# paper

*by* Avg Paper

# Creasing in Sweet Orange (*Citrus sinensis* L. Osbeck): The Role of Aminoethoxyvinylglycine

**Zahoor Hussain[1, 2*], Zora Singh[2], Raheel Anwar[3], M. Irfan Ullah[1], Faheem Khadija[4] and Mujahid Ali[1]**

*[1]University College of Agriculture, University of Sargodha-Sargodha.*

*[2]Curtin Horticulture Research Laboratory, Curtin University, Perth, Australia.*

*[3]Institute of Horticultural Sciences, University of Agriculture, Faisalabad.*

*[4]Citrus Research Institute, Sargodha*

***For correspondence:** zahoor.hussain@uos.edu.pk

## Abstract

Creasing is known as albedo breakdown and a physiological disorder in sweet oranges. In the current study, aminoethoxyvinylglycine (AVG) a reversible ethylene inhibitor with different concentration (0, 20, 40 and 60 mg $L^{-1}$) was sprayed at various fruit developmental stages such as fruit set (FS), golf ball (GB) and color break (CB) stage to alleviate creasing as well as to promote textural properties of sweet orange fruit in cv. 'Washington Navel (W. Navel) and Lane Late (L. Late) was investigated. At ripening 35-fruit/replication were collected randomly from tree to check the albedo breakdown and fruit rind characteristics. Creasing was substantially alleviated with the spray application of AVG and fruit quality was significantly improved. The creasing was significantly reduced when AVG (60 mg $L^{-1}$) was sprayed at GB (27.86% and 24.29%) stage with respect to control (52.14 and 51.53%) in W. Navel during both years, respectively. The spray application at FS stage (22.86%) was more active than the control (51.43%) in cv. L. Late sweet orange during second harvest season. In conclusion, all the applications of AVG substantially alleviate the creasing (%), improve the textural properties, fruit weight, diameter and rind thickness of W. Navel and L. Late oranges.

**Keywords:** Sweet orange; creasing; ethylene inhibitor; AVG; fruit quality

## Introduction

Sweet orange belongs to genus citrus which is an important genus for flowering plants and belongs to family Rutaceae. It is originated from subtropical as well as tropical regions in the world (Ismail and Zhang, 2004) and many species thought to be native of China. However, the genus citrus includes sweet orange, mandarins. Lime lemon and grape fruit. According to area and production, citrus is 2nd most important horticultural crop after grapes in the whole world. Sweet orange is leading citrus group which grown all over the world (FAOSTAT, 2013).

Quality is a primary concern to citrus producers and processor as well as consumers and is determined by the fruit firmness, smoothness, gloss and colour. However, the sweet orange fruit attractive due to its fruit rind. The citrus fruit peel is composed of white tissues known as albedo and orange tissues which are known as flavedo. Albedo tissues of fruit rind prone to rupture which is known as creasing in sweet oranges (Monselise *et al*., 1976). Creasing affects different cultivars of citrus like W. Navel, Valencia, Navelina and Nova mandarins (Ali *et al*., 2000; Gambetta *et al*., 2000; Greenberg *et al*., 2006; Hussain, 2014; Saleem *et al*., 2014; Hussain and Singh, 2015 a & b). However, creasing was first time reported by Le-Roux and Crous, (1938) in South Africa during 1938. Now, albedo breakdown is prime issue in orange producing countries in the world such as South Africa, USA, China, Spain and Uruguay as well as in Australia (Bower, 2004; Greenberg *et al*., 2006; Hussain, 2014; Hussain and Singh, 2015 a & b). According to an estimate more than 50 % Australian sweet orange loss due to creasing (Treeby *et al*., 1995; Bower, 2004; Treeby *et al*., 2007). It is very difficult to detect creasing at early stage of fruit development. However, it is easily detectible at maturity and the color break stage of fruit developmental (Monselise *et al*., 1976). There are so many factors are involved in development of creasing such as crop fruit size, rind thickness, deficiency of elements, fruit position, load and irrigation (Treeby *et al*., 2007; Bower, 2004). Although, it has been previously described that ethylene is involved for creasing in oranges, but the existing information is unconvincing.

It is well known that citrus fruit is in non-climacteric nature, which produce very limited amount of endogenous ethylene and respiration process is also very slow. Ethylene is a gaseous plant hormone which is used as ripening agent and changing fruit colour in citrus (Bleecker, 2000; Ladaniya, 2007). Rath and Prentice (2004) and Ladaniya (2007) stated that ethylene also plays important role in softening of fruits and vegetables due to decaying cell membranes. The application of ethephone or ethereal as ethylene source significantly improved the ripening, respiration and color changes in sweet oranges (Augustí *et al*., 2002; Burg, 2004; Ladaniya, 2007). However, it is reported previously that ethylene played key role in creasing of oranges (Monselise *et al*., 1976; Pham, 2009; Hussain, 2014). Currently, Hussain and Singh (2015b) claimed higher ethylene production in the creased fruit with respect to normal ones in oranges. It has been reported that ethylene biosynthesis can be inhibited by the use of $CoSO_4$ and 1-Methylcyclopropene (1-MCP) as well as polyamines (PAs). AVG is an inhibitor of ethylene biosynthesis which inhibit the activities of 1-aminocyclopropane-1-carboxylic acid (ACC) in plant tissues (Rath *et al*., 2006). AVG is commonly available in the market in the name of 'ReTain™' which is used for pre-harvest for improving physiological disorders such as fruit drop in different fruit plants especially temperate fruits (Rath *et al*., 2006). Similarly, Al-Husseini (2012) also conducted an experiment of AVG (20-60 mg $L^{-1}$) to determined drops and quality oranges. In the current research work, the role of AVG on creasing (%), rind textural characteristics, weight, diameter and rind thickness at different fruit developmental stages like FS, GB and CB in orange cultivars (W. Navel and L. Late) was evaluated.

## Materials and Methods

### Experimental Details and Treatments

**Experimental Details:** The current study was done on commercial citrus groove which is located in Gingin (latitude 21° 31° S, longitude 55° 155° E) Western Australia. 25-year old uniform oranges trees of W. Navel and L. Late were used in both experiments. Trifoliate orange is common stock which is used for grafting sweet oranges in Australia.

**Experiment No. 1.**

**of AVG sprayed at different fruit developmental stages in sweet orange cv. W. Navel**

In the 1st experiment, an aqueous solution containing different concentrations of AVG, applied at the FS, GB and at the CB stage on creasing incidence, textural properties of rind, weight, diameter and rind thickness was studied in sweet orange cv. W. Navel.

**Experiment No. 2. Evaluating Different Concentrations of Aminoethoxyvinylglycine (AVG) applied at different fruit developmental stages in Sweet Orange cv. L. Late**

The 2end experiment was performed on lane late oranges by using the same spray treatments of AVG at same fruit developmental stages and same parameters were recorded as described in experiment no. 1.

**Treatments and Experimental Design:** Different concentration of AVG (20, 40 and 60 mg $L^{-1}$) was sprayed at FS (Fruit size: 15±5 mm), GB (Fruit size 40±5 mm) and CB stage (Fruit size: 80±5 mm) of W. Navel and L. Late by spraying with hand sprayer (The Selecta Trolleypak Mk II, Acacia Ridge, Australia). Both experiments were conducted under randomised complete block design (RCBD) with two factors (treatments and stages of AVG application).

**Data Collection:** The experiment was repeated in two consecutive years {2011 (a) and 2012 (b)}. The data were not pole due to difference in mean squares during both seasons were heterogeneous. The detail of all the parameters studied in the current study is given as:

**Creasing (%):** At commercial maturity, 35-fruit harvested per replication from both cultivars to determine the incidence of creasing (%). The creasing (%) was observed by the recommendation of Treeby et al., (1995) and Pham, (2009) based on the effected fruit. The following formula was used to calculate the creasing (%).

$$\text{Creasing (\%)} = \frac{\text{(Total number of creased fruit) x 100}}{\text{Total number of fruit assessed}}$$

**Textural properties:**

Textural properties were recorded by using a textural analyzer (TA Plus, AMETEK Lloyd instruments Ltd., Hampshire, UK). The collected data were subject to processes by using Nexygen® 4.6 software and details are as:

**Compression force (N):**

The compression force measured with the help of textural analyzer. 10-fruit per replication selected with 75 mm height and test was established at strain of 50% of fruit length with 200 mm/minutes speed.

**Rind hardness test (N):**

Different 10-fruit per replication were selected for rind hardness. The fruit rind was peeled (2.5 cm wide × 0.6 cm thick) by slicer (Zyliss slice 2 folding Mandolin Slicer, Swiss). A 4 mm diameter cylinder probe was used to check rind hardness, attached to the load cell and all the samples were placed onto the flat plate. Hardness was the first penetration of probe at speed of 100 mm/minutes and expressed as force (N).

**Rind tensile strength test (N):**

To measure the tensile strength, rind of orange carefully removed at a size of (2.5 x 5 cm area with 6 mm thickness). The tensile force was measured at the maximum load and limit points where the rind deflection occurred.

**Measurement of fruit weight, diameter and rind thickness:**

Ten fruit were selected from randomly harvested fruit to measure weight on digital balance (GF-10K, A&D Limited, Tokyo, Japan) and mean fruit weight was calculated by dividing ten on total fruit weight and expressed in gram (g). Similarly, Fruit diameter and rind thickness of selected were determined by using digital Vernier calliper from each treatment and expressed in mm.

**Results**

**Creasing (%):** Creasing (%) significantly alleviated by the exogenous application of AVG at FS, GB and CB stage in sweet oranges cv. W. Navel and L. Late in harvest season 1 and 2 (Fig. 1). The results showed that exogenous applications of AVG reduced creasing (%) regardless of stage of application in W. Navel in both consecutive seasons. However, same trend was also noted in L. Late sweet orange in harvest season 2. The spray application of AVG have resulted significantly ($p < 0.05$) reduction in creasing (%) than the control in cv. Lane Late during harvest season 2. The GB stage (39.46% and 34.11%) was more effective in reducing creasing with respect to its application at FS and CB in cv. Navel during harvest season 1 and 2. However, the treatment (60 mg $L^{-1}$) of AVG resulted significant reduction in creasing (27.86 % and 24.29 %) related to the control (52.14 and 51.53 %) in W. Navel during harvest season 1 and 2. The non-significant ($p < 0.05$) interaction was observed in cv Washington Navel and L. Late sweet oranges during both harvest season.

**Textural properties of oranges fruit rind**

**Fruit compression force:** All the application of AVG significantly improved the firmness force irrespective of its application at FS, GB and CB stage in harvest season 1 and harvest season 2 (Fig. 2 and 3). Similarly, the spray application 40-60 mg $L^{-1}$ of AVG showed higher compression force than control and (20 mg $L^{-1}$) AVG in W. Navel and L. Late at harvest season 1. However, in harvest season 2, all the spray application significantly improved the fruit compression force compared with the control in both cultivars. Similarly, all spray applications of AVG was effective when sprayed at FS, GB and CB stage. However, the CB stage of application was resulted higher fruit compression force (310.20 N) with respect to FS (262.40 N) and GB stage (269.20 N) in W. Navel sweet orange in harvest season 1. In cv. W. Navel non-significant effect was observed during harvest season 2. However, non-significant effect was observed in W. Navel sweet orange in harvest season 2. The non-significant ($p < 0.05$) interaction for compression force was observed in both cultivars during both harvest seasons.

**Rind hardness:** The results showed that all the treatments of AVG improved the rind hardness force (N) when spray was applied at the FS, GB and CB stage of W. Navel and L. Late sweet oranges during both harvest seasons (Fig. 2 and 3). All the spray treatments of AVG resulted significantly mean hardness with respect to control in L. Late in harvest season 1 only. Similar findings were observed at treatment 60 mg $L^{-1}$ of AVG than the control and 20-40 mg$L^{-1}$ AVG in W. Navel during harvest season 1. However, all the treatments of AVG (40-60 mg $L^{-1}$) resulted substantially improve the hardness with respect to the control and AVG (20 mg$L^{-1}$) in both cultivars of sweet orange.

**Rind tensile strength:** It is significantly improved with spray of AVG irrespective of its application at different developmental stages of fruit in sweet orange cv. W. Navel and L. Late during harvest season 1 and harvest season 2 (Fig. 2 and 3). The results showed that AVG (20-60 mg $L^{-1}$) resulted significantly improvement on rind tensile force than the control sweet orange L. Late in harvest season 1. Similar findings were observed in harvest season 2 in both cultivars. When all the treatments were compared, the FS stage (71.42 N) was more effective stage of AVG application followed by its application at the GB (57.85 N) and CB stage (59.97

N) in sweet orange L. Late in harvest season 1. However, stages of spray application did not effect on rind tensile strength W. Navel sweet orange. In general, AVG (60 mg $L^{-1}$) resulted higher rind tensile force (51.21 N) compared to all other treatments and control (39.86 N) in cv. W. Navel during harvest season 1.

**Fruit weight:** Fruit weight was significantly ($p < 0.05$) increased with application of AVG at FS, GB and CB stage in the both cultivars during both seasons (Table 1). When we compared the effect of AVG treatments related to its stage of application, then results showed that mean fruit weight increase with increased in concentration in both cultivars in both seasons. However, the treatment AVG (60 $mgL^{-1}$) resulted significantly increased in fruit weight (279.80 and 253.61 g) regarding control (263.61 and 232.20 g) in W. Navel in both seasons. Similar findings were observed in cv. L. Late. Similarly, when we compared the stage of application, the FS increased fruit weigh than GB and CB stage irrespective of cultivars and seasons. The interaction between treatments and different stages of application was also found to be non-significant ($p < 0.05$) for fruit weight in both cultivars during both seasons.

**Fruit diameter:** Fruit diameter increased significantly ($p < 0.05$) with the increased in concentrations of AVG at all stages of its application in both cultivars during both seasons (Table 2). When we compared the effect of AVG treatments related to its stage of application, then results showed that mean fruit diameter increases with increased in AVG concentration in both cultivars in both seasons. However, the treatment AVG (60 mg $L^{-1}$) resulted significantly increased in diameter (84.69 and 81.98 mm) and (80.93 and 83.02 mm) regarding control (77.61 and 73.46 mm) and (75.76 and 78.67 mm) in W. Navel and L. Late, respectively in both seasons. Similarly, when we compared the stage of application, the GB stage was more effective stage of AVG application regarding fruit diameter (82.71 mm) followed by CB (81.37 mm) and FS (81.01 mm) in W. Navel in both seasons. However, CB (82.93 mm) stage was more effective than FS (82.59 mm) and GB (79.38 mm) in L. Late Sweet orange.

**Rind thickness:** The AVG significantly ($p < 0.05$) increased the rind thickness irrespective of its application at FS, GB and CB stage in the both cultivars during both seasons (Table 3). When the effect of AVG treatments related to its stage of application was compared, the results showed that mean rind thickness increase with increased in concentration in both cultivars during both seasons. However, the treatment AVG (60 mg $L^{-1}$) resulted significantly increased in rind thickness (5.18 and 5.43 mm) and (4.77 and 5.18 mm) regarding control (4.69 and 4.92 mm) and 4.31 and 4.69 mm) in W. Navel and L. Late in both seasons. Similarly, comparing the stage of application, the CB stage resulted higher rind thickness (5.10 and 5.28 mm) followed by GB (4.95 and 4.92 mm) and CB (3.61 and 4.87 mm) stage in cv. L. Late in both seasons. In W. Navel, CB (5.28 mm) stage was more effective stage AVG application followed by GB (4.92 mm) and FS (4.87 mm) in harvest season 1 only. In harvest season 2, GB (5.35 mm) stage was more effective than CB (5.15 mm) and FS (5.06 mm) stage in W. Navel the mean fruit rind thickness significantly ($p < 0.05$) higher, when AVG was sprayed at the GB (5.35 mm) with respect to the CB (5.15 mm) and FS stage (5.06 mm) in W. Navel during harvest season 2.

**Discussion**

Creasing (%) significantly alleviated by the exogenous application of irreversible ethylene inhibitor AVG at FS, GB and CB stage in sweet oranges W. Navel and L. Late in harvest season 1 and 2 (Figure 1). In conclusion, among all the treatments, AVG (60 mg $L^{-1}$) was more effective than all other treatments and control in both cultivars and both harvest seasons. Similarly, the GB stage (27.86 and 24.29 %) was more suitable stage for AVG application with respect to control (52.14 and 51.53 %) in sweet orange W. Navel harvest season 1 and harvest season 2 respectively. However, in cv. L. Late, the CB (22.86%) stage was more effective followed by FS (29.29%) as compared to control (51.43 and 59.29 %) during harvest season 1 and harvest season 2 (Fig. 1). It has been reported previously that different factors such as climate, crop load, fruit position, rind thickness, rootstocks and endogenous production of ethylene are responsible for creasing in oranges (Pham, 2009). It has been previously reported that higher level of endogenous ethylene involved in creasing of Valencia and W. Navel sweet orange (Monselise *et al.*, 1976; Pham, 2009), due to higher activity of ethylene biosynthesis enzymes (Hyodo and Nishino, 1981). Similarly, Hussain (2014) and Hussain and Singh (2015 b) also reported higher level of ethylene in the effected fruit of Navelina, W. Navel, L. Late and Valencia Late sweet oranges. AVG is an inhibitor of ethylene, which inhibits ethylene production in plant tissues by preventing the synthesis of ACC enzymes (Ladaniya, 2007). Similarly, another ethylene inhibitor putrescine significant reduces creasing in oranges which also supports the envelopment of ethylene in creasing (Hussain, 2014; Hussain and Singh, 2015a). Similar findings were observed by Saleem *et al*. (2014) and Hussain (2014) in the creased fruit of oranges. Possibly, the reduction in creasing may be due to reduction in the activities of cell wall degrading enzymes by the inhibition of endogenous ethylene with the exogenous application of AVG. Similarly, Li *et al*. (2009), Hussain (2014) and Saleem *et al*. (2014) claimed higher activities ACC enzymes in creased fruit of oranges.

The treatments 20-60 mg $L^{-1}$ of AVG significantly enhanced the textural/rheological properties of fruit rind compared to the control at all stages of spray application in both cultivars during both harvest seasons (Fig. 2 A-F and 3 A-F). The AVG is an irreversible endogenous ethylene inhibitor which inhibits ethylene and retained the fruit firmness, rind hardness and rind tensile strength force due to reducing the activity of S-adenos-ylmethionine decarboxylase (SAMDC) (Bregoli *et al*., 2002).

All the treatments of AVG significantly increased the weight, diameter and rind thickness irrespective of stages of spray application in W. Navel and L. Late (Table 1-3). It also has been reported that AVG are used to inhibit free ethylene production and altered the activities of S-adenos-ylmethionine decarboxylase (SAMDC) and improved the fruit weight, diameter, growth and SSC (Byers *et al*., 2005; Greene, 2005). Similar findings were observed in various horticultural fruits crops like tomatoes (Jeong *et al*., 2002), peaches (Kim *et al*., 2004; Rath *et al*., 2004), nectarine (Rath and Prentice, 2004), apples (Greene, 2005) and oranges (Al-Husseini, 2012).

## Conclusion

It is concluded from the current study that the reduction in creasing of sweet orange fruit with the exogenous application of AVG attributed due to the reduction in the endogenous ethylene production by inhibiting the synthesis of ACC synthase enzymes. Similarly, the AVG retained the fruit firmness, rind hardness and rind tensile strength force due to reducing the activity of S-adenos-methionine decarboxylase (SAMDC) by inhibition of endogenous ethylene which indicates the role of AVG in the creasing in sweet oranges.

## References


Agusti, M., Martinerz-Fuentes, A., Mesejo, C., 2002. Citrus fruit quality physiological basis and techniques of improvement. Agrociencia., VI: 1-16

Ali, A., Summers., L.L., Klein, G.J., Lovatt, C.J., 2000. Albedo breakdown in California. Proc. Int. Soci. Citri., 2: 1090-1093

Al-Husseini, A, 2012. Efficacy of ethylene biosynthesis inhibitors (AVG and $CoSO_4$) on pre-harvest fruit drop and quality in Washington Navel and Lane Late sweet orange (*Citrus sinensis* (L.) Osbeck). Master thesis, Curtin University, Perth- Australia.

Bower, J.P, 2004. The physiological control of citrus creasing. *Acta Horticulturae*, 632: 111-115

Bleecker, A.B., Kende, H., 2000. Ethylene: A gaseous signal molecule in plants. *Annu. Rev. Cell Dev. Biol*., 16: 1–18

Bregoli, A.M., Scaramagli, S., Costa, G, Sabatini, E., Ziosi., V., Biondi, S., Torrigiani P., 2002. Peach (*Prunus persica* L.) fruit ripening: aminoethoxyvinylglycine (AVG) and exogenous polyamines affect ethylene emission and flesh firmness. Physiol Plant., 114: 472-481

Burg, S.P., 2004. Heat transfer and water loss. In: Postharvest physiology and hypobaric storage of fresh produce. CABI Publishing. pp. 654.

Byers, R.E., Car-Baugh, D.H., Combs, L.D., 2005. Ethylene inhibitors delay fruit drop, maturity, and increase fruit size of 'Arlet' apples. *HortScience*., 40: 2061-2065

FAOSTAT. 2013. Food and Agriculture Commodities production. http://faostat.fao.org/

Gambetta, G., Arbiza, H., Ferenczi, A., Gravina, A., Orlando, L., Severino V., Telias, A., 2000. Creasing in 'Washington Navel' orange in Uruguay: study and control. Proc. Inter Soci of Citri IX Cong. Florida, USA. p. 453-455.

Greenberg, J., Kaplan, I. Fainzack, M., Egozi, Y. Hasan, M. Hochberg, A., Porat, R., 2006. Effects of 2,4-D, 2,4-DP and 3,5,6-TPA combined with 'Bonus NPK' fertilizer on 'Shamouti' orange. *Et Hadr*., 48: 25-27

Greene, D.W, 2005. Time of aminoethoxyvinylglycine application influences pre-harvest drop and fruit quality of 'McIntosh' apples. HortScience, 40:2056-2060

Hussain, Z, 2014. Role of polyamines and ethylene in creasing sweet orange fruit. Ph.D thesis, Curtin University, Perth- Australia.

Hussain, Z., Z. Singh, 2015a. Involvement of polyamines in creasing of sweet orange [*Citrus sinensis* (L.) Osbeck] fruit. *Scientia Horticulturae*., 190: 203-210

Hussain, Z., Z. Singh, 2015. Involvement of ethylene in causation of creasing in sweet orange [*Citrus sinensis* (L.) Osbeck] fruit**.** *Aus. J. crop Sci*., 9(1): 1-8.

Hyodo, H., T. Nishino, 1981. Wound-induced ethylene formation in albedo tissue of citrus fruit. *Plant Physiol*., 67: 421-423

Ismail, M.A., Zhang, J.X. 2004. Postharvest citrus diseases and their control. Outlooks Pest Management., 15: 29-35.

Jeong, J., Huber, D.J., Sargent, S.A., 2002. Influence of 1-methylecyclopropene (1-MCP) on ripening and cell wall matrix polysaccharides of avocado. *Post-harvest Biol. Technol*., 25: 241-256

Kim, I.S., Choi., C.D., Lee H.J., Byun, J.K., 2004. Effects of aminoethoxyvinylglycine on pre-harvest drop and fruit quality of 'Mibaekdo' peaches. *Acta Horti*., 653: 173-178.

Ladaniya, M, 2007. Citrus Fruit: Biology, Technology and Evaluation. *Academic press, India*. pp: 558.

Le-Roux, J.C., Crous P.A., 1938. Effect of fertilizer on creasing of Mediterranean sweet oranges. *Farming in South Africa*., 13: 66-68.

Li, J., Zhanga, P., Chena, J., Yao, Q., Jiang, Y., 2009. Cellular wall metabolism in citrus fruit pericarp and its relation to creasing fruit rate. *Scientia Horticulturae*., 122: 45-50

Monselise, S.P., Weiser, M., Shafir, N., Goren R., Goldschmidt, E.E., 1976. Creasing of orange peel-physiology and control. *J. Horti. Sci*., 51: 341-351.

Pham, T. T. M., Singh Z., Behhoudian, H., 2012. Different surfactants improve calcium uptake into leaf and fruit of 'Washington Navel' sweet oranges and reduced albedo breakdown. *J. Plant Nutrition*., 35(6): 889-904

Pham, T.T.M, 2009. Pre-harvest factors affecting fruit quality in sweet oranges with an emphasis on albedo breakdown. Ph.D thesis, Curtin University, Perth- Australia.

Rath, A.C., Prentice, A.J., 2004. Yield increase and higher flesh firmness of ' arctic Snow' nectarines both at harvest in australia and after export to Taiwan follwing pre-harvest application of Retain® Plant growth regulator (Aminoethoxylycine, AVG). *Aust. J. Exper. Agri*.,. 44:343-351

Rath, A.C., Wargo, J.M., Mills, S., 2004. Aminoethoxyvinylglycine (AVG) applications to commercial blocks of 'Tatura 204', 'Golden Queen' and 'Taylor Queen' peaches delays fruit maturity and increases fruit size and quality. *Acta Horti*., 653: 167-171.

Saleem, B.A., Hassan, I., Singh, Z., Malik, A.U. Pervez. M.A., 2014. Comparative changes in the rheological properties and cell wall metabolism in rind of healthy and creased fruit of Washington Navel and Navelina sweet orange (*Citrus sinensis* [L.] Osbeck). *Aust. J. Crop Sci*., 8(1): 62-70

Treeby, M.T., Storey, R., Bevington, K.B., 1995. Rootstock, seasonal and fruit size influences on the incidence and severity of albedo breakdown in Bellamy Navel oranges. *Aust. J. Experi. Agri*., 35:103-108.

Treeby, M.T., Gambetta, R.E., Arbiza, G., Ferenczi, H., Gravina, A., Orlando, A., Severino, L., Telias V., Henriod, A., Bevington K.B., Storey, R., 2007. Irrigation management and rootstock effects on Navel orange [*Citrus sinensis* (L.) Osbeck] fruit quality. Agri. *Water Manag*., 91: 24-32.

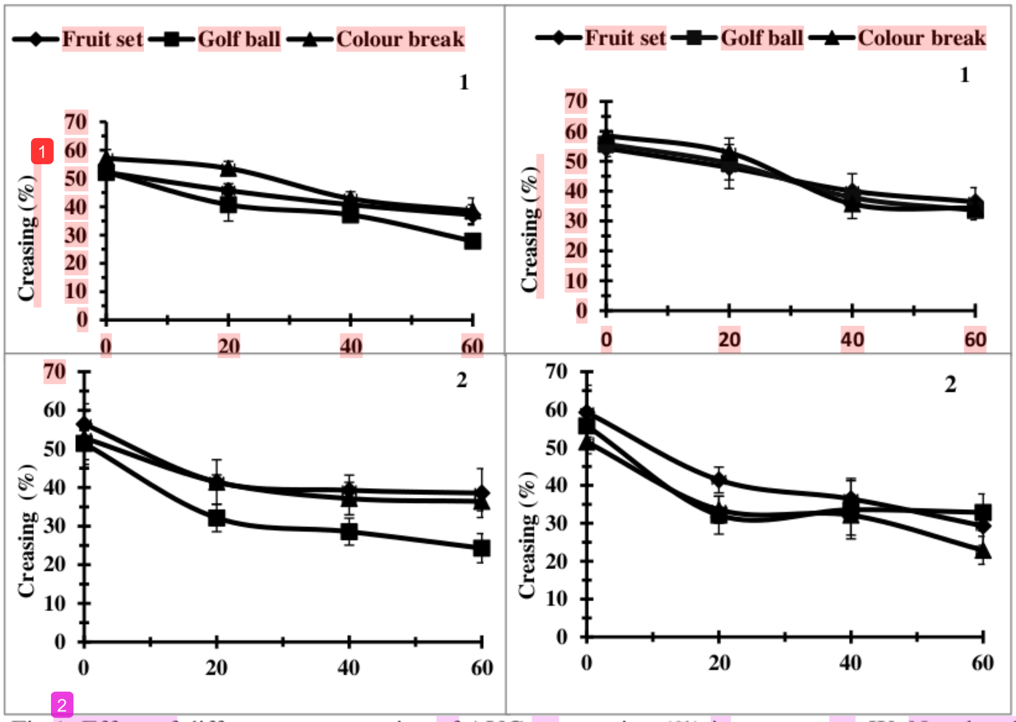
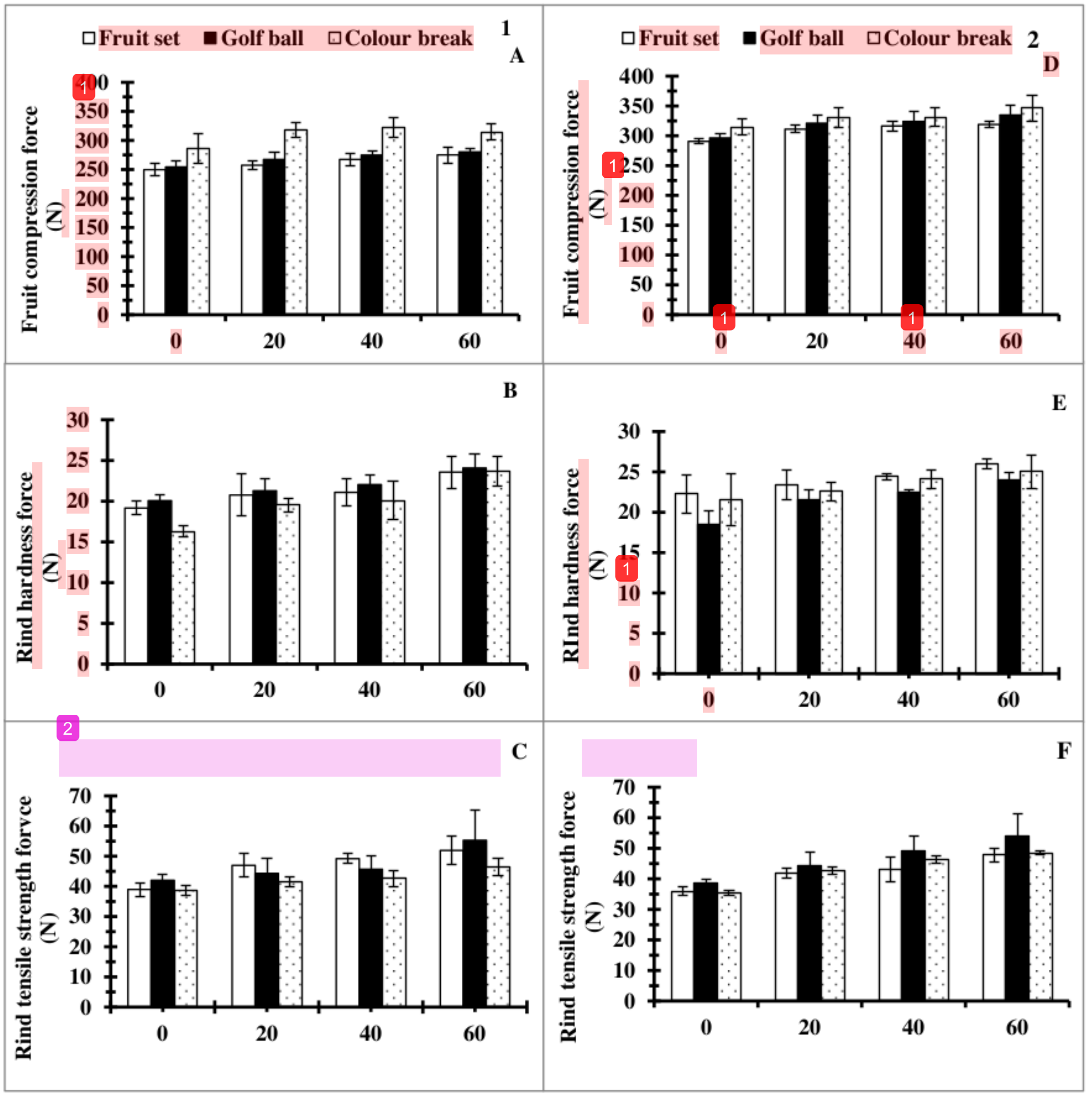



Fig.1: Effect of different concentration of AVG on creasing (%) in oranges cv. W. Navel and L. Late.



□ Fruit set ■ Golf ball □ Colour break
1
2
A
B
C
D
E
F
Fruit compression force (N)
Rind hardness force (N)
RInd hardness force (N)
Rind tensile strength forvce (N)
Rind tensile strength force (N)
0
20
40
60

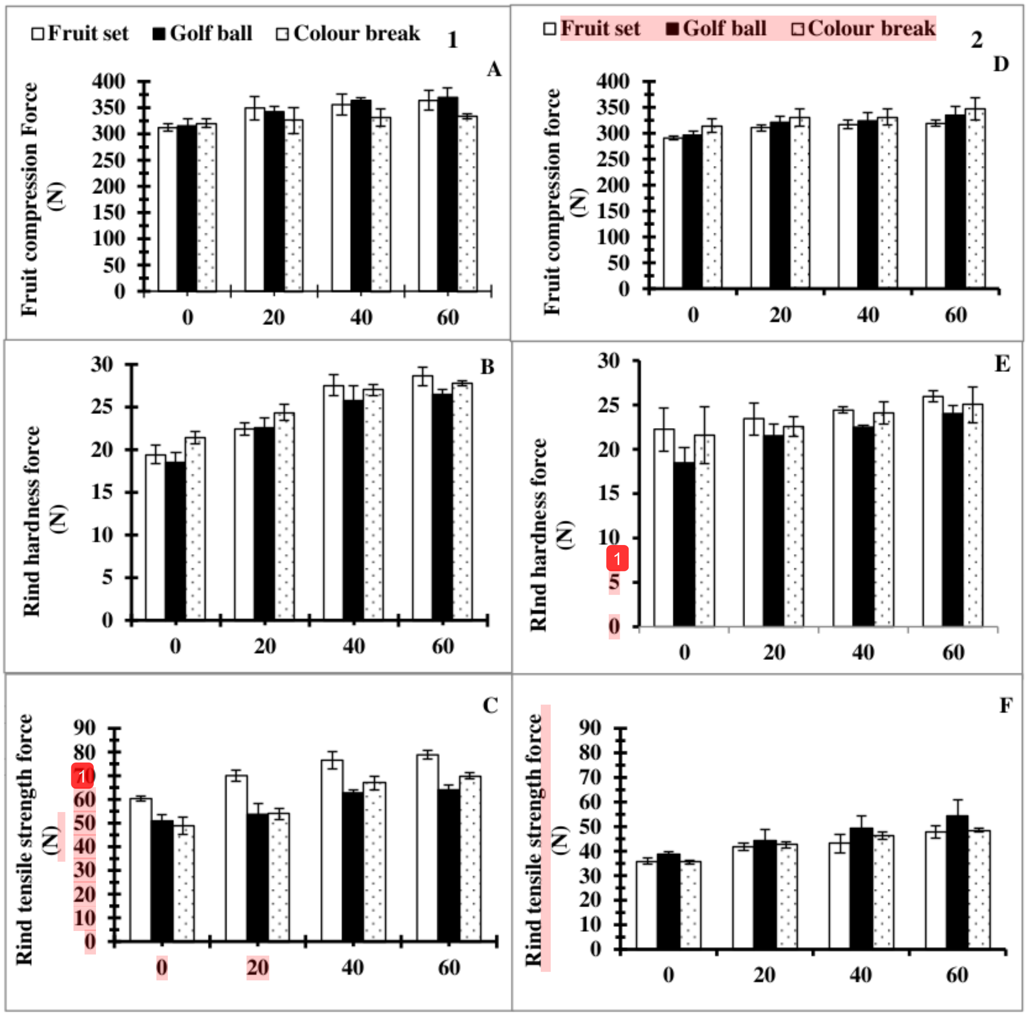

□Fruit set ■Golf ball □Colour break
1
A
Fruit compression Force (N)
400
350
300
250
200
150
100
50
0
0
20
40
60
□Fruit set ■Golf ball □Colour break
2
D
Fruit compression force (N)
400
350
300
250
200
150
100
50
0
0
20
40
60
B
Rind hardness force (N)
30
25
20
15
10
5
0
0
20
40
60
E
RInd hardness force (N)
30
25
20
15
10
5
0
0
20
40
60
C
Rind tensile strength force (N)
90
80
70
60
50
40
30
20
10
0
0
20
40
60
F
Rind tensile strength force (N)
90
80
70
60
50
40
30
20
10
0
0
20
40
60

Table no. 1: Impact of AVG on fruit weight of sweet orange cv. W. Navel and L. Late.

| Fruit weight (g) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| W. Navel | | | | | | | | |
| | FS | | GB | | CB | | Mean (Treat) | |
| Treatments | harvest season 1 | harvest season 2 | harvest season 1 | harvest season 2 | harvest season 1 | harvest season 2 | harvest season 1 | harvest season 2 |
| Control | 270.20 ab | 234.80 ab | 257.20 b | 242.5ab | 263.20 ab | 219.20 b | 263.61b | 232.20b |
| AVG.20mgL$^{-1}$ | 271.80 ab | 237.5ab | 263.21 ab | 244.20 ab | 273.00 ab | 234.00 ab | 269.31ab | 238.61ab |
| AVG.40mgL$^{-1}$ | 274.51 ab | 238.2ab | 272.50 ab | 261.70 a | 278.30 ab | 245.81 ab | 275.10a | 248.60ab |
| AVG.60mgL$^{-1}$ | 279.20 a | 246.2ab | 281.00 a | 265.50 a | 279.00 ab | 249.00 ab | 279.80a | 253.61a |
| Mean (stage) | 273.90 a | 239.2ab | 268.51 a | 253.50a | 273.41 a | 237.00 b | | |
| LSD ($p < 0.05$) | | | | | | | | |
| Treatments | | | 10.8 | 16.95 | | | | |
| Stage | | | ns | 14.68 | | | | |
| Treatments × stages | | | ns | ns | | | | |
| L. Late | | | | | | | | |
| | FS | | GB | | CB | | Mean (Treat) | |
| Treatments | harvest season 1 | harvest season 2 | harvest season 1 | harvest season 2 | harvest season 1 | harvest season 2 | harvest season 1 | harvest season 2 |
| Control | 265.2ab | 270.20 ab | 263.20 b | 247.21b | 263.80 b | 268.2ab | 264.10 b | 261.90 b |
| AVG.20mgL$^{-1}$ | 278.20 ab | 281.80 a | 272.0ab | 270.80ab | 269.51 ab | 283.00 a | 273.20 b | 278.51 a |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| AVG.40mgL$^{-1}$ | 292.00 ab | 287.01 a | 272.2ab | 272.50a | 273.20 ab | 283.30 a | 279.21 ab | 280.90 a |
| AVG.60mgL$^{-1}$ | 295.50 ab | 294.20 a | 298.2a | 276.00a | 280.49 ab | 281.50 a | 291.40 a | 283.90 a |
| Mean (stage) | 282.80 a | 283.31 a | 276.41a | 266.61b | 271.80 a | 279.00 a | | |
| LSD ($p < 0.05$) | | | | | | | | |
| Treatments | | | 16.92 | 12.92 | | | | |
| Stages | | | ns | 22.37 | | | | |
| Treatments × stages | | | ns | ns | | | | |

n = 4 replications (10 fruit per replication), ns = not-significant; treat = Treatments.

Table no. 2: Impact of AVG on fruit diameter of sweet orange cv. W. Navel and L. Late

| Fruit diameter (mm) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| W. Navel | | | | | | | | |
| | FS | | GB | | CB | | Mean (Treat) | |
| Treatments | harvest season 1 | harvest season 2 | harvest season 1 | harvest season 2 | harvest season 1 | harvest season 2 | harvest season 1 | harvest season 2 |
| Control | 79.92 bcd | 67.69 c | 75.50 d | 75.50 b | 77.42 cd | 77.18 ab | 77.61 b | 73.46 b |
| AVG.20mgL$^{-1}$ | 79.92 bcd | 81.8 ab | 82.47 abcd | 79.56 ab | 80.75 abcd | 78.56 ab | 81.05 ab | 79.97 a |
| AVG.40mgL$^{-1}$ | 81.40 abcd | 82.13a | 85.55 ab | 80.91 ab | 83.36 abc | 79.66 ab | 83.44 a | 80.90 a |
| AVG.60mgL$^{-1}$ | 82.79 abc | 83.39 a | 87.30 a | 82.23 a | 83.97 abc | 80.91 ab | 84.69 a | 81.98 a |
| Mean (stage) | 81.01 a | 78.76 a | 82.71 a | 79.55 a | 81.37 a | 78.92 a | | |
| LSD ($p < 0.05$) | | | | | | | | |
| Treatments | | | 3.59 | 1.59 | | | | |
| Stage | | | ns | ns | | | | |
| Treatments × stages | | | ns | 2.75 | | | | |

| L. Late | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | FS | | GB | | CB | | Mean (Treat) | |
| Treatments | harvest season 1 | harvest season 2 | harvest season 1 | harvest season 2 | harvest season 1 | harvest season 2 | harvest season 1 | harvest season 2 |
| Control | 76.55 ab | 80.80 abc | 75.52 b | 76.80 cd | 75.20 b | 78.41 bcd | 75.76 b | 78.67 b |
| AVG.20mg $L^{-1}$ | 77.03 ab | 86.10 a | 79.58 ab | 75.05 d | 78.66 ab | 83.11 ab | 78.43 ab | 81.42 ab |
| AVG.40mg $L^{-1}$ | 77.80 ab | 81.46 abc | 79.72 ab | 78.77 bcd | 79.33 ab | 84.02 ab | 78.95 ab | 81.4 ab |
| AVG.60mg $L^{-1}$ | 79.34 ab | 81.98 abc | 82.69 a | 80.88 abc | 80.75 ab | 86.19 a | 80.93 a | 83.02 a |
| Mean (stage) | 77.68 a | 82.59 a | 79.38 a | 77.87 b | 78.49 a | 82.93 a | | |
| LSD ($p < 0.05$) | | | | | | | | |
| Treatments | | | 3.19 | 2.89 | | | | |
| Stages | | | ns | 2.51 | | | | |
| Treatments × stages | | | ns | ns | | | | |

n = 4 replications (10 fruit per replication), ns = not-significant; treat = Treatments

Table no. 3: Impact of AVG on rind thickness of sweet orange cv. W. Navel and L. Late

| Rind thickness (mm) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| W. Navel | | | | | | | | |
| | FS | | GB | | CB | | Mean (Treat) | |
| Treatments | harvest season 1 | harvest season 2 | harvest season 1 | harvest season 2 | harvest season 1 | harvest season 2 | harvest season 1 | harvest season 2 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Control | 4.57 cd | 4.68 c | 4.47 d | 5.08 abc | 5.04 abc | 4.98 bc | 4.69 b | 4.92 b |
| AVG.20mgL$^{-1}$ | 4.89 bcd | 5.09 abc | 5.03 abc | 5.30 ab | 5.23 ab | 5.04 abc | 5.05 a | 5.14 ab |
| AVG.40mgL$^{-1}$ | 4.97 bc | 5.15 abc | 5.08 ab | 5.44 ab | 5.47 a | 5.16 abc | 5.17 a | 5.25 a |
| AVG.60mgL$^{-1}$ | 5.05 abc | 5.32 ab | 5.10 ab | 5.56 a | 5.38 ab | 5.40 ab | 5.18 a | 5.43 a |
| Mean (stage) | 4.87 b | 5.06 b | 4.92b | 5.35 a | 5.28 a | 5.15 ab | | |
| LSD ($p < 0.05$) | | | | | | | | |
| Treatments | | | 0.25 | 0.28 | | | | |
| Stage | | | 0.21 | 0.24 | | | | |
| Treatments × stages | | | Ns | ns | | | | |
| L. Late | | | | | | | | |
| | FS | | GB | | CB | | Mean (Treat) | |
| Treatments | harvest season 1 | harvest season 2 | harvest season 1 | harvest season 2 | harvest season 1 | harvest season 2 | harvest season 1 | harvest season 2 |
| Control | 3.42 b | 4.57cd | 4.67 a | 4.46 d | 4.84 a | 5.04 abc | 4.31 b | 4.69 b |
| AVG.20mgL$^{-1}$ | 3.52 b | 4.89 bcd | 4.91 a | 5.03 abc | 5.13 a | 5.23 ab | 4.52 ab | 5.05 a |
| AVG.40mgL$^{-1}$ | 3.62b | 4.96 bc | 5.04 a | 5.08 ab | 5.21 a | 5.47a | 4.62 ab | 5.17 a |
| AVG.60mgL$^{-1}$ | 3.88b | 5.05 ab | 5.20 a | 5.10 ab | 5.22 a | 5.38 ab | 4.77 a | 5.18 a |
| Mean (stage) | 3.61 b | 4.87 b | 4.95 a | 4.92 b | 5.10 a | 5.28 a | | |
| LSD ($p < 0.05$) | | | | | | | | |
| Treatments | | | 0.34 | 0.21 | | | | |
| Stages | | | 0.30 | 0.43 | | | | |
| Treatments × stages | | | ns | ns | | | | |

n = 4 replications (10 fruit per replication), ns = not-significant; treat = Treatment paper

ORIGINALITY REPORT

| 36% | 26% | 18% | 31% |
|---|---|---|---|
| SIMILARITY INDEX | INTERNET SOURCES | PUBLICATIONS | STUDENT PAPERS |

PRIMARY SOURCES

| | | |
|---|---|---|
| 1 | Submitted to Higher Education Commission Pakistan<br>Student Paper | 13% |
| 2 | espace.curtin.edu.au<br>Internet Source | 11% |
| 3 | www.cropj.com<br>Internet Source | 1% |
| 4 | www.ishs.org<br>Internet Source | 1% |
| 5 | Submitted to Massey University<br>Student Paper | 1% |
| 6 | Tam Thi Minh Pham, Zora Singh, M. H. Behboudian. "DIFFERENT SURFACTANTS IMPROVE CALCIUM UPTAKE INTO LEAF AND FRUIT OF 'WASHINGTON NAVEL' SWEET ORANGE AND REDUCE ALBEDO BREAKDOWN", Journal of Plant Nutrition, 2012<br>Publication | 1% |
| 7 | hortsci.ashspublications.org | |

Internet Source

1%

| | | | |
|---|---|---|---|
| 8 | Submitted to Curtin University of Technology<br>Student Paper | 1% |
| 9 | Submitted to University of Stellenbosch, South Africa<br>Student Paper | 1% |
| 10 | www.ajol.info<br>Internet Source | 1% |
| 11 | J. Greenberg, S. Holtzman, M. Fainzack, Y. Egozi, B. Giladi, Y. Oren, I. Kaplan. "EFFECTS OF NAA AND GA3 SPRAYS ON FRUIT SIZE AND THE INCIDENCE OF CREASING OF 'WASHINGTON' NAVEL ORANGE", Acta Horticulturae, 2010<br>Publication | 1% |
| 12 | Submitted to University of Newcastle<br>Student Paper | 1% |
| 13 | hdl.handle.net<br>Internet Source | 1% |
| 14 | Bernardita Sallato, Claudia Bonomelli, Johanna Martiz. "Differences in quality parameters and nutrient composition in Fukumoto oranges with and without creasing symptoms", Journal of Plant Nutrition, 2016<br>Publication | <1% |

| | | |
|---|---|---|
| 15 | Joseph Riov, Shang Fa Yang. "Autoinhibition of Ethylene Production in Citrus Peel Discs", Plant Physiology, 1982<br>Publication | <1 % |
| 16 | Submitted to University of Western Sydney<br>Student Paper | <1 % |
| 17 | McCarty, J.L.. "The spatial and temporal distribution of crop residue burning in the contiguous United States", Science of the Total Environment, 20091015<br>Publication | <1 % |
| 18 | Zahoor Hussain, Zora Singh. "Involvement of polyamines in creasing of sweet orange [Citrus sinensis (L.) Osbeck] fruit", Scientia Horticulturae, 2015<br>Publication | <1 % |
| 19 | www.scialert.net<br>Internet Source | <1 % |
| 20 | scholar.sun.ac.za<br>Internet Source | <1 % |
| 21 | Submitted to The Scientific & Technological Research Council of Turkey (TUBITAK)<br>Student Paper | <1 % |
| 22 | Yildiz, Kenan, Burhan Ozturk, and Yakup Ozkan. "Effects of aminoethoxyvinylglycine (AVG) on preharvest fruit drop, fruit maturity, | <1 % |

and quality of â€˜Red Chiefâ€™ apple", Scientia Horticulturae, 2012.
Publication

| 23 | Amarante, Cassandro Vidal Talamini do, Blum, Luiz Eduardo Bassay and Steffens, Cristiano André. "Coloração do fruto, distúrbios fisiológicos e doenças em maçãs 'Gala' e 'Fuji' pulverizadas com aminoetoxivinilglicina", Sociedade Brasileira de Fruticultura, 2013.<br>Publication | <1% |
|---|---|---|
| 24 | Nemat Hassan, Zeinab El-bastawisy, Heba Ebeed, Mamdouh Nemat Alla. "Role of defense enzymes, proteins, solutes and Δ1-pyrroline-5-carboxylate synthase in wheat tolerance to drought", Rendiconti Lincei, 2015<br>Publication | <1% |

| | | | |
|---|---|---|---|
| Exclude quotes | Off | Exclude matches | Off |
| Exclude bibliography | Off | | |

# paper

GRADEMARK REPORT

FINAL GRADE

# /0

GENERAL COMMENTS

**Instructor**

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8

PAGE 9

PAGE 10

PAGE 11

PAGE 12

PAGE 13

PAGE 14

PAGE 15

PAGE 16

PAGE 17