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EFFECT OF FOLIAR APPLICATIONS OF ORGANIC AND INORGANIC SUBSTANCES ON GROWTH AND YIELD OF PHALSA

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ABSTRACT

A field experiment was implemented in 2023 at the Regional Horticultural Research Station, Navsari Agricultural University, Navsari, Gujarat using a Completely Randomized Design (CRD) with 11 treatments including different concentrations of GA_3, NAA, Ethrel, novel organic liquid nutrients, G-IV micronutrients, and a control. Foliar sprays were applied twice - at the pre-blooming stage and after fruit set and the experiment was repeated three times. The results showed that GA_3 @ 200 mg/L was most effective, leading to the earliest flowering (37.16 days), earliest fruit set (76.83 days), highest number of fruits at pea stage (129.16), most pickings (5.5), highest number of fruits per 100 g (149.83), and maximum yield (0.586 kg/plant or 976 kg/ha). Ethrel @ 2 ml/L resulted in the earliest first picking (116.16 days) and NAA @ 200 mg/L recorded the highest fruit set (80.09 %) and lowest fruit drop (19.9 %). Overall, GA_3 @ 200 mg/L proved superior for improving growth, fruit set, and yield.

***Keywords* :** Phalsa, foliar application, organic and inorganic substances.

Introduction

Phalsa (*Grewia asiatica*) is a native fruit crop that is widely cultivated across several states in India. It belongs to the family Tiliaceae, with India considered its probable centre of origin. Botanically classified as a berry, the fruit has a pleasant flavour and ranges in taste from sour to sweet. Being a subtropical crop, phalsa can be grown in most parts of the country except at higher altitudes. It is commercially cultivated in states such as Punjab, Haryana, Uttar Pradesh, and Andhra Pradesh. In Gujarat, its cultivation is limited to specific regions, including Ahmedabad, Vadodara, Kutch, Valsad, and parts of the Saurashtra region (Meena *et al*., 2017). Phalsa can thrive in neglected areas and under conditions of water scarcity where few other crops can survive. Its cultivation is relatively simple and demands minimal management, making it a suitable option for small-scale farmers and home gardeners (Lamo *et al*., 2017). The plant is hardy and drought-tolerant, requiring very little care. The ripe fruits, measuring 5 to 12 mm in diameter, are purple to black in colour. However, due to their short shelf life, they are best suited for local markets (Anand, 1960) or should be processed immediately after harvesting to prevent spoilage (Salunkhe and Desai, 1984).

Phalsa naturally grows in the form of a bush, so no initial training is required. As it bears fruits on the current season's growth, regulating flowering through severe annual pruning before spring is essential to ensure better fruit quality. Pruning is the most critical practice in phalsa cultivation. Cutting the plants back annually to a height of around 100 cm promotes the development of new shoots and results in a higher yield of marketable fruits compared to more severe pruning practices (Singh and Sharma, 1961). On other hand in North India and in Andhra Pradesh, some fruit growers use very drastic methods of cutting the plant or burring them to the ground level. This practice is also followed in Kutch area of Gujarat state (Singh and Singh, 1983).

Plant growth regulators (PGRs) or phytohormones are organic compounds, either naturally synthesized or chemically produced, that influence growth and various physiological processes at locations different from where they are formed, even when present in very small quantities. The external application of these growth substances has become a vital part of modern agricultural practices, particularly in the cultivation of fruit crops.

Gibberellic acid (GA_3) plays a vital role in promoting various physiological processes such as cell elongation, cell division, delayed senescence, breaking seed dormancy, root initiation, and stimulating flowering. It also contributes to increased plant height, leaf production, and a reduction in the juvenile phase before flowering, ultimately enhancing both yield and fruit quality. Since GA_3 influences both vegetative and reproductive growth, it is highly effective in improving the productivity of fruit crops (Singh *et al.*, 2018). Naphthalene acetic acid (NAA) has a natural ability to promote flower bud formation beyond its role in thinning. By inducing chemical thinning, NAA helps reduce crop load, which in turn enhances flower bud development. Its application increases both average yield and fruit weight. However, at higher concentrations, NAA can reduce fruit size, making lower concentrations preferable to minimize adverse effects on fruit development (Singh *et al.*, 2018). Ethephon has been identified as a highly effective agent for promoting flower bud formation. Nevertheless, its use on bearing trees is somewhat restricted because it also induces fruit thinning (Byers, 2003). Ethylene, released by ethephon, plays a crucial role in ensuring uniform ripening of phalsa fruits and accelerating maturity, thereby significantly reducing the number of harvests required (Lamo *et al.*, 2020). Novel organic liquid nutrient is patented product prepared from Banana Pseudostem at Banana Pseudostem Processing Unit, Navsari Agricultural University, Navsari, Gujarat. It contains N (0.062 %), P (0.018 %), K (0.180 %), Ca (0.031 %), Mg (0.092 %), S (0.010 %), Fe (109.3 %), Mn (5.73 ppm), Zn (2.92 ppm) and Cu (0.40 ppm). It also contains biochemical properties and microbes (Desai *et. al.,* 2016). The foliar application of micronutrients in very minute quantity enhances the growth and yield. Grade IV micronutrient is an inorganic compound. It contains Fe-4 %, Mn-3 %, Zn-6 %, Cu-0.8 % and B-0.8 %.

Materials and Methods

Experimental Site: This research was carried out during the period of January to May 2023 at the Regional Horticultural Research Station, ASPEE College of Horticulture, Navsari Agricultural University, Navsari.

Experimental design and treatments: The experimental design was CRD with three repetitions and eleven treatments. The standard error of the mean (SEm ±) was calculated for each variable, and the critical difference (CD) at the 5% level of probability was determined to compare treatment means where the effects of treatments were found to be significant. The percentage co-efficient of variation (CV %) was also worked out for to understand the variability of experimental material for all the case. Two plants were selected per treatment and total sixty-six plants are observed. Treatment details are as under: The experiment included eleven treatments: GA_3 at 100 mg L^{-1} (T_1) and 200 mg L^{-1} (T_2); NAA at 100 mg L^{-1} (T_3) and 200 mg L^{-1} (T_4); Ethrel at 1 ml L^{-1} (T_5) and 2 ml L^{-1} (T_6); novel organic liquid nutrients at 1 % (T_7) and 2 % (T_8); G-IV micronutrient at 1 % (T_9) and 2 % (T_{10}); and a control with water spray (T_{11}). Foliar applications were administered at two stages: first at the pre-blooming stage and second after fruit set.

The phalsa plants were pruned during the first week of January 2023 using sharp secateurs. Immediately after pruning, the cut ends were treated with Bordeaux paste to prevent fungal infections. Well-decomposed farmyard manure (FYM) was applied at 10 kg per plant, along with chemical fertilizers, *i.e*., 100 g N: 100 g P: 50 g K/plant as basal dose were applied in all the treatments during the month of January, 2023 and second dose of N 100 g was applied in February, 2023. The first irrigation was given immediately after pruning. Later on, the irrigation was given at twenty days interval as per requirement, starting from pruning till maturity.

Results and Discussion

Flowering and Fruiting Parameters

Days taken to 1st flowering

The minimum (37.16) days for 1st flowering were recorded when phalsa plants were treated with foliar spray of GA_3 @ 200 mg L^{-1} (T_2) at pre blooming stage and after fruit set which, as shown in table 1 and it was statistically at par with T_1 (37.33), T_6 (39.16), T_5 (39.50) treatment while, the maximum (48.83) days taken for 1st flowering were observed in control (T_{11}). The days taken for 1st flowering were significantly reduced by GA_3 @ 200 mg l^{-1}. The observed effect may be attributed to the application of gibberellic acid, which increases the total metabolite content in plant cells. This enhancement in metabolite production and photosynthate availability during critical growth stages facilitates an earlier transition from the vegetative to the reproductive phase, thereby promoting increased flowering and early fruit set. These findings are consistent with those reported by Debnath *et al.* (2011) and Lakra *et al.* (2022) in phalsa. Additionally, flowering earliness was significantly promoted by Ethrel at 2 ml L^{-1} and 1 ml L^{-1}, likely due to the breaking of bud and shoot dormancy. The floral induction results align with the observations of Lamo *et al.* (2017) in phalsa.

Days taken to fruit set

The days taken to 1^{st} picking after pruning as influenced by organic and inorganic substances on phalsa is presented in Table 1. The minimum (116.16) days taken for 1^{st} picking were recorded in (T_6) which, was statistically at par with T_5 (119.00), T_2 (121.83) and T_1 treatment (122.33) while, the maximum (129.00) days taken for 1^{st} picking were noted in control (T_{11}). The number of days to first picking after pruning was significantly influenced by the application of both organic and inorganic substances. Ethrel promoted early fruit ripening and accelerated maturity, thereby reducing the total number of harvests. Lower concentrations of NAA and GA_3, as well as higher concentrations of Ethrel, induced earlier ripening and harvesting compared to higher concentrations of NAA and GA_3 in phalsa. These results are in agreement with the findings of Debnath *et al.* (2011) and Patel H. T. (2016) in phalsa.

Number of fruits at pea stage

Data in Table 1 showed that there was significant effect on no. of fruits at pea stage by different treatments. The maximum no. of fruits at pea stage (129.16) were recorded in T2 and were at par with T1 statistically (122.83) while, the minimum no. of fruits at pea stage (90.33) were noted in control (T_{11}). The total no. of fruits at pea stage was significantly increased by GA_3 200 mg l^{-1}. The increased number of fruits in response to higher concentrations of growth substances, such as GA_3, may be attributed to enhanced translocation of hormones, nutrients, and other factors to the ovary tissues, thereby stimulating fruit formation. These findings are consistent with the observations of Sharma and Tiwari (2015) in guava.

Fruit set (%)

The effect of organic and inorganic substances on fruit set percentage is presented in Table 1. The fruit set ranged from 46.77 *per cent* to 80.09 *per cent*. The highest fruit set (80.09 %) was obtained with NAA at 200 mg l^{-1} followed by NAA at 100 mg l^{-1} (78.43 %) which, was at par with each other. The minimum fruit set (46.77 %) was noted in control (T_{11}). Application of organic and inorganic substances, improved fruit set significantly but the response was variable with the organic and inorganic substances and their concentrations. It may be assumed that the application of synthetic hormones brings about fruit set by providing the hormonal stimulus for fruit set and growth that would normally occur with pollination. The superiority of NAA over GA_3 may be due to the fact that in fruit set, auxin is more directly involved than gibberellins, which are reported to effect fruit set indirectly through stimulation of production of auxin in the plant body. The increased fruit set observed with higher concentrations of NAA may be attributed to enhanced translocation of hormones, nutrients, and other factors to the ovary tissues, thereby stimulating greater fruit formation (Sharma and Tiwari, 2015). The results of increased in fruit set are in agreement with the findings of Debnath *et al.* (2011) in phalsa and Majumder *et al.* (2017) in ber. Ghosh *et al.* (2009) observed highest fruit set in pomegranate with the application of NAA at 25 ppm. Similarly, More *et al.* (2016) reported maximum fruit set (80.59 %) with NAA at 800 ppm in guava. Chaudhary *et al.* (2016) recorded the highest fruit set per shoot (14.81) with GA_3 at 50 ppm in custard apple. Bhosle *et al.* (2018) reported maximum fruit set (32.31 %) in pomegranate with a combined application of $FeSO_4$ (0.5 %), $ZnSO_4$ (0.5 %), and GA_3 (50 ppm).

Fruit drop (%)

The effect of organic and inorganic substances on fruit drop percentage is presented in Table 1. Fruit drop varied from 19.90 % to 53.21 %. The lowest fruit drop (19.90 %) was observed with NAA at 200 mg L^{-1} (T_4), followed by NAA at 100 mg L^{-1} (21.55 %), with both treatments being statistically at par. The highest fruit drop (53.21 %) occurred in the control (T_{11}). Fruit drop percentage was significantly influenced by the application of organic and inorganic substances, with NAA at 200 mg L^{-1} resulting in the lowest fruit drop. Reduced fruit drop also might have contributed increased number of fruits per node. The increase in the number of fruits might be due to the reduction of fruit drop with NAA and GA_3 treatments, which might have resulted in the increased fertilization and reduction in embryo abortion. Another possible reason may be delayed formation of abscission layers in flowers and fruits. Auxins inhibit fruit abscission by preventing the physiological breakdown of calcium pectate in the middle lamella (Debnath *et al.*, 2011). High levels of internal auxins are correlated with reduced fruit drop, as they help maintain fruit retention (Sharma and Tiwari, 2015, in guava). The observed reduction in fruit drop aligns with the findings of Gill and Bal (2009) in ber with the application of NAA at 30 ppm. Singh *et al.* (2008) reported minimum fruit drop (50.90 %) in aonla with combined application of $ZnSO_4$ (0.5 %), NAA (10 mg L^{-1}), and GA_3 (25 mg L^{-1}). Similarly, Chaudhary *et al.* (2016) recorded the lowest fruit drop per shoot (2.69) in custard apple with GA_3 at 50 ppm.

Days taken to 1st picking

Days taken to 1st picking after pruning as influenced by organic and inorganic substances on phalsa is presented in Table 1. The data presented in Table 1 clearly indicate that the different treatments had a significant effect on the number of days required for the first picking. The minimum (116.16) days taken for 1st picking were recorded in (T_6) which, was statistically at par with T_5 (119.00), T_2 (121.83) and T_1 (122.33) while, the maximum (129.00) days taken for 1st picking were noted in control (T_{11}). The number of days to first picking after pruning was significantly affected by the application of organic and inorganic substances. Ethrel accelerated fruit ripening and maturity, which in turn significantly reduced the total number of harvests. NAA and GA_3 at lower concentrations and ethrel at higher concentrations induced early ripening and pickings compared to higher concentrations in phalsa. These findings are also in accordance with the Debnath *et al.* (2011) and Patel H. T. (2016) in phalsa.

Number of pickings: A perusal of data presented in Table 1 clearly indicated that there was significant effect on no. of pickings by different treatments. The maximum no. of picking (5.5) was recorded in (T_2) which, was statistically at par with T_1 (5.33), T_3 (5.16) and T_4 (5.33) while, the minimum no. of pickings (3) was noted in control (T_{11}). The total number of pickings were significantly induced by GA_3 @ 200 mg l^{-1}. This effect may be attributed to the fact that higher doses of GA_3 extended the crop duration in phalsa, resulting in an increased number of pickings. Similar findings were reported by Kacha *et al.* (2014) and Lamo *et al.* (2020) in phalsa. These studies also observed that the application of Ethrel positively contributed to reducing the number of harvests.

Yield Parameters

Number of fruits per 100 g

It is seen from the data presented in Table 2 and are shown graphically in Fig. 3 that the no. of fruits per 100 g are ranged from 130.13 to 149.83. It is observed from the results Table 2 that the when phalsa plants were treated with foliar spray of treatment (T_2) at pre blooming stage and after fruit set recorded significantly maximum no. of fruits per 100 g (149.83) which, is at par with treatment T_1 (149.33) while, the minimum no. of fruits per 100 g (130.13) was noted in control (T_{11}). The total number of fruits per 100 g were significantly induced by GA_3 @ 200 mg l^{-1}. The increase in fruit weight may be attributed to enhanced cell division and enlargement, along with greater accumulation of sugars, water, and pulp under the influence of exogenous application of organic and inorganic substances. These findings are consistent with the observations of Debnath *et al.* (2011), Kacha *et al.* (2014), Patel (2016), Lamo *et al.* (2020), and Verma *et al.* (2023) in phalsa.

The greatest reduction in fruit weight was observed with NAA at 200 mg L^{-1} and 100 mg L^{-1}, which may be attributed to the high fruit set (Table 2), leading to competition among developing fruitlets for nutrients. Chaudhary *et al.* (2016) and Prajapati *et al.* (2016) recorded maximum fruit weight of custard apple when GA_3 applied at a concentration of 20 mg L^{-1} + NAA @ 15 mg^{-1}. Bagul *et al.* (2021) recorded higher fruit weight with the treatment of GA_3 @ 100 ppm in sapota.

Fruit yield (kg/plant) and fruit yield (kg/ha)

The data presented in Table 2 clearly indicate that the different treatments had a significant effect on fruit yield, both per plant (kg/plant) and per hectare (kg/ha). The highest fruit yield was recorded as 0.586 kg per plant and 976 kg per hectare was recorded with the treatment T_2 applied at pre blooming stage and after fruit set which, was at par with the treatment T_1 (0.584 kg/plant and 973 kg/ha). While, minimum fruit yield (0.273 kg/plant) and (455 kg/ha) was recorded in the treatment T_{11} *i.e.*, control (water spray).

The higher fruit yield may be attributed to GA_3 facilitating faster translocation and mobilization of stored metabolites and photosynthates from source tissues. Gibberellic acid promotes cell division and enlargement, leading to an increased number of fruits, improved physiology of developing fruits, larger berry size, greater fruit weight, and higher fruit volume, ultimately resulting in increased fruit yield. These findings are in agreement with the observations of Debnath *et al.* (2011), Kacha *et al.* (2014), Patel H. T. (2016), Lamo *et al.* (2017), Singh *et al.* (2017), Lamo *et al.* (2020), and Lakra *et al.* (2022) in phalsa.

Increased yield due to GA_3 application might be attributed to its significant role in reducing fruit drop and increasing fruit retention percentage with production of greater sized fruits of ber were also reported by Majumder *et al.* (2017), Sharma and

Tiwari (2015) in guava, Chaudhary *et al.* (2016) in custard apple. Prajapati *et al.* (2016) in custard apple reported that fruit yield/tree was increased by application of GA_3 20 + NAA 15 mg/l which might be due to spraying of plant growth regulators in which gibberellic acid promoted cell enlargement, cell division and increasing the number and size of fruits ultimately resulted in fruit yield.

Table 1: Effect of organic and inorganic substances on growth in phalsa

Treatments	Days taken to 1st flowering	Days taken to fruit set	Days taken to 1st picking	No. of fruits at pea stage	Fruit set (%)	Fruit drop (%)	No. of pickings
T_1: GA_3 @ 100 mg l^{-1}	37.33	78.50	121.83	122.83	68.89	31.10	5.33
T_2: GA_3 @ 200 mg l^{-1}	37.16	76.83	122.33	129.16	68.40	31.58	5.50
T_3: NAA @ 100 mg l^{-1}	44.33	81.33	122.50	116.50	78.43	21.55	5.16
T_4: NAA @ 200 mg l^{-1}	43.66	80.66	123.50	117.33	80.09	19.90	5.00
T_5: Ethrel @ 1 ml l^{-1}	39.50	84.00	119.00	109.66	61.00	38.99	3.83
T_6: Ethrel @ 2 ml l^{-1}	39.16	83.83	116.16	113.83	61.01	38.97	4.16
T_7: Novel organic liquid nutrients @ 1 %	46.50	81.66	124.83	104.83	57.29	42.69	4.33
T_8: Novel organic liquid nutrients @ 2 %	46.00	80.83	123.33	105.16	55.24	44.74	4.66
T_9: Grade IV micronutrient @ 1 %	47.33	84.16	128.00	99.83	53.22	46.76	4.66
T_{10}: Grade IV micronutrient @ 2 %	46.33	84.83	128.50	98.66	51.33	48.66	4.50
T_{11}: Control (Water spray)	48.83	86.00	129.00	90.33	46.77	53.21	3.00
SEm ±	0.99	1.72	2.42	3.46	1.42	1.42	0.20
CD at 5 %	2.92	5.08	7.14	10.23	4.19	4.19	0.59
CV %	3.96	3.63	3.39	5.47	3.97	6.46	7.63

Table 2: Effect of organic and inorganic substances on yield in phalsa

Treatments	No. of fruits per 100 g	Fruit yield (kg/plant)	Fruit yield (kg/ha)
T_1: GA_3 @ 100 mg l^{-1}	149.33	0.584	973
T_2: GA_3 @ 200 mg l^{-1}	149.83	0.586	976
T_3: NAA @ 100 mg l^{-1}	133.83	0.464	773
T_4: NAA @ 200 mg l^{-1}	132.83	0.465	775
T_5: Ethrel @ 1 ml l^{-1}	134.33	0.400	667
T_6: Ethrel @ 2 ml l^{-1}	139.50	0.407	678
T_7: Novel organic liquid nutrients @ 1 %	136.66	0.390	649
T_8: Novel organic liquid nutrients @ 2 %	135.66	0.389	649
T_9: Grade IV micronutrient @ 1 %	138.66	0.377	628
T_{10}: Grade IV micronutrient @ 2 %	134.33	0.353	589
T_{11}: Control (Water spray)	130.16	0.273	455
SEm ±	2.70	0.01	17.07
CD at 5 %	7.98	0.03	50.41
CV %	3.40	4.16	4.16

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