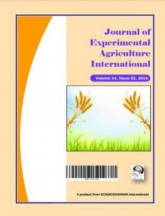

Journal of Experimental Agriculture International

21(3): 1-6, 2018; Article no.JEAI.38465
ISSN: 2457-0591
(Past name: American Journal of Experimental Agriculture, Past ISSN: 2231-0606)

Influence of Bio-regulators on the Fruit Quality and Yield Attributes of Phalsa (*Grewia subinaequalis* DC)

Gurpinder Kaur[1*], Maninderjit Singh[1] and Manpreet Singh[1]

[1]P.G. Department of Agriculture, Khalsa College, Amritsar, Punjab, India.

Authors' contributions

This work was carried out in collaboration between all authors. Author GK designed the study, performed the statistical analysis and wrote the protocol. Author Maninderjit Singh wrote the first draft of the manuscript. Authors Maninderjit Singh and Manpreet Singh managed the analyses of the study. Author Manpreet Singh managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JEAI/2018/38465
Editor(s):
(1) Aleksander Lisowski, Professor, Department Agricultural and Forestry Engineering, Warsaw University of Life Sciences, Poland.
Reviewers:
(1) Zubair Tak, SKUAST-K, India.
(2) Jayath P. Kirthisinghe, University of Peradeniya, Sri Lanka.
Complete Peer review History: http://www.sciencedomain.org/review-history/23669

Original Research Article

Received 27th November 2017
Accepted 13th February 2018
Published 17th March 2018

ABSTRACT

Aims: To examine the influence of bioregulators on the fruit quality and yield attributes of phalsa.
Study Design: Randomised Block Design.
Place and Duration of Study: Phalsa orchard, Department of Horticulture, Khalsa College, Amritsar during 2015-2016.
Methods: The present study comprised of ten treatments which replicated thrice. The treatments were consisted of Gibberellic acid (GA_3 @ 50, 100 and 150 ppm), Naphthalene Acetic Acid (NAA @ 25, 50 and 75 ppm), Ethrel (@ 250, 500 and 1000 ppm) and control. The thirty plants of uniform vigour were randomly selected for the study and these were applied with different concentrations of NAA and GA_3 at fruit set whereas ethrel was sprayed at 20 to 25 days before fruit harvest. Uniform sized mature fruits were harvested and a sample of ten randomly selected fruits were being taken from each replication for fruit physical and biochemical analysis and then average was worked out for each parameter. The observations were recorded *viz*., fruit length (cm), fruit breadth (cm), fruit weight (g), fruit colour, total soluble solids (TSS%), titratable acidity (%), TSS: acid ratio, reducing sugars (%), total sugars (%), ascorbic acid (mg/100 g pulp), stone length (cm), stone breadth (cm),

**Corresponding author: E-mail: gurpinder.sohal@gmail.com;*

stone weight (g), harvesting span (days), number of pickings and fruit yield per plant (kg).
Results: The results revealed that GA_3 150 ppm treated plants yielded fruits with maximum fruit length (1.26 cm), fruit breadth (1.43 cm), fruit weight (1.20 g), reducing sugars (7.49 %), ascorbic acid (31.10 mg/100 g pulp) and yield (3.48 kg/plant). Minimum stone length (0.50 cm), stone breadth (0.33 cm) and stone weight (0.045 g) were recorded in fruits obtained from plants treated with NAA 25 ppm. Ethrel 1000 ppm significantly improved TSS (20.23%), fruit colour (purple black), total sugars (12.79 %) whereas reduced the titratable acidity (1.54 %), harvesting span (22.81 days) and number of pickings (3.90).
Conclusion: The results of the present study concluded that plants treated with GA_3 150 ppm registered a significant improvement in fruit physical and biochemical parameters and also fruit yield per plant was increased. The fruits obtained from the plants treated with NAA 25 ppm had small sized and minimum weighed stone. Whereas the yield attributes were enhanced with the application of ethrel 1000 ppm in terms of advancement of harvesting and also reduction in number of pickings. Hence ethrel 1000 ppm may be applied to improve the fruit quality parameters as well as yield parameters and also to fetch the premium price in the market due to their attractive colour appearance than control.

Keywords: Phalsa; bio-regulators; fruit physical parameters; fruit biochemical parameters; yield.

1. INTRODUCTION

The Phalsa (*Grewia subinaequalis* DC) belonging to the family Tiliaceae, is an important indigenous fruit for arid and semi-arid region because of its hardy nature and capacity to tolerate high temperature and even to be grown under prolonged dry spells [1]. India is considered to be the home of phalsa and it is commercially cultivated in Punjab, Uttar Pradesh, Madhya Pradesh, Haryana and Rajasthan [2]. In Punjab, it is mostly grown in Ropar, Hoshiarpur, Gurdaspur and Amritsar district. The area under phalsa in Punjab is only 30 hectares with an annual production of 196 tonnes [3].

Plant growth regulators are chemicals that effect flowering, ageing, root growth, prevention and promotion of stem elongation, color enhancement of phalsa fruits. A very small concentration of these substances produces major growth changes. They are widely used for increasing fruit set, controlling fruit drop, enhancing quality and uniform maturity. Among growth regulators GA_3, NAA, Ethrel are widely used for enhancing superior characters of the fruit crop. Application of GA_3 results in increased yield and better grade of phalsa [4]. The use of bioregulator like GA_3 has proved effective for increasing the size of berry or fruit and improved quality in crop like grape, citrus, ber etc [2]. Parthenocarpic development of fruits is also a result of gibberellins action [5]. It is thought that NAA may influence the rate of metabolic activity of developing embryos and even also stimulate ethylene biosynthesis which inhibits fruit growth and promote the abscission of weaker fruits. Naphthalene acetic acid shows positive attitude towards the reduction of fruit drop in many fruit crops.

Application of ethrel improves fruit quality in terms of TSS, reducing and total sugar [6]. Ethrel is a compound that decomposes to release the natural plant hormone ethylene. Its main use in fruit production is to enhance fruit ripening by permitting its harvest about one week earlier and also reduces the span of harvesting and number of pickings significantly [6]. The bioregulators have proved to be effective in increasing fruit set and yield in phalsa as well as quality of fruit in terms of TSS, reducing sugars and total sugars. Keeping the role of bioregulators in view, the present study was carried out for improved fruit set, quality and yield of phalsa.

2. MATERIALS AND METHODS

The trial was conducted on well maintained 9 years old phalsa orchard of Department of Horticulture, Khalsa College Amritsar during 2015-16. In the trial 30 uniforms sized trees were selected and sprayed with different concentrations of bioregulators as NAA (25, 50 and 75 ppm), GA_3 (50, 100 and 150 ppm) and Ethrel (250, 500 and 1000 ppm). NAA and GA_3 were sprayed at fruit set, whereas Ethrel was sprayed 20 to 25 days prior to harvesting to find out the optimum concentration of these bioregulators. Uniform sized mature fruits were harvested for carrying out physicochemical analysis. A sample of ten randomly selected fruits was being taken from each treatment and their size was noted using the vernier's caliper.

The weight of fruits from randomly drawn sample was computed with the help of Wensar PGB 200-1 mg electronic weighing balance. The fruits were evaluated for colour rating by a panel of five judges on the scorecard (maximum 10 points) based on colour. Fruits were rated as follows:

Table 1. Scorecard for colour rating of phalsa fruits

Acceptability	Grading	Colour
Excellent	9.1-10	Purple black
Very good	8.1-9	Cherry red
Good	7.1-8	Light red
Fair	6.1-7	Greenish red
Poor	6 and below	Light green

The stones from the same sample were extracted and their size and weight were recorded with the similar procedures taken for fruits. The fruit TSS was analyzed with the help of hand refractometer. Titratable acidity was calculated by titrating diluted juice against N/10 NaOH by using phenolphthalein as an indicator. The diluted juice was prepared by adding distilled water in the ratio of 1:10. The endpoint of the titration was permanent pink colour. The acidity was calculated and expressed in terms of citric acid [7] by using the below given formula,

$$\text{Titratable acidity (\%)} = \frac{0.064 \times \frac{N}{10}\text{NaOH}}{\text{Volume of juice taken}} \times 100$$

Reducing sugars and total sugars were analyzed by Lane and Eynon method [8]. Ascorbic acid was analysed by Indophenol dye method [9]. The fruits were picked at regular intervals when ripe, the number of pickings was recorded and days taken to ripe from fruit sets were counted as harvesting span. The fruits were picked on alternate days and were weighed by using physical balance. Average yield per plant was worked out. The recorded data were computed by the standard procedures of the Randomized Block Design (RBD) and the effects of treatments were tested at 5 percent level of significance.

3. RESULTS AND DISCUSSION

3.1 Fruit Physical Parameters

The data presented in Table 2 revealed that most of the treatments improved the fruit size, however the plants treated with GA_3 150 ppm (T_9) yielded fruits with maximum length (1.26 cm) and breadth (1.43 cm). The former treatment was also found to be at par with the treatment T_6 (Ethrel 1000 ppm) with fruit length and breadth of 1.18 cm and 1.42 cm respectively.

The significant increment in fruit size over control by the use of gibberellins had been noticed and this increase might be due to the indirect effect of gibberellins on the level of auxins that ultimately caused cell elongation by enlargement of vacuoles and loosening of cell wall after increasing its palatability. Also, increase in fruit size by the use of ethrel could be attributed due to increase in the availability of photosynthates and nutrients to the remaining fruits thereby increasing the size of individual fruits. Increase in fruit size was also observed by [10] with ethrel and by [11] and [12] with gibberellins. GA_3 150 ppm (T_9) treated plants gave fruits with maximum weight of 1.20 g, which might be due to the fact that gibberellins increase the cell division and translocation of food material [12]. Treatment T_9 was also found to be at par with the treatment T_6 (Ethrel 1000 ppm) with fruit weight of 1.14 g. Results of these findings were confirmed by [4], [1] and [10]. The plants treated with treatment T_6 produced fruits with excellent purple-black colour. This might be due to the fact that ethrel enhanced chlorophyll degradation and increased carotene synthesis [13].

3.2 Fruit Biochemical Parameters

The data regarding fruit biochemical parameters as influenced by various concentrations of ethrel, NAA and GA_3 are presented in Table 3. Significant TSS (20.23 %) was observed in fruits obtained from plants treated with ethrel 1000 ppm. This may be due to the quick metabolic transformation of starch and pectin into soluble compounds and rapid translocation of sugars from the leaves to the developing fruits [14]. The results of these findings were also confirmed by [4,2] and [6].

The fruits with minimum acidic content (1.54 %) were obtained from plants treated with ethrel 1000 ppm. This might be due to the fact that ethrel enhance the conversion of organic acids to sugars which increases the sugar content and decreases the acidity [15]. The present study is in conformity with the findings of [1] and [10]. The data related to sugars showed that plants treated with Ethrel 1000 ppm yielded fruits with maximum reducing sugars (7.49 %) and total sugars (12.79 %). This might be due to that ethrel promoted hydrolysis of starch into sugars

[6]. The present results are in conformity with the findings of [1] and [10]. Ascorbic acid content in fruits increased significantly by the use of gibberellins. Maximum ascorbic acid content (31.10 mg/100 g pulp) was observed in fruits obtained from plants treated withGA_3 150 ppm. This might be due to the possible catalytic influence of gibberellic acid on biosynthesis of ascorbic acid from sugar or inhibition of oxidative enzymes or both [16]. The results of these findings are in conformity with [17] and [18].

3.3 Stone Parameters

The data presented in Table 4 revealed that all the treatments showed non-significant effect on the stone size in phalsa. Minimum stone length (0.50 cm) and stone breadth (0.33 cm) was registered under the treatment T_1. From the data, it has been observed that NAA 25 ppm treated plants gave fruits with least stone weight (0.045 g). The present study is in conformity with the findings of [12].

3.4 Yield Parameters

The presented data (Table 5) showed that ethrel significantly improved the yield parameters in phalsa. Ethrel 1000 ppm treated plants registered minimum harvesting span (22.81 days) than rest of the treatments. The number of pickings also significantly reduced by the use of ethrel.

A minimum number of pickings (3.90) was recorded in plants treated with ethrel 1000 ppm. This might be due to that ethrel hasten the maturation process [19]. These findings are in conformity with the findings of [1] and [6]. The plants treated with GA_3 150 ppm registered

Table 2. Influence of various bio-regulators on fruit physical parameters of phalsa (*Grewia subinaequalis* DC)

Treatments	Fruit size		Fruit weight (g)	Fruit colour
	Fruit length (cm)	Fruit breadth (cm)		
T_1- NAA 25 ppm	0.91±0.01	1.13±0.03	0.98±0.01	7.60±0.10
T_2- NAA 50 ppm	1.00±0.02	1.22±0.01	1.04±0.02	7.80±0.10
T_3–NAA 75 ppm	1.08±0.04	1.28±0.02	1.07±0.01	7.90±0.10
T_4- Ethrel 250 ppm	1.19±.03	1.33±0.02	1.06±0.01	8.80±0.15
T_5- Ethrel 500 ppm	1.09±0.04	1.33±0.02	1.08±0.01	8.90±0.10
T_6- Ethrel 1000 ppm	1.18±0.02	1.42±0.02	1.14±0.01	9.20±0.10
T_7- GA_3 50 ppm	1.23±0.01	1.35±0.01	1.13±0.01	8.40±0.10
T_8- GA_3 100 ppm	1.23±0.01	1.40±0.01	1.13±0.02	8.60±0.15
T_9- GA_3 150 ppm	1.26±0.02	1.42±0.02	1.20±0.10	8.70±0.10
T_{10}- Control	0.95±0.02	1.11±0.02	0.78±0.01	7.10±0.15
CD (*P*=.05)	**.08**	**.06**	**.06**	**.70**

**CD (P=.05) means critical difference among treatments at 5 percent level of significance*

Table 3. Influence of various bio-regulators on fruit bio-chemical parameters of phalsa (*Grewia subinaequalis* DC)

Treatments	TSS (%)	Titratable acidity (%)	Reducing sugars (%)	Total sugars (%)	Ascorbic acid (mg/100 g pulp)
T_1- NAA 25 ppm	15.23±0.30	2.97±0.31	5.38±0.35	9.78±0.48	22.60±0.72
T_2- NAA 50 ppm	15.81±0.36	2.27±0.26	5.49±0.29	10.52±0.50	23.86±0.90
T_3- NAA 75 ppm	15.75±0.23	2.29±0.28	5.54±0.36	10.47±0.50	23.91±0.82
T_4- Ethrel 250 ppm	16.07±0.31	2.22±0.30	6.02±0.43	10.69±0.30	25.03±0.45
T_5- Ethrel 500 ppm	18.48±0.43	1.80±0.20	6.77±0.54	12.75±0.48	25.28±0.33
T_6- Ethrel 1000 ppm	20.23±0.75	1.54±0.35	7.49±0.39	12.79±0.69	25.62±0.38
T_7- GA_3 50 ppm	17.13±0.75	2.22±0.23	6.69±0.37	12.35±0.51	30.06±0.92
T_8- GA_3 100 ppm	16.78±0.53	2.10±0.30	7.32±0.45	12.04±0.28	30.98±0.50
T_9- GA_3 150 ppm	18.09±0.46	1.97±0.40	7.28±0.28	12.62±0.34	31.10±0.66
T_{10}- Control	15.16±0.62	2.42±0.40	5.27±0.31	10.15±0.15	20.02±0.53
CD (*P*=.05)	**.38**	**.52**	**.41**	**.82**	**.99**

**CD (P=.05) means critical difference among treatments at 5 percent level of significance*

Table 4. Influence of various bio-regulators on stone parameters of phalsa (*Grewia subinaequalis* DC)

Treatments	Stone length (cm)	Stone breadth (cm)	Stone weight (g)
T_1- NAA 25 ppm	0.50	0.33	0.04±0.02
T_2- NAA 50 ppm	0.56	0.40	0.07±0.01
T_3–NAA 75 ppm	0.53	0.40	0.06±0.01
T_4- Ethrel 250 ppm	0.53	0.40	0.11±0.01
T_5- Ethrel 500 ppm	0.56	0.43	0.08±0.01
T_6- Ethrel 1000 ppm	0.56	0.43	0.08±0.01
T_7- GA_3 50 ppm	0.53	0.41	0.10±0.02
T_8- GA_3 100 ppm	0.56	0.43	0.11±0.02
T_9- GA_3 150 ppm	0.56	0.46	0.09±0.01
T_{10}- Control	0.58	0.40	0.11±0.01
CD (*P*=.05)	**NS**	**NS**	**0.02**

**CD (P=.05) means critical difference among treatments at 5 percent level of significance*

Table 5. Influence of various bio-regulators on yield parameters of phalsa (*Grewia subinaequalis* DC)

Treatments	Harvesting span (days)	Number of pickings	Yield (kg/plant)
T_1- NAA 25 ppm	27.71±0.34	6.56±0.38	2.51±0.20
T_2- NAA 50 ppm	27.32±0.43	6.31±0.31	2.76±0.10
T_3- NAA 75 ppm	26.72±0.38	6.08±0.43	2.80±0.10
T_4- Ethrel 250 ppm	23.02±0.13	4.39±0.23	2.85±0.09
T_5- Ethrel 500 ppm	23.51±0.48	4.15±0.32	3.17±0.29
T_6- Ethrel 1000 ppm	22.81±0.32	3.90±0.25	3.36±0.32
T_7- GA_3 50 ppm	26.42±0.38	6.01±0.14	3.23±0.35
T_8- GA_3 100 ppm	25.13±0.25	5.57±0.35	3.47±0.45
T_9- GA_3 150 ppm	24.12±0.33	5.26±0.29	3.48±0.43
T_{10}- Control	30.52±0.33	7.13±0.25	1.95±0.22
CD (*P*=.05)	**.07**	**.58**	**.15**

**CD (P=.05) means critical difference among treatments at 5 percent level of significance*

maximum yield (3.48 kg/plant) and was followed by treatments T_8 and T_6 with fruit yield of 3.47 and 3.36 kg/plant respectively. All of these treatments were found to be at par with each other. Yield is a complex character and is characterized by increase in weight of individual fruit and number of fruits. It might be due to the fact that GA_3 increased the translocation and mobilization of photosynthates from source to sink [5]. The results are in accordance with the findings of [4,17] and [20] in ber, [21] in Plum and [22] in mango.

4. CONCLUSION

The results of the present study concluded that plants treated with GA_3 150 ppm and ethrel 1000 ppm registered significant improvement in fruit physical and biochemical parameters and also fruit yield per plant was increased. The fruits obtained from the plants treated with NAA 25 ppm had small sized and minimum weighed stone. Whereas the yield attributes were enhanced with the application of ethrel at 1000 ppm in terms of advancement of harvesting and also reduction in number of pickings. Hence ethrel 1000 ppm may be applied to improve the fruit quality parameters as well as yield parameters and also to fetch the premium price in the market due to their attractive colour appearance than control.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Singh JP, Kumar S, Katiyar PN, Dwivedi AK. Effect of calcium nitrate, GA_3 and ethrel on fruiting, ripening and chemical traits of phalsa (*Grewia subinaequalis* D. C.). 2011;Annals Hort 4:72-76.

2. Kacha HL, Viradia RR, Leua HN, Jat G, Tank AK. Effects of NAA, GA_3 and ethrel on yield and quality of phalsa under south-surashtra condition. Asian J Hort. 2012;7: 242-245.
3. Pujari S. Phalsa cultivation in India – Production area, Climate, Harvesting and Fruit handling; 2015. Available:http://www.yourarticlelibrary.com/cultivation/phalsa-cultivation-in-india-production-area-climate-harvesting-and-fruit-handling/24703
4. Debnath A, Vanajalatha, Umarfarooque M, Reddy M. Effect of NAA, GA_3, Kinetin and Ethrel on yield and quality in phalsa. Asian J Hort. 2011;6:474-477.
5. Krishnamoorthy HN. Gibberellins. Plant growth substances. 1981;77-87.
6. Kacha HL, Jat G, Patel SK. Performance of various plant growth regulators on yield and quality of phalsa (*Grewia asiatica* L.). Hortflora Res Spec. 2014;3:292-294.
7. AOAC. Official and tentative, methods of analysis. Association of official analytical chemist, 14th Ed. Washington, DC; 1980.
8. Rangana S. Manual for Analysis of Fruit and Vegetable products. Tata McGraw Hill Co. Pvt. Ltd., New Delhi, 1977;9-13.
9. Rangana S. Manual for Analysis of Fruit and Vegetable products. Tata McGraw Hill Co. Pvt. Ltd., New Delhi. 1977;94-98.
10. Meitei SB, Patel RK, Deka BC, Deshmukh NA, Singh A. Effect of chemical thinning on yield and quality of peach cv. Flordasun. African J Agricultural Res. 2013;8:3558-3565.
11. Shukla HS, Kumar V, Tripathi VK. Effect of gibberellic acid and boron on development and quality of aonla fruit "Banarasi". ISHS Acta Hort. 2011;890:375.
12. Chandra R, Rawat M, Singh SS, Singh KK. Effect of foliar application of various growth regulators on yield and quality of Aonla cv.Na-7 National Academy Agricultural Sci. 2015;33:2123-2127.
13. Al-Mughrabi MA, Bacha MA, Abdelrahman AO. Influence of pre harvest application of ethrel and 2, 4-D on fruit quality of Balady orange. Agri Sci. 1989;1:95-102.
14. Tripathi VK, Shukla PK. Effect of plant bio-regulators, zinc sulphate and boric acid on yield and quality of strawberry cv. Chandler. J Asian Hort. 2007;4:15-18.
15. Singh P, Kumar S, Maji S. Effect of ethrel on post harvest changes in papaya (*Carica papaya* L.) fruits. HortFlora Res Spect. 2012;1:225-230.
16. Kher R, Bhat S, Wali VK. Effect of foliar application of GA_3, NAA and CCC on physico-chemical characterstics of guava cv. Sardar. Haryana J Hort Sci. 2005;34: 31-32.
17. Tripathi D, Pandey AK, Pal AK, Yadav MP. Studies on effect of plant growth regulators on fruit drop, development, quality and yield of ber cv. Banarasi Karaka. Progressive Horticulture. 2009;41:184-186.
18. Wahdan MT, Habib SE, Bassal MA, Qaoud EM. Effect of some chemicals on growth, fruiting, yield and fruit quality of "Succary Abiad" mango cv. J American Sci. 2011; 7:651-658.
19. Tyler K, May D, Miller R. Ethrel sprays reduce number of pickings in hand-harvested cantaloupes. California Agriculture. 1970; 24:6-7.
20. Gill KS, Bal JS. Impact of application of growth regulators on Indian jujube. International Jujube Symposium. 2011; 993:119-124.
21. Kaur H, Singh A, Gupta M, Randhawa JS. Effect of NAA and gibberellic acid on pre-harvest fruit drop and quality of Satluj Purple plum. Haryana J Hort Sci. 2008; 37:31-32.
22. Rohit S. Effect of GA_3 and urea spray on flowering fruit retention and fruit quality of mango cv. Langra. Doctoral dissertation, JNKKV; 2014.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history/23669