Original Research Article

Influence of Plant Growth Regulators and Boron on Nutritional Quality and Shelflife of Aonla Fruit

J.S. Patel*, J.J. Dhruve, G.N. Motka and A.D. Patel

Department of Horticulture, B. A. College of agriculture, Anand Agricultural University, Anand – 388 110(Gujarat), India

*Corresponding author

A B S T R A C T

Aonla (Emblica officinalis Gaertn.) is an important crop indigenous to Indian subcontinent which is used in alternative medicine, health foods and herbal products. Plant growth regulators and micro nutrients play a vital role in growth, development, fruit retention and quality reported in many fruit crops. A field experiment was undertaken on Aonla (Emblica officinalis Gaertn.) at Horticultural Research cum Demonstration Farm, Department of Horticulture, B.A. College of Agriculture, Anand Agricultural University, Anand in order to evaluate the performance of plant growth regulators (Gibberellic acid and Naphthalene acetic acid), micro nutrient (boron) alone and their combinations applied as foliar spray at pin head and pea stage for improvement of aonla fruit quality. The significant differences were observed for total soluble solids, total soluble sugars and ascorbic acids among all the treatments. The shelflife also increased and found to be significant among all the treatments. Whereas, the internal fruit necrosis, fibre, tannin and acidity content was significantly decreased in treated samples as compared to the control. Hence, these treatments could be useful to improved nutritional quality and storage life of aonla fruit.

Keywords
Aonla, Boron, Nutrition, PGR, Quality

Article Info
Accepted: 20 March 2017
Available Online: 10 April 2017

Introduction

Aonla or Indian gooseberry (Emblica officinalis Gaertn.) is one of the important indigenous fruit of India, which belongs to family ‘Euphorbiaceae’, subfamily ‘Phyllanthoidae’ is native of Tropical South-East Asia, particularly in central and southern India. Emblica known by several vernacular names such as Amla, Chukna, Nelli, Sobju, Amlaki, Dhatriphala, Amlet, Amlay, Amolphal in different parts of the country. The fruit is known for Kayakalp (restore health and vitality) and has been recognized as ‘Amrit Phal’ in ancient Indian mythological literatures like Vedas, Puran, Ramayana, Kadambari, Charak Shmhita, etc. It is regarded as sacred tree (Singh, 2012). Its commercial cultivation is common in India, particularly in Uttar Pradesh, Haryana, Punjab and Gujarat etc. In India, it is estimated that aonla is cultivated in about 108.00 thousand hectares with production of 1286 thousand MT with an average productivity of 11.73 MT ha\(^{-1}\) (Anonymous, 2013). In Gujarat, it is estimated that aonla is cultivated in about 11.75 thousand hectares with production of 112.30 thousand MT with the main cultivated pockets are Kheda, Anand, Vadodara and Panchmahal districts (Anonymous, 2013).
Foliar feeding has been used as a means of supplying supplemental doses of nutrients, plant hormones, stimulants and other beneficial substances. Therefore, judging which foliar materials to apply and at what plant stage to spray are important principles to make best uses of this technique. The application of plant growth regulator (PGR) can provide significant economic advantages to citrus growers when used in appropriate situations as these have proven effective in stimulating a number of desired responses such as increase in fruit size and delay in fruit maturity. Fruit development is thought to be triggered by hormones that the endogenous gibberellins status of the developing citrus ovaries is the limiting factor for the initiation of fruit development. Foliar application of different levels of GA₃ (5, 50, 100 and 500 mg/l) to young fruit let’s just after fruit set have been reported to clearly increase the fruit weight, peel thickness, juice content with improved taste. Various scientists (Talon et al., 1990; Berhow, 2000; Sarad Gurung et al., 2016) have reported that nutrient management is one of the most important factor in improving the plant growth and yield through increasing photosynthetic efficiency. Micronutrients deficiency in soil and plants is a worldwide nutritional problem and very severe in many countries.

In Gujarat, the nutrient deficiencies particularly micronutrients are common due to climate and nature of soil. By choosing appropriate fertilizer rates, the grower can drive a crop toward earlier and heavier fruit setting. Boron (B) is very important for optimal plant growth, physiological and biochemical pathways in citrus cultivation under agro-climatic conditions of Gujarat. The application of boron improves the citrus fruit yield and its juice quality. Foliar or soil application of zinc increases the biosynthesis of chlorophyll and carotenoid synthesis that are important for proper performance of photosynthetic process. There were very little research work had been done on this aspect. Hence, the present experiment was undertaken to find out the effect of growth regulators and micronutrient for better quality and shelf life of anola fruit under the climatic conditions of middle Gujarat.

Materials and Methods

The present investigation entitled “influence of plant growth regulators and boron on nutritional quality and shelf-life of anola fruit was carried out during the year 2012-2013 and 2013-2014 under field conditions at the Horticultural Research Farm, Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand. The treatments comprised combination of plant growth regulators and boron T₁: Control i.e. water spray, T₂: NAA 20 mg/l, T₃: NAA 40 mg/l, T₄: GA₃ 25 mg/l, T₅: GA₃ 50 mg/l, T₆: Boron 0.25 %, T₇: Boron 0.50 %, T₈: NAA 20 mg/l + GA₃ 25 mg/l, T₉: NAA 40 mg/l + GA₃ 50 mg/l, T₁₀: NAA 20mg/l + GA₃ 25 mg/l + Boron 0.25% and T₁₁: NAA 40 mg/l + GA₃ 50 mg/l + Boron 0.50% at pin head (1st week of August) and pea stage (1st week of September) on yield and fruit quality characters. The experiment was laid out in a Completely Randomized Design with eleven treatment combinations and repeated thrice. The total soluble solids (TSS) were recorded in percentage with help of hand refractometer. The small pieces of head were crushed out and a drop of juice was put on the glass prism of refractometer and observations were recorded from eyepiece and average reading of total soluble solids was worked out. The ascorbic acid and acidity (Ranganna, 1979), total soluble sugars (Dubois et al., 1956), fiber (Maynord, 1970), tannin (Saini et al., 2001) contents were analysed.

Results and Discussion

The total soluble solids was found significantly higher in treatment T₁₁(17.44%).
which was at par with T10 (17.00%). Significantly the minimum total soluble solids (Table 1) was found in treatment T1 (13.22%), which was at pat with treatment T4 (13.97%). The increase in total soluble solid might be due to rapid transformation of complex carbohydrates into soluble sugars and also fast mobilization of metabolites from source to sink under influence of growth substances like GA₃ which promote quick metabolic transformation of starch and pectin into soluble sugars and rapid mobilization of photosynthetic metabolites and minerals from other parts of the plant. Similarly NAA increase the TSS which might be due to synthesis of auxin in plant, it increase the physiological activities leading to increased TSS in fruits. Boron treatment ascribed due to auxin synthesis which in term increase the metabolites available for TSS. The results are also in opinion with the findings of Singh et al., (2002) in ber, Srivastava and Jain (2006) in mango, Ghosh et al., (2009), Srivastava et al., (2009), Yadav et al., (2010), Singh et al., (2007) and Shukla et al., (2011) in aonla.

The analysis of anola fruit revealed a significant (p<0.05) variation (4.79 to 6.12%) in anola total soluble sugar content among all treatments (Table 1). The total soluble sugars was found significantly higher in treatment T11 (6.12%), which was followed by T10 (5.60%), T9 (5.59%), and T3 (5.28%). The spray application of GA₃ had shown significant increase in the total sugars of aonla fruits. This might be due to activation of enzymes which affect the physiological processes, which in turn hydrolyzed the starch and helps in metabolic activity during the change in available starch into sugar and soluble solid content. NAA had shown significant increase in the total sugar of aonla fruits and this might be due to synthesis of auxin in plant, it increased the physiological activities. The results are also in accordance with the findings of Bhati and Yadav (2003) in ber, Ghosh et al., (2009), Srivastava et al., (2009), Yadav et al., (2010) and Shukla et al., (2011) in aonla.

The influence of different plant growth regulators and boron on ascorbic acid content was found significant (Table 1). Significantly the maximum and minimum ascorbic acid content was found in treatment T11 (901mg/100g) and T1 (740 mg/100g), respectively. The non significant difference was found among treatment T8 (876), T9 (885)and T10 (896).The increase in ascorbic acid might be due to catalytic influence of growth regulators on its bio-synthesis from its precursor glucose-6-phosphates throughout the development of fruits which is thought to be precursor of vitamin- C. The application of gibberellic acid, NAA and boron may have favorably influenced the metabolic activities possibly due to their increased endogenous level which increased the ascorbic acid of aonla fruit. The results are also in accordance with the findings of Srivastava and Jain (2006) in mango, Shukla et al., (2011), Srivastava et al., (2009) and Yadav et al., (2010) in aonla fruit.

The shelf life of aonla fruits was extended up to 16 days at room temperature when the treatment was given in combination of plant growth regulators and boron i.e. NAA 40 mg/l+ GA₃ 50 mg/l+ Boron 0.50% at pin head and pea stage (Table 1). It might be due to antagonistic effect of GA₃ which inhibit ethylene production and delayed the conversion of starch to sugar. The results are also in view with the findings of Srivastava and Jain (2006) in mango. Yadav and Shukla (2009) in aonla.
Table 1: Influence of different plant growth regulators and boron on total soluble solids, total soluble sugars, ascorbic acid, physiological loss in weight and shelf-life at maturity stage of aonla fruit cv. Gujarat Aonla

| Treatment                        | Total Soluble Solids (°B) | Total sugars (%) | Ascorbic acid (mg/100 g pulp) | Shelf-life (Days) | Physiological loss in weight (%) at 12th day of storage | Physiological loss in weight (%) at 24th day of storage |
|----------------------------------|---------------------------|------------------|-------------------------------|-------------------|--------------------------------------------------------|--------------------------------------------------------|
| T₁: Control (Water spray) at pin head and pea stage | 13.22                     | 4.82             | 739.79                        | 11.13             | 14.10                                                  | 26.90                                                  |
| T₂: NAA 20 mg/l at pin head and pea stage          | 15.23                     | 5.01             | 844.72                        | 12.89             | 14.06                                                  | 24.28                                                  |
| T₃: NAA 40 mg/l at pin head and pea stage          | 15.18                     | 5.28             | 879.21                        | 13.61             | 12.20                                                  | 23.97                                                  |
| T₄: GA₃ 25 mg/l at pin head and pea stage          | 13.97                     | 5.00             | 815.58                        | 12.47             | 12.89                                                  | 22.90                                                  |
| T₅: GA₃ 50 mg/l at pin head and pea stage          | 14.73                     | 4.80             | 852.23                        | 13.57             | 12.95                                                  | 23.87                                                  |
| T₆: Boron 0.25 % at pin head and pea stage         | 13.30                     | 4.79             | 748.23                        | 14.34             | 12.97                                                  | 23.40                                                  |
| T₇: Boron 0.50 % at pin head and pea stage         | 14.05                     | 5.05             | 786.87                        | 13.51             | 13.14                                                  | 21.88                                                  |
| T₈: NAA 20 mg/l + GA₃ 25 mg/l at pin head and pea stage | 16.37                     | 5.23             | 876.11                        | 13.88             | 12.49                                                  | 23.05                                                  |
| T₉: NAA 40 mg/l + GA₃ 50 mg/l at pin head and pea stage | 16.56                     | 5.59             | 885.54                        | 14.15             | 14.17                                                  | 24.62                                                  |
| T₁₀: NAA 20 mg/l + GA₃ 25 mg/l + Boron 0.25% at pin head and pea stage | 17.00                     | 5.60             | 896.39                        | 15.85             | 11.58                                                  | 22.81                                                  |
| T₁₁: NAA 40 mg/l + GA₃ 50 mg/l + Boron 0.50% at pin head and pea stage | 17.44                     | 6.12             | 901.89                        | 16.13             | 10.75                                                  | 19.81                                                  |
| S. Em+                                           | 0.41                      | 0.22             | 13.61                         | 0.50              | 0.62                                                   | 0.68                                                   |
| C. D. @ 5%                                       | 1.17                      | 0.62             | 38.80                         | 1.42              | 1.94                                                   | 1.94                                                   |

Interaction effect

| Y X T (year x treatment) | NS | NS | NS | NS | NS | NS |
|--------------------------|----|----|----|----|----|----|
| C.V. %                   | 6.62| 10.23| 3.98| 8.83| 7.94| 7.13|
Table 2 Influence of different plant growth regulators and boron on internal fruit necrosis, fibre, tannin and acidity at maturity stage of aonla fruit cv. Gujarat Aonla-1

| Treatment | Internal fruit necrosis (%) | Fibre content (%) | Tannin content (%) | Acidity (%) |
|-----------|----------------------------|------------------|-------------------|-------------|
| T1: Control (Water spray) at pin head and pea stage | 13.14 | 3.05 | 2.63 | 1.96 |
| T2: NAA 20 mg/l at pin head and pea stage | 12.57 | 2.88 | 2.39 | 1.78 |
| T3: NAA 40 mg/l at pin head and pea stage | 11.15 | 2.54 | 2.49 | 1.76 |
| T4: GA3 25 mg/l at pin head and pea stage | 12.00 | 2.45 | 2.45 | 1.86 |
| T5: GA3 50 mg/l at pin head and pea stage | 11.46 | 2.55 | 2.43 | 1.80 |
| T6: Boron 0.25 % at pin head and pea stage | 7.86 | 2.68 | 2.68 | 1.89 |
| T7: Boron 0.50 % at pin head and pea stage | 4.83 | 2.59 | 2.39 | 1.89 |
| T8: NAA 20 mg/l + GA3 25 mg/l at pin head and pea stage | 11.43 | 2.47 | 2.47 | 1.63 |
| T9: NAA 40 mg/l + GA3 50 mg/l at pin head and pea stage | 9.49 | 2.29 | 2.30 | 1.52 |
| T10: NAA 20 mg/l+ GA3 25 mg/l+ Boron 0.25% at pin head and pea stage | 5.16 | 2.37 | 2.22 | 1.47 |
| T11: NAA 40 mg/l+ GA3 50 mg/l+ Boron 0.50% at pin head and pea stage | 3.02 | 1.96 | 1.79 | 1.44 |
| S. Em+ | 0.40 | 0.11 | 0.21 | 0.04 |
| C. D. @ 5% | 1.14 | 0.31 | 0.67 | 0.12 |

The different plant growth regulators and boron exhibited significant influence on physiological loss in weight of aonla fruits. Among the different treatments, combination of plant growth regulators and boron treatment i.e. NAA 40 mg/l+ GA3 50 mg/l+ Boron 0.50% at pin head and pea stage was found significantly superior over the rest of the treatments and lowest physiological loss in weight after 12th and 24th day storage period for anola fruit. Similar trend was also recorded after 24th day storage period (Table 1). The reduction of weight loss in the fruits treated with GA3 might be due to its anti-senescence action. The plant growth regulators and boron treatment resulted in to decrease in the tissue permeability and thereby reduces the rate of water loss. The reduced PLW in fruits during storage is mainly due to reduced rate of transpiration and respiration. The results are also in accordance with the findings of Srivastava and Jain (2006) in mango, Yadav and Shukla (2009) in aonla fruits.

The physiological disorders like internal necrosis are a very dangerous for the aonla cultivation. The minimum internal fruit necrosis (3.02) was measured with foliar the application of NAA 40 mg/l + GA3 50 mg/l + Boron 0.50% at pin head and pea stage (T11) and maximum internal fruit necrosis was recorded under control (Table 2). It may be due to the fact that boron has significant role
in mobilization of food material from source to sink as a result accumulate the photosynthates which control fruit necrosis. The results are also in line with the findings of Singh et al., (2001) in aonla.

The influence of different plant growth regulators and boron on fibre content was found significant (Table 2). Significantly the minimum and maximum fibre content was found in treatment T_{11} (1.96%) and T_1 (3.05%), respectively. This might be due to activation of enzymes which affect the physiological processes and in turn hydrolyzed the starch and helped in reducing fruit fibre. The results are also in accordance with the findings of Singh et al., (2007) in aonla.

The analysis of anola fruit revealed a significant (p<0.05) variation (1.79 to 2.68%) in anola total tannin content among all treatments (Table 2). Significantly higher tannin content was recorded in treatment T_6 (2.68%) which was followed by treatments T_1 (2.63%) T_3(2.49%), T_4 (2.45%) and T_5(2.43%). However lower tannin content was found in treatment T_{11} (1.79). This might be due to activation of enzymes which affect the physiological processes, which improve the bio-chemical substances in fruit. The results are also in accordance with the findings of Singh et al., (2007) in aonla.

Significantly higher and lower titratable acidity was found in treatment T_1 (1.96%) and T_{11} (1.44%), respectively (Table 2). However, the non significant difference was found among treatments T_9 (1.52%), T_{10} (1.47%) and T_{11} (1.44%). This may be due to PGR’s and nutrients which might have either been fastly converted into sugar and their derivatives by reactions involving reversal of glycolytic pathway which activated bio-chemical processes for sugar accumulation in the fruits and thus acidity percentage was decreased in fruits. Similarly, boron also resulted in lower acidity which might be due to the fact that mineral compounds reduced the acidity in fruits, since it is neutralized in parts during metabolic pathways which used in the respiratory process as substrate leading to decreased acidity in fruits. The results are also in opinion with the findings of Singh et al., (2002) and Bal et al., (2007) in ber, Srivastava et al., (2009, Yadav et al., (2010) and Shukla et al., (2011) in aonla.

Among different plant growth regulators and boron treatments, the treatment T_{11} (Sprays of NAA 40 mg/l + GA_{3} 50 mg/l + Boron 0.50 % at pin head and pea stage) recorded maximum net realization of 2, 48, 987 ` ha^{-1} with BCR 1: 3.55 as compared to treatment T_1 i.e. control (Water spray at pin head and pea stage) recorded the lowest net realization 1, 31,151 ` ha^{-1} with BCR 1: 2.70, respectively.

From the foregoing discussion and the results obtained from this investigation, it can be concluded that foliar spray of NAA 40 mg/l + GA_{3} 50 mg/l + Boron 0.50% at pin head and pea stage in aonla fruits found beneficial for better fruit quality i.e. increased in total soluble solids, total soluble sugars, ascorbic acid and decreased in internal fruit necrosis, fibre, tannin and acidity content and ultimately acidity percentage was decreased in fruits.

Significantly minimum physiological loss in weight and maximum shelf-life of fruit was also found with same treatment. Thus overall it can be concluded that spraying NAA 40 mg/l + GA_{3} 50 mg/l + Boron 0.50% was useful to improved nutritional quality and storage life of aonla fruit and found significantly superior along with maximum net realization 2, 48, 987 ha^{-1} with BCR 1: 3.55.
References

Anonymous (2013). Indian Horticulture Database, National Horticulture Board, Ministry of Agriculture, Government of India.

Bal, J. S. and Randhawa, J. S. (2007). Effect of NAA on fruit drop and quality of ber, Haryana J. hortic. Sci., 36 (3-4): 231-232.

Berhow MA. (2000) Effect of early plant growth regulator treatments on flavonoid levels in grapefruit. Plant Growth Regul. 30: 225-232.

Bhati, B. S. and Yadav, P. K. (2004). Effect of foliar application of urea and NAA on the yield parameters of ber (Ziziphus mauritiana Lamk.) cv. ‘Gola’, Haryana J. Hort. Sci., 33 (3-4): 189-190.

Ghosh, S. N.; Bera, B.; Roy, S.; Kundu, A. and Roy, S. K. D. (2009). Effect of nutrients and plant growth regulators on fruit retention, yield and physico-chemical characteristics in aonla cv. ‘NA-10’, J. Horti. Sci., 4(2): 164-166.

Kassem, H. A.; Amal, M.; El-Kobbia.; Hend A.; Marzouk and M.M. El –Sebaiey. (2010). Effect of foliar sprays on fruit retention, quality and yield of Costata persimmon trees., Emir. J. food Agric., 22 (4): 259 -274.

Ojha, C. M. and Pathak, R. K. (1993). Changes in chemical composition of aonla cultivars during growth and development of fruits., Prog. Hort., 25 (1-2): 42-46.

Patel, N. M.; Patel, D. K.; Verma, L.R. and Patel M. M. (2010). Effect of cultural and chemical treatments on fruit set and fruit yield of custard apple (Annona squamosa L.) cv. ‘Sindhan’, Asian J. Hort. 5(2): 498-502.

Reddy, P. A. and Prasad, D.M. (2012). Effect of PGRs on fruit characters and yield of pomegranate cv. ‘Ganesh’. Int. J. of plant, Animal and Envt. Sci., 2(2):91-93.

Sarad Gurung, S. K. Mahato, C. P. Suresh and Binoy Chettri (2016). Impact of Foliar Application of Growth Regulators and Micronutrients on the Performance of Darjeeling Mandarin. American Journal of Experimental Agriculture 12(4): 1-7

Shukla, A. K. (2011). Effect of foliar application of calcium and boron on growth, productivity and quality of Indian gooseberry., Indian J. Agric. Sci., 81(7):628-32.

Shukla, H. S.; Kumar, V.; and Tripathi, V. K. (2011). Effect of gibberellic acid and boron on development and quality of aonla fruits ‘Banarasi’., Acta Horticulture., 890: 375-380.

Singh, H.K.; Srivastava, A.K.; Dwivedi, R. and Kumar, P. (2001). Effect of micro-nutrients on plant growth, fruit quality, yield and internal fruit necrosis of aonla cv. ‘Francis’., Prog. Horti., 33(1):80-83.

Singh, R.; Godara, N. R. and Ahlawat, V. P. (2002). Qualitative attributes as affected by foliar sprays of nutrients and growth regulators in ber cv. ‘Umran’. Haryana J. hort. Sci., 31 (1-2): 23-25.

Singh, I. S. (2012). Aonla-Production, Handling and Processing, Westville Publishing House, New Delhi.

Singh, J. K.; Prasad, J. and Singh, H. K. (2007). Effect of micro-nutrients and plant growth regulators on yield and physico-chemical characteristics of aonla fruits cv. ‘Narendra Aonla-10’, Indian J. Hort., 64(2): 216-218.

Srivastava, C. P.; Singh, H. K.; Vishwanath. and Pratap. B. (2009). Efficacy of foliar feeding of plant growth regulators along with urea on yield and quality of aonla (Emblica...
*Emblica officinalis* Gaertn.) cv. ‘NA-7’ fruits., 
*Annals of Horticulture.*, 2(1): 77-79.

Srivastava, D. and Jain, D. (2006). Effect of urea and GA₃ on fruit retention, growth and yield of mango cv. ‘Langra’ during on year., *Karnataka J. Agric. Sci.*, 19(3):754-756.

Talon M L, Zacarias, Prima M E (1990). Hormonal changes associated with fruit set and development in mandarin differing in their parthenocarpic activity. *Physiol. Plant.*, 79:400-406.

Yadav, S. and Shukla, H. S. (2009). Effect of various concentrations of plant growth regulators and mineral nutrients on quality parameters and shelf-life of aonla fruit (*Emblica Officinalis* Gaertn.) *Indian J. Agric. Biochem.*, 22(1): 51 - 56.

---

**How to cite this article:**

Patel, J.S., J.J. Dhruve, G.N. Motka and Patel, A.D. 2017. Influence of Plant Growth Regulators and Boron on Nutritional Quality and Shelflife of Aonla Fruit. *Int.J.Curr.Microbiol.App.Sci.* 6(4): 2533-2540. doi: https://doi.org/10.20546/ijcmas.2017.604.295