The Pharma Innovation Journal 2021; 10(8): 93-95

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(8): 93-95

www.thepharmajournal.com
Received: 02-06-2021
Accepted: 12-07-2021

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Response of salicylic acid and triacontanol on growth, yield of Ber (*Ziziphus mauritiana* Lamk.) cv. Gola

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Abstract
A field experiment entitled "Response of Salicylic acid and Triacontanol on Growth, Yield and Quality of Ber (*Ziziphus mauritiana* Lamk) cv. Gola" conducted during 2020-21 at instructional Farm, Department of Horticulture, College of Agriculture, Ummedganj (Agricultural University, Kota). It consisted of 16 treatment combinations with four levels of salicylic acid (control, SA @ 100, 150 and 200 ppm) and four levels of triacontanol (control, TRIA @ 5.0, 7.5 and 10.0 ppm) and replicated thrice in Factorial Randomized Block Design. The application of salicylic acid @ 150 ppm among the different concentrations proved significantly superior over rest of the treatments in respect to growth parameters *viz*. tree spread E-W (6.35 m) and N-S (6.10 m), canopy volume (2.99 m^3), shoot length at 30, 60 and 90 DAS (108.93, 117.83 and 120.66 cm), shoot diameter at 30, 60 and 90 DAS (6.09, 7.72 and 8.46 mm), per cent growth (12.56%), minimum days taken to flower initiation (12.01) and per cent fruit set (11.38%), maximum fruit retention per cent (54.55%) and minimum fruit drop per cent (38.95%) while, duration of flowering and days taken to maturity were found non-significant. This treatment also gives maximum fruit weight (27.58 g), yield $plant^{-1}$ (13.62 kg) and yield ha^{-1} (3787 kg).

Keywords: Salicylic acid, *Ziziphus mauritiana*, response of Salicylic acid, Kota

1. Introduction
Ber (*Zizyphus mauritiana* Lamk.) is one of the most common fruit, indigenous to an area joined from India to china. The genus *Zizyphus* has been derived from 'Zizaif' which is the Arabic name of the fruit (Baily, 1947). The ber belongs to the family Rhamnaceae which has about 50 genera and more than 600 species (Pareek, 1983) [2]. It is known as the king of arid zone fruits, is one of the ancient fruit and origin of ber is said to be India to south –western Asia. It is grown under neglected soil type. It is a very nutritious fruit and is rich in vitamin C content (Morton, 1987) [3]. The fruits are very nutritious and rich source of ascorbic acid (90-280 mg/100g), vitamin 'A' (55 mg/ 100g), Thiamine (0.13 mg/100g), Riboflavin (0.19 mg/100g), total soluble solids (17- 20%), acidity (0.21%), Beta carotene (81 µg/100g), protein (0.8 g/100g), fat (0.3 g/100g), carbohydrate (17 g/100g), calcium (4 mg100/g), phosphorus (9 mg /100g), and iron (1.8 mg/100g), fresh ber fruit contains total sugars (5.4-10.5g), reducing sugar (1.4-6.2g), non - reducing sugar (3.2-8.0g) (Yadav and Singh, 2001) [4].
It's bark is useful to heal ulcer, wounds, scabies, throat problems and burning sensation of the body. Fruits are useful to purify and enrich blood, treat chronic bronchitis, fever and enlargement of the liver. Its seeds are also used to treat dry cough and skin eruptions. The juice of ber root is used as a purgative and externally in gout and rheumatism (Mukhtar *et al.*, 2004) [5]. However, its leaves are used for the treatment of diabetes mellitus (Abdel – Zaher*et al.*, 2005) [6]. It is a drought hardy and can grow under the most hazardous condition of soil,water and climate and thus it has highly recommended for the arid and desert area of India. It's cultivation provides some income even on marginal and poor soil with limited irrigation water (Pareek, 1983) [2].

2. Materials and methods
2.1 Tree spread E-W and N-S (m)
Spread of plants was measured in two opposite directions (East-West and North-South) with the help of measuring tape and average spread of the tree was calculated in meter.

2.2 Canopy volume (m^3)
Canopy volume was calculated with the help of following formula and expressed in cubic meter-

Canopy volume = r^3 x [2/3 – x + x^3/3]

Where, r = Radius of crown (m)
x = Crown height (m)

2.3 Shoot length (cm)
For measuring the shoot length, four uniform shoots which are vigorous types are selected randomly and tagged. The length of these shoots was measured at 30 days interval, up to 90 days in centimetres with the help of scale.

2.4 Shoot diameter (mm)
For measuring the diameter of shoot, the five randomly selected shoots were marked in each treatment. The initial diameter of shoot was measured by digital vernier caliper at the time of treatment application. Then periodical observations were taken at 30 days interval up to 90 days.

2.5 Percent growth
Initial observation was taken into consideration for calculation of final growth and it was expressed in percentage.

2.6 Days taken to flower initiation
Days taken to initiation of flowering were recorded by visual observations through regular visiting of the orchard during experimentation period.

2.7 Duration of flowering
Total days were counted from initiation of flowering to fruit set on tagged reproductive shoots and average it.

2.8 Fruit set (%)
Five uniform branches around each tree were selected and tagged. The number of flower buds was counted from the selected cymes before the first spray. Thereafter, seven days after the second spray, the number of small fruits set on each tagged branch was counted. The per cent fruit set was calculated as follows:

$$\text{Per cent fruit set (\%)} = \frac{\text{Number of fruits set}}{\text{Total number of flowers on selected cymes}} \text{ X } 100$$

2.9 Fruit drop (%)
The number of fruits retained on the five tagged branches was counted ten days before harvest. The per cent fruit drop was calculated as follows:

$$\text{Fruit drop (\%)} = \frac{\text{Total fruit set} - \text{Number of fruits retained}}{\text{Total fruit set on selected cymes}} \text{ X } 100$$

2.10 Fruit retention (%)
Total numbers of fruits set present on the tagged shoots were counted and then the total number of fruits was again counted at the time of fruit maturity. The per cent fruit retention was calculated on the basis of initial number of fruit set.

2.11 Days taken to maturity
Days were counted after fruit set to reach fruit at full maturity stage from the tagged cymes.

2.12 Fruit weight (g)
The weight of fruits was recorded by using monopar electronic balance and expressed in grams and average was calculated.

2.13 Fruit yield per tree (Kg)
Fruits harvested from each successive pickings were weighed on balance from each treatment and total weight of fruits per tree was expressed as in kilogram.

2.14 Estimated Yield per hectare
The yield of fruits per hectare was calculated by multiplying the yield of fruits per tree with number of trees per hectare.

3. Result and discussion
The observations were recorded on the different aspects such as growth components *i.e.* tree spread E-W and N-S, canopy volume, shoot length, shoot diameter, percent growth, days taken to flower initiation, duration of flowering, percent fruit set, fruit drop, fruit retention and days taken to maturity. Yield attributes *i.e.* fruit weight, yield plant^{-1}, estimated yield ha^{-1}. Data indicated that the different growth hormones had a significant effect on tree spread (E-W) and (N-S), canopy volume, shoot length, shoot diameter, per cent growth, days taken to flower initiation, per cent fruit set, fruit drop per cent and fruit retention percent. the maximum tree spread (E-W) and (N-S), canopy volume, shoot length, shoot diameter, per cent growth, days taken to flower initiation, per cent fruit set, fruit drop per cent and fruit retention percent were observed under treatment S_2 followed by S_3 and minimum in the water spray in terms of above observations (Table 1,2).The increase in plant height by salicylic acid could be due to conserved IAA and gibberellins (Tomaszewski and Thimman 1996) [7] and also because of the activity of salicylic acid in regulation of pentose-phosphate pathway and there by induced cell growth and elongation in plants (Pankaj and Sharma 2003) [8]. The stimulation on such growth characters were attributed to application of different concentration of Triacontanol (Table. 1, 2). The treatmentT_3 (triacontanol- 10 ppm) increases the plant spread E-W (6.33 m) and N-S (6.05 m), canopy volume (2.96 m^3), shoot length of ber at 30, 60 and 90 DAS (108.06), (115.20) and (118.03) cm, shoot diameter of ber at 30, 60 and 90 DAS (6.05), (7.30) and (7.84) mm, per cent growth (12.23%), and maximum fruit set (11.16%), fruit retention percent (51.64%) and minimum days taken to flower initiation (13.49), minimum duration of flowering (64.60), minimum fruit drop (40.36%) and minimum days taken to maturity (134.08 days). The increase in stem and root growth was perhaps attributed by the increase in water uptake, especially by the treatment with Triacontanol. Power *et al.* (2000) found that spray of 0.5 per cent triacontanol resulted in the highest value for vine length, number of leaves and 100 leaves weight in betel vine. Triacontanol induced improvement in growth of strawberry as observed in the present study might be due to increasing the level of RuBisCO5, regulation of many genes (Praveen et al., 2011) [9].

The interactive effect of salicylic acid and triacontanol, treatment S_2T_3 (salicylic acid- 150 ppm + triacontanol- 10 ppm) increased plant spread E-W (6.54 m), canopy volume (3.32 m^3), shoot diameter at 30 and 90 DAS (6.19 and 8.66 mm), per cent growth(13.15 %), per cent fruit retention (74.70%) and fruit drop percent (30.31%) as compared to rest of treatments. These treatments had significant effect on growth parameters over control.

Table 1: Effect of salicylic acid and triacontanol on growth components of ber sv. Gola.

Treatment	Tree spread E-W (m)	Tree spread N-S (m)	Canopy volume (m^3)
Salicylic acid			
Water spray	5.90	5.55	2.33
SA - 100 ppm	6.06	5.81	2.57
SA - 150 ppm	6.35	6.10	2.99
SA - 200 ppm	6.14	6.07	2.83
SEm±	0.03	0.01	0.02
CD(p=0.05)	0.09	0.03	0.05
Triacontanol			
Water spray	5.89	5.61	2.30
Triacontanol - 5.0 ppm	6.04	5.73	2.54
Triacontanol - 7.5 ppm	6.19	6.15	2.91
Triacontanol - 10.0 ppm	6.33	6.05	2.96
SEm±	0.03	0.01	0.02
CD(p=0.05)	0.09	0.03	0.05

Table 2: Effect of salicylic acid and triacontanol on shoot length

Treatment	Shoot length (cm)		
	30 DAS	60 DAS	90 DAS
Salicylic acid			
Water spray	99.80	100.44	103.25
SA - 100 ppm	103.68	111.00	113.83
SA - 150 ppm	108.93	117.83	120.66
SA - 200 ppm	107.06	115.14	117.98
SEm±	0.99	1.00	1.00
CD(p=0.05)	2.87	2.88	2.88
Triacontanol			
Water spray	101.24	105.80	108.61
Triacontanol - 5.0 ppm	103.96	110.54	113.37
Triacontanol - 7.5 ppm	106.22	112.87	115.71
Triacontanol - 10.0 ppm	108.06	115.20	118.03
SEm±	0.99	1.00	1.00
CD(p=0.05)	2.87	2.88	2.88

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