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Effects of foliar application of boron and Gibberellic acid on growth and fruit set of phalsa (*Grewia asiatica* L.)

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Abstract
The present experiment entitled "Effects of Foliar Application of Boron and Gibberellic acid on growth and of Phalsa (*Grewia asiatica* L.)" was conducted at Garden, College of Horticulture, Department of Fruit Science, Chandra Shekhar Azad University of Agriculture and Technology Kanpur, Uttar Pradesh in the year 2018-2019. It was carried out in randomized block design with 10 treatment and each treatment replicated thrice. The results of this study on the effect of Boron 20-50 ppm and GA_3 30 ppm (with and without) foliar spray on Phalsa of growth regulators boron (Bo) and GA_3 were discussed and interpreted in the light of previous research in India and abroad. The study showed significant findings and concluded that T_{10} (50 ppm boron+30ppm GA_3) resulted maximum as length of phalsa shoot and fruit set and at T_9 (40 ppm boron+30ppm GA_3) resulted as the maximum diameter shoot and fruit (0.94 cm and 1.06 cm), number flowering days (68.77), and length of phalsa fruit (0.07 cm) was maximum.

Keywords: Phalsa, foliar spray, boron, Gibberellic acid, significant

Introduction
Phalsa (*Grewia subinaequalis* D.C.), which is also known as star apple is a subtropical fruit of India. It belongs to the family "*Tiliaceae*". This family have about 41 genera and 400 species which are mostly distributed in the tropical and subtropical region of the world. Among various fruits grown in the country, minor fruits in spite of high nutritive content and health benefits have not received much attention with respect to value addition because of low yield and lack of improved cultivars.

The plants can tolerate even a temperature of 45 ^{0}C and freezing temperature for a few days. High temperature helps in ripening of fruits. Rains at the time of flowering affect fruit set and crop yield. Phalsa can be grown on a wide variety of soils even on moderately sodic soil. It grows well in well-drained, loamy soils. The plant is sensitive to water-logging which makes it chlorotic. Iron chlorosis is common problem in calcareous soil.

The fruits are highly perishable in nature and due to its perishability, it cannot be exported but its processed products are very appreciable. Ripe fruits are consumed fresh in desserts, or processed into refreshing soft drinks like squash, RTS, sharbat etc. which are enjoyed during hot summer months in India. The attractive crimson red to dark purple colour of phalsa fruit is due to anthocyanin pigments mainly, delphinidin-3-glucoside, cyanidin-3-glucoside and pelargonidin-3, 5 diglucoside. Phalsa fruit are small and born in profusely. They do not ripen with a definite spell of time and thus become a problem to grower.

Keeping in view there need to work out the effective dose of boron on the growth, flowering and yield attributes of phalsa, the present experiment was undertaken with following objectives

1. To study the effect of foliar application of boron and GA_3 on growth.
2. To study the effect of foliar application of boron and GA_3 on flowering.
3. To study the effect of foliar application of boron and GA_3 on fruit setting of phalsa.

Methods and Material
The experiment was conducted in the Garden, Department of Horticulture, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (Uttar Pradesh) during the year 2018-2019. The effect of foliar application of boron on plant growth, flowering and yield of Phalsa (*Grewia asiatica* L.) was carried out under Kanpur agro climatic conditions at the research farm.

As the fruits are born on new growth regulators therefore application of fertilizer is essential to encourages vegetative growth. Recommended dose of N, P & K was applied to get proper growth and higher yield of better quality fruits. Well established thirty plants of phalsa cv. Sharbati were taken for the present experiment and uniform cultural practices were done timely. Healthy bushes of phalsa were pruned to a height of 60 cm from the ground level on 25 December during 2018-2019. The data obtained on each aspect on each treatment were statistically computed in factorial RBD design with 10 treatments and each treatment thrice replicated by which making the total number of 30 plant and their spacing row to row 3×3 m and plant to plant 2.5×2.5m. The observations regarding days of sprouting of shoots, number of sprouted shoots, total number of canes per plant, percentage of fruit sets, length of shoots per cane (cm) and fruit size were recorded. Statistical analyses of the data obtained in the different sets of experiments were calculated as suggested by Panse and Sukhatme and results were evaluated at 5% significance.

Table 1: Treatment and their contribution for experiment

Sl. No.	Treatment Symbol	Treatment Contribution
1.	T_1	Control (water spray)
2.	T_2	Boron 20 ppm
3.	T_3	Boron 30 ppm
4.	T_4	Boron 40 ppm
5.	T_5	Boron 50 ppm
6.	T_6	GA_3 30 ppm
7.	T_7	Boron 20 ppm + $GA_3$30 ppm
8.	T_8	Boron 30 ppm + $GA_3$30 ppm
9.	T_9	Boron 40 ppm + $GA_3$30 ppm
10.	T_{10}	Boron 50 ppm + $GA_3$30 ppm

Result and Discussion

The findings of the present study as well as relevant discussion have been presented under following heads:

Length of phalsa shoot (cm): Pruning of the experimental phalsa bushes during the year of 2018-2019 was done on 25 December. New shoots emerged and fruits were born on them. At first picking, the length of tagged shoots were measured and the data recorded were analysed statistical (Appendix I). The mean values were summarised and displayed in table-2. It is obvious from the mean values that boron, GA_3 and coupled treatment of boron and GA_3 in increasing levels increased the length of shoots progressively during the investigation. Treatment of T_{10} (boron 50 ppm + GA_3 30 ppm) maximised (140.86 cm) significantly length of phalsa shoot followed by treatment T_9 presenting 135.39 cm length of phalsa shoot and 110.14 cm.

Significantly lesser length of shoots were expressed under control (T_1) followed by treatment of T_2 (boron 20 ppm). Remaining treatmentsT_3, T_4, T_5, T_6, T_7 and T_8 presenting 116.51, 123.41, 122.83, 127.08, 130.12 and 133.41 cm respectively. When a deep vision was focused on the treatment of T_3, T_4, T_5, and T_6, the response of these treatments were significantly greater over control but when compared among one another did not differ significantly. Similarly treatment of T_7 and T_8 expressed 130.12 and 133.41 cm length of shoots of phalsa when compared in between found to be non-significant variation. Treatment T_8 when compared among treatment T_3, T_4, and T_5 there were significant influences. As far as, treatment T_7 showed significant variation when compared with treatment T_3 but when compared with treatment T_4 and T_5 did not vary significantly.

Table 2: Effect of foliar nutrition of boron with and without GA_3 on length of phalsa shoots (cm)

Symbol	Treatments	Length of shoot (cm)
T_1	Control (water spray)	110.14
T_2	Boron 20 ppm	113.36
T_3	Boron 30 ppm	116.51
T_4	Boron 40 ppm	123.41
T_5	Boron 50 ppm	122.83
T_6	GA_3 30 ppm	127.08
T_7	Boron 20 ppm+GA_3 30 ppm	130.12
T_8	Boron 30 ppm+GA_3 30 ppm	133.41
T_9	Boron 40 ppm+GA_3 30 ppm	135.39
T_{10}	Boron 50 ppm+GA_3 30 ppm	140.86
	S.E. Difference	5.47
	C.D. @ 5%	11.49

Diameter of phalsa shoot (cm)

The diameter of phalsa shoots were recorded at first picking and the data were subjected to statistical analysis (Appendix II). The mean values summarised and presented in table-3. The effect of foliar nutrition of boron, GA_3 and their coupled treatments promoted diameter of phalsa shoot positively and consistently during the investigation. Increasing doses of boron and levels of GA_3 concentration increased diameter of shoots of phalsa.

The perusal of data indicated that treatment of T_9 (boron 40 ppm + GA_3 30 ppm) significantly maximised (0.94 cm) diameter of shoot followed by treatment of treatment of T_{10} (boron 50 ppm + GA_3 30 ppm) and T_8 (boron 30 ppm + GA_3 30 ppm) recording 0.92 and 0.90 cm diameter of phalsa shoot respectively. Remaining treatment of boron 20 ppm (T_2), boron 30 ppm (T_3), boron 40 ppm (T_4), boron 50 ppm (T_5), GA_3 30 ppm (T_6) and boron 20 ppm+ GA_3 30 ppm (T_7) expressing 0.71, 0.73, 0.77, 0.78, 0.88 and 0.89 cm diameter of shoot respectively. Treatments of T_6 and T_7 showed significantly equal when compared in between, as well as, among treatments of T_2, T_3, T_4, and T_5 when compared in between treatments of T_4 and T_5 as well as treatments of T_3 and T_4 and treatments of T_2 and T_3 did not differ significantly. Among treatments of T_5, T_3 and T_2, when treatment T_1 and T_2 compared with treatment T_5 showed significant variation.

Table 3: Effect of foliar nutrition of boron with and without GA_3 on diameter of phalsa shoot (cm)

Symbol	Treatments	Diameter of shoot (cm)
T_1	Control (water spray)	0.66
T_2	Boron 20 ppm	0.71
T_3	Boron 30 ppm	0.73
T_4	Boron 40 ppm	0.77
T_5	Boron 50 ppm	0.78
T_6	GA_3 30 ppm	0.88
T_7	Boron 20 ppm+GA_3 30 ppm	0.89
T_8	Boron 30 ppm+GA_3 30 ppm	0.90
T_9	Boron 40 ppm+GA_3 30 ppm	0.94
T_{10}	Boron 50 ppm+GA_3 30 ppm	0.92
	S.E. Difference	0.026
	C.D. @ 5%	0.046

Days to flowering of phalsa

Days to flowering was greatly influenced with the spraying of foliar nutrition of boron, GA_3 and coupled treatments of boron with GA_3. The data were obtained regarding days to flowering and subjected to statistical analysis (Appendix III). The mean values summarised and displayed in table -4. The influence of boron concentrations increased days to flowering in ascending order of magnitude and combine treatments also gave this tune up to treatment of T_9 (Boron 40 ppm+GA_3 30 ppm) barring treatment of T_{10} (Boron 50 ppm+GA_3 30 ppm). In this context couple treatment of Boron 40 ppm+GA_3 30 ppm (T_9) exhibited significantly maximum 68.82 days to flowering closely followed by treatment of Boron 50 ppm+GA_3 30 ppm (T_{10}) recording 68.77 days to flowering. Treatment T_1 (control) expressed 64.37 days to flowering being significantly lesser followed by treatment T_2 (boron 20 ppm) showed 65.04 days to flowering respectively. Treatments of T_3 T_4, T_5,T_6,T_7 and T_8 i.e. Boron 30 ppm, Boron 40 ppm, Boron 50 ppm, GA_3 30 ppm, Boron 20 ppm+GA_3 30 ppm and Boron 30 ppm+GA_3 30 ppm presenting 66.35, 67.46, 68.07, 67.18, 68.01 and 68.41 days to flowering respectively. The treatments of T_3, T_4, T_5, T_6, T_7 and T_8 when compared among themselves all the treatments did not differ significantly in each other, whereas, when all the treatments were compared with most effective treatment T_9 treatment of, T_4, T_5, T_6, T_7, T_8 and T_{10} were found to be non-significant influences, whereas, treatments of T_2 and T_3 exhibiting 65.04 and 66.35 days to flowering respectively. When these treatments compared with most effective treatment of T_9 (68.82 days) found to be significant variation in this regard.

Table 4: Effect of foliar nutrition of boron with and without GA_3 on days to flowering of phalsa.

Symbol	Treatments	Days to flowering
T_1	Control (water spray)	64.37
T_2	Boron 20 ppm	65.04
T_3	Boron 30 ppm	66.35
T_4	Boron 40 ppm	67.46
T_5	Boron 50 ppm	68.07
T_6	GA_3 30 ppm	67.18
T_7	Boron 20 ppm+GA_3 30 ppm	68.01
T_8	Boron 30 ppm+GA_3 30 ppm	68.41
T_9	Boron 40 ppm+GA_3 30 ppm	68.82
T_{10}	Boron 50 ppm+GA_3 30 ppm	68.77
	S.E. Difference	1.023
	C.D. @ 5%	2.15

Fruit set (%)

The effect of foliar nutrition of boron and GA_3 as well as couple treatments of boron and GA_3 profoundly influenced fruit set percentage in phalsa. In this context data obtained were subjected to statistically analysis. The mean values were summarised and presented in table-5. Different levels of boron promoted fruit set percentage of phalsa fruit in increasing attitude. GA_3 concentration of 30 ppm also enhanced fruit set percentage during investigation. As well as couple treatments of different concentrations of boron with GA_3 30 ppm also enhanced fruit set percentage aggressively. In this regard treatment T_{10} (Boron 50 ppm+GA3 30 ppm) significantly influenced maximum 74.88 fruit set percentage followed by treatment of Boron 40 ppm+GA_3 30 ppm (T9) revealing 74.56% fruit set. Untreated plants (control) were demonstrated lesser fruit set percentage (61.21%) being significant closely followed by T_2 (boron 20ppm) recorded 63.20% fruit set.

Remaining treatments T_3, T_4, T_5, T_6, T_7 andT_8 named Boron 30 ppm, Boron 40 ppm, Boron 50 ppm, GA_3 30 ppm, Boron 20 ppm+GA_3 30 ppm and Boron 30 ppm+GA_3 30 ppm revealing 65.39, 67.56, 69.14, 70.89, 71.16 and 73.03 % fruit set respectively. Among treatments of T_6, T_7,T_8, T_9 andT_{10} when compared each other found to be significantly equal, whereas, T_2, T_3, T_4, and T_5 exhibited significant variation when compared with most effective treatment T_{10} (74.88% fruit set). In this regard all the treatments influencing significant variation over control barring treatments of T_2 and T_3, revealed that 63.20 and 65.39 % fruit set respectively.

Table 5: Effect of foliar nutrition of boron with and without GA_3 on fruit set percentage of phalsa

Symbol	Treatments	Fruit set (%)
T_1	Control (water spray)	61.21
T_2	Boron 20 ppm	63.20
T_3	Boron 30 ppm	65.39
T_4	Boron 40 ppm	67.56
T_5	Boron 50 ppm	69.14
T_6	GA_3 30 ppm	70.89
T_7	Boron 20 ppm+GA_3 30 ppm	71.16
T_8	Boron 30 ppm+GA_3 30 ppm	73.03
T_9	Boron 40 ppm+GA_3 30 ppm	74.56
T_{10}	Boron 50 ppm+GA_3 30 ppm	74.88
	S.E. Difference	2.34
	C.D. @ 5%	4.93

Length of phalsa fruit

All the levels of boron concentrations as well as GA_3 30 ppm promoted fruit length and their couple treatments also enhanced fruit length of phalsa during experimentation. The data obtained were statistically processed. The mean values were summarised and displayed in table-6.

All the treatments were significantly exerted to enhanced fruit length over control (0.81 cm) except treatment of T_2, and T_3 recording 0.83 and 0.85 cm fruit length respectively. Plants under treated with boron 40ppm +GA_3 30 ppm (T_9) expressed significantly maximum (0.97 cm) fruit length followed by treatment of boron 50ppm +GA_3 30 ppm (T_{10}) and boron 30 ppm+$GA_3$30 ppm (T_8) recording 0.95 cm length, whereas, significantly poorest fruit length (0.81 cm) was recorded under the plants which were untreated (control). Treatments of boron 40 ppm (T_4), boron 50 ppm (T_5), GA_3 30 ppm (T_6) and boron20 ppm+GA_3 30 ppm (T_7) influenced 0.88, 0.89, 0.92 and 0.94 cm fruit length respectively. When a slight vision focused on mean values of fruit length, it was found that treatments of T_5, T_6, T_7, T_8, T_9 and T_{10} did not varied significantly. As far as, treatments of T_4, T_5, T_6, and T_7 when compared among themselves gave non-significant variation in this regard.

Table 6: Effect of foliar nutrition of boron with and without GA_3 on length of phalsa fruits (cm)

Symbol	Treatments	length of phalsa fruits (cm)
T_1	Control (water spray)	0.81
T_2	Boron 20 ppm	0.83
T_3	Boron 30 ppm	0.85
T_4	Boron 40 ppm	0.88
T_5	Boron 50 ppm	0.89
T_6	GA_3 30 ppm	0.92
T_7	Boron 20 ppm+GA_3 30 ppm	0.94
T_8	Boron 30 ppm+GA_3 30 ppm	0.95
T_9	Boron 40 ppm+GA_3 30 ppm	0.97
T_{10}	Boron 50 ppm+GA_3 30 ppm	0.95
	S.E. Difference	0.03
	C.D. @ 5%	0.06

Diameter of phalsa fruit

Boron in different concentrations and GA_3 30 ppm influenced consistently and positively to diameter of phalsa fruit. Coupled treatments of boron concentration with GA_3 30 ppm also hastened fruit diameter in investigation. Thus, data obtained were subjected to statistical analysis. The mean values summarised and presented in table-7. Coupled treatment of Boron 40 ppm+GA_3 30 ppm (T_9) significantly revealed the maximum (1.06 cm) diameter of phalsa fruit followed by treatment of boron 50 ppm+GA_3 30 ppm (T_{10}) exhibited 1.05 cm diameter. In this regard the plants devoid with boron and GA_3 (control) recorded significantly poorest diameter (0.92) cm of fruit followed by treatment of boron 20 ppm (T_2) exhibiting 0.95 cm fruit diameter. Remained treatments i.e. Boron 30 ppm (T_3), Boron 40 ppm (T_4), Boron 50 ppm (T_5), GA_3 30 ppm (T_6), Boron 20 ppm+GA_3 30 ppm (T_7) and Boron 30 ppm+GA_3 30 ppm (T_8) expressing 0.97, 1.02, 1.03, 1.01, 1.02 and 1.04 cm fruit diameter respectively. The treatments of T_4, T_5, T_7, T_8, T_9 and T_{10} were significantly enhanced fruit diameter of phalsa fruit over control barring treatments of T_2, T_3 and T_6. When among treatments T_3, T_4, T_5, T_6, T_7, T_8, T_9 and T_{10} were compared each other found to be non-significant influences in experimentation.

Table 7: Effect of foliar nutrition of boron with and without GA_3 on diameter of phalsa fruit (cm)

Symbol	Treatments	Diameter of fruit (cm)
T_1	Control (water spray)	0.92
T_2	Boron 20 ppm	0.95
T_3	Boron 30 ppm	0.97
T_4	Boron 40 ppm	1.02
T_5	Boron 50 ppm	1.03
T_6	GA_3 30 ppm	1.01
T_7	Boron 20 ppm+GA_3 30 ppm	1.02
T_8	Boron 30 ppm+GA_3 30 ppm	1.04
T_9	Boron 40 ppm+GA_3 30 ppm	1.06
T_{10}	Boron 50 ppm+GA_3 30 ppm	1.05
	S.E. Difference	0.05
	C.D. @ 5%	0.09

Conclusion

The study reveals that the results treatment of boron 40 ppm coupled with GA_3 30 ppm (T_9) showed significantly maximum diameter of shoot, days to flowering, length of fruit, diameter of fruit per hectare of phalsa fruit. In other hand, treatment of boron 50 ppm +GA_3 30 ppm enhanced significantly length of shoot and fruit set percentage only. Other treatment of different level of boron, GA_3 30 ppm as well as remained couple treatments of boron with GA_3 also improved above parameters though, the maximum attributory characters including yield were enhanced by the coupled treatment of boron 40 ppm with GA_3 30 ppm. So it is advice to orchardist, grower and research workers to spraying of boron 40 ppm + GA_3 30 ppm for improving fruit setting and yield for enhancing economy and prosperity of phalsa growing region and country.

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