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Response of growth promoting substances on flowering, fruiting and yield behavior of ber (*Ziziphus mauritiana* Lamk) cv. Apple ber

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Abstract
Plant growth substances play a significant role in many physiological phenomena for improving the flowering, fruiting and yield behavior of fruit plants. The experiment was conducted at the Dry Land Horticulture Farm Surgi, SKS College of Agriculture & Research Station, Rajnandgaon on three years old ber plants cv. Apple ber during the year 2019-20. The growth promoting substances i.e. NAA, GA3, 2, 4-D, Urea and Humic acid were used. The experiment was laid on Randomized Block Design with 16 treatments which were replicated three times and each treatment contains ten plants. The treatments were assigned randomly on each replication. The treatments namely Control (T0), Urea 1% (T1), Urea 2% (T2), Urea 3% (T3), GA3 10 ppm (T4), GA3 25ppm (T5), GA3 40ppm (T6), NAA 10 ppm (T7), NAA 30ppm (T8), NAA 50ppm (T9), 2,4-D 5ppm (T10), 2,4-D 10ppm (T11), 2,4-D 15ppm (T12), Humic acid 1% (T13), Humic acid 1.5% (T14), Humic acid 2% (T15) were tested. The application of growth promoting substances were done in morning at the stage of flowering (September, 2019) and fruit development i.e. mustard stage (October, 2019) and marble stage (November, 2019) of fruit. The result revealed that maximum initial fruit set (3711), fruit retention (24.92%) and minimum fruit drop (75.07%) were recorded with NAA 50 ppm. Highest fruit yield (37.62kg/ Plant) produced with 40ppm GA3 over control (8.35 kg/Plant).

Keywords: Plant growth substances, NAA, apple ber, fruit, yield, humic acid, behavior

Introduction
Ber (*Ziziphus mauritiana* Lamk.) is an important arid fruit crop that belongs to the family Rhamnaceae. In India, ber is cultivated in various part of the country particu- larly in arid and semi-arid regions comprising of 52,000 ha area producing 6.39 lakh MT of fruits (Anonymous, 2019) [2]. The major growing regions are Rajasthan, Madhya Pradesh, Uttar Pradesh, Haryana, Punjab, Gujarat, Bihar, Maharashtra, Andhra Pradesh and Tamil Nadu. Ber is a nutritious and delicious table fruit. The fruit is a rich source of ascorbic acid, vitamin B-complex andminerals and the root, stem bark, flower and seed are used in Ayurveda to treat indigestion, headache, cough etc. The leaves are good fodder for animals, especially goats and ships. The ber is a hardy plant and shows summer-deciduous nature and can grow under low-inputs which makes the plant sustain salinity and drought and becomes a popular fruit crop of arid and semi-arid regions. In spite of having vast potential, the ber fruit has limited cultivation, unlike the other fruit crops as for commercial production. It needs proper care and adequate plant management (Singh and Bal, 2006) [17]. Generally, ber growers faced various problems like low and inferior quality yield, flower and fruit drops and poor fruit setting. These problems occur due to various factors, i.e. improper nutrition management, inadequate cultivation practices and changes in environment variables. Plant nutrition's help in the production of raw materials that require the plant to sustained normal growth. However, the hormones help in translocation of raw materials and regulate the normal physiological process in plants. Imbalance of hormones in the plant altered normal physiological processes that directly affects on the reproductive response of the plants (Singh *et al*., 1991) [16].
Among various ber cultivars, Apple ber is gaining popularity among farmers of many parts of India. Unlike local and hybrid cultivars, the specialty of the Apple ber is the bigger size of fruit, weight of each fruit is 50-100 g. It starts bearing fruits after 6 month of planting and gives fruit twice in a year having total bearing age of 20 years. This tree gives 25-30 kg fruits on first year and from second year onward gives 40-50 kg of fruits. The ber plant is well known for its profuse flowering and fruiting but prone to fruit drop which hinders the ber production.

During their long period of stay on the tree fruit face the vagaries of the climatic conditions changing during the months of September to January. Therefore it is very essential to control the fruit drop to obtain profitable yield. There are several factors causing fruit drop but biochemical and physiological behaviour of plant plays a vital role. In view of this optimum level of plant growth regulators and nutrients should be applied at proper time is practical solution to overcome the problem of fruit drop and ensure good setting and retention of fruits on the tree. The higher fruit set and retention in fruit on the tree is induced by the application of plant hormones resulting in good growth rate of fruit and contributing in final size of the fruits. An imbalance of auxins, cytokinine and gibberellins may leads to the formation of abscission at the stem point and eventually cause fruit drop. Flower requires an endogenous hormonal stimulation to set fruit, especially sufficient amount of auxin and gibberelline (Singh and Bal, 2008) [18].

NAA is synthetic auxin hormone, inhibits the physiological breakdown of calcium and magnesium pectate at the middle lamella of the cell wall thereby preventing abscission of fruit. It also strengthens the petiole which ultimately reduces the fruit drop. The exogenous application of GA3 increases the size of fruit by increasing rate of cell division and cell enlargement. GA3 induces higher activity of α and β-amylase which degrade starch and mobilize carbohydrate reserve in the plants. GA3 affects the activity of enzyme invertase cause hydrolysis of sucrose and yielding glucose and fructose thereby increasing TSS content. GA3 also contribute to high vitamin C content. It enhances the activity of auxin thereby reducing the fruit drop. Similarly the application of 2, 4-D reduces the fruit drop by contributing to the high level of auxin in plant and lowering the ethylene concentration. Among many nutrients nitrogen plays a major role in vegetative growth and better flowering, fruiting and fruit retention (Karole and Tiwari, 2016) [10]. Urea is the cheapest source of nitrogen, as it is water soluble, less corrosive and high nitrogen content makes it useful in foliar feeding. It stimulates the function of several enzymes therefore its spray helps in reduction of fruit drop and improving quality of fruits. Humic acid is a well known bio-stimulant which enhances the plant growth stimulates plant enzymes and increases production. It thickens the cell wall of the fruits and increases the shelf life of the fruit (Bons and Kaur, 2019) [4].

Plant growth substances plays a significant role in many physiological phenomena for improving the flowering and fruiting behavior and quality attributes has not been properly investigated in Chhattisgarh conditions. Hence, present experiment framed to find the suitable pre harvest treatments and their doses for improving fruit set and yield of ber in Chhattisgarh state. Keeping the above facts in mind, the study was conducted to assess the performance of pre-harvest treatments effective for controlling fruit retention, fruit drop and enhancing yield parameters (Krishna *et al*., 2017) [11].

Material and Methods

The experiment was conducted at the Dry Land Horticulture Farm Surgi, SKS College of Agriculture & Research Station, Rajnandgaon on three years old ber plants cv. Apple ber during the year 2019-20. Rajnandgaon situated at 21.0 N latitude and 81.03 E longitudes at an altitude of 307 meters above the mean sea level in the western part of the Chhattisgarh plains. The growth promoting substances i.e. NAA, GA3, 2, 4-D, Urea and Humic acid were used. The experiment was laid on Randomized Block Design with 16 treatments which were replicated three times and each treatment contains ten plants. The treatments were assigned randomly on each replication. The treatments namely Control (T0), Urea 1% (T1), Urea 2% (T2), Urea 3% (T3), GA3 10 ppm (T4), GA3 25ppm (T5), GA3 40ppm (T6), NAA 10 ppm (T7), NAA 30ppm (T8), NAA 50ppm (T9), 2,4-D 5ppm (T10), 2,4-D 10ppm (T11), 2,4-D 15ppm (T12), Humic acid 1% (T13), Humic acid 1.5% (T14), Humic acid 2% (T15) were tested. The application of growth promoting substances were done in morning at the stage of flowering (September, 2019) and fruit development i.e. mustard stage (October, 2019) and marble stage (November, 2019) of fruit. All the 15 treatment along with control (water spray) were applied on whole tree as much sufficiently that each part of plant sufficiently got wet. Spray was done according to the treatment assigned to each plant.

The observation on number of flower per shoot, fruit set, fruit retention, fruit drop, fruit Weight, pulp weight and yield. The following methods were used to taken quantitative observations during the experiment. The number of flower per shoot counted by selecting three branches of similar length and size projecting opposite direction to each other. Each of the three selected branches of all trees were tagged prior to flowering. Number of flower per shoot counted at periodic interval till the end of flowering before spraying. The average number of flowers per shoot was recorded from each treatment before spraying, by counting the total number of fruits set of the respective tagged shoots of each treatment and average number of fruit per shoot was derived. The number of fruit those were set, recorded at 15 days interval and their number counted at the time of harvest. The percent of fruit retention calculated by the formula.The amount of fruit drop recorded from the fruit setting to the time of harvest. The percentage of fruit drop determined by average of the data obtained from each treatment. The fruit with pale green colour of good size considered to be the mature fruit. The picking of fruit started from last week of November 2019 to the last week of January 2020.The weight of each picking per plant recorded in kilograms and summed up to get average weight of each treatment. Total 10 pickings were done at regular intervals. Data recorded on various aspects in the field and laboratory were subjected to statistical analysis of variance technique as given by Gomez and Gomez (1985) [8]. The significant differences between treatments were compared with the critical differences at 5 per cent level of significance.

Results and Discussion

Response of different growth promoting substances on fruit set, fruit retention and control of fruit drop

Initial Fruit set

The physical characteristics of the fruits are an expression of fruiting activity of the plant which was significantly influenced by the all the plant growth promoting substance applied over the control. The range of fruit set i.e. 2924 to 3711 was found under present investigation. The poorest fruit set found to be 2924 under the treatment (T0). The table 1 and fig.1 clearly depicts that the maximum number of fruit set (3711) found under the treatment of NAA 50 ppm (T9). Thus treatment of plant with 50ppm NAA resulted in 7.2% more fruit set as compared to control. Thus the increase in fruit

setting is due to acceleration of metabolic activities of the plant by increasing meristematic growth which leads to increase in vegetative growth, increase in photosynthesis and ultimately enhance higher flowering and fruit setting. These results are in close similarity with the findings of Gangadhar *et al.,* (2019) [7] in ber and Majumder *et al.,* (2017) [12] in ber.

Fruit retention

The application of different growth promoting substances greatly influenced the fruit retention of ber. It is clearly apparent from the table 1 and fig. 2 that the maximum fruit retention (24.92%) was observed under the treatment of plant with 50ppm NAA (T9). The minimum fruit set (8.34%) recorded under control (T0). All the concentration of NAA and GA3 greatly hasten the fruit set percentage over control. Thus the enhancement of fruit set by treatment of NAA is due to physiological process of inhibiting the abscission layer formation resulting in less fruit drop. Auxin also plays a vital role in cell division, cell elongation, photosynthesis, RNA synthesis and membrane permeability resulting in high water and nutrient uptake which lead to low fruit drop and high fruit retention. These finding is line with reports of Chaudhury *et al.,* (2020) [6] in ber and Ghosh *et al.,* (2009) [9].

Fruit drop

It is clear from the observation recorded that the increasing concentration of the NAA reduces quantum of fruit drop. The minimum fruit drop (75.07%) was recorded with the treatment 50 ppm NAA (T9) and the maximum fruit drop (91.66%) was noted under control as shown in table 1 and depicted in fig. 3. The reduction in fruit drop is due to increase in auxin level which prevent the abscission by inhibiting the enzymatic activity of pectinase, polygalactauronase and cellulasase. These results are in agreement with the findings of Singh *et al.,* (2001) [19], Yadav and Chaturvedi (2004) [20] and Sarshwati *et al.,* (2003) [13] in mandarin.

Table 1: Response of growth promoting substances on fruits set, fruit retention and fruit drop in ber.

S. No	Treatments		Average no. of fruit set	Fruit retention %	Fruit drop %
1.	T0	Control (Water spray)	2924	8.34	91.66
2.	T1	Urea (1%)	3276	17.02	82.97
3.	T2	Urea (2%)	3296	19.07	80.93
4.	T3	Urea (3%)	3347	19.92	80.07
5.	T4	GA3(10 ppm)	3456	22.89	77.11
6.	T5	GA3 (25ppm)	3503	23.04	76.96
7.	T6	GA3(40ppm)	3550	23.38	76.61
8.	T7	NAA (10 ppm)	3570	23.60	76.39
9.	T8	NAA(30ppm)	3699	24.06	75.94
10.	T9	NAA(50ppm)	3711	24.92	75.07
11.	T10	2,4-D (5ppm)	3381	20.5	79.5
12.	T11	2,4-D (10ppm)	3406	20.86	79.13
13.	T12	2,4-D (15ppm)	3434	21.40	78.60
14.	T13	Humic acid 1%	3102	8.91	91.08
15.	T14	Humic acid 1.5%	3153	10.55	89.45
16.	T15	Humic acid 2%	3270	10.70	89.27
S.E.(d) ±			2.63	0.85	0.85
C.D. at 5%			5.93	1.74	1.74

Response of pre harvest treatment of different growth promoting substances for physical parameters and yield of ber

Fruit weight

All the growth promoting substance appreciably improved the fruit weight over the control. The maximum fruit weight (50.99 g) is recorded with the treatment (T6), pre harvest spray of GA3 40ppm. It may be due to the involvement of GA3 in the cell division higher synthesis of metabolites and translocation of food materials to the developing fruits cause increase in fruit weight. The minimum fruit weight (31.89gm) recorded with control (T0). These results in close similarity with the results of Painkara *et al*., (2012) [21] in mango cv. Langra, Shukla *et al*., (2011) [14] in aonla. The results are presented in table 2 and depicted in fig.4.

Pulp weight

The pulp weight increase appreciably with all the growth promoting substances over control. The treatment (T6), spray of GA3 40ppm resulted in maximum increase in pulp weight (46.45gm) whereas the minimum pulp weight (28.42gm) obtained with control (T0) as shown in table 2 and depicted in fig 5. It may be due to involvement of GA3 in cell division, expansion and increase in the intercellular space of mesocarpic cell and increase in water absorption and translocation of metabolites and sugars to the expanded cell. This result is in close conformity with the results of Adhikary *et al*., (2019) [1] in ber.

Yield

The ultimate object of all experiment is to increase the yield per plant. The fresh yield of fruit is significantly influenced by all the growth promoting substances but maximum yield (37.62Kg/plant) obtained with the treatment (T6), spray of GA3 40ppm and second highest yield (35.94Kg/plant)obtained with treatment (T9), spray with NAA 50ppm. As regard the minimum fruit yield (8.35Kg/plant) obtained with control (T0) as in table 2 and fig 6. Both the growth hormone NAA and GA3 progressively increase the yield on increasing its concentration. These results are in close conformity with the finding of Bhowik and Banik (2011) [3], Sindha *et al*., (2018) [15] in custard apple and Chandra *et al*., (2015) [5] in anola

Table 2: Response of growth promoting substances on fruit weight (g), pulp weight (g), and fruit yield (Kg/plant).

S. No	Treatments		Fruit weight (g)	Pulp weight (g)	Yield (Kg/plant)
1.	T0	Control (Water spray)	31.89	28.42	8.35
2.	T1	Urea (1%)	36.65	33.9	19.64
3.	T2	Urea (2%)	36.66	33.47	22.03
4.	T3	Urea (3%)	36.76	33.34	23.08
5.	T4	GA3(10 ppm)	46.79	42.73	33.77
6.	T5	GA3 (25ppm)	47.44	43.31	34.48
7.	T6	GA3(40ppm)	50.99	46.45	37.62
8.	T7	NAA (10 ppm)	43.07	39.24	29.6
9.	T8	NAA(30ppm)	43.17	39.29	32.80
10.	T9	NAA(50ppm)	45.68	41.75	35.94
11.	T10	2,4-D (5ppm)	32.08	28.40	20.72
12.	T11	2,4-D (10ppm)	33.86	30.13	22.27
13.	T12	2,4-D (15ppm)	33.93	30.15	22.89
14.	T13	Humic acid 1%	36.37	32.58	10.18
15.	T14	Humic acid 1.5%	36.87	33.09	12.22
16.	T15	Humic acid 2%	38.71	34.88	13.08
S.E.(d) ±			0.38	0.74	0.95
C.D. at 5%			0.77	1.52	1.96

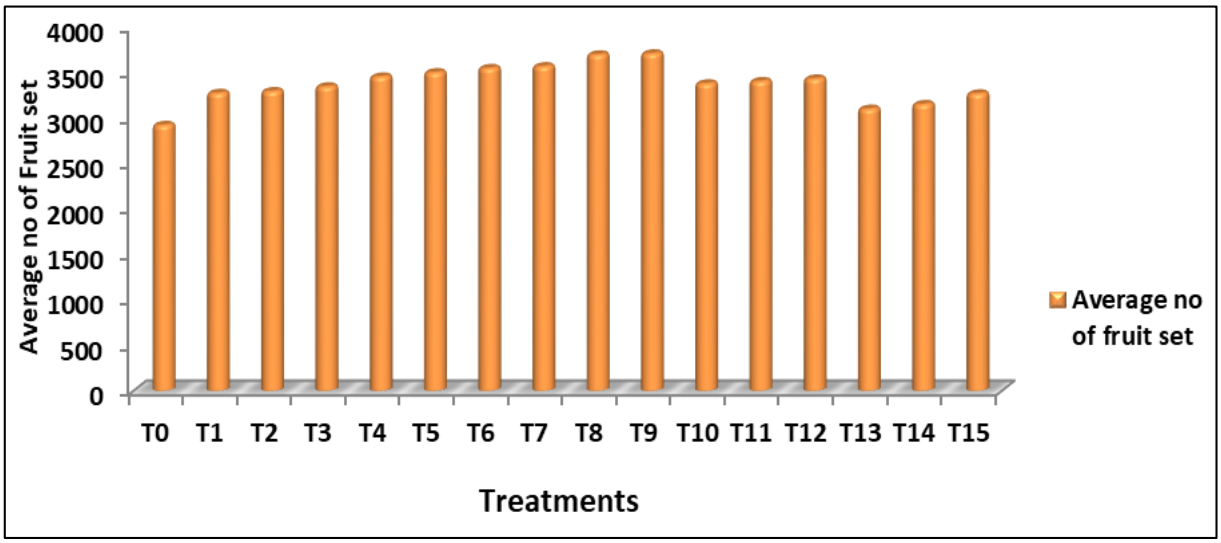

Fig 1: Response of growth promoting substances on fruit set

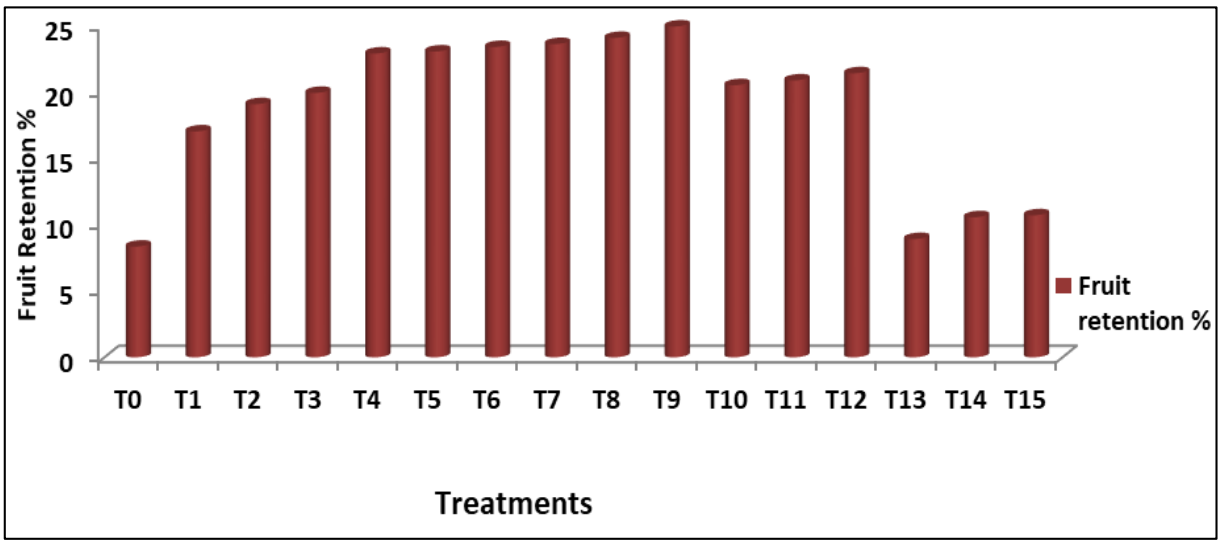

Fig 2: Response of growth promoting substances on Fruit retention %

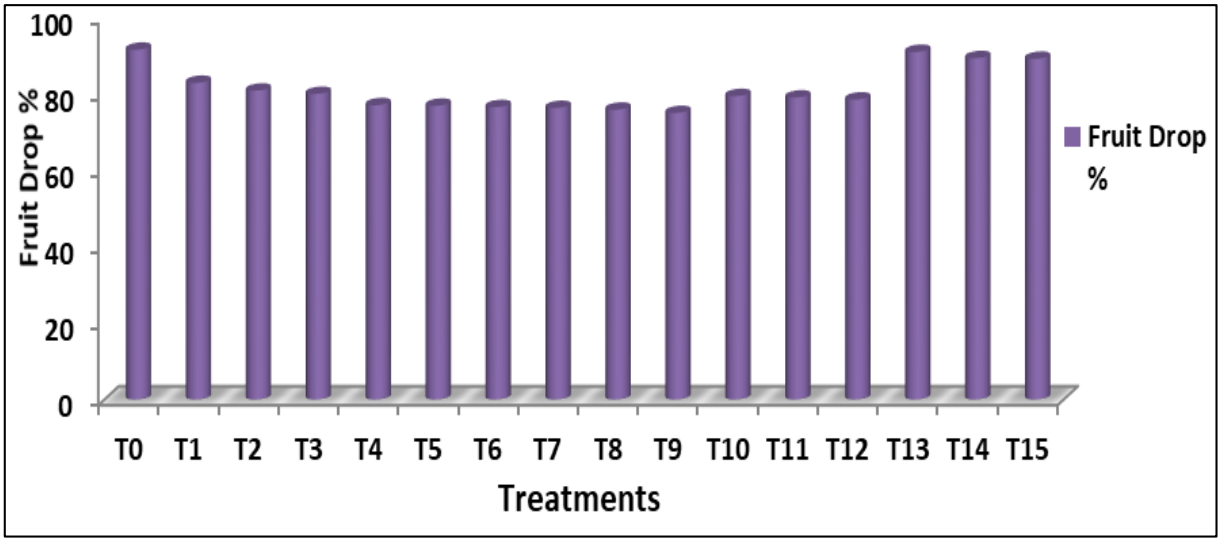

Fig 3: Response of growth promoting substances on Fruit drop %

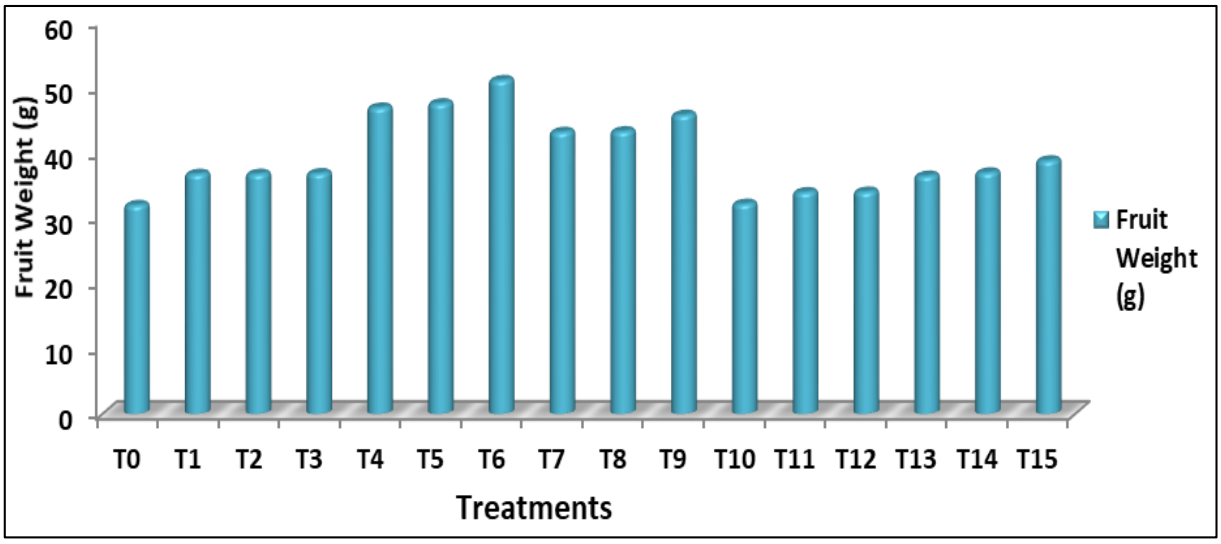

Fig 4: Response of growth promoting substances on Fruit weight (g)

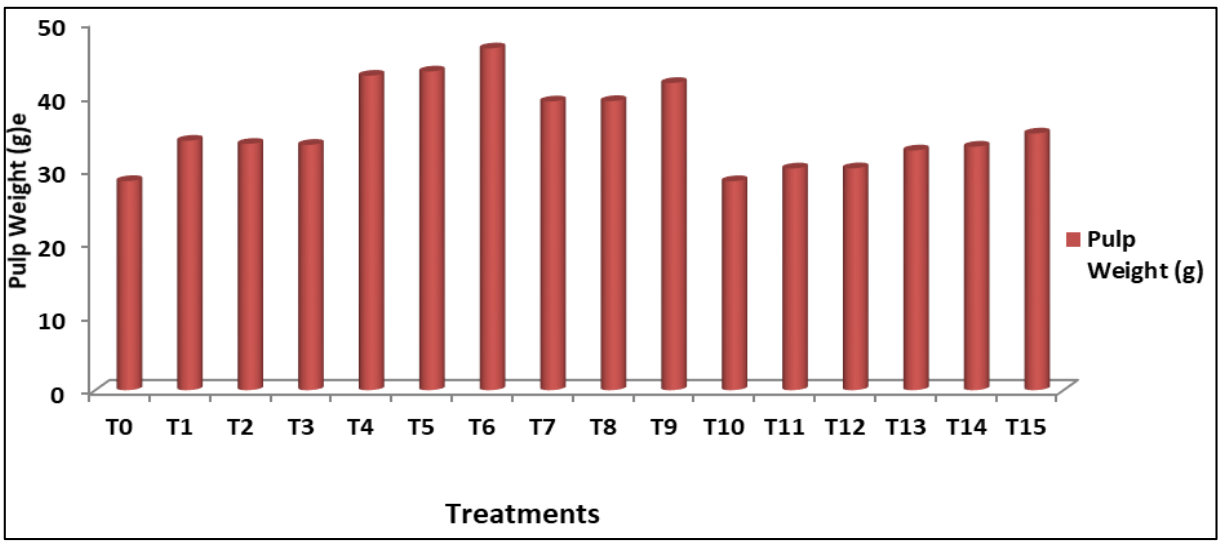

Fig 5: Response of growth promoting substances on Pulp weight (g)

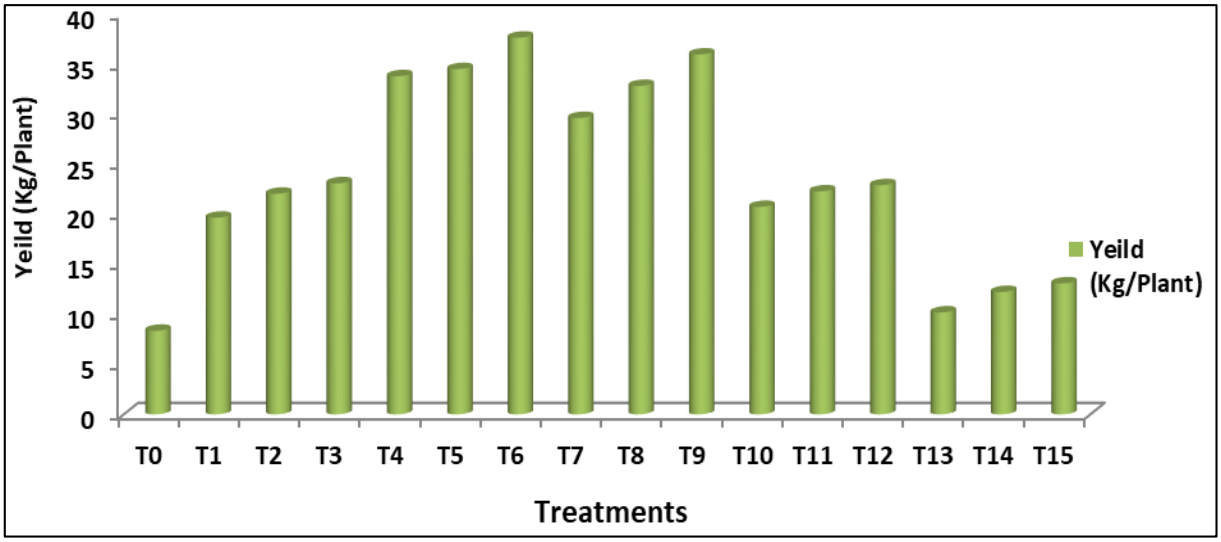

Fig 6: Response of growth promoting substances on Fruit Yeild (Kg/Plant)

Conclusion

The results of the present experiment conducted on 3 years old ber cv. Apple ber plants showed that the treatment T9 (NAA 50ppm) was found most appropriate dose of NAA for obtaining maximum fruit set, retention and minimum fruit drop. The Treatment T6 (GA3 40ppm) has given maximum yield, fruit weight and pulp weight of fruits. Hence spray of these plant growth promoting substances may be useful for maximum production and quality fruits. It could be concluded that the results of this experiment will be useful with particular reference for maximum flowering, fruiting and yield behavior of apple ber fruits which is beneficial for growing farmers.

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