use of suitable rootstock/scion combinations would endorse sustainable production of watermelon. Thus, employment of grafting techniques is imperative for intensive watermelon farming.

References

Alan, O., Zdemir, N., and Nen, Y. (2007). Effect of grafting on watermelon plant growth, yield and quality. *J. Agron*. 6, 362–365.

Ambika, S., Manonmani V. and Somasundaram, G. (2014). Review on Effect of Seed Size on Seedling Vigour and Seed Yield. *Research Journal of Seed Science*, 7, 31-38.

Bruton, B.D., Fish, W.W., Roberts, W., and Popham, T.W. (2009). The influence of rootstock selection on fruit quality attributes of watermelon. *Open Food Sci. J*., 3, 5-34.

Bletsos, F., Passam, H.C., (2010). Grafting: an environmentally friendly technique to overcome soil-borne diseases and improve the out of season production of watermelon, cucumber and melon. In: Sampson, A.N. (Eds.), Horticulture in the 21st Century, Nova, N.Y. Pp. 81-120.

Colla, G., Rouphael, Y., Cardarelli, M., Salerno, A., and Rea, E. (2010). The effectiveness of grafting to improve alkalinity tolerance in watermelon. *Environmental and Experimental Botany*, 68(3), 283-291.

Ding, M., Bie, B., Jiang, W., Duan, Q., Du, H., and Huang, D. (2011). Physiological advantages of grafted watermelon (*Citrullus lanatus*) seedlings under low-temperature storage in darkness. *Hort Science*, 46(7), 993-996.

Davis, A. R., Perkins-Veazie, P., Sakata, Y., Lopez-Galarza, S., Maroto, J. V., Lee, S. G., and Cohen, R. (2008). Cucurbit grafting. *Critical Reviews in Plant Sciences*, 27(1), 50-74.

Dube, J., Ddamulira, G., and Maphosa, M. (2020). Watermelon production in Africa: challenges and opportunities. *International Journal of Vegetable Science*, 1-9.

El-Sayed, S.F., Haassan H.A. and Gaara, M.A. (2015). Effect of different rootstocks on plant growth, yield and quality of watermelon. Annals of

Agric. Sci., Moshtohor ISSN 1110-0419 Vol. 53(1) (2015), 165– 175.

El-Eslamboly, A. A. S. A., and Abdel-Wahab, M. A. S. (2014). Grafting salinity tolerant rootstocks and magnetic iron treatments for cantaloupe production under conditions of high salinity soil and irrigation water. *Middle East J. of Agric. Res*, 3(3), 677-693.

Fallik, E., and Ilic, Z. (2014). Grafted vegetables–the influence of rootstock and scion on postharvest quality. *Folia Horticulturae*, 26(2), 79-90.

Gao, Q. H., Wu, Y., Xu, K. and Gao, H. (2006). Responses of grafted eggplant seedling roots to low temperature stress. *Chinese J App Environ Biol.*, 17, 390-394

Gao, P., Xing, W.W., Li, S.H., Shu, S., Li, H., Li, N., Shao, Q.S., and Guo, S.R. (2015). Effect of pumpkin rootstock on antioxidant enzyme activities and photosynthetic fluorescence characteristics of cucumber under Ca $(NO_3)_2$ stress. *Acta Hort.*, 1086, 177–188.

Guler, Z., Candir, E., Yetisir, H., Karaca, F. and Solmaz, I. (2014). Volatile organic compounds in watermelon (*Citrullus lanatus*) grafted onto 21 local and two commercial bottle gourd (*Lagenaria siceraria*) rootstocks. *Journal of Horticultural Science and Biotechnology*, 89 (4), 448–452.

Huang, Y., Li, J., Hua, B., Liu, Z., Fan, M., and Bie, Z. (2013). Grafting onto different rootstocks as a means to improve watermelon tolerance to low potassium stress. *Scientia Horticulturae*, 149, 80-85.

Huang, Y., Zhao, L., Kong, Q., Cheng, F., Niu, M., Xie, J. and Bie, Z. (2016). Comprehensive mineral nutrition analysis of watermelon grafted onto two different rootstocks. *Horticultural Plant Journal*, *2*(2), 105-113.

Hassell, R. L., Memmott, F., and Liere, D. G. (2008). Grafting methods for watermelon production. *HortScience*, 43(6), 1677-1679.

Johkan, M., Oda, M. and Mori, G. (2008). Ascorbic acid promotes graft-take in sweet pepper plants (Capsicum annuum L.). *Sci Hortic*, 116, 343-347.

Karaagac, O. and Balkaya, A. (2013). Interspecific hybridization and hybrid seed yield of winter squash (*Cucurbita maxima* Duch.) and pumpkin (*Cucurbita moschata* Duch.) lines for rootstock breeding. *Scientia Horticulturae*, 149, 9-12.

King, S.R., Davis, A.R., Zhang, X.P., Crosby, K. (2010). Genetics, breeding and selectionof rootstocks for Solanaceae and Cucurbitaceae. *Sci. Hortic*., 127, 106–111.

Kombo, M. D., and Sari, N. (2019). Rootstock effects on seed yield and quality in watermelon. Horticulture, Environment, and Biotechnology, 60(3), 303-312.

Kong, Q., Chen, J., Liu, Y., Ma, Y., Liu, P., Wu, S., Huang, Y., Bie, Z. (2014). Genetic diversity of Cucurbita rootstock germplasm as assessed using simple sequence repeat markers. *Scientia Horticulturae* 175, 150–155.

Kubota, C., McClure, M. A., Kokalis-Burelle, N., Bausher, M. G., and Rosskopf, E. N. (2008). Vegetable grafting: History, use, and current technology status in North America. *HortScience*, 43(6), 1664-1669.

Kyriacou, M. C., and Soteriou, G. (2015). Quality and postharvest performance of watermelon fruit in response to grafting on interspecific cucurbit rootstocks. Journal of Food Quality, 38(1), 21-29.

Läuchli, A. (1984, December). Responses and adaptations of crops to salinity. In Symposium on Tomato Production on Arid Land 190 (pp. 243-246).

Lauchli, A. (1984). Salt exclusion: An adaption of legumes for crops and pastures under saline conditions. In R.C. Staples and G.H. Toennissen, eds., "Salinity Tolerance in plants", Wiley Inter Science, New York, pp. 171-188.

Lee, J.M. and Oda, M. (2003). Grafting of herbaceous vegetable and ornamental crops. Hort. Rev. (Amer. Soc. Hort. Sci.) 28, 61–124.

Lee, J.M., Kubota, C., Tsao, S.J., Hoyos Echevarria, P., Morra, L. and Oda, M., (2010). Current status of Vegetable grafting: diffusion grafting techniques, automation. *Sci. Hortic.*, 127, 93–105.

Lee, J. M. (1994). Cultivation of grafted vegetables: Current status, grafting methods, and benefits. *Hortscience* 29, 235–39.

Ling, K. S., and Levi, A. (2007). Sources of resistance to Zucchini yellow mosaic virus in Lagenaria siceraria germplasm. *HortScience*, 42(5), 1124-1126.

Liu, H.Y., Zhu, Z.J., Lu, G.H., Qian, Q.Q. (2003). Study on relationship between physiological changes and chilling tolerance in grafted watermelon seedlings under low temperature stress. *Sci. Sinica Agric*., 36, 1325-1329.

Liu, Y.Q., Liu, S.Q., Wang, H.B. (2004). Effect of salt-tolerant stock on growth, yield, and quality of watermelon, *Shandong. Agric. Sci.* 4, 30-31.

Liu, H.Y., Zhu, Z.J., Diao, M., Guo, Z.P. (2006). Characteristic of the sugar metabolism in leaves and fruits of grafted watermelon during fruit development. *Plant Physiol. Commun*., 42, 835-840.

Martyn, R.D. and Netzer, D. (1991). Resistance to races 0, 1, and 2 of *Fusarium oxysporum f. sp. niveum* in PI-296341-FR (*Citrullus* sp.) *HortScience* 26, 429-432.

Martyn, R. D. (1996). Fusarium wilt of watermelon. Pages 13-14 in: Compendium of Cucurbit Diseases. T. A. Zitter, D. L. Hopkins, and C. E. Thomas, eds. American Phytopathological Society Press, St. Paul, MN.

Martínez-Ballesta, M. C., Alcaraz-López, C., Muries, B., Mota-Cadenas, C., and Carvajal, M. (2010). Physiological aspects of rootstock–scion interactions. *Scientia Horticulturae*, 127(2), 112-118.

Masanao, U. and Y. Hisaya. (1996). Development of full automatic grafting robot for fruit vegetables. Robot Tokyo. 109, 59–65.

Matsuo, S., Ishiuchi, D. and Kohyama, T. 1985. Breeding of new cultivars of bottle gourd ‘Renshi’ for rootstock of watermelon. Bull. Veg. Ornam. Crops Res. Stn. Japan, C8:1-21 (in Japanese with English summary).

Miguel, A. and Maroto, J.V. (1996). El injerto herbáceo en la sand´ıa (*Citrullus lanatus*) comom alternativa a la desinfección qu´ımica del suelo. Investigación Agraria. Producción y Protección Vegetales 11, 239–253.

Miguel, A., Maroto, J. V., San Bautista, A., Baixauli, C., Cebolla, V., Pascual, B. and Guardiola, J. L. (2004). The grafting of triploid watermelon is an advantageous alternative to soil fumigation by methyl bromide for control of Fusarium wilt. *Scientia Horticulturae*, *103*(1), 9-17.

Mizrahp, Y. and Pasternak, D. (1985). Effect of salinity on quality of various agricultural crops. *Plant and Soil*, 89, 301-307.

Oda, M. (1995). New grafting methods for fruit-bearing vegetables in Japan. Japan Agricultural Research Quarterly, JARQ., 29,187-194.

Oda, M. (2002). Grafting of vegetable crops. Sci. Rep. Agric. Biol. Sci., Osaka Pref. Univ. 53: 1–5.

Passam, H. C. (2003). Use of grafting makes a comeback. *Fruit Veg. Technol*, *3*(4), 7-9.

Paroussi, G., Bletsos, F., Bardas, G. A., Kouvelos, J. A., and Klonari, A. (2004, September). Control of Fusarium and Verticillium wilt of watermelon by grafting and its effect on fruit yield and quality. In *III Balkan Symposium on Vegetables and Potatoes 729* (pp. 281-285).

Parida, A. K., and Das, A. B. (2005). Salt tolerance and salinity effects on plants: a review. *Ecotoxicology and environmental safety*, 60(3), 324-349.

Paris, H. S. (2015). Origin and emergence of the sweet dessert watermelon, Citrullus lanatus. *Annals of Botany*, 116(2), 133-148.

Petropoulos S. A., Khah E. M. and Passam H. C. (2012). Evaluation of rootstocks for watermelon grafting with reference to plant development, yield and fruit quality. *International Journal of Plant Production.* 6(4): 481-492.

Proietti, S., Rouphael, Y., Colla, G., Cardarelli, M., Agazio, M. D., Zacchini, M., Rea, E., Moscatello, S. and Battistelli, A. (2008). Fruit quality of mini-watermelon as affected by grafting and irrigation regimes. *Journal of the Science of Food and Agriculture*, 88,1107–1114.

Pulgar, G., Villora, G., Moreno, D. A., and Romero, L. (2000). Improving the mineral nutrition in grafted watermelon plants: Nitrogen metabolism. *Biologia Plantarum*, *43*(4), 607-609.

Sakata, Y., Ohara, T., and Sugiyama, M. (2005, September). The history and present state of the grafting of cucurbitaceous vegetables in Japan. In: *III International Symposium on Cucurbits 731* (pp. 159-170).

Soteriou, G. A., and Kyriacou, M. C. (2015). Rootstock-mediated effects on watermelon field performance and fruit quality characteristics. *International journal of vegetable science*, 21(4), 344-362.

Shu, C., Yang, R., Yin, L., Ai, X., Wang, S. and Zhao, W. (2016). Selection of Rootstocks for Better Morphological Characters and Resistance to Low-Temperature Stress in the Sweet Pepper Cultivar ‘Hongxing No. 2’. *Hortic. Environ. Biotechnol*., 57(4), 348-354.

Suzuki, M., S. Sasaya, and Kobayashi, K. (1998). Present status of vegetable grafting systems. *Japan Agr. Res.*, Quarterly 32, 105–112.

Yajima, I., Sakakibara, H., Ide, J., Yanai, T. and Hayashi, K. (1985). Volatile flavour components of watermelon. *Agricultural and Biological Chemistry*, 49, 3145–3150.

Yetisir, H., and Erhan, A. (2013). Rootstocks effect on plant nutrition concentration in different organ of grafted watermelon.

Yetisir, H., and Sari, N. (2003). Effect of different rootstock on plant growth, yield and quality of watermelon.

Australian journal of experimental agriculture, 43(10), 1269-1274.

Zhou, X.G. and Everts, K.L. (2007). Characterization of a Regional Population of *Fusarium oxysporum f. sp. niveum* by Race, Cross Pathogenicity, and Vegetative Compatibility. Phytopathology 97, 461–469.

Zhou, X. G., Everts, K. L., and Bruton, B. D. (2010). Race 3, a new and highly virulent race of *Fusarium oxysporum f. sp. niveum* causing Fusarium wilt in watermelon. *Plant Dis*. 94, 92-98.

Zong, L., Tedeschi, A., Xue, X., Wang, T., Menenti, M., and Huang, C. (2011). Effect of different irrigation water salinities on some yield and quality components of two field-grown Cucurbit species. *Turkish Journal of Agriculture and Forestry*, 35(3), 297-307.