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Enhancing Growth, Yield and Economic Viability of Fig (*Ficus carica* L.) cv Brown Turkey through Plant Growth Regulators and Foliar Nutrient Applications

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ABSTRACT: An investigation was carried out to study the "Effect of plant growth regulators and foliar application of nutrients on growth, yield and economics of fig (*Ficus carica* L.) cv. Brown Turkey" during the year 2022-2023 at Sadashivpet village, Sangareddy district, Telangana State. The experiment was laid out in a randomized block design with seventeen treatments comprising of a combination of two plant growth regulators *viz.*, GA_3 and NAA with two doses of 50 and 30 ppm and four nutrients 1% Ca $(NO_3)_2$, 1% KNO_3, 0.5% 19-19-19 and 0.5% Borax along with a control treatment. The results of the experiments revealed that among the different treatments imposed, the treatment T_1(GA_3 @ 50 ppm + 1% Ca $(NO_3)_2$) recorded improved physical parameter like maximum fruit length (50.82 mm), fruit diameter (45.35 mm) and average fruit weight (41.30 g) where as treatment T_9 (NAA @ 50 ppm + 1% Ca $(NO_3)_2$) recorded maximum number of fruits (393.32) and fruit yield per tree (15.94 kg). Economic studies indicated that, the treatment T_9 (NAA @ 50 ppm + 1% Ca $(NO_3)_2$) recorded maximum benefit: cost ratio (4.25) and was followed by T_1 (GA_3 @ 50 ppm + 1% Ca $(NO_3)_2$).

Keywords: Ber, growth, nutrients, plant growth regulators, yield.

INTRODUCTION

Fig (*Ficus carica* L.) is an important sub tropical fruit crop of the world. It is a deciduous tree belongs to moraceae family, and is one of the earliest cultivated fruit trees (Stover *et al*., 2007). This fruit originated in the Middle East and has since spread around the world, particularly in the Mediterranean region (Kehal *et al*., 2021). Turkey is the leading country with 27 % of world's fresh figs and 53 % of dry figs accounting for 51 % of world's exports (Yilmaz *et al*., 2017; Allegra *et al*., 2019). In India, fig is considered to be a minor fruit crop and the commercial cultivation of fig is mostly confined to states of Maharashtra, Gujarat, Uttar Pradesh, Karnataka and Tamil Nadu and Telangana.

Heavy fruit drop; poor quality, low yields became a menace among fig growers in Telangana state, a thorough research work is essential to enhance yields along with quality improvement, so that fig cultivation becomes more remunerative. Promising chemicals that are widely used to improve fruit set, yield and fruit quality include micronutrients, plant growth regulators such as gibberellic acid (GA_3) and auxins, and carbohydrates such as sucrose (Lovatt, 2013). Swatantra Yadav *et al*. (2021) investigated on foliar feeding of GA_3 and NAA on fruit drop, retention, yield and quality of ber fruit (*Ziziphus mauritiana* Lamk.) cv. Banarasi Karaka and the results un-wrapped that NAA @ 30 ppm maximized fruit set and GA_3 @ 40 ppm enhanced fruit set, fruit retention and lesser fruit drop. Nitrogen is essential for plant growth and development, whereas, boron for effective fruit set. Different growth regulators and nutrients increase the economic yield facilitating harvesting (Pandey *et al*., 1988). It is therefore, necessary to standardize the most effective way for increased yield and economic viability of fig under the Deccan plateau of the country.

MATERIALS AND METHODS

Field study was conducted at Sadashiv pet village of Sanga Reddy district situated in Deccan Plateau of Telangana state at 17.6º North latitude and 77.95º East longitude and at an altitude of 534 m above the Mean Sea Level. The experiment was laid out in a randomized block design with seventeen treatments with two plants per treatment replicated twice and treatments comprised of a combination of two plant growth regulators *viz.*, Gibberellic Acid (GA_3) and Naphthalene Acetic Acid (NAA) with two doses of 50 and 30 ppm and four nutrients 1% Ca $(NO_3)_2$, 1% KNO_3, 0.5% 19-19-19 and 0.5% Borax along with a control treatment.

Preparation of plant growth regulator solutions: Gibberellic acid and Naphthalene acetic acid solutions of 50 ppm and 30 ppm were prepared by weighing 0.05g and 0.03 g of gibberellic acid and naphthalene acetic acid were dissolved in a little quantity of ethanol and volume is made upto 1000ml using distilled water respectively.

Preparation of foliar spray nutrient solutions: Solutions of Calcium nitrate and potassium nitrate of 1% were prepared by weighing 10g of calcium nitrate and potassium nitrate each and dissolved in a little quantity of distilled water separately then diluted to one litre. The 19-19-19 and borax solutions of 0.5% was prepared by weighing 5g of 19-19-19 and borax each separately and were dissolved in a little quantity of distilled water, then diluted to one litre.

The treatments were imposed to the crop with combination in three different levels *i.e.* immediately after bud initiation, 15 days after first spray and 15 days after second spray by using power sprayer. Each treatment consisted of two plants from each replication which were selected for recording Biometric observations were taken following by DUS guidelines.

Plant growth parameters: Five fruits were selected randomly from each replication of the treatment. Fruit length was measured with the help of digital vernier calipers, the distance between the stalk end and floral end of the fruit was measured and it was expressed in centimeters. Fruit diameter was measured with the help of digital vernier calipers at widest middle point where maximum girth was noticed and it was expressed in centimeters. Fruits were weighed with the help of electronic balance and average fruit weight was calculated and is expressed in grams. The number of fruits per tree was physically counted when they were matured, harvested and were expressed as number per tree. Fruits were harvested when they were fully mature. Number of fruits and fruit weight per tree was recorded at every harvest. The total yield was calculated by adding the values obtained in different harvests and it is expressed in kilogram per tree.

The expenditure incurred on purchase of fertilizers, plant protection chemicals, growth regulators, labour charges was worked out and expressed as cost of cultivation. The total fruit yield was computed per hectare and the total income was worked out based on the market rate which was prevalent during the time of study.Net returns of each treatment was calculated by deducting the total cost of cultivation from the gross returns and is expressed as rupees per hectare. Benefit: cost ratio (BCR) of each treatment was calculated by using the following formula

$$\text{B : C ratio} = \frac{\text{Gross returns (Rs. ha}^{-1})}{\text{Total cost of cultivation (Rs. ha}^{-1})}$$

The data on the growth, yield attributes and yield were tabulated and subjected to statistical analysis using method of analysis of variance (ANOVA) for Randomized Block Design (RBD) by Fisher and Yates (1963). Whenever ‘F’ test was found significant for comparing the means of two treatments, critical difference (C.D. at 5%) were worked out.

RESULTS AND DISCUSSION

Fruit length: Fruit length was significantly influenced by foliar application of plant growth regulators and nutrients. Maximum fruit length (50.82 mm) was obtained in the treatment T_1 (GA_3 @ 50 ppm + 1% Ca $(N0_3)_2$) which was significantly superior over rest of the treatments but was at par with T_9 (NAA @ 50 ppm + 1% Ca $(NO_3)_2$). Minimum fruit length (38.15 mm) was observed in T_{17} (control) (Table 1, Plate 1 and Fig. 1).

Significant increase in fruit length with spray application of GA_3 might be due to stimulation of cell elongation and membrane permeability which resulted in higher water uptake (Chaudhary *et al*., 2006). The findings of Rane (1962) also states that GA_3 increased fruit length with increasing concentration of GA_3 in fig lend support to the findings of present study.

Calcium is an important mineral in the formation of cell membrane and development, helps to increase fruit physical attributes (Bitange *et al*., 2019). Calcium improves the efficiency of photosynthesis and is associated with hormone metabolism, which promotes the synthesis of auxin essential for fruit growth (Kazemi, 2014; Mosa *et al*., 2015). Thus, it might have contributed to the increased fruit length. These results are in conformity with those reported by Irget *et al.* (1999) in fig, Banday *et al.* (2005) in Strawberry cv. Confitura, Meena *et al.* (2012) in Perlette grapes. Arvind Bhatt *et al.* (2012) in mango, Morgado-González *et al.* (2018) in fig cv. Brown Turkey.

Fruit diameter: Fruit diameter was significantly influenced by the foliar application of plant growth regulators GA_3 and NAA and nutrient spray. Maximum fruit diameter (45.35 mm) was obtained in the treatment T_1 (GA_3 @ 50ppm + 1% Ca $(NO_3)_2$) which was significantly superior to rest of the treatments but was at par with T_9 (45.01 mm). Least fruit diameter (34.18 mm) was observed in T_{17} (control) (Table 1, Plate 2, Fig. 1).

Spray application of Gibberellic acid might have increased cell wall plasticity and created water diffusion pressure deficit, which resulted in more water uptake, thereby causing cell elongation. GA_3 results in increasing the length as well as the diameter of fruits. Increase in fruit diameter were also observed due to application of GA_3 in other fruits like mango (Singh, 1977), litchi (Suryanarayna and Das 1974), guava (Ram 1979), dates (Mohammed *et al.*, 1986), ber (Singh *et al*., 1982) and olives (Bini and Giannone 1985).

Application of calcium nitrate causes fruit enlargement by increasing cell size. Increase in fruit diameter of fig might be due to cell division initially and cell enlargement in the later stages which might pertain to the fact that calcium nitrate promotes cell expansion and increases volume of intercellular space in the mesocarpic cell and enhanced mobilization of photosynthesis thereby increasing the nitrogen availability. The results are in conformity with the findings of Brahmachari *et al*. (1996) in guava, Rodrigues *et al.* (1999; Aydin *et al*. (2001); Caetano and Carvalho (2006) in fig and Arvind Bhatt *et al.* (2012) in mango.

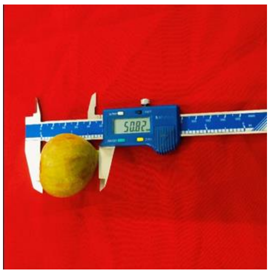

Plate 1. Fruit length.

Plate 2. Fruit diameter.

Average fruit weight: The fruit weight of fig cv. Brown Turkey significantly differed among the various treatments. Maximum fruit weight (41.30 g) was obtained in T_1 (GA_3 50 ppm + 1% Ca $(NO_3)_2$) which was significantly superior to rest of the treatments but was at par with T_9. Least fruit weight (31.35 g) was recorded in T_{17} (control) (Table 1 and Plate 3 and Fig. 1).

The increase in fruit weight with application of GA_3 50ppm + 1% Ca $(NO_3)_2$ could be attributed to increase in fruit size (length and breadth). An increase in fruit weight with combined foliar application of nutrients and Gibberellic acid might be due to rapid cell division and translocation of sugars resulted into higher pulp content. It could also be due to higher mobilization of food and minerals from leaves towards the developing fruits which are extremely active metabolic sink.

Calcium is responsible for cell division and enlargement thereby increase in fruit length and volume which are directly proportional to fruit weight. Increase in fruit weight might be due to faster mobilization of metabolites in the fruits and involvement in cell division and cell expansion as well as the increase in the volume of intercellular space in mesocarpic cells (Purohit *et al*., 2019). The above finding is in accordance with the results of Sankar *et al*. (2013) in Alphonso mango and Jyothi *et al*. (2018) in mango cv. Langra.

Plate 3. Average fruit weight.

Number of fruits and fruit yield per tree: The foliar application of different doses of plant growth regulators and nutrients significantly influenced the number of fruits and fruit yield per tree in fig cv. Brown Turkey. Maximum number of fruits per tree (393.32) and fruit yield (15.94 kg) was obtained in treatment T_9 (NAA @ 50 ppm + 1% Ca $(N0_3)_2$) which was followed by T_1. Least number of fruits per tree (290.05) and fruit yield (9.09 kg) was recorded in T_{17} (control) (Table1 & Fig. 2).

Application of NAA at pea stage of fruit development might have helped in the production of more number of fruits and might have prevented fruit drop. These results are in conformity with those reported by Yadav and Rana (2006) in ber, Vidya *et al*. (2015); Adi Reddy and Manohar Prasad (2012) in pomegranate, Anshuman Singh and Singh (2015) in aonla.

Calcium nitrate significantly influenced the number of fruits and fruit yield per tree. This might be due to increase in fruit set, low percentage of fruit drop, more retention of fruits, better physiology of developing fruits in terms of increased fruit size and fruit weight. These results are in conformity with the findings Arvind Bhatt *et al*. (2012) in mango.

Economics: Significant difference among the treatments was observed with respect to gross returns, net returns and benefit to cost ratio with foliar application of plant growth regulators and nutrients in fig cv. Brown Turkey.

Highest gross returns (Rs. 1, 91, 280/-), net returns (Rs. 1, 46, 265/-) per hectare and benefit to cost ratio (4.25) was recorded in T_9 (NAA @ 50 ppm + 1% Ca $(NO_3)_2$) which was followed by T_1 (GA_3 @ 50 ppm + 1% Ca $(NO_3)_2$). Least gross returns, net returns and benefit to cost ratio was recorded in T_{17} control (Table 2 and Fig. 3).

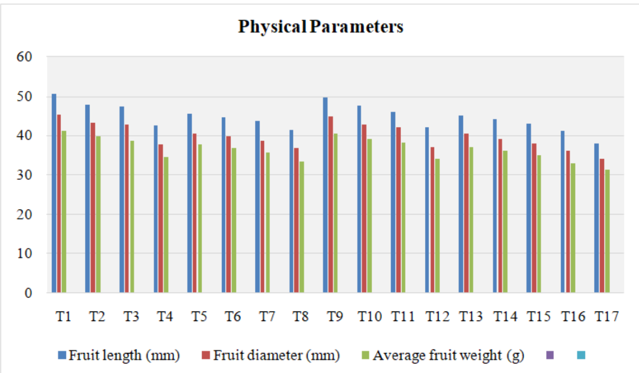

Fig. 1. Effect of plant growth regulators and foliar application of nutrients on physical parameters (fruit length (mm), fruit diameter (mm), average fruit weight (g)) of fig (*Ficus carica*) cv. Brown Turkey of fig (*Ficus carica*) cv. Brown Turkey.

Table 1: Effect of plant growth regulators and foliar application of nutrients on fruit growth, yield attributes and yield of Fig (*Ficus carica*) cv. Brown Turkey.

Treatments	Fruit length(mm)	Fruit diameter (mm)	Average fruit weight(g)	Number of fruits per tree	Fruit yield per tree (kg)
T_1 GA_3 50 ppm + 1% Ca $(NO_3)_2$	50.82	45.35	41.30	382.11	15.78
T_2 GA_3 50 ppm + 1% KNO_3	47.99	43.39	39.89	370.65	14.78
T_3 GA_3 50 ppm + 0.5% 19-19-19	47.46	42.84	38.83	357.33	13.87
T_4 GA_3 50 ppm + 0.5% Borax	42.79	37.89	34.69	311.30	10.79
T_5 GA_3 30 ppm + 1% Ca $(NO_3)_2$)	45.60	40.68	37.80	342.24	12.93
T_6 GA_3 30 ppm + 1% KNO_3	44.88	39.90	36.86	331.24	12.20
T_7 GA_3 30 ppm + 0.5% 19-19-19	43.80	38.78	35.77	321.02	11.48
T_8 GA_3 30 ppm + 0.5% Borax	41.51	36.89	33.48	306.24	10.25
T_9 NAA 50 ppm + 1% Ca $(NO_3)_2$	49.86	45.02	40.55	393.32	15.94
T_{10} NAA 50 ppm + 1% KNO_3	47.76	43.02	39.16	378.02	14.80
T_{11} NAA 50 ppm + 0.5% 19-19-19	46.19	42.26	38.24	368.19	14.07
T_{12} NAA 50ppm + 0.5 % Borax	42.18	37.10	34.10	317.21	10.81
T_{13} NAA 30ppm + 1% $Ca(NO_3)_2$	45.14	40.61	37.21	348.13	12.95
T_{14} NAA 30ppm + 1% KNO_3	44.40	39.30	36.15	338.57	12.23
T_{15} NAA 30 ppm + 0.5% 19-19-19	43.25	38.17	35.18	327.15	11.50
T_{16} NAA 30 ppm + 0.5% Borax	41.20	36.21	33.05	311.88	10.30
T_{17} Control (No growth regulator and foliar nutrient spray)	38.15	34.18	31.35	290.05	9.09
SEm ±	0.62	0.59	0.50	4.81	0.22
CD (p=0.05)	1.81	1.73	1.44	13.93	0.64

Table 2: Effect of plant growth regulators and foliar application of nutrients on economics of fig cv. Brown Turkey.

Treatments	Gross Returns (Rs.ha^{-1})	Net Returns (Rs. ha^{-1})	B:C
T_1 GA_3 50 ppm + 1% Ca $(NO_3)_2$	189360	142920	4.08
T_2 GA_3 50 ppm + 1% KNO_3	177360	130320	3.77
T_3 GA_3 50 ppm + 0.5% 19-19-19	166440	120114	3.59
T_4 GA_3 50 ppm + 0.5% Borax	129480	83040	2.79
T_5 GA_3 30 ppm + 1% Ca $(NO_3)_2$)	155160	109320	3.38
T_6 GA_3 30 ppm + 1% KNO_3	146400	99960	3.15
T_7 GA_3 30 ppm + 0.5% 19-19-19	137760	92034	3.01
T_8 GA_3 30 ppm + 0.5% Borax	123000	77160	2.68
T_9 NAA 50 ppm + 1% Ca $(NO_3)_2$	191280	146265	4.25
T_{10} NAA 50 ppm + 1% KNO_3	177600	131985	3.89
T_{11} NAA 50 ppm + 0.5% 19-19-19	168840	123939	3.76
T_{12} NAA 50ppm + 0.5 % Borax	129720	84705	2.88
T_{13} NAA 30ppm + 1% $Ca(NO_3)_2$	155400	110415	3.45
T_{14} NAA 30ppm + 1% KNO_3	146760	101175	3.22
T_{15} NAA 30 ppm + 0.5% 19-19-19	138000	93129	3.08
T_{16} NAA 30 ppm + 0.5% Borax	123600	78615	2.75
T_{17} Control (No growth regulator and foliar nutrient spray)	109080	67080	2.60
SEm ±	2720	2720	0.06
CD (p=0.05)	7930	7930	0.18

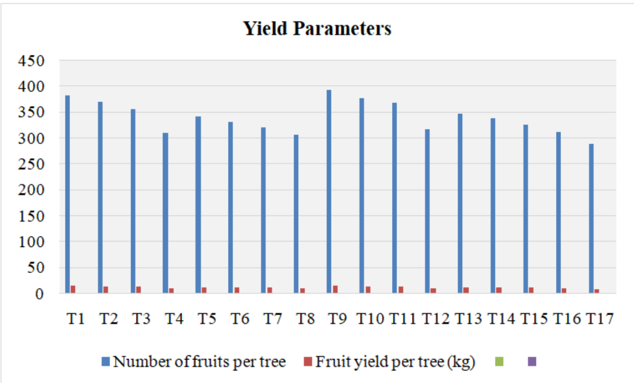

Fig. 2. Effect of plant growth regulators and foliar application of nutrients on yield parameters (Number of fruits per tree andfruit yield per tree (kg)) of fig (*Ficus carica*) cv. Brown Turkey of fig (*Ficus carica*) cv. Brown Turkey.

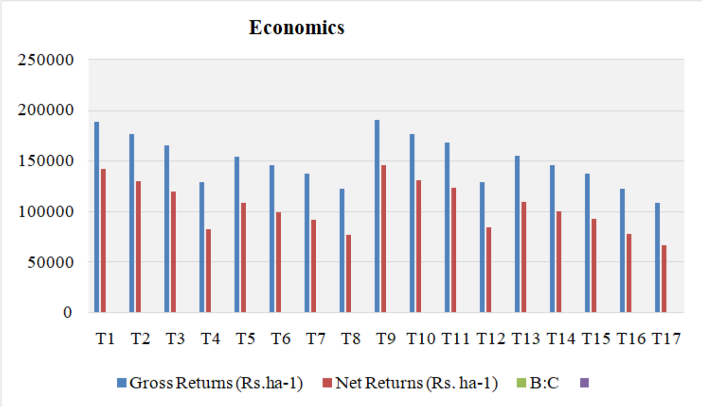

Fig. 3. Effect of plant growth regulators and foliar application of nutrients on economics (gross returns (Rs.ha[-1]), net returns (Rs.ha[-1]) and b:c)) of fig (*Ficus carica*) cv. Brown Turkey of fig (*Ficus carica*) cv. Brown Turkey.

CONCLUSIONS

Spray application of GA_3 @ 50 ppm + 1% Ca $(N0_3)_2$ and NAA @ 50 ppm + 1% Ca $(NO_3)_2$ enhanced the fruit physical parameters fruit length, diameter, average fruit weight, number of fruits per tree and fruit yield per tree. Higher gross returns, net monetary returns and profitability was registered with spray application of NAA @ 50 ppm + 1% Ca $(NO_3)_2$ followed by GA_3 @ 50 ppm + 1% Ca $(NO_3)_2$ can be recommended for fig for higher yield attributes, yield and monitory returns.

FUTURE SCOPE

— Effect of novel plant growth regulators and organic manures application on growth, yield, quality and shelf life of fig (*Ficus carica* L.) cv. Brown Turkey.
— Evaluation of different commercial fig varieties in Telangana and standardization of fertigation protocols for commercially grown cultivars in fig.

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