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# Application of Plant Growth Regulators to improve Fruit Yield and Quality in Indian Gooseberry (*Emblica officinalis* Gaertn.)

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## ABSTRACT

Application of plant growth substances on bearing trees of aonla cultivar Narendra Aonla-6 significantly increased fruit retention. The minimum fruit drop was recorded with the use of NAA (15 ppm) + Thiourea (0.1%) followed by 2,4-D (10 ppm) + Thiourea (0.1%) and GA3 (50 ppm) + Thiourea (0.1%). The maximum increase in size, weight and volume of fruits and the maximum fruit yield were noted on trees sprayed with NAA (15 ppm) + Thiourea (0.1%). The improvement in fruit quality parameters (TSS, ascorbic acid, sugars and acidity) was highest with the application of GA3 (50 ppm) + Thiourea (0.1%) which showed non-significant difference with NAA (15 ppm) + Thiourea (0.1%). Results revealed that foliar application of NAA (15 ppm) + Thiourea (0.1%) or GA3 (50 ppm) + Thiourea (0.1%), twice during mid-May and mid-July, may effectively overcome the problem of fruit drop leading to higher yield of quality fruits.

**Keywords:** Indian gooseberry, fruit drop, yield, plant growth regulators, aonla.

## INTRODUCTION

Aonla, the Indian gooseberry (*Emblica officinalis* Gaertn; *Euphorbiaceae*), has a long history of cultivation in India and is regarded as one of the most important indigenous fruits. Aonla fruits are rich in Vitamin C and constitute a good source of dietary fibres, minerals and phenolic compounds. The fresh fruits are mostly processed into value added products such as murabba (preserve) and candy and are also used as ingredient in traditional Ayurvedic medicine (Pathak, 2001; Singh *et al.*, 2008). Aonla trees are hardy in nature, adapt well under varying soil conditions, have low water requirement and exhibit salt tolerance. The wastelands which do not otherwise support arable crops may be put to productive use by planting aonla orchards. Tree characteristics such as deep root system, sparse foliage and dormancy of fruitlets (in July-August) make aonla a promising fruit species for arid and semi-arid regions. In recent past, a set of factors including feasibility of commercial aonla cultivation in marginal lands, availability of improved varieties and huge possibilities for the value-addition of fruits have enabled rapid coverage of vast area under aonla cultivation in many parts of Uttar Pradesh, Haryana, Rajasthan, Maharashtra, Gujarat, Andhra Pradesh and Tamil Nadu states of India (Pathak, 2001). This is favourable development from a sustainable rural development perspective as increase in area under aonla cultivation may prove conducive to the growth of nursery business and may spur the development of small cottage-based processing industries which could provide regular employment and income to rural youth, women and landless labourers.

The bearing aonla trees often suffer from heavy fruit drop which significantly lowers down the yield. Fruit drop often causes poor fruit set in majority of the cultivars and may result in substantial crop loss in susceptible ones. Among the major causes accounting for fruit drop are self-incompatibility, inadequate pollination, nutritional deficiency, water stress, insect-pest and disease infestations and hormonal imbalances (Allemullah and Ram, 1990 and Singh *et al.*, 2008). Based on the premise that suboptimal biosynthesis and poor translocation of phytohormones may be a major cause of fruit drop, a number of studies have been carried out to assess the potential of plant growth regulators (PGRs) in overcoming this problem in different fruit crops. Yet, no systematic efforts have been made to test the efficacy of PGRs to provide viable solution to heavy fruit which often takes a heavy toll in commercial aonla orchards. Therefore, the present investigation was undertaken

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to study the effects of foliar application of different PGRs on final fruit retention as well as yield and quality fruits in aonla cv. Narendra Aonla-6 (NA-6) so as to provide aonla growers a cost effective remedy for the management of this problem.

## MATERIALS AND METHODS

This experiment was carried out at the Main Experiment Station and P.G. Laboratory of the Department of Horticulture, Narendra Deva University of Agriculture and Technology, Faizabad, Uttar Pradesh, India during the period 2005-2006. The experiment was carried out with 11-year old plants of aonla cultivar NA-6, raised in sodic soils and uniform in vigour and productivity. The plants were maintained under uniform cultural operations throughout the experimentation. Four plant growth regulators [naphthalene acetic acid (NAA), gibberellic acid ($GA_3$), 2,4-dichloro phenoxy acetic acid (2,4-D) and thio-urea (TU)] either alone or in combination with each other, were applied. Trees sprayed with tube-well (normal) water served as control. There were a total of 8 treatments with details as under:

$T_1$- control (normal water)

$T_2$- NAA (15 ppm)

$T_3$- 2,4-D (10 ppm)

$T_4$- $GA_3$ (50 ppm)

$T_5$- TU (0.1%)

$T_6$-NAA (15 ppm) + TU (0.1%)

$T_7$- 2,4-D (10 ppm) + TU (0.1%) and

$T_8$- $GA_3$ (50 ppm) + Thio-urea (0.1%)

The experiment was laid out in a randomized block design (RBD) with three replications. The chemicals were sprayed as aqueous solution using Tween (TM) 20 as surfactant. The first spray was done on 15th May, 2005 and second spray on 15th July, 2005. The fruits were harvested during the end of November, 2005 at the best physiological maturity. The data on initial fruit set, fruit drop, fruit retention and physico-chemical characteristics of fruits and fruit yield were recorded and subjected to statistical analysis (Panse and Sukhatme, 1989) to draw valid inference.

## RESULTS AND DISCUSSION

All the chemical treatments significantly reduced fruit drop (Table 1) as compared to control and the minimum fruit drop was recorded with the use of NAA (15 ppm) + TU (0.1%) followed by the application of 2,4-D (10 ppm) + TU (0.1%) and $GA_3$ (50 ppm) + Thiourea (0.1%). A corresponding increase in fruit retention (Table 1) was also noted under the same treatments and the maximum final fruit retention (26.35 %) was obtained in the trees sprayed with NAA (15 ppm) + TU (0.1%). Application of NAA, $GA_3$ and 2,4-D significantly enhanced fruit retention in mango (Ahmed *et al.*, 2012) and use of thiourea increased the formation fruitful buds in grape (Balasubrahmanyam *et al.*, 1975) and mango (Tongumpai *et al.*, 1997). Fruit drop, an abscission phenomenon, often occurs due to auxin deficiency in growing fruits and could be prevented by the exogenous application of synthetic auxins such as NAA and 2,4-D. The role of gibberellins and thiourea in controlling fruit drop appears to be indirect. While gibberellins are known to promote auxin biosynthesis, thiourea exhibits bud breaking properties and synergistic effects to auxin and gibberellin action (Krishnamoorthy, 1993).

**Table 1:** Effect of plant growth regulators on fruit drop and retention in aonla cultivar Narendra Aonla-6

| Treatments | Initial fruit set (%; Before foliar spray) | Fruit drop (%) | Fruit retention (%) |
|---|---|---|---|
| $T_1$ | 73.00 | 82.54 | 17.46 |
| $T_2$ | 74.75 | 76.00 | 24.00 |
| $T_3$ | 74.30 | 76.25 | 23.75 |
| $T_4$ | 74.00 | 77.00 | 23.00 |
| $T_5$ | 73.80 | 77.55 | 22.45 |
| $T_6$ | 76.40 | 73.65 | 26.35 |
| $T_7$ | 75.90 | 74.20 | 25.80 |
| $T_8$ | 75.50 | 75.15 | 24.85 |
| SEm ± | - | 1.56 | 0.94 |
| CD (P=0.05) | - | 4.72 | 2.84 |

The fruit size (length and breadth), fruit weight and fruit volume were significantly improved by different PGRs over control (Table 2). The maximum fruit length and breadth (4.1 and 4.4 cm, respectively) were recorded with the application of NAA (15 ppm) + TU (0.1%) followed by 2,4-D (10 ppm) + TU (0.1%) and $GA_3$ (50 ppm) + Thiourea (0.1%). Available evidence shows that exogenously applied PGRs often significantly increase fruit size (Agustí *et al.*, 1994, Erner *et al.*, 1993), which may primarily be attributed to auxin- and gibberellin-mediated cellular elongation (Krishnamoorthy, 1993). A positive correlation between auxin content and fruit growth exists in different fruit crops. Besides triggering auxin biosynthesis, gibberellins are also implicated in preferential flow of metabolites from vegetative parts to developing fruits (Krishnamoorthy, 1993). The increase in fruit weight and volume in NAA, 2,4-D and $GA_3$ treated trees seems again due to their role in cell enlargement and division, increase in intercellular spaces in the mesocarpic cells and higher translocation of photosynthates and mineral nutrients from vegetative parts towards the developing fruits that are extremely active metabolic sink (Krishnamoorthy, 1993). There were non-significant differences in specific gravity of fruits under different treatments which might be due to

proportionate increase in the weight and volume of fruits in trees sprayed with different PGRs.

**Table 2:** Effect of plant growth regulators on size, weight, volume and specific gravity of fruits in aonla cultivar Narendra Aonla-6

| Treatments | Fruit size (cm) | | Fruit weight (g) | Fruit volume ($cm^3$) | Specific gravity |
|---|---|---|---|---|---|
| | Length | Breadth | | | |
| $T_1$ (Control) | 3.58 | 3.80 | 37.00 | 35.92 | 1.03 |
| $T_2$ | 3.90 | 4.15 | 42.00 | 41.17 | 1.02 |
| $T_3$ | 3.85 | 4.13 | 41.50 | 40.69 | 1.02 |
| $T_4$ | 3.83 | 4.13 | 41.00 | 39.80 | 1.03 |
| $T_5$ | 3.75 | 3.95 | 40.25 | 39.08 | 1.03 |
| $T_6$ | 4.10 | 4.40 | 45.30 | 43.98 | 1.03 |
| $T_7$ | 4.00 | 4.32 | 43.70 | 42.84 | 1.02 |
| $T_8$ | 4.00 | 4.30 | 43.25 | 42.40 | 1.02 |
| SEm ± | 0.08 | 0.11 | 1.30 | 1.16 | - |
| CD (P=0.05) | 0.24 | 0.32 | 3.93 | 3.53 | - |

The highest total soluble solids (TSS) content in fruits (Table 3) was obtained with the combined spray of $GA_3$ (50 ppm) + Thiourea (0.1 %) followed by application of NAA (15 ppm) + Thiourea (0.1 %). Ber (*Zizyphus mauritiana* cv. Gola) trees sprayed with $GA_3$ (Bankar and Prasad 1990) and guava trees treated with NAA (Iqbal *et al.*, 2009) recorded higher TSS content in fruits. The PGRs used in this study ($GA_3$, NAA and 2, 4-D) are known to increase membrane permeability in plant cells which might facilitate accelerated breakdown of organic acids stored in cell vacuoles with consequent increase in TSS content. During ripening carbohydrates convert into simple sugar, which may ultimately increase the TSS content of fruits (Krishnamoorthy, 1993).

The acidity of fruit pulp (Table 3) was markedly reduced under all the treatments as compared to control except with 2, 4-D (10 ppm) and Thiourea (0.1 %) when used alone. It could have been possible due to transformation of organic acids into sugars at the time of ripening. The Vitamin-C (ascorbic acid) content of fruits (Table 3) was significantly improved by different PGRs as compared to the control. The maximum ascorbic acid content (670 mg/100 g fruit pulp) was noted with the application of $GA_3$ (50 ppm) + Thiourea (0.1 %) closely followed by spray of NAA (15 ppm) + Thiourea (0.1 %). Similar results have been reported in other fruit crops (Iqbal *et al.*, 2009). As ascorbic acid is synthesized from sugars, particularly L-glucose, any increase in sugar content in fruits would be conducive to the higher synthesis of ascorbic acid in fruits (Krishnamoorthy, 1993). Both reducing and non-reducing sugars (Table 3) in aonla fruits significantly increased in trees sprayed with $GA_3$ (50 pm) + Thiourea (0.1 %) followed by NAA (15 ppm) + Thiourea (0.1 %). This might be due to involvement of PGRs in the breakdown of organic acids into sugars at the time of fruit ripening. Further, plant growth regulators might assist the translocation of sugars from vegetative parts to developing fruits. Gibberellin is known to play a crucial role in the sugar metabolism of plants. Gibberellins actively participate in the hydrolysis of sucrose and starch. They promote the activity of enzyme invertase which catalyzes the hydrolysis of sucrose, thereby yielding glucose and fructose. Gibberellins also induce higher activity of □- and ß-amylases which degrade starch and represent best means for the mobilization of carbohydrate reserves in the plant. Moreover, bound gibberellins exist in pant tissues at gibberellin glycocides (*i.e.* conjugates with sugar), suggesting their role in sugar metabolism (Krishnamoorthy, 1993).

**Table 3:** Effect of plant growth regulators on physico-chemical constituents of fruits in aonla cultivar Narendra Aonla-6

| Treatments | TSS (%) | Acidity (%) | Ascorbic acid (mg $100^{-1}$ g pulp) | Sugars (%) | | |
|---|---|---|---|---|---|---|
| | | | | Reducing | Non-reducing | Total |
| $T_1$ (Control) | 9.40 | 2.10 | 580 | 2.15 | 2.00 | 4.15 |
| $T_2$ | 10.80 | 1.93 | 620 | 3.10 | 2.28 | 5.38 |
| $T_3$ | 10.60 | 2.00 | 620 | 2.85 | 2.28 | 5.13 |
| $T_4$ | 11.70 | 1.90 | 638 | 3.10 | 2.30 | 5.40 |
| $T_5$ | 10.50 | 2.03 | 618 | 2.80 | 2.27 | 5.07 |
| $T_6$ | 12.00 | 1.80 | 649 | 3.30 | 2.38 | 5.68 |
| $T_7$ | 11.90 | 1.84 | 642 | 3.20 | 2.34 | 5.54 |
| $T_8$ | 12.40 | 1.75 | 670 | 3.42 | 2.45 | 5.87 |
| SEm ± | 0.24 | 0.05 | 17.97 | 0.08 | 0.09 | 0.16 |
| CD (P=0.05) | 0.74 | 0.16 | 54.53 | 0.24 | 0.26 | 0.49 |

The maximum fruit yield (68.83 kg/tree) was recorded with the use of NAA (15 ppm) + Thiourea (0.1 %), which was statistically at par with the yields obtained in 2,4-D (10 ppm) + Thiourea (0.1 %) and $GA_3$ (50 ppm) + Thiourea (0.1 %) treated trees (Fig. 1). The foliar application of different PGRs has been found to increase yield in fruit crops which is attributed to higher fruit set and reduction in fruit drop (Modise *et al.*, 2009), increase in growth rate of fruits (Agustí *et al.*, 2002) and increase in final fruit size (Agustí *et al.*, 1994).

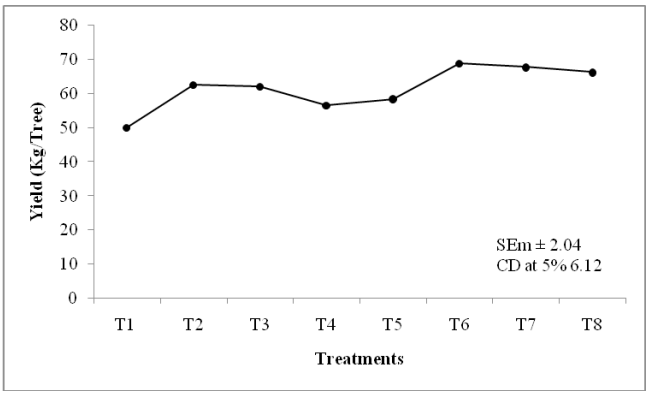


**Fig. 1:** Effect of plant growth regulators on fruit yield (kg/tree) in aonla cultivar Narendra Aonla-6

## CONCLUSION

In concluding remarks, it is suggested that the use of synthetic auxins (naphthalene acetic acid; NAA) and gibberellins ($GA_3$) in combination with thiourea during mid-may and mid-July may provide an effective solution to minimize yield losses in aonla caused by heavy fruit drop. An increase in fruit quality may be the additional gain with the use of these plant growth regulators. Such a strategy may be of particular importance in sodic soils characterized by production constraints such as limited availability of different mineral nutrients for optimum tree growth and yield.

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