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Influence of Foliar Sprays of 2,4-D, Urea, Zinc Sulphate, Bavistin and their Combinations on Growth, Yield and Leaf Chlorophyll Content of Kinnow Mandarin

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ABSTRACT

The experiment was conducted during March, 2019-November, 2020 at the experimental orchard, Department of Horticulture, CCS Haryana Agricultural University, Hisar, to find out the best concentration of foliar application of growth regulators, nutrients and fungicides in improvement of growth and chlorophyll content of leaves. Total eighteen treatments, i.e., 2,4-D 10 ppm, 2,4-D 15 ppm, GA_3 15 ppm, GA_3 20 ppm, Urea 1%, Urea 1.5%, Zinc Sulphate 0.5%, Zinc Sulphate 0.75%, Bavistin 1000 ppm and their combinations with three replications on 9-year-old Kinnow plants were taken. The growth parameters i.e., plant spread (4.90 m (EW) and 4.68 m (NS); 5.02 m (EW) and 4.84 m (NS) during 2019–20 and 2020–21, respectively), trunk diameter (28.31 cm and 28.74 cm during 2019–20 and 2020–21, respectively), leaf area (30.54 cm^2 and 31.58 cm^2 during 2019–20 and 2020–21, respectively) and leaf chlorophyll content (2.01mg g^{-1} of fresh weight and 2.19 mg g^{-1} of fresh weight during 2019–20 and 2020–21, respectively) and yield (75.46 kg/plant and 78.92 kg/plant during 2019–20 and 2020–21, respectively) were found maximum with foliar application of 2,4-D 15 ppm+Urea 1.5%+Zinc Sulphate 0.75%+Bavistin 1000 ppm. Plant height (4.87 m and 4.99 m during 2019–20 and 2020–21, respectively) was effectively improved by foliar application of GA_3 20 ppm+Urea 1.5%+Zinc Sulphate 0.75%+Bavistin 1000 ppm.

KEYWORDS: Kinnow mandarin, 2,4-D, Urea, $ZnSO_4$, Bavistin, growth, yield, chlorophyll

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1. INTRODUCTION

Kinnow is a hybrid between King mandarin (*Citrus nobilis* Lour) X Willow Leaf mandarin (*Citrus deliciosa* Tenora) is considered as one of the major citrus fruit crops belongs to family Rutaceae. It was developed by H.B. Frost in 1915 and introduced in India by Dr. J.C. Bakhshi at the Regional Fruit Research Station, Abohar (Punjab) during 1958. Punjab, Haryana, the lower Himalayan regions of Himachal Pradesh, Uttar Pradesh, and some areas of Karnataka, Kerala, and Tamil are the best places to grow kinnow. Kinnow has good tree vigour, high cropping potential, wider adaptability, more economic return and better performance than other citrus fruits. The Kinnow Mandarin is prized for its high vitamin C content, unique aroma, consistent processing quality, abundance of nutrients, early fruiting, and ability to produce medium-sized, globose to oblate fruits (Banyal et al., 2025). lower and fruit drop is a major problem faced by citrus growers (Modise et al., 2009) and it has become a limiting factor in citrus production.

A plant growth regulator enhances the rapid changes in physiological and biochemical characters and improves crop productivity. Growth regulators are used to increase fruit size either by directly stimulating cell divison or indirectly by reducing fruit number through the usage plant growth regulators that inhibit flower development or induce flower abscission (Gill et al., 2023). Auxin facilitated the ovary to remain attached with the shoot and resulted in lower fruit drop (Jat and Kacha, 2014). Application of GA3 has been reported to increase production by reducing the per cent fruit drop (Ullah et al., 2014). The concentrations of plant growth regulators, particularly auxin and abscisic acid (ABA), play a significant role in retaining Kinnow fruits on the trees (Vamshi et al., 2023). Balancing of essential nutrients and plant growth regulators, such as auxins, gibberellins and cytokinins, plays a crucial role in enhancing citrus health and performance (Neware et al., 2017; Shamsi et al., 2019). Nutrients and micronutrients can significantly improve crop yield and quality and improve post-harvest life of produce. They play a significant role in disease resistance and lignin biosynthesis, since they function as enzyme activators. Application of micronutrients and 2,4-D together increases the TSS levels (Senjam and Singh, 2021). Timely application of micronutrients increases fruit size and quality, control fruit drop, and encourage photosynthesis (Ruchal et al., 2020). Citrus crops face severe problems like low fruit quality (small size, degraded color), as well as significant pre-harvest fruit drop because of the absence of vital macro and micronutrients in the soil (Ibrahim et al., 2007). In Haryana State citrus quality production is declining due to deficiency of these trace elements caused by soil alkalinity, lower organic matter content and competition from other nutrients .The foliar spray of fruit trees has gained much importance in recent years as fertilizers application through soil are needed in greater amount because some portion leaches down and some does not become available to the plant due to complex chemical reactions Use of different fungicides was play a crucial role in growth and development of plant and also improves quality of fruits with longer shelf life (Sukrampal et al., 2022).

Hence, selection of suitable combination of the plant growth regulators and nutrients is essential to produce high-quality citrus fruits and reduce citrus fruit drop (Kaur et al., 2016). So, keeping in view the above facts the present study had been framed to investigate the effect of plant growth regulators and nutrients on fruit drop and quality of Kinnow mandarin within arid regions of Haryana

2. MATERIALS AND METHODS

The present experiment was carried out during the year March, 2019-November, 2020 on nine years old Kinnow mandarin trees in experimental orchard of the Department of Horticulture, CCS Haryana Agricultural University, Hisar and the chemical analysis was undertaken in the laboratory of Department of Horticulture and Soil Science, CCS HAU, Hisar.

The experiment was laid out in randomized block design with three replications, comprising 18 treatment combinations i.e. T_1: 2,4-D 10 ppm; T_2: 2,4-D 15 ppm; T_3: GA_3 15 ppm; T_4: GA_3 20 ppm; T_5: Urea 1%; T_6: Urea 1.5%; T_7: Zinc Sulphate 0.5%; T_8: Zinc Sulphate 0.75%; T_9: Bavistin 1000 ppm; T_{10}: 2,4-D 10 ppm+Urea 1%+Zinc Sulphate 0.5%+Bavistin 1000 ppm; T_{11}: 2,4-D 15 ppm+Urea 1%+Zinc Sulphate 0.5%+Bavistin 1000 ppm; T_{12}: GA_3 15 ppm+Urea 1%+Zinc Sulphate 0.5%+Bavistin 1000 ppm; T_{13}: GA_3 20 ppm+Urea 1%+Zinc Sulphate 0.5%+Bavistin 1000 ppm; T_{14}: 2,4-D 10 ppm+Urea 1.5%+Zinc Sulphate 0.75%+Bavistin 1000 ppm; T_{15}: 2,4-D 15 ppm+Urea 1.5%+Zinc Sulphate 0.75%+Bavistin 1000 ppm; T_{16}: GA_3 15 ppm+Urea 1.5%+Zinc Sulphate 0.75%+Bavistin 1000 ppm; T_{17}: GA_3 20 ppm+Urea 1.5%+Zinc Sulphate 0.75%+Bavistin 1000 ppm; T_{18}: Control. Foliar application was done twice, first in the last week of May and second in the last week of July.

2.1. *Observation recorded*

The height of the plant was measured with the help of a measuring pole up to the maximum point of height, ignoring only the off- type shoots, if any and expressed in meter (m). Distance between the point to which most of the branches of the tree had grown in the East-West and North-South direction were measured with the help of a measuring pole and expressed in meter (m). In each direction, four twigs were selected on the tree and the number of flowers was counted per twig. Trunk diameter was measured with the help of Digital Vernier's Calipers from 10 cm above ground level of the trunk and expressed in centimeter (cm). Leaf area was taken with the help of Leaf area meter. Five leaves were taken from each replication and expressed in cm^2.

A method developed by Hiscox and Israelstam (1979) was used for the estimation of chlorophyll. Representative samples of leaves were collected in the month of August and then washed. The chlorophyll content of selected leaves was measured by using spectrophotometer. One hundred mg of leaf tissue was placed in a vial, then 5 ml dimethyl sulphoxide (DMSO) was added into it and kept overnight so that chlorophyll could be extracted into fluid and the tissue became chlorophyll free. A 3 ml aliquot of chlorophyll extract was transferred to a cuvette and the absorbance values were recorded at 645 and 665 nm against a blank (DMSO) by using a spectrophotometer. The chlorophyll contents were calculated by using the following equations:

$$\text{Chlorophyll 'a'} = \frac{(12.3 \times A665)-(0.86 \times A645)}{a \times \text{weight of tissue} \times 1000} \times \text{volume of DMSO}$$

Where, a= path length

Total chlorophyll=chlorophyll 'a'+chlorophyll 'b'

3. RESULTS AND DISCUSSION

A perusal of data in table 1 indicates that plant spread and plant height was significantly affected by various growth regulators, nutrients and fungicides treatments and their combinations. Maximum plant spread (4.90 m (EW)

Table 1: Effect of foliar application of growth regulators, nutrients and fungicides on plant spread (m) and plant height (m) of Kinnow mandarin

Treatments	Plant spread (m)				Plant height (m)	
	EW		NS			
	2019–20	2020–21	2019–20	2020–21	2019–20	2020–21
T_1: 2,4-D 10 ppm	4.30	4.39	4.10	4.23	4.35	4.44
T_2: 2,4-D 15 ppm	4.33	4.42	4.13	4.15	4.36	4.48
T_3: GA_3 15 ppm	4.28	4.35	4.08	4.19	4.25	4.38
T_4: GA_3 20 ppm	4.25	4.33	4.06	4.17	4.30	4.42
T_5: Urea 1%	4.30	4.41	4.10	4.21	4.50	4.63
T_6: Urea 1.5%	4.61	4.71	4.40	4.53	4.60	4.72
T_7: Zinc sulphate 0.5%	4.23	4.30	4.04	4.11	4.50	4.62
T_8: Zinc sulphate 0.75%	4.28	4.32	4.06	4.13	4.50	4.64
T_9: Bavistin 1000 ppm	4.15	4.18	3.91	4.01	4.15	4.22
T_{10}: 2,4-D 10 ppm+Urea 1%+Zinc sulphate 0.5%+Bavistin 1000 ppm	4.33	4.41	4.13	4.25	4.60	4.71
T_{11}: 2,4-D 15 ppm+Urea 1%+Zinc sulphate 0.5%+Bavistin 1000 ppm	4.57	4.66	4.36	4.49	4.75	4.85
T_{12}: GA_3 15 ppm+Urea 1%+Zinc sulphate 0.5%+Bavistin 1000 ppm	4.48	4.55	4.28	4.39	4.60	4.72
T_{13}: GA_3 20 ppm+Urea 1%+Zinc sulphate 0.5%+Bavistin 1000 ppm	4.44	4.51	4.24	4.35	4.70	4.81
T_{14}: 2,4-D 10 ppm+Urea 1.5%+Zinc sulphate 0.75%+Bavistin 1000 ppm	4.79	4.87	4.57	4.72	4.83	4.88
T_{15}: 2,4-D 15 ppm+Urea 1.5%+Zinc sulphate 0.75%+Bavistin 1000 ppm	4.90	5.02	4.68	4.84	4.83	4.90
T_{16}: GA_3 15 ppm+Urea 1.5%+Zinc sulphate 0.75%+Bavistin 1000 ppm	4.65	4.75	4.44	4.61	4.80	4.85
T_{17}: GA_3 20 ppm+Urea 1.5%+Zinc sulphate 0.75%+Bavistin 1000 ppm	4.78	4.87	4.56	4.69	4.87	4.99
T_{18}: Control	4.01	4.04	3.80	3.88	4.01	4.02
CD (p=0.05)	0.23	0.23	0.22	0.22	0.20	0.21
SEm±	0.079	0.08	0.075	0.078	0.071	0.072

and 4.68 m (NS); 5.02 m (EW) and 4.84 m (NS) during 2019–20 and 2020–21, respectively) was observed with T_{15} (2,4-D 15 ppm+Urea 1.5%+Zinc Sulphate 0.75%+Bavistin 1000 ppm) which was found at par with T_{17} and T_{14} treatments during both years. Minimum plant spread of 4.01 m (EW) and 3.80 m (NS); 4.04 m (EW) and 3.88 m (NS) during 2019–20 and 2020–21, respectively was observed with control which was closely followed by T_9 treatment during both the years.

Maximum plant height (4.87 m and 4.99 m during 2019–20 and 2020–21, respectively) was observed with T_{17} i.e., GA 20 ppm+Urea 1.5%+Zinc Sulphate 0.75%+Bavistin 1000 ppm which was found at par with T_{15}, T_{14}, T_{16}, T_{11} and T_{13} during both the years. Minimum plant height (4.01 m and 4.02 m during 2019–20 and 2020–21, respectively) was observed with control which was closely followed by T_9 treatment during both the years.

Observations pertaining to trunk diameter, leaf area and yield were presented in table 2. Trunk diameter, leaf area and yield were significantly increased by various growth regulators, nutrients and fungicides treatments and their combinations. Maximum trunk diameter (28.31 cm and 28.74 cm during 2019–20 and 2020–21, respectively), leaf area (30.54 cm^2 and 31.58 cm^2 during 2019–20 and 2020–21, respectively) and yield (75.46 kg/plant and 78.92 kg/plant during 2019–20 and 2020–21, respectively) were found with T_{15} treatment i.e., 2,4-D 15 ppm+Urea 1.5%+Zinc Sulphate 0.75%+Bavistin 1000 ppm. The results obtained

Table 2: Effect of foliar application of growth regulators, nutrients and fungicides on trunk diameter (cm) and leaf area (cm^2) of Kinnow mandarin

Treatments	Trunk diameter (cm)		Leaf area (cm^2)		Yield (kg/tree)	
	2019–20	2020–21	2019–20	2020–21	2019–20	2020–21
T_1: 2,4-D 10 ppm	24.70	24.71	25.50	26.89	69.34	71.57
T_2: 2,4-D 15 ppm	25.26	25.52	25.72	26.98	69.57	71.80
T_3: GA_3 15 ppm	23.51	23.84	24.91	26.22	61.21	63.89
T_4: GA_3 20 ppm	23.09	23.40	25.00	25.89	62.63	64.40
T_5: Urea 1%	23.63	23.96	26.01	26.56	67.07	69.10
T_6: Urea 1.5%	25.87	26.16	27.34	27.95	69.36	71.62
T_7: Zinc sulphate 0.5%	25.67	25.89	26.96	27.83	61.57	63.43
T_8: Zinc sulphate 0.75%	24.38	24.69	26.12	26.76	61.64	63.34
T_9: Bavistin 1000 ppm	22.31	22.62	24.17	25.49	60.35	62.14
T_{10}: 2,4-D 10 ppm+Urea 1%+Zinc sulphate 0.5%+Bavistin 1000 ppm	27.12	27.54	28.76	29.41	71.52	74.08
T_{11}: 2,4-D 15 ppm+Urea 1%+Zinc sulphate 0.5%+Bavistin 1000 ppm	27.15	27.55	29.27	30.23	73.19	75.77
T_{12}: GA_3 15 ppm+Urea 1%+Zinc sulphate 0.5%+Bavistin 1000 ppm	26.76	27.09	27.65	28.53	70.84	74.09
T_{13}: GA_3 20 ppm+Urea 1%+Zinc sulphate 0.5%+Bavistin 1000 ppm	27.21	27.59	28.86	29.97	71.59	74.09
T_{14}: 2,4-D 10 ppm+Urea 1.5%+Zinc sulphate 0.75%+Bavistin 1000 ppm	27.49	27.86	30.03	31.03	74.26	77.27
T_{15}: 2,4-D 15 ppm+Urea 1.5%+Zinc sulphate 0.75%+Bavistin 1000 ppm	28.31	28.74	30.54	31.58	75.46	78.92
T_{16}: GA_3 15 ppm+Urea 1.5%+Zinc sulphate 0.75%+Bavistin 1000 ppm	27.06	27.40	29.86	30.42	74.42	76.65
T_{17}: GA_3 20 ppm+Urea 1.5%+Zinc sulphate 0.75%+Bavistin 1000 ppm	27.60	28.07	30.15	31.35	75.19	77.73
T_{18}: Control	20.74	20.79	22.42	24.09	59.22	60.41
CD (p=0.05)	1.15	1.16	1.23	1.28	3.09	3.20
SEm±	0.397	0.403	0.427	0.443	1.072	1.107

for trunk diameter with T_{15} were found at par with T_{17}, T_{14} and T_{13} treatments and for leaf area with T_{17}, T_{14} and T_{16} treatments. However, minimum trunk diameter i.e., 20.74 cm and 20.79 cm, leaf area i.e., 22.42 cm^2 and 24.09 cm^2 and yield i.e., 59.22 kg/plant and 60.41 kg/plant were found with control during both the years.

The increase in growth parameters with the application of different plant growth regulators, nutrients and fungicides in combination might be due to favorable influence of applied nutrients on vegetative characteristics because of their catalytic or stimulatory effect on most of the physiological and metabolic processes of plants. Cell enlargement also leads to shoot elongation ultimately resulted in increase of vegetative growth. The increase in vegetative growth by 2,4-D might be accordance to that auxins show main role in cell elongation, cell division, vascular tissue differentiation, apical dominance, leaf senescence and fruit abscission. The probable cause of increased shoot length might be the better utilization of carbohydrates, nitrogen and other nutrients, which had been aided by growth regulators (Babaie et al., 2014). The increase in diameter might be due to higher cell activity and the synthesis of more food material through a process of photosynthesis (Kamboj et al., 2017). Foliar applied urea is an effective and most efficient source of nitrogen in citrus production and thus enchanced vegetative growth (El-Kobbia et al., 2011). Nitrogen is an integral part

Table 3: Effect of foliar application of growth regulators, nutrients and fungicides on leaf chlorophyll content (mg g^{-1} of fresh weight) of Kinnow mandarin

Treatments	Chl. 'a' (mg g^{-1} of fresh weight)		Chl. 'b' (mg g^{-1} of fresh weight)		Total Chl. (mg g^{-1} of fresh weight)	
	2019–20	2020–21	2019–20	2020–21	2019–20	2020–21
T_1: 2,4-D 10 ppm	1.07	1.09	0.34	0.38	1.41	1.47
T_2: 2,4-D 15 ppm	1.10	1.19	0.35	0.38	1.45	1.57
T_3: GA_3 15 ppm	0.95	0.97	0.32	0.34	1.27	1.31
T_4: GA_3 20 ppm	0.98	1.05	0.32	0.36	1.30	1.41
T_5: Urea 1%	1.25	1.28	0.40	0.42	1.65	1.70
T_6: Urea 1.5%	1.35	1.42	0.43	0.46	1.78	1.88
T_7: Zinc sulphate 0.5%	1.19	1.26	0.38	0.41	1.57	1.67
T_8: Zinc sulphate 0.75%	1.16	1.21	0.36	0.40	1.52	1.61
T_9: Bavistin 1000 ppm	0.91	0.96	0.31	0.32	1.22	1.28
T_{10}: 2,4-D 10 ppm+Urea 1%+Zinc sulphate 0.5%+Bavistin 1000 ppm	1.32	1.38	0.43	0.45	1.75	1.83
T_{11}: 2,4-D 15 ppm+Urea 1%+Zinc sulphate 0.5%+Bavistin 1000 ppm	1.42	1.50	0.44	0.49	1.86	1.99
T_{12}: GA_3 15 ppm+Urea 1%+Zinc sulphate 0.5%+Bavistin 1000 ppm	1.26	1.31	0.40	0.43	1.66	1.74
T_{13}: GA_3 20 ppm+Urea 1%+Zinc sulphate 0.5%+Bavistin 1000 ppm	1.36	1.43	0.44	0.48	1.80	1.91
T_{14}: 2,4-D 10 ppm+Urea 1.5%+Zinc sulphate 0.75%+Bavistin 1000 ppm	1.47	1.58	0.51	0.56	1.98	2.13
T_{15}: 2,4-D 15 ppm+Urea 1.5%+Zinc sulphate 0.75%+Bavistin 1000 ppm	1.49	1.61	0.52	0.58	2.01	2.19
T_{16}: GA_3 15 ppm+Urea 1.5%+Zinc sulphate 0.75%+Bavistin 1000 ppm	1.42	1.51	0.47	0.51	1.90	2.02
T_{17}: GA_3 20 ppm+Urea 1.5%+Zinc sulphate 0.75%+Bavistin 1000 ppm	1.46	1.55	0.48	0.51	1.94	2.06
T_{18}: Control	0.91	0.92	0.30	0.32	1.21	1.24
CD (p=0.05)	0.06	0.06	0.02	0.02	0.08	0.08
SEm±	0.019	0.021	0.006	0.007	0.026	0.027

of chlorophyll structure which primarily absorb light energy needed for photosynthesis, so it may contribute to higher photosynthetic efficiency. The increase in tree height may be attributed to increased dimensions in cells of pith and cortex region (Prasad et al., 2015). Zinc is involved in the synthesis of tryptophan which is a precursor of IAA synthesis and consequently increased tissue growth and development. Zinc also has important role in starch metabolism, nucleic acid metabolism, protein biosynthesis and increases photosynthesis rate and chlorophyll content (Neware et al., 2017). An increase in fruit retention may be the cause of an increase in fruit yield, number of fruits, average weight of fruits and a decrease in fruit drop (El-Kobbia et al., 2011). Due to accretion of more food material in the trees leads to an efficient exploitation of the same for development of fruit which leads to better fruit diameter and yield.

These results are in accordance with the findings of Malik et al. (2000) who reported that urea increase tree growth of Kinnow mandarin, Dawood et al. (2001) who noticed that the growth of Washington Navel orange enhanced with zinc application, Prasad et al. (2015) who observed maximum vegetative growth with urea+$ZnSO_4$+2,4-D treatment of Kinnow mandarin.

The data presented in table 3 reflect that leaf chlorophyll content of Kinnow mandarin was significantly affected by different foliar application of growth regulators, nutrients and fungicides treatments and their combinations. The content of chlorophyll 'a' (1.49 mg g^{-1} of fresh weight and 1.61 mg g^{-1} of fresh weight during 2019–20 and 2020–21, respectively), chlorophyll 'b' (2,4-D 15 ppm+Urea 1.5%+Zinc Sulphate 0.75%+Bavistin 1000 ppm) and total chlorophyll content (2.01mg g^{-1} of fresh weight and 2.19 mg g^{-1} of fresh weight during 2019–20 and 2020–21, respectively) were found maximum with T_{15} treatment (2,4-D 15 ppm+Urea 1.5%+Zinc Sulphate 0.75%+Bavistin 1000 ppm). Overall, chlorophyll 'a', chlorophyll 'b' and total chlorophyll content increased during succeeding year as compared to first year of investigation. Minimum content of chlorophyll 'a' (0.91 mg g^{-1} of fresh weight and 0.92 mg g^{-1} of fresh weight during 2019–20 and 2020–21, respectively), chlorophyll 'b' (0.30 mg g^{-1} of fresh weight and 0.32 mg g^{-1} of fresh weight during 2019–20 and 2020–21, respectively) and total chlorophyll (1.21 mg g^{-1} of fresh weight and 1.24 mg g^{-1} of fresh weight during 2019–20 and 2020–21, respectively) were observed with control during both the years.

The increased concentration of chlorophyll in leaves might be due to the increased concentration of auxin, which increased the leaf area and photosynthesis. Growth hormones have been shown to play an important role in regulating the amount and distribution of assimilates in plants (Galston and Davies, 1969). The increase in chlorophyll content in leaves might be due to the supply of sufficient nutrients especially nitrogen, which is essential element for the synthesis of chlorophyll (Awasthi et al., 1996). Foliar application of zinc increases the biosynthesis of chlorophyll and carotenoid synthesis that are important for proper performance of photosynthetic process (Gurung et al., 2016). Similar results were reported by (Ilyas et al., 2015) who noticed highest concentrations of pigments with foliar spray of zinc (0.3%) in Kinnow, Neware et al. (2017) found that foliar application of GA_3, $ZnSO_4$, $FeSO_4$ and $MnSO_4$ recorded highest chlorophyll content in sweet orange leaves.

4. CONCLUSION

Foliar application growth regulators, nutrients and fungicides treatments and their combinations had significant effect on growth and yield of Kinnow mandarin. Foliar application of 2,4-D 15 ppm+Urea 1.5%+Zinc Sulphate 0.75%+Bavistin 1000 ppm proved most effective in enhancing growth parameters i.e., plant spread, trunk diameter, leaf area, leaf chlorophyll content and yield of Kinnow mandarin. Plant height was effectively improved by foliar application of GA_3 20 ppm+Urea 1.5%+Zinc Sulphate 0.75%+Bavistin 1000 ppm.

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