Journal of Applied and Natural Science 8 (4): 2305-2310 (2016)

JANS

Influence of pre-harvest application of gibberellin and brassinosteroid on fruit growth and quality characteristics of pear (*Pyrus pyrifolia* (Burm.) Nakai) cv. Gola

Vinod Singh Thapliyal[1], P. N. Rai[1] and Lokesh Bora[*2]

[1]Department of Horticulture, College of Agriculture, G.B. Pant University of Agriculture and Technology, Pantnagar- 263145 (Uttarakhand), INDIA

[2]Department of Fruit Crops, Horticultural College & Research Institute, Tamil Nadu Agricultural University, Coimbatore- 641003 (Tamil Nadu), INDIA

[*]Corresponding author. E-mail: lokeshbora36099@gmail.com

Received: April 26, 2016; Revised received: September 30, 2016; Accepted: December 8, 2016

Abstract: Quality of fruit crop is an important parameter to decide the acceptability of the product. The present study consists of seventeen year old pear (*Pyrus pyrifolia* (Burm.) Nakai) trees subjected to seven treatments *viz.,* GA_3 (50 ppm,100 ppm), BR (0.5 ppm, 1.0 ppm), and GA_3 + BR (50 ppm + 0.5 ppm and 100 ppm + 1 ppm) and water as control, sprayed thrice at 15 days intervals starting from petal fall stage. Each treatment was replicated thrice with one tree served as a treatment unit. The experiment was conducted in Randomized Block Design. The fruits treated with GA_3 @ 50 ppm (T_1) showed the highest fruit length (6.98 cm), breadth (6.81 cm), weight (175.9 g) and volume (171.16 cc). An improvement in terms of fruit quality was observed either alone or in combined application of GA_3 and BR. The application of BR @ 1 ppm (T_4) recorded the highest TSS (12.91°Brix) and lowest titrable acidity (0.42%) while the highest ascorbic acid content (6.95 mg / 100 g) and non reducing sugar (0.44%) was estimated under GA_3 @ 100 ppm + BR @ 1 ppm (T_6). Total sugar (7.88%) and reducing sugar (7.45%) was observed highest in GA_3 @ 50 ppm + BR @ 0.5 ppm (T_5). Based on this research combined application of GA_3 + BR had a positive effect and therefore can be recommended for spray on pear in order to obtain higher yield and better quality.

Keywords: Brassinosteroids, Gibberellin, Pear, Physio-biochemical, Quality characteristics

INTRODUCTION

About 23.53 millions MT of pear is produced around the world (FAOSTAT, 2013) of which 315,000 MT is produced in India with an area of 42,000 ha (NHB, 2014). The area, production and productivity of pear in the state of Uttarakhand is around 15,081 ha; 108,120 MT and 7.16 tonne ha^{-1}, respectively (Anonymous, 2014). On the basis of availability of new promising Oriental pear [*Pyrus pyrifolia* (Burm.) Nakai] cultivar like 'Gola', the area under its cultivation is increasing. The cultivation of Gola has been a unique success in the subtropical region of North India due to its hardy nature and good shipping quality. The pear cv. 'Gola' is mainly cultivated in *tarai* region of Uttarakhand and Punjab, which is harvested in the month of July. In comparison to the other low chilled early cultivars, with 300-750 chilling hours depending on the varieties and can also withstand high temperature and hot winds during summer. Gola has higher productivity with better quality fruits. The cultivar also has the tendency to bear small sized fruits with inferior quality, due to which their potential to fetch heavy price in market is hampered. Improving marketable yield of good quality sub-tropical pear fruits has always been a challenge for fruit breeders and pear growers. If the cultivar can be improved with respect to its fruit size, marketing value can also be raised. In absence of suitable breeding programme, the problem can only be efficiently tackled by using plant bio-regulators (PBRs). However, exogenous application of various PBRs *viz.,* Auxins, Gibberellins, Cytokinins, etc. have been shown to have role in vegetative growth control, flowering, fruiting, yield and fruit quality in pear trees (Muniz *et al.,* 2015). Application of plant bio-regulators have resulted in better enhancement in yield and quality of various fruit crops by improving the internal physiology of developing fruits, which ultimately lead to improved size, and quality (Dussi, 2011). So, it is necessary to overcome these problems for improving fruit physical and quality attributes by using different pre-harvest application of plant bio-regulators *viz,* gibberellin and 24- epi-brassinolide. Therefore, considering the above facts and constraints, the present study was undertaken to elucidate the effect of gibberellin and brassinosteroids on Gola pear (*Pyrus pyrifolia* (Burm) Nakai) under *tarai* conditions.

ISSN : 0974-9411 (Print), 2231-5209 (Online)

MATERIALS AND METHODS

The experiment was conducted at Horticulture Research Centre, Patharchatta GBPUAT, Pantnagar located 8 km away from the main campus at an altitude of 29 ºN latitude and 79.3 º E longitudes, 243.84 meters above mean sea level and. Seventeen years old bearing pear (*Pyrus pyrifolia* (Burm.) Nakai) trees of cv. Gola of uniform vigor and size, maintained under uniform cultural practices were selected for investigation. The experiment was laid out in Randomized Block Design (RBD) consisting of seven treatments. All the treatments were replicated thrice and one tree served as a unit of treatment in each replication. Seventeen year old pear trees were subjected to seven treatments *viz.,*GA_3 @ 50 ppm (T_1), GA_3 @ 100 ppm (T_2), BR @ 0.5 ppm (T_3)BR @ 1 ppm (T_4) GA $_3$ @ 50 ppm + BR @ 0.5 ppm (T_5)GA3 @ 100 ppm + BR @ 1 ppm (T_6), T_7 water as control. The applications of various treatments as above were given thrice, first spray at petal fall on 3rd March, 2014 and second and third spray after fifteen days interval i.e., 18th March, and 2nd April, 2014, respectively. The observations were recorded on the basis of various fruit physical and quality characters *viz.,* total soluble solids, acidity, ascorbic acid contents, total sugars, reducing sugar and non reducing sugars. Randomly from each treatment, six fruits were undertaken and these were analyzed for their physico-biochemical characters. The fruits were harvested at harvest maturity on dated 12th July, 2014. Total soluble solid in fruits was recorded at room temperature using hand refractometer and expressed in term of ° Brix using hand refractometer (Atazo, Japan). For acidity, fruit juice was titrated with 0.1 N NaOH and the results were expressed in terms of percentage of maleic acid as described by Ranganna (1986). The Ascorbic acid was estimated by 2, 6-dichlorphenol-indophenol visual titration method as AOAC (1980) was expressed in terms of mg per 100 g pulp. Sugars were estimated as per standard method as AOAC (1980). The observations were subjected to statistical analysis by using randomized block design (RBD). Mean differences were tested by 'F' test at (5 %) level of significance (LOS). Critical difference (CD) at 5% level of significance was used for comparison among treatments. The data was statistically analysed by method of analysis of variance using RBD as described by Panse and Sukhatme (1985).

RESULTS

The fruit length of pear, *(Pyrus pyrifolia* (Burm.) Nakai) cv. Gola of all the treatments was recorded at 30 days interval in the tagged shoots for the period from 10th April to 10th July. Data in table 1 suggests that all treatments at 0.05 % significance level had prominent effect in improving the fruit length over control. The minimum fruit length (6.21 cm) was observed in cotrol, which was significantly lesser than all the other treatments. Finally at the time just before harvesting i.e., 10th July, the maximum mean fruit length (6.98 cm) was recorded under the treatment of T_1 (GA_3 @ 50 ppm), which was significantly superior to all other treatments. The next best treatment regarding this character was T_5 i.e., 6.79 cm. The fruit breadth was recorded at different periods from 10th April to 10th July. It is apparent from the data presented in table 2 shows that concerned treatments significantly influenced the fruit size when measured in terms of fruit breadth, during the entire course of study. Based on data collected just prior to harvesting i.e., 10th July, fruits treated with 50 ppm of GA_3 (T_1) showed the highest mean fruit breadth (6.81cm). Treatments other than T_1 showing significant increase in fruit breadth over control, whereas T_5 (6.68 cm), T_6 (6.55 cm) and T_3 (6.51 cm) were found statistically at par with each other. The observations recorded in term of fruit weight revealed that foliar spray of all the treatments had significant effect on fruit weight over control (Table 3). The maximum mean fruit weight (175.90 g) was noticed due to the application of GA3 @ 50 ppm (T_1), followed by T_2 (172.27 g) and T_3 (171.36 g) which were statistically at par with each other. Significant difference occurs between T_1 Vs T_4, T_1 Vs T_5 and T_1 Vs T_6. The lowest mean fruit weight (161.33 g) was observed in untreated control fruits followed by combined application of GA_3 + BR, T_6 and T_5 i.e., 164.65 g and 166.43 g, respectively.

The data pertaining the influence of various treatments on fruit volume as per table 3 clearly demonstrates that various values varied from 156.56 to 171.16 cc under different treatments. The highest volume was recorded in the treatment GA_3 at 50 ppm (T1) followed by 100 ppm GA_3 (T_2) i.e., 168.72 cc. These treatments were however, statistically *at par* with each other, but significantly ($p<0.05\%$) superior to control. The fruit volume was recorded to be lowest in control which was statistically at par with combined application of GA_3 @100 ppm + BR @ 1ppm (T_6) i.e., 161.35 cc.

Statistical analysis of data presented in table 4 reveals that TSS is significantly ($p<0.05\%$) influenced by spray of various treatments viz., GA_3, BR and their combinations. The maximum total soluble solid content (12.91°Brix) was recorded in fruits treated with BR @1 ppm (T4) which was however at par with T_6 (12.79 °Brix). The minimum TSS was recorded in control (11.51 °Brix), closely followed by T_1 (11.76 ° Brix), T_2 (12.07 °Brix) and T_3 (12.12 °Brix). However, statistically significant difference was observed in T_1, T_4 and T1, T_6.

The data regarding the influence of various bioregulators on ascorbic acid content in pear fruits varied significantly among the treatments and over control (Table 4). The mean value of the ascorbic acid ranged from 6.06 to 6.95 mg/100 g of pulp. Among all the

Table 1. Effect of pre-harvest spray of GA_3 and BR on fruit length of pear (*Pyrus pyrifolia* (Burm.) Nakai) cv. Gola.

Treatments	Fruit length (cm)			
	10-April	10-May	10-June	10-July
GA_3 @ 50 ppm (T_1)	1.81	4.89	6.05	6.98
GA_3 @ 100 ppm (T_2)	1.44	4.38	5.67	6.54
BR @ 0.5 ppm (T_3)	1.53	4.44	5.71	6.68
BR @ 1 ppm (T_4)	1.41	4.32	5.65	6.55
GA_3 @ 50 ppm + BR @ 0.5 ppm (T_5)	1.72	4.74	5.85	6.79
GA_3 @ 100 ppm + BR @ 1 ppm (T_6)	1.57	4.63	5.77	6.70
Control(T_7)	1.29	4.12	5.33	6.21
SEm±	0.03	0.06	0.12	0.09
CD (0.05)	0.08	0.18	0.35	0.26

Table 2. Effect of pre-harvest spray of GA_3 and BR on fruit breadth of pear (*Pyrus pyrifolia* (Burm.) Nakai) cv. Gola.

Treatments	Fruit breadth (cm)			
	10-April	10-May	10-June	10-July
GA_3 @ 50 ppm (T_1)	1.75	4.68	5.83	6.81
GA_3 @ 100 ppm (T_2)	1.39	4.18	5.39	6.35
BR @ 0.5 ppm (T_3)	1.46	4.35	5.57	6.51
BR @ 1 ppm (T_4)	1.35	4.23	5.42	6.40
GA_3 @ 50 ppm + BR @ 0.5 ppm (T_5)	1.69	4.56	5.72	6.68
GA_3 @ 100 ppm + BR @ 1 ppm (T_6)	1.50	4.41	5.61	6.55
Control(T_7)	1.22	3.96	5.13	6.08
SEm±	0.02	0.07	0.06	0.07
CD (0.05)	0.58	0.20	0.17	0.21

Table 3. Effect of pre-harvest spray of GA_3 and BR on fruit weight, fruit volume and specific gravity of pear (*Pyrus pyrifolia* (Burm.) Nakai) cv. Gola.

Treatments	Fruit weight (g)	Fruit volume (cc)	Specific gravity
GA_3 @ 50 ppm (T_1)	175.90	171.16	1.03
GA_3 @ 100 ppm (T_2)	172.27	168.72	1.02
BR @ 0.5 ppm (T_3)	171.36	166.14	1.03
BR @ 1 ppm (T_4)	167.42	163.17	1.03
GA_3 @ 50 ppm + BR @ 0.5 ppm (T_5)	166.43	164.85	1.01
GA_3 @ 100 ppm + BR @ 1 ppm (T_6)	164.65	161.35	1.02
Control (T_7)	161.33	156.56	1.03
SEm±	2.06	1.56	0.01
CD (0.05)	6.37	4.83	NS

treatments under study, GA_3 @ 100 ppm + BR @ 1ppm (T6) recorded the highest ascorbic acid content which was at par with the treatment 1 ppm BR (T_4) and 100 ppm GA_3 (T_2) i.e., 6.83 mg/100 g and 6.73 mg/100 g respectively. At the same, lowest value of 6.06 mg/100 g for this trait was recorded in the untreated control (T_7) fruits followed by application of GA_3 50 ppm in T1 (6.36 mg/100 g). However, significant difference in ascorbic acid was observed in T_1 Vs T_4 and T_6.

Data presented in table 5 and Fig1, shows that the total sugars content in fruits were significantly enhanced by different treatments during the period of investigation. The highest total sugar (7.88%) was found in the fruits from trees treated with GA_3 @ 50 ppm + BR @ 0.5 ppm (T_5), which was however, statistically at par with the treatments T_6 (7.72%), T_3 (7.60%) and T_1 (7.42%). The total sugar in fruits was recorded least under control (T_7) i.e., 6.82% and T_2 (7.11%). The reducing sugars content in fruits were significantly enhanced by different treatments. The higher value for reducing sugars (7.45%) was observed in the fruits from trees treated with 50 ppm GA_3 + 0.5 ppm BR (T_5) closely followed by 100 ppm GA + 1 ppm BR (T_6), 0.5 ppm BR (T_3) and 50 ppm GA_3 (T_1) i.e., 7.29% ,7.20% and 7.05%, respectively which were statistically at par with each other. The reducing sugars in fruits were however, found to be significantly lower (6.47%) in control (T_7) among all the treatments but statistically at par with T_4 (6.84%) and T2 (6.75%). It is evident from the data presented in Table 5 that mean values of non reducing sugars varied from 0.11 to 0.44 %. However, it also reveals that treatments did not differ significantly for this trait. The maximum mean value (0.44%) of non reducing sugars was observed with the treatment GA_3 @ 100 ppm + BR @ 1ppm (T_6), while minimum (0.35%) was recorded in control (T_7).

DISCUSSION

Fruit length followed a linear pattern of growth in all

Table 4. Effect of pre-harvest spray of GA_3 and BR on TSS, titrable acidity and ascorbic acid content in pear (*Pyrus pyrifolia* (Burm.) Nakai) cv. Gola.

Treatments	TSS (^{0}Brix)	Acidity (%)	Ascorbic acid (mg/100 g)
GA_3 @ 50 ppm (T_1)	11.76	0.56	6.36
GA_3 @ 100 ppm (T_2)	12.07	0.54	6.73
BR @ 0.5 ppm (T_3)	12.12	0.52	6.46
BR @ 1 ppm (T_4)	12.91	0.42	6.83
GA_3 @ 50 ppm + BR @ 0.5 ppm (T_5)	12.19	0.50	6.45
GA_3 @ 100 ppm + BR @ 1 ppm (T_6)	12.79	0.45	6.95
Control (T_7)	11.51	0.59	6.06
SEm±	0.236	0.022	0.149
CD (0.05)	0.73	0.07	0.46

Table 5. Effect of pre-harvest spray of GA_3 and BR on total sugars, reducing and non reducing sugar content in pear (*Pyrus pyrifolia* (Burm.) Nakai) cv. Gola.

Treatments	Sugars		
	Total (%)	Reducing (%)	Non-reducing (%)
GA_3 @ 50 ppm (T_1)	7.42	7.05	0.37
GA_3 @ 100 ppm (T_2)	7.11	6.75	0.36
BR @ 0.5 ppm (T_3)	7.60	7.20	0.40
BR @ 1 ppm (T_4)	7.19	6.84	0.35
GA_3 @ 50 ppm + BR @ 0.5 ppm (T_5)	7.88	7.45	0.43
GA_3 @ 100 ppm + BR @ 1 ppm (T_6)	7.72	7.29	0.44
Control (T_7)	6.82	6.47	0.35
SEm±	0.171	0.19	0.11
CD (0.05)	0.59	0.60	NS

the treatments during the entire course of study. Stern and Gazit (2003) described a similar trend in 'Yu Her Pau' litchi for over two years in Taiwan. They hypothesize that sprays of GA_3 during stage I of fruit growth would increase fruit and aril weight. This might be due to the promotion of cell multiplication, cell expansion and differentiation and continuous mobilization of nutrients and assimilates. Choi *et al*. (2002) reported that spraying GA_3 increased the fruit size and firmness in cherry fruits. Tuan and Ruey (2013) obtained fruits with enhanced fruit length and size after treating the trees of wax apple with 30 ppm GA_3. Similar perceptions are also proclaimed by Banday *et al*. (2005), who witnessed the enhancing effect of GA_3 on the size quality of two strawberry cultivars 'Cofitura' and 'Brigton'.

The present results may be attributed to influence of the bio regulator on cell extension and cell division. Grapevine fruits cv. Thompson Seedless when treated with GA_3, experienced an increase in size and production (Abu- Zahra, 2010). Similarly, Canli and Orhan (2009) reported that trees receiving GA_3 at 25 ppm yielded larger fruit in '0900 Ziraat' sweet cherry. Fruit breadth in the control was lowest (6.08 cm) of all the treatments followed by T_2 (6.35 cm). Identical results were reported by foliar spray of GA_3 on fruit physical characteristics of cape gooseberry by Wanyama *et al*. (2006). Exogenous application of gibberellins is known to influence fruit size in various crops (Zhang and Whiting, 2011). According to Richard (2006) gibberellic acid is reported to promote growth by increasing plasticity of the cell wall followed by the hydrolysis of starch into sugars which reduces the cell water potential, resulting in the entry of water into the cell thus causing an increase in size.

The increase in fruit weight was mainly due to cell division in the initial stages and later due to faster cell expansion associated with the influx of water and metabolites into the fruits which cause an overall increase in the weight of fruits. Sachs and Weaver (1968) opined that the role of hormones in fruit development might be due to mobilization of elaborated food materials, accompanied by the increase in water uptake, solute storage and synthesis of organic components. Khassawneh *et al*. (2006) also indicated that spraying with GA_3 stimulate cell division and cell enlargement which are reflected on fruit weight increase. Our results were also found to be in agreement with that of Saraswathi *et al*. (2003) who observed that GA_3 significantly influenced the fruit weight as well as yield in mandarin. Similarly, Sayed *et al*. (2004) reported that fruit weight, peel thickness and fruit diameter of Valencia oranges were increased due to spraying with GA_3.

The growth of a plant cell is primarily driven by the water uptake into cytoplasm and vacuole of the cell. The vacuole expands rapidly, pressing the plasmalemma against the cell wall. The enlargement of the cell takes place due to the development of turgor pressure within the cell. Therefore, the plant hormones might alter the physical properties of the cell in order to enhance the berry growth. Application of GA_3 increases growth rate by changing the osmotic potential of the cell. In other words, the role of GA_3 in improving fruit quality namely; fruit weight, volume and fruit diameter may be explained due to its role in increasing cell elongation (Pharis and King, 1995). The obtained results of GA_3 sprays are in line with those reported by El-Sese (2005) who found that Balady mandarin trees sprayed with GA_3 resulted in increased fruit volume. The obtained results are also supported by Mostafa *et al.* (2001) on pear, Abd El-Migeed (2002) on Washington navel and El - Sharkawy and Mehaisen (2005) on guava.

The rise in TSS by application of BR might be due to mobilization of metabolites from source to sink and also the conversion of starch and acids into sugars. These results also confirm the finding of HongBo *et al.* (2013) who recorded higher TSS in 'Baiyulong' pitaya fruits with the treatment of brassinolide applied at 1 ppm. The increase in TSS with brassinosteroid was also reported by Champa *et al.* (2014) in grapes, Gomez *et al.* (2006) in passion fruit and Roghabadi and Pakkish (2014) in sweet cherry.

Vitamin C content in the fruits varies among the crop species and is affected by the environmental factors, time of fruit harvesting, plant vigour, the age of the plant and the use of growth regulators. The prospective increase in ascorbic acid might also be due to catalytic activities of GA_3 on precursor glucose-6-phoshate which in combination with brassinosteroids.

Application of GA_3 increases total sugar by increasing the capacity of fruits to draw more carbohydrates through increased auxin content directly or indirectly due to the quick metabolic transformation of soluble compounds (Singh *et al*., 1993). The steroidal hormone BR is involved in increasing the content of ABA (Symons *et al*., 2006). Increased ABA induces the sugar metabolic pathway. Therefore, application of BRs indirectly increases the sugars in fruits. In this study also, the combined effect of BR (0.5 ppm) + GA_3 (50 ppm) increased the total sugars. This is in line with the findings of Velu (2001) in Muscat, Tambe (2002) in Thompson Seedless and Bhat *et al.* (2004) in Flame Seedless grapes.

The increase in reducing sugars might be ascribed to the conversion of starch and acids into sugars in addition to continuous mobilization of carbohydrates from leaves to fruits (Antognozzi *et al*., 1993). Synergistic interaction between brassinosteriods with gibberellins was also elaborated by Gregory and Mandava (1982). The result corroborate with the earlier records of Padashetti *et al.* (2010) in Arka Neelamani and Thompson seedless by foliar application of GA_3 @ 50 ppm + BR @ 1 ppm twice at fruit set stage resulted in increased reducing sugar (%). Foliar spray of growth regulators alone or in combinations is helpful to increase the sugar level, which could be due to translocation of carbohydrate as a result of maintenance of better assimilating power of leaves over a longer period. The synergistic activity of both GA_3 and BRs increases the metabolic activities in various crops which favors rise in the rate of photosynthesis and increase in the amount of chlorophyll content, thus affecting the overall quality of the fruits. Symons *et al.* (2006) also observed that brassinosteroids are involved in enhancing the quality of the grapes.

Conclusion

The use of plant bioregulators, natural compounds, helps to stimulate the plant itself via activation of gene expression in a certain period of development and also they do not allow the development of biotypes or coevolution of pests. The application of bioregulators is an easy method which can be utilized by farmer's community as well. The time of application play a crucial role for desirable output. Therefore, the combined application of gibberellin and brassinosteroid either @ GA_3 (100 ppm) + BR (1 ppm) or GA_3 (50 ppm) + BR (0.5 ppm) as pre-harvest sprays at 15 days interval starting from the petal fall stage may be recommended for improvement in fruit quality of Gola pear in *tarai* region. The further studies are needed to explore molecular mechanism for understanding the mechanism deciphering the role of brassinosteroids in signal transduction.

ACKNOWLEDGEMENTS

The author is highly thankful to the Department of Horticulture for granting graduate assistantship for conducting research.

REFERENCES

Abd El-Migeed, D.C.M.M.M. (2002). Improving productivity and fruit quality of Washington navel orange trees by using some macro-elements and GA_3 sprays. *Egypt J. of App. Sci.,* 17(10): 787- 801

Anonymous (2014). Indian horticulture database. National Horticulture Board, Gurgaon, Haryana.

Abu-Zahra, T.R. (2010). Berry size of Thompson seedless as influenced by the application of gibberellic acid and cane girdling. *Pak. J. of Bot.,* 42: 1755-1760

Antognozzi, E., A. Battistelli, F. Famiani, S. Moscatello, F. Stanica and A. Tombesi, (1993). Influence of CPPU on carbohydrate accumulation and metabolism in fruits of *Actinidia deliciosa* (A. Chev.). *Sci. Hort.,* 65(1): 37-47

AOAC (1980). Official methods of Analysis. 13th edition. Association of Official Analytical Chemist, Washington,

Banday, F.A., Sofi, S.A. and Hafiza, A. (2005). Effect of growth regulators on physico-chemical characters and yield attributes of strawberry. *App. Biological Res.,* 7 (1/2): 27-30

Bhat, Z.A., Srihari, D. and Reddy, Y.N. (2004). Effect of BR's and CPPU along with BA on number of leaves, leaf area and leaf dry matter in grape cv. Flame Seedless. *Annals of Agri. Bio. Research,* 9(1): 25-28

Canli, F.A. and Orhan, H. (2009). Effects of pre-harvest gibberellic acid applicationson fruit quality of '0900 Ziraat' sweet cherry. *HortTechnol.,* 19: 127-129

Champa, W.A.H., Gill, M.I.S., Mahajan, B.V.C. and Arora, N.K. (2014). Pre-harvest treatments of brassinosteroids on improving quality of table grapes (Vitis vinifera) cv. Flame seedless. *Intl J. of Agric. Sci. and Vet. Medicine*, 1(2): 96-104

Choi, C., Wiersma, P., Toivonen, A.P. and Kappel, F. (2002). Fruit growth, firmness and cell wall hydrolytic enzyme activity during development of sweet cherry fruit treated with gibberellic acid (GA_3). *J. of Hort. Sci. and Biotechnol.,*77(5): 615-621

Dussi. M.C. (2011). Sustainable use of plant bioregulators in pear production., Acta Hort., 909: 353-368

El-Sese, A.M.A. (2005). Effect of gibberellic acid (GA_3) on yield and fruit characteristics of Balady mandarin. *Assiut Journal of Agricultural Sciences.* 36(1): 23-35

El-Sharkawy, S.H.M.M. and Mehaisen, S.M.A. (2005). Effect of gibberellin and potassium foliage sprays on productivity and fruit quality of guava trees. *Egyptian J. of Basic and App. Sci.,* 20(3): 151-162

FAOSTAT (2013). FAO Statistical Yearbook. Food and Agriculture Organization of the United Nations, Rome, Italy.

Gomez, M.M.A., Campostrini, E., Leal, N.R., Viana, A.P., Ferraz, T.M., Siqueira, N.D., Rosa, R.C.C., Netto, A. T., Nunez-Vazquez, M. and Zullo, M.A.T. (2006). Brassinosteroid analogue effects on the yield of yellow passion fruit plants (*Passiflora edulis* f. *flavicarpa*). *Scientia Horticulturae,* 110(3): 235-240

Gregory, L.E. and Mandava, N.B. (1982). The activity and interaction of brassinolide and gibberellic acid in mung bean epicotyls. *Plant Physiology*, 54: 239-43

Hong Bo, L., Wang, J., Chen, Y. and Run Tang, L. (2013). Effects of brassinolide on fruit growth and quality of pitaya. *J. of Southern Agriculture,* 44(7): 1150-1153

Khassawneh, N.M.A., Karam, N.S. and Shibli, R.A. (2006). Growth and flowering of black iris (*Iris nigricans* Dinsm.) following treatment with plant growth regulators. *Scientia Horticulturae,* 107(2) :187-193

Mostafa, E.A.M., Saleh, M.M. and Abd El-Migeed, M.M. M. (2001). Improving Le Cont pear trees productivity by spraying, GA_3 and sucrose. *Arab University J. of Agriculture Sciences,* 9(1): 373-385

Muniz, J., Kretzschmar, A.A., Rufato L., Luz, A.R., Hipólito, J.S., Silveira, F.N and Sander, G. (2015). The use of PGR and fertiliser on the 'rocha' pear to increase the productivity. *Acta Hort.,* 1094: 367-372.

NHB (2014). Indian Horticulture Database. National Horticulture Board, Gurgaon, Haryana.

Padashetti, B.S., Angadi, S.G. and Pattepur, S. (2010). Effect of pre-harvest spray of growth regulators on growth, quality and yield of seedless grape genotypes. *The Asian J. of Horticulture,* 5(1): 218-221

Panse, V.G. and Sukhatme, P.V. (1985). Statistical methods foragricultural workers.4th ed. ICAR, New Delhi.

Pharis, R.P. and King, R.W. (1995). Gibberellic and reproductive development in seed plants. *Ann.* Rev. *Plant Physiology*, 36: 517-568

Ranganna, S. (1986). Handbook of analysis and quality control for fruits and vegetable products. 2nd Edition. TATA MC Graw Hill Publishing Company Limited. New Delhi. 122 pp.

Richard, M. (2006). How to grow big peaches. Report presented at Department of Horticulture, Virginia Tech. Blacksburg, 8pp.

Roghabadi, M.A. and Pakkish, Z. (2014). Role of brassinosteroid on yield, fruit quality and postharvest storage of 'Tak Danehe Mashhad' sweet cherry (*Prunus avium* L.). *Agricultural Communications,* 2(4): 49-56

Sachs, R.M. and Weaver, R.L. (1968). Gibberellin and auxin induced berry elongation in (*Vitis vinifera* L.). *J. of Horticulture Sciences,* 43: 185-195

Saraswathi, T., Rangasamy, P., Azhakiamanavalan, R.S. (2003). Effect of preharvest spray of growth regulators on fruit retention and quality of mandarins (*Citrus reticulata* Balanco). *South Indian Horticulture,* 51: 110-112

Sayed, R.A., Solaiman, B.M. and Abo-El Komsan, E.O. (2004). Effect of foliar sprays of some 3 mineral nutrients, GA3 and or bio-stimulant on yield and fruit quality of Valencia orange trees grown in sandy soil. *Egyptian Journal of Basic and Applied Sciences*, 19: 222-238

Singh, S., Singh, I.S. and Singh, D.N. (1993). Physico-chemical changes during development of seedless grapes (*Vitis vinifera* L.). *Orissa J. of Horticulture,* 21: 43-46

Stern, R.A. and Gazit, S. (2003). The reproductive biology of the litchi. *Horticultural Reviews*, 28: 393-453

Symons, G.M., Davies, C., Shavrukov, Y., Dry, I.B., Reid, J. B. and Thomas, M.R. (2006). Grapes on steroids. Brassinosteroid are involved in grape berry ripening. *Plant Physiology,* 140(1): 150-158

Tambe, T.B. (2002). Effects of gibberellic acid in combination with brassinosteroid on berry size, yield and quality of Thompson Seedless grape. *J. of Maharashtra Agriculture University,* 27(2): 151-153

Tuan, N.M. and Ruey, Y.C. (2013). Effect of gibberellic acid and 2,4- Dichlorophenoxyacetic acid on fruit development and fruit quality of wax apple. *International J. of Biology Food, Veterinary and Agriculture Engineering,* 7(1): 28-36

Velu, V. (2001). Studies on bud load and certain crop thinning practices on vigour, yield and quality of grapes (*Vitis vinifera* L.) cv. Muscat. Thesis, M.Sc. TNAU, Coimbatore. 88p.

Wanyama, D.O., Wamocha, L.S., Ngamau, K. and Ssonkko, R.N. (2006). Effect of gibbrellic acid on growth and fruit yield of greenhouse grown cape gooseberry. *African Crop. Science J.*, 14(4): 319-323

Zhang, Y.P., Zhu, X.H., Ding, H.D., Yang, S.J. and Chen, Y. Y. (2013). Foliar application of 24-epibrassinolide alleviates high-temperature induced inhibition of photosynthesis in seedlings of two melon cultivars. *Photosynthetica,* 51(3): 341-349