Int.J.Curr.Microbiol.App.Sci (2017) *6*(5): 1929-1938

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 6 Number 5 (2017) pp. 1929-1938**
Journal homepage: http://www.ijcmas.com

Review Article https://doi.org/10.20546/ijcmas.2017.605.214

A Review on Effect of Plant Growth Regulators on Physico-Chemical Attributes of Phalsa (*Grewia subinaequalis* D.C.)

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Keywords

Phalsa, Physico-chemical attributes, Plant growth regulators

Article Info

Accepted:
19 April 2017
Available Online:
10 May 2017

ABSTRACT

The present investigation entitled "The effect of foliar feeding of plant growth regulators on physico-chemical attributes of phalsa (*Grewia subinaequalis* D.C.)" was conducted at Main Experiment Station, Horticulture, Narendra Deva University of Agriculture & Technology, Kumarganj, Faizabad, Uttar Pradesh during 2014-2015 in Randomized Block Design and replication three and ten treatments T_1 - Control (Water spray), T_2-GA_3 50 ppm, T_3-GA_3 100 ppm,T_4-GA_3 150 ppm,T_5-NAA 50 ppm,T_6-NAA 100 ppm,T_7 –NAA 150 ppm, T_8 Ethrel 50 ppm, ethrel T_9 100 ppm, ethrel T_{10} 150 ppm. Physico-chemical characters like as fruit length & width, weight of 50 fruits, pulp-stone ratio, ascorbic acid content, etc. were increased and acidity per cent was reduced with the application of GA_3 @ 150 ppm, however total soluble solids and sugars (reducing, non-reducing, total sugar) content were improved by ethrel 100 ppm amd it is also effective in reducing acidity. It is clear from the data foliar application of GA_3@150 ppm effective to increase vegetative growth, yield and quality parameter respectively and ethrel@100 ppm was found best in quality improvement in phalsa fruits. A wider research has been done in the use of plant growth regulators and it is very effective in all fruits crops specially subtropical and tropical fruit crops. Hence plant growth regulators are very effective in improving physico-chemical attributes or quality of phalsa fruits.

Introduction

Phalsa (*Grewia subinaequalis* D.C.) is a subtropical fruit belongs to family Tiliaceae and its fruit are known as berry. Phalsa is a quick growing very hardy shrub which thrives well in arid and semi-arid region as well as in salt affected wasteland condition. It has high nutritional value, containing mineral like iron, phosphorus and vitamins like A and C having, 50-60 per cent juice, 10-11 per cent sugar. The fruits are very delicious, tasty and used as table purpose. The fruits are excellent for making juice and squash, ready to serve, nectar, syrup. However, it is mostly used as fresh fruit and has cooling effect. Application of growth substances *viz.*, auxins and gibberellins has been effective in increasing fruit set and yield in several fruit crops including phalsa. Characteristics of fruits such as length, width, pulp-stone ratio and weight of 50 fruits were increased due to foliar feeding plant growth regulators and they can also improve fruit quality, plant growth regulators improve better formation and translocation of food, hormonal signaling by gibberellins, similar results were found by Chandra *et al.*, 2015. Gibberellins decreases

in acidity due to hormones application [might be due to increase translocation of carbohydrates and increase metabolism due to conversion of acids to sugar. Gibberellins improved quality of fruits supported by many researches in fruit crops such as Yadav *et al.,* (1974), Singh *et al.,* (1977), Grewal *et al.,* (2000), Sharma *et al.,* (2002), Young *et al.,* (2003), Yadav *et al.,* (2005), Kher, (2005), Singh *et al.,* (2011) and Byas *et al.,* (2014)].

Plant growth regulators signaling the various metabolic processes in plants such as apical dominance, inhibition of apical dominance, regulating flowering and early ripening by using ethrel in less amounts is very effective. Plant growth regulators can also increase the ascorbic acid content in fruits by synthesis of catalytic activity of several enzymes and co-enzymes which are essential in ascorbic acid synthesis. So that plant growth regulators may improve physico-chemical characters like as fruit length & width, weight of 50 fruits, pulp-stone ratio, ascorbic acid content, total soluble solids, sugars through better formation and translocation of carbohydrates, starch hydrolysis and early maturation phalsa fruits by ethrel Kacha *et al.,* (2014). Hence plant growth regulators are very effective in improving physico-chemical attributes or quality of phalsa fruits (Bankar *et al.,* 1990; Chundawat *et al.,* 1973; Ray *et al.,* 1992; Byas *et al.,* 2014; Yadav *et al.,* 2011; Ahmed *et al.,* 2012; Agarwal *et al.,* 2010; Ghosh *et al.,* 2009; Kumar, 2010; Garasiya *et al.,* 2013; Karole *et al.,* 2016). Review on physico-chemical attributes of fruits: -

Randhawa and Sharma (1962) observed that spray of NAA at 25, 50 and 75 ppm on sweet orange (*Citrus sinensis* Osbeck) var. Jaffa, pineapple and Mosambi increased the fruit size. Prasad and Bajpai (1963) found that spray of NAA with concentrations of 25-75 ppm at full bloom stage and again 10days later on phalsa (*Grewia asiatica* L.) var. Sharbati increased fruit size, while, maximum diameter was obtained with 50ppm NAA.

Prasad and Jauhari (1963) reported that spraying of NAA and 2,4,5-T ranging from 10-100 ppm on 16 year old tree of litchi (branches of newly fruit set) at 1st April and 15 days later improved fruit size.

Prasad and Prasad (1966) reported that GA_3 and NAA each 25, 50 and 100 ppm concentration were applied on the plant of grape at full bloom and fruit setting stage. Among these GA_3 100ppm was the best treatment for improved the TSS content.

Srivastava and Singh (1969) observed that application of GA_3 at 25ppm and 50ppm of litchi, 4 weeks after fruit set, increased the TSS content.

Veera and Das (1971) reported that mangoes cv. Banganpalli was sprayed with NAA and GA_3 each at 10, 20 and 40, ppm concentration. All the concentration increased TSS content and greatest increased was found with spraying of 40 ppm NAA.

Prasad and Pathak (1972) found that newly set mango fruits were sprayed with NAA at 25, 50, 75 and 100 ppm. All treatments increased the total soluble solids. The lowest concentration 25 ppm was most effective.

Yadav and Pandey (1974) observed that application of GA_3 increase the bunch weight in grape without deteriorating the fruit quality.

Singh *et al.,* (1977) reported that mango fruit weight was increased by the application of GA_3, NAA and 2,4 5-T each at 50,100 and 250 ppm Concentration. Rahman *et al.,* (1980) reported that pineapple plant cv. Giant kew, were treated with NAA at 0-80ppm gave increase fruit weight as compared to control.

Biswas *et al.*, (1988) also reported that the TSS increased due to its action on converting complex substances into simple ones, which enhances the metabolic activity in guava fruits.

Rema and Sharma (1991) reported significantly maximum fruit weight and volume with the application of 150 ppm NAA or 480 ppm Ethrel [ethephon] + 150 ppm NAA during full bloom, whereas total soluble solids was also recorded with the 480 ppm Ethrel during full bloom, as well as after applying 920 ppm Ethrel or 960 ppm Ethrel + 2.5ppm 2, 4D one week before harvesting in phalsa fruit.

Brahmachari and Rubi (2000) stated that spraying of GA_3, Kinetin and Melic Hydrazide increase fruit retention and reduced fruit drop in litchi cv. Purbi.

Brahmachari and Rubi (2001) advocated that foliar application of 2, 4,5-T (50-100 ppm), GA_3 (100-200 ppm), CCC (500-1000) Cu $(NO_3)_2$ and $CuCl_2$ (82%) increased fruit retention.

Ingle *et al.*, (2001) reported that foliar application of 2, 4-D (10 ppm) NAA (30 ppm) and Gibberellic acid (25 ppm) with dry grass mulching increased the number of fruit of Nagpur mandarin.

Young *et al.*, (2003) noted that foliar application of GA_3 (at 0, 25, 50 and 100 mg/liter) in Satsuma mandarin, improved physico-chemical attributes.

Sharma *et al.*, (2002) observed that foliar application of zinc sulphate (0.25 or 50%), 2, 4, 5-T (10 and 20 ppm) and GA_3 (25 or 50 ppm) increased the fresh weight, fruit volume, juice content, number of seeds per fruit, acidity, ascorbic acid content and total soluble solids of Kagzi lime.

Sharma *et al.*, (2003) noted that foliar application of $ZnSO_4$ (0.25 and 0.50%), 2, 4, 5-T (10 and 20 ppm) and/or GA_3 (25 and 50 ppm) increased the fresh weight, volume and number of seeds per fruit in Kagzi lime.

Bhati and Yadav (2005) reported that foliar application of Urea 2 per cent and NAA at 20 ppm, in ber cv. Gola, increased fruit length, fruit breadth, fruit weight and pulp-stone ratio

Kher *et al.*, (2005) observed that foliar application of GA_3 (30, 60, 90 and 120 ppm), CCC (300, 600, 900 and 1200 ppm) and NAA (20, 40, 60 and 80 ppm) effective to increase fruit weight, specific gravity firmness, total soluble solids, total sugars, reducing sugar and minimum acidity content in guava cv. Sardar.

Prasad *et al.*, (2006) observed that foliar application of NAA at 10, 20, 30 and 40 ppm, 2,4-T at 10, 20, 30 and 40 ppm, 2, 4, 5-T at 20, 40, 60 and 80 ppm, GA_3 at 50, 100, 150 and 200 ppm improved the flowering behavior, fruit set and fruit retention of mango.

Dutta and Banik (2007) revealed that foliar feeding of nutrients and plant growth regulators significantly increased the fruit length, diameter, individual fruit weight and ultimately crop yield of guava. Maximum (6.24 cm) fruit length was obtained with treatment of urea + K_2SO_4 + $ZnSO_4$ + NAA followed by urea + K_2SO_4 + $ZnSO_4$.

Singh *et al.*, (2009) obtained maximum fruit yield as well as physico-chemical quality with foliar application of GA_3 (50 ppm) + 2, 4-D (10 ppm) +urea 2% followed by GA_3 (50 ppm) + NAA (15 ppm + urea 2%) on aonla. Katiyar *et al.*, (2010) reported that foliar sprays of 25 and 30 ppm NAA and GA_3 in conjunction with urea were improved fruit size, maximum T.S.S. and sugar content of ber cv. Banarasi Karaka.

Debnath *et al.,* (2011) reported that the influence of NAA @ 25 and @ 50 ppm, GA_3 @ 50 and @ 100 ppm, kinetin @ 15 and @ 50 ppm, ethrel @ 250 and @ 500 ppm on yield and quality parameters of phalsa (*Grewia subinaequalis* DC). Among all the treatments, GA3 @ 100 ppm was note most effective to improving yield per plant (3.05 kg), and per hectare (7.63t) and hundred fruit weight (61.48 g). Ethrel 500 ppm recorded maximum total soluble solids content (25.72%). Maximum reducing sugar (18.91%), TSS to acid ratio (10.98), pulp weight (51.45 g), pulp to stone ratio (5.85 g) and minimum titratable acidity (2.26%) and stone weight (8.83 g) was recorded with GA_3 @ 100 ppm. Kinetin @ 30 ppm recorded maximum shelf life (51.46 hr) of the fruits.

Anawal *et al.,* (2015) indicated that NAA 40 ppm was found effective in increasing number of fruits per tree (62.44), fruit length (8.66 cm), fruit diameter (8.71 cm), fruit weight (262.23 g), fruit volume (255.44 ml), TSS (16.76˚B), total sugars (15.58 %), reducing sugars (13.83 %), non-reducing sugars (1.75 %) against control in the pomegranate cv. Bhagwa.

Singh *et al.,* (2015) conducted that the effect of pruning intensity, foliar feeding of P.G.R. and micro nutrients on physico-chemical attributes of phalsa (Grewia subinaequalis) fruits. Significantly higher fruit size (length and breadth) was analyzed by foliar spray of ZnSO4 @ 0.4 per cent. The maximum weight of fifty fruits was recorded with foliar feeding of ZnSO4 @ 0.4 per cent. Significantly higher TSS value in fruits was analyzed by foliar spray of ZnSO4 0.4 per. The maximum reducing, non-reducing and total sugars have been observed with foliar spray of ZnSO4 0.4 per cent reduction in acidity of fruit was observed with the foliar spray of ZnSO4 0.4 per cent. The foliar spraying of ZnSO4 0.4 per cent was found significantly most effective in increasing ascorbic acid content of fruit.

Chandra *et al.,* (2015) observed that the spray of GA_3 had maximum impact to increase the size, weight and volume of fruit. However, the NAA @ 50 ppm was found to increase the pulp thickness, while the maximum weight of pulp was found when the trees are treated with the combined spray of NAA + 2, 4-D 25 ppm (T_6). The yield per treatment and TSS of fruit was appreciably influenced by all the growth regulators over control. However, the maximum impact (21.67 kg yield and 10.02 ^{0}Brix TSS) was recorded under T9 treatment (2, 4-D 50 ppm). The maximum acidity (1.86 %) was found under T7 treatment, spray of GA3 50 ppm. The Vitamin C content of fruits was recorded maximum (563.44 mg/100 g) under T6 treatment (NAA + 2, 4-D 25 ppm). From the findings of present study, it might be concluded that spray of growth regulators like GA3, NAA and 2, 4-D alone or in combination may increase the yield and quality of aonla.

Rokaya *et al.,* (2016) revealed that the fruits treated with GA_3 at 20 ppm retained higher fruit weight (128.6 g), more firmness (3.54 kg/cm^2), better juice recovery (57.75%), and greater TSS/acid ratio (21.24) at the end of study (20 December). The PLW was found less with GA_3 at 30 ppm in both ambient (5.17%) and cellar (6.69%) condition as against untreated fruits (9.52% and 11.76%). Similarly, the decay loss was minimum in the fruits treated with GA_3 at 30 ppm both with ambient (1.02%) and cellar condition (8.21%) as against control with ambient (5.54%) and cellar (21.58%) in guava.

Rajput *et al.,* (2015) concluded that the treatment T_{10} (0.2% boron + GA3 60 ppm+ NAA 150 ppm + ethrel 750 ppm) was found best for physical parameters and treatment T5(0.2% boron + NAA 150 ppm) for yield point of view, while for quality point of view the treatment T_9 (0.2% boron + ethrel 1000 ppm) was found best. As far as the relative

economics of the treatment is concerned, the maximum net realization of Rs. 1,72,807 per hectare with highest 1:6.6 cost benefit ratio (CBR) was obtained by the treatment T_5 (0.2% boron + NAA 150 ppm) as compared to other treatments. Therefore, the treatment T_5 (0.2% boron + NAA 150 ppm) is best among all treatment for higher production.

Table.1 Various treatment effects on physic-chemical properties of fruits

Treatments	Fruit length	Fruit width	Pulp/ stone ratio	Weight of fifty fruits(g)	TSS° Brix	Total sugars	Non-reducing sugars	Reducing sugars (%)	Acidity (%)	Ascorbic acid content
T_1 Control(water spray)	0.88	1.07	1.05	29.94	18.98	16.98	2.96	13.71	2.56	26.00
T_2 GA_3 @ 50 ppm	0.94	1.13	1.17	42.00	20.33	17.70	3.05	14.48	2.37	37.33
T_3 GA_3 @ 100 ppm	0.96	1.14	1.21	43.00	20.58	18.16	3.34	14.58	2.35	38.67
T_4 GA_3 @ 150 ppm	0.97	1.15	1.21	43.53	20.33	18.23	3.56	14.63	2.29	40.00
T_5 NAA @ 50 ppm	0.91	1.12	1.2	40.66	20.95	17.77	3.24	14.40	2.39	37.67
T_6 NAA @ 100 ppm	0.93	1.13	1.19	42.33	21.20	18.23	3.68	14.37	2.42	36.67
T_7 NAA @ 150 ppm	0.95	1.14	1.19	43.33	21.45	17.68	3.28	14.23	2.43	35.33
T_8 Ethrel @ 50 ppm	0.91	1.11	1.16	39.67	22.17	19.57	4.13	15.15	2.35	34.00
T_9 Ethrel @ 100 ppm	0.90	1.05	1.16	35.67	23.60	19.88	4.24	15.42	2.32	33.67
T_{10} Ethrel @ 150 ppm	0.89	1.03	1.17	33.00	22.58	19.72	4.21	15.33	2.32	33.33
SEm±	0.01	0.01	0.01	0.46	0.39	0.23	0.08	0.08	0.03	0.53
C. D.	0.03	0.03	0.03	1.38	1.18	0.70	0.24	0.27	0.09	1.59

Materials and Methods

Twenty years old phalsa plants were selected for at Main Experimental Station, Department of Horticulture, Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad (U.P.) during the year 2014-15. The experiment was laid out in a Randomized Block Design with ten treatments and replicated thrice. The treatments consisted of three levels each of gibberellic acid 50, 100 and 150 ppm, naphthalene acetic acid 50, 100 and 150 ppm, ethrel 50, 100 and 150 ppm and control. The growth regulators were applied twice *i.e.*, first spray at pre-bloom and second spray just after fruit set. The length and breadth of fruits were recorded at the colour break stage with the help of vernier callipers. The pulp: stone ratio was calculated in relation to pulp and stone weight, weight of 50 fresh fruits have been taken by electronic balance and chemical analysis was done to determine quality parameters of the fruit.

Results and Discussion

The maximum fruit size was observed with foliar spray of GA_3 150 ppm. These can be attributed to nature of gibberellins to increase the vegetative growth due to which more food

material might be made available to the developing fruits. These results are in close conformity with findings of Chandra *et al.,* (2015) with the spray of GA $_3$ in anola and Singh *et al.,* (2015) in phalsa and Kundu *et al.,* (2013) in pear with application of Gibbrellin and also reported by Brahmchari *et al.,* in1996 fruit length, diameter, weight of litchi cv. Purbi highest with GA_3 50 ppm. The highest pulp: stone ratio was measured with foliar spray of GA_3 150 ppm. The results are in close conformity with the findings of Kumar *et al.,* (2014) in phalsa. The results of experiment indicated that the weight of 50 fruits (43.53 g) was recorded maximum in treatment GA_3 150 ppm followed by NAA @ 150 ppm (43.33) and GA_3 100 ppm (43.00), It may be due to the involvement of GA_3 to increase the cell division and translocation of food material which might be responsible to improve the weight of fruits, similar effects observed by Kher *et al.,* (2005) in guava, Kacha *et al.,* 2014 in phalsa, Chandra *et al.,* (2015) in aonla fruits and Singh *et al.,* (2015).

The TSS was significantly increased (25.23 %) with treatment of ethrel @ 100 ppm followed by ethrel 150 ppm. The increase in total soluble solids and sugar percentage may be caused due to better formation and translocation of carbohydrates, starch hydrolysis and early maturation of fruits. The present findings are in conformity with those reported by Sandhu and Bal (1989) in ber, Biswas *et al.,* (1988) in guava, Goswami *et al.,* 2013 in pomegranate. Kacha *et al.,* (2014) in phalsa also reported increased TSS and sugars with ethrel 1000 ppm followed by ethrel 750 ppm. The reducing sugars, non-reducing sugar and total sugars contents in fruit juice of phalsa have been increased significantly by plant growth regulators Similar findings were also reported by Brahmachari *et al.,* (2000) in guava, Goswami *et al.,* 2013 in pomegranate and by Sandhu and Bal 1989 in ber (400 ppm ethrel), Kacha *et al.,* (2014) in phalsa.$GA_3$150 ppm was found superior in decreasing acidity followed by GA_3 50 ppm. The reason for decrease in acidity due to hormones application (GA_3 and NAA) might be due to increase translocation of carbohydrates and increase metabolism due to conversion of acids to sugar. The results revealed that GA_3 150 ppm significantly increased. Ascorbic acid (39.20 mg/100g), It might be due to increase in synthesis of catalytic activity of several enzymes and co-enzymes which are instrumental in ascorbic acid synthesis, close conformity to Kher *et al.,* (2005) in guava and Kacha *et al.,* (14) in phalsa. Ethrel (100 ppm) was found effective improving the fruit quality of phalsa confirming to results of Kacha *et al.,* (2014) in phalsa.

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How to cite this article:

Ashok Kumar Meena, A.K. Singh and Bhujbal Singh. 2017. A Review on Effect of Plant Growth Regulators on Physico-Chemical Attributes of Phalsa (*Grewia subinaequalis* D.C.). *Int.J.Curr.Microbiol.App.Sci.* 6(5): 1929-1938. doi: https://doi.org/10.20546/ijcmas.2017.605.214