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EVALUATION OF EFFECTS OF PLANT GROWTH REGULATORS (PGRS), CALCIUM AND COW URINE ON STORAGE LIFE OF AONLA FRUIT (*EMBLICA OFFICINALIS* GAERTN.) CV. NA-7 WITH BENEFIT: COST RATIO OF DIFFERENT TREATMENTS

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ABSTRACT

Aonla or Indian gooseberry is an indigenous fruit to Indian subcontinents, which is regarded as amritphal. It is cultivated in India in 95000 ha area out of which more than 70% area covered by cultivar NA-7. An investigation was carried out on effect of pre-harvest spray of Salicylic Acid @ 2 m mol + Mulch, Calcium Nitrate (CN) @ 1% + Mulch, Benzyl Adenine (BA) @ 75 ppm + Mulch, Salicylic acid @ 2 m mol + BA (Benzyl Adenine) @75ppm + Mulch, Salicylic acid @ 2 m mol + Calcium nitrate @1% + Mulch, Calcium nitrate @ 1% + BA (Benzyl Adenine) @ 75ppm + Mulch, Cow Urine @ 35% + Mulch, Mulch and control on storage life of Aonla fruit at Fruit Science Laboratory, Department of Fruit Science, College of Horticulture and Forestry, A.N.D.U.A &T, Kumarganj, Ayodhya during the year 2021-22. These treatments were sprayed two times on Aonla tree, in order to standardize the best pre-harvest treatment for improving storage life of Aonla fruits.

Key words : Amritphal, Indigenous, Salicylic acid, Cow-urine, Pre-harvest, Storage-life.

Introduction

Aonla is indigenous fruit of India (Barthakar and Arnold, 1991). Apart from India, aonla trees are also found in natural forests in various countries, including Cuba, USA, Pakistan, Sri Lanka, Malaysia, China, Java and the West Indies (Singh *et al*., 2019). It is used in Ayurvedic medicine to make Triphala and Chyavanprash. Due to its hardy nature, high productivity, nutritional and therapeutic values and its suitability for various value-added products, aonla has become an important fruit crop in the 21st century (Pathak, 2003). The fruit is effective against several ailments and can be used to create various value-added products. Additionally, aonla powder, made from the fruit, is considered superior to synthetic vitamin C in treating deficiencies. Nutritional, commercial and medicinal significance of aonla fruit makes it popular all over the world (Goyal *et al*., 2007). Aonla is an excellent source of ascorbic acid (300-900 mg/100 g), amino acid and minerals along with phytochemicals such as polyphenols, tannins, emblicol, linoleic acid, corilagin, phyllemblin and rutin (Ghorai and Sethi, 1996; Jain and Khurdiya, 2004; Murthy and Joshi, 2007; Baliga and Dsouza, 2011).

In India, aonla is cultivated on 95000-hectare area with 1107000 MT production (NHB 2019-20). Among the commercial grown varieties of aonla, cultivar 'NA-7' is the most popular variety of aonla which covered more than 70 per cent area of total cultivated area of our country. Narendra Aonla-7 is mid-season, precocious and prolific bearer. Fruits are medium to large, semi-translucent and free from necrosis. In north India blemished fruit is a serious problem and such types of fruits has poor market quality and are not very much suitable for processing. Calcium plays an important role in maintaining quality of fruits and calcium treatments helps to retain fruit firmness, increase vitamin-C content,

decreased storage breaks down and rotting. Cow urine have antifungal properties which prevent many fungal diseases and also have micronutrient such as calcium, iron, zinc, magnesium, potassium. Salicylic acid is best known as plant growth hormone for its different physiological responses such as seed germination, vegetative growth, photosynthesis, respiration, thermogenesis, flower formation, seed production and reduce biotic and abiotic stresses. Benzyladenine is a first-generation synthetic cytokinin that elicits plant growth and development responses, setting blossoms and stimulating fruit richness by stimulating cell division. Mulching is to prevent loss of water by evaporation, prevention of soil erosion, weed control, to reduce fertilizer leaching, to promote soil productivity, to enhance yield and quality of field and fruit crops. Black polythene displayed the best physico-chemical characteristics of fruits together with the greatest soil moisture retention and enhanced features. On the ninth day of storage, the mulch produced 80% more marketable fruits than the control hat applying several mulches to a 15-year-old mango tree (Das Kaushik and Dutta Pallab, 2018).

Materials and Methods

The present study "Pre-harvest spray of PGRs, calcium and cow urine on yield and quality of aonla fruit (*Emblica officinalis* Gaertn.) cv. NA-7" was carried out on thirty-year-old aonla tree cultivar NA-7 during the years 2021- 2022 at Fruit Science Laboratory, Department of Fruit Science, College of Horticulture and Forestry, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.), India. The study was conducted in Factorial Completely Randomized Design with nine treatments Salicylic Acid @ 2 m mol + Mulch, Calcium Nitrate (CN) @ 1% + Mulch, Benzyl Adenine (BA) @ 75 ppm+ Mulch, Salicylic acid @ 2 m mol + BA (Benzyl Adenine) @ 75ppm + Mulch, Salicylic acid @ 2 m mol + Calcium nitrate @ 1% + Mulch, Calcium nitrate @ 1% + BA (Benzyl Adenine) @ 75ppm + Mulch, Cow Urine @ 35% + Mulch, Mulch and control and was replicated three times.

To determine the weight loss of the fruit during post-harvest storage, both treated and control fruit were weighed at different sampling intervals of 0, 3, 6 and 9 days after harvesting of fruit. Then weight loss was calculated as the difference between initial fruit weight and the fruit weight at time of measurement and expressed in percentage.

$$\text{P.L.W.} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

Acidity was determined by the sample titrated against N/10 NaOH method (Rangana, 1977). T.S.S. of fruits was taken with hand refractometer. Ascorbic acid of fruit was determined by sample prepare in metaphosphoric acid and titrated against 2, 6-dichlorophenol indophenol dye (Somogyi, 1945).

Estimation of benefit: cost ratio

The incremental benefit: Cost ratio was calculated by the analysis of input cost, incremental input cost, gross return and incremental gross return.

(i) Incremental cost input

The total cost was calculated for each treatment by adding the value of each input *i.e.*, Labour charges, cost of chemicals etc. in each treatment during the experiment. Incremental cost input was calculating by subtracting the input cost of control from each treatment to find out the comparative input cost for respective treatments.

(ii) Incremental gross income

Gross income was estimated on the basis of the average market price of fruit at the respective time. Incremental gross return was calculated by subtracting the gross return of control from the gross return of each treatment to find out the comparative gross return for respective treatments.

(iii) Incremental Benefit: cost ratio

It was calculated by dividing incremental gross return by incremental input cost. Formula used for this calculation is:

$$\text{ICBR} = \frac{\text{Incremental input cost}}{\text{Incremental gross return}}$$

Results and Discussion

Physiological loss in weight of fruit

The study found that the PLW percentage of aonla fruits increased progressively with the storage period at ambient temperature. All treatments showed significant differences in physiological weight loss, with the minimum PLW of 7.1% recorded with the treatment of calcium nitrate + mulch and the maximum of 9.8% in the control. Aonla showed a self-life of up to 6 days with 9.5% PLW at ambient conditions during 9 days. The PLW% differed significantly with days of storage, with the minimum PLW of 5.8% recorded on the 3rd day and the maximum of 11.5% on the 9th day. The interaction effect of preharvest treatments and days of storage was found to be significant showed in Table 1.

Table 1 : Effect of pre-harvest treatments on physiological loss in weight (PLW) of fruits in aonla cv. NA-7during storage.

Treatments	PLW (%)			
	3 days	6 days	9 days	Mean
T_1: Control	6.37	10.12	12.32	**9.8**
T_2: Salicylic Acid @2 mmol + Mulch	5.88	9.22	11.22	**9.4**
T_3: Calcium Nitrate (CN) @1! + Mulch	3.87	7.80	9.66	**7.1**
T_4: Benzyl Adenine (BA) @75 ppm+ Mulch	6.14	9.95	12.05	**8.8**
T_5: Salicylic acid @ 2 mmol + BA (Benzyl Adenine) @75ppm + Mulch	5.77	9.37	11.27	**9.4**
T_6: Salicylic acid @ 2 mmol + Calcium nitrate @ 1% + Mulch	5.12	9.20	11.20	**8.5**
T_7: Calcium nitrate @ 1% + BA (Benzyl Adenine) @ 75ppm + Mulch	5.87	9.80	11.90	**9.2**
T_8: Cow Urine @ 35% + Mulch	6.86	10.18	12.28	**8.8**
T_9: Mulch	6.72	9.61	11.71	**9.6**
Mean	**5.8**	**9.5**	**11.5**	**8.9**

Characters	Treatments	Days	Treatments × Days
S.Em ±	1.35	0.78	2.33
C.D. at 0.05%	3.82	2.20	6.61

Table 2 : Effect of preharvest treatments on T.S.S of fruits in aonla cv. NA-7during storage.

Treatments	T.S.S (^{0}Brix)				
	0 days	3 days	6 days	9 days	Mean
T_1: Control	8.86	8.92	9.60	10.28	9.4
T_2: Salicylic Acid @ 2 mmol + Mulch	9.33	10.49	10.95	11.41	10.5
T_3: Calcium Nitrate (CN) @1% + Mulch	9.43	9.49	9.98	10.47	9.8
T_4: Benzyl Adenine (BA) @75 ppm+ Mulch	9.66	9.73	10.28	10.83	10.1
T_5: Salicylic acid @2 mmol + BA (Benzyl Adenine) @75ppm + Mulch	10.26	10.98	11.45	11.92	11.2
T_6: Salicylic acid @2 mmol + Calcium nitrate @ 1% + Mulch	9.73	10.66	11.24	11.82	10.9
T_7: Calcium nitrate @ 1% + BA (Benzyl Adenine) @75ppm + Mulch	9.33	10.18	10.63	11.07	10.3
T_8: Cow Urine @ 35% + Mulch	10.33	10.75	11.29	11.83	11.1
T_9: Mulch	9.86	11.11	11.45	12.37	11.2
Mean	9.6	**10.3**	**10.8**	**11.3**	10.5

Characters	Treatments	Days	Treatments × Days
S.Em±	0.07	0.04	0.12
C.D at 0.05%	0.19	0.11	0.33

Calcium nitrate plays a crucial role in reducing weight loss in fruits, as it is a key constituent of the fruit layer. Similarly, results were obtained by postharvest application of calcium nitrate on apple cv. Jonagold. The calcium nitrate treatments reduced weight loss percentage during storage as compared to control (Rabiei *et al*., 2011). Foliar spraying of calcium nitrate, calcium chloride, naphthalene acetic acid and salicylic acid on guava fruits and found fruits treated with calcium nitrate recorded minimum physiological loss in weight (Kaur *et al*., 2019).

Total soluble solids : According to the study, aonla fruits' total soluble solid (TSS) content considerably rose when they were stored at room temperature. TSS varied significantly across all treatments. Fruits treated with cow urine and mulch (T8) had the highest TSS, whereas control (T_1) had the lowest. Three days had the lowest TSS while nine days had the most. Preharvest treatments and days of storage were found to have a substantial interaction impact mentioned in Table 2.

Total soluble solid increased during storage due to

Table 3 : Effect of preharvest treatments on Acidity of fruits in aonla cv. NA-7during storage.

Treatments	Acidity (%)				
	0 days	3 days	6 days	9 days	Mean
T_1: Control	2.42	2.61	2.76	2.92	**2.7**
T_2: Salicylic Acid @ 2 mmol + Mulch	1.91	2.06	2.37	2.70	**2.3**
T_3: Calcium Nitrate (CN) @ 1% + Mulch	2.22	2.43	2.54	2.65	**2.5**
T_4: Benzyl Adenine (BA) @ 75 ppm + Mulch	2.23	2.46	2.58	2.74	**2.5**
T_5: Salicylic acid @ 2 mmol + BA (Benzyl Adenine) @ 75ppm + Mulch	1.92	2.22	2.35	2.48	**2.2**
T_6: Salicylic acid @ 2 mmol + Calcium nitrate @ 1% + Mulch	2.18	2.26	2.44	2.62	**2.4**
T_7: Calcium nitrate @ 1% + BA (Benzyl Adenine) @ 75ppm + Mulch	1.94	2.00	2.31	2.56	**2.2**
T_8: Cow Urine @ 35% + Mulch	1.85	1.98	2.23	2.48	**2.1**
T_9: Mulch	2.25	2.60	2.75	2.89	**2.6**
Mean	**2.1**	**2.3**	**2.5**	**2.7**	**2.4**

Characters	Treatments	Days	Treatments × Days
S.Em ±	**0.04**	**0.02**	**0.07**
C.D at 0.05%	**0.12**	**0.07**	**0.21**

hydrolysis of polysaccharides into monosaccharides. Postharvest treatments with salicylic acid in different doses on apple cv. Jonagold and were found salicylic acid treated fruits significantly maintained total soluble solid as compared to others treatments (Kazem *et al*., 2011).

Acidity

Aonla fruit acidity rose during storage, according to the study. The fruits (T_8) treated with cow urine and mulch had the lowest recorded acidity (2.1%), while the fruits (T_9) in the control group had the highest recorded acidity (2.7%). Fruits that had been treated with mulch and cow urine had the lowest acidity at 3.3% intervals, while the control group had the highest acidity (2.92%) after nine days of storage. Significant results were obtained regarding the relationship between preharvest treatments and days of storage showed in Table 3.

Minimum acidity in aonla fruit during storage is due to the availability of potassium and nitrogen in cow urine which have negative relation with titrable acidity. (Spironella *et al*., 2004). The reference related to cow urine is lacking. The minimum acidity next to T_8 the treatment T_7. Similar result was found as postharvest application of calcium nitrate on apple fruits cv. Jonagold during storage (Rabiei *et al*., 2011). Similarly, Zeraatgar *et al*. (2018) was found in Chinese jujube.

Ascorbic acid

When treated with cow urine + mulch (T_8) and salicylic acid + calcium nitrate + mulch (T_6), aonla fruits demonstrated the least amount of ascorbic acid loss throughout 0 days to 9 days of storage at room temperature, according to the study. At 3-day intervals, ascorbic acid loss was 433.7 mg/100g at the lowest, and 403.5 mg/100g at the highest, as per the data collected at 6-day intervals. At intervals of nine days, the control group (T_1) saw the highest ascorbic acid loss, which was measured at 386.28 mg/100g. Significant results were obtained regarding the relationship between preharvest treatments and days of storage mentioned in Table 4.

Fruit ascorbic acid decreased during storage due to oxidation of ascorbic acid. Calcium nitrate and salicylic acid play important role to maintained ascorbic acid during storage. Similar result was obtained by Ennab *et al*. (2019) with the treatment of salicylic acid (200 and 400 ppm), putrescine (50 and 100 ppm) as postharvest treatment and further, reported that both chemicals were effective to maintain ascorbic acid during storage.

Economics of various treatments in aonla cv. NA-7

It is apparent from the estimated economics that maximum cost of cultivation and comparative input was recorded when the plants were subjected to preharvest treatment salicylic acid + calcium nitrate + mulch (T_6) *i.e.*, Rs. 67,508.8/ha and Rs. 64,508.8/ha respectively followed by T_7 (Calcium nitrate + benzyl adenine + mulch) with Rs. 66,400/ha and Rs. 63,400/ha.

An introspection to data reported that maximum gross return and comparative gross return was recorded in cow urine + mulch (T_8) with Rs. 5,59,360/ha and Rs. 2,07,360 /ha respectively followed by T_5 (Salicylic acid + benzyl

Table 4 : Effect of preharvest treatments on Ascorbic acid of fruits in aonla cv. NA-7during storage.

Treatments	Ascorbic acid(mg/100g)				
	0 days	3 days	6 days	9 days	Mean
T_1: Control	450.00	421.80	401.41	386.28	**414.9**
T_2: Salicylic Acid @ 2 mmol + Mulch	455.33	423.87	408.53	393.17	**420.2**
T_3: Calcium Nitrate (CN) @ 1% + Mulch	452.33	428.30	414.42	399.13	**423.5**
T_4: Benzyl Adenine (BA) @ 75 ppm+ Mulch	455.33	434.24	417.24	401.98	**427.2**
T_5: Salicylic acid @ 2 mmol + BA (Benzyl Adenine) @75ppm + Mulch	470.66	439.29	422.46	407.22	**434.9**
T_6: Salicylic acid @2 mmol + Calcium nitrate @ 1% + Mulch	467.66	440.53	431.34	416.01	**438.9**
T_7: Calcium nitrate @ 1% + BA (Benzyl Adenine) @ 75ppm + Mulch	462.33	436.21	418.27	403.28	**430.0**
T_8: Cow Urine @ 35% + Mulch	477.00	445.31	431.26	416.23	**442.5**
T_9: Mulch	467.66	433.51	423.42	408.25	**433.2**
Mean	**462.0**	**433.7**	**418.7**	**403.5**	**429.5**

Characters	Treatments	Days	Treatments × Days
S.Em±	0.10	0.06	0.17
C.D at 0.05%	0.28	0.16	0.48

Table 5 : Effect of preharvest on economics of various treatments.

Treatments	Cost input (Rs/ha)	Incremental cost input (Rs/ha)	Gross return (Rs/ha)	Incremental gross return (Rs/ha)	Incremental benefit: cost ratio
T_1: Control	3000		352000		
T_2: Salicylic Acid @ 2 mmol + Mulch	24308.8	21308.8	387360	35360	1.659
T_3: Calcium Nitrate (CN) @ 1% + Mulch	63700	60700	415680	63680	1.049
T_4: Benzyl Adenine (BA) @75 ppm + Mulch	23200	20200	431840	79840	3.952
T_5: Salicylic acid @2 mmol + BA (Benzyl Adenine) @ 75ppm + Mulch	27008.8	24008.8	469120	117120	4.878
T_6: Salicylic acid @ 2 mmol + Calcium nitrate @ 1% + Mulch	67508.8	64508.8	467680	115680	1.793
T_7: Calcium nitrate @ 1% + BA (Benzyl Adenine) @75ppm + Mulch	66400	63400	452160	100160	1.579
T_8: Cow Urine @ 35% + Mulch	**44500**	**41500**	**559360**	**207360**	**4.996**
T_9: Mulch	17940	14940	420800	68800	4.605

adenine + mulch) with Rs. 4,79,520/ha and Rs. 1,27,520 /ha. Maximum comparative benefit cost ratio was found in cow urine + mulch (T_8) with 4.996% and minimum benefit cost ratio was found in T_3 (Calcium nitrate + mulch) showed in Table 5.

Similarly, Gupta *et al.* (2006) observed highest cost benefit ratio (1: 18.9) from cow urine 5%, however, highest additional yield value of Rs. 6520 per hectare with cow urine 50%. Malaco *et al.* (2017) observed the use of cow urine as an alternative to the use of synthetic chemicals is recommended to farmers for it is cost effective, economical, as well as safe for mankind and environment. Korade *et al.* (2019) found benefit: Cost ratio of application 10% cow urine with 25 ppm NAA was more effective having B:C ratio of 2.41 as compared to 1.74 in control.

Conclusion

The study reveals that preharvest treatments of aonla fruits with calcium nitrate and mulch showed minimal

physiological loss in weight (PLW) and can be stored for up to 9 days, compared to 6 days for untreated fruits. The treatments also showed the highest amount of total soluble solid (TSS) and minimal acidity, with the acidity content rapidly increasing during storage. The treatments also produced maximum ascorbic acid, which decreased with storage. The calcium nitrate and mulch treated fruits maintained the highest quality during storage, allowing for up to 9 days of storage with minimal loss of quality and lowest physical weight. For long-term storage, calcium nitrate and mulch with two sprays (Ist week of October and Ist week of November) are recommended for aonla growers.

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