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Research Article

EFFECT OF FOLIAR SPRAY OF UREA AND ZINC SULPHATE ON MORPHOLOGICAL, YIELD AND QUALITY ATTRIBUTES OF GUAVA (*Psidium guajava* L.) *Cv.* "APPLE COLOUR"

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Abstract- An experiment was conducted on seven year old tree of guava *cv.* Apple Colour at Mandsaur, (M.P.) to study the effect of nutrients spray on morphological, yield and quality attributes of guava. The plant height increased (0.42 m, 0.39 m and 0.41m), with urea @ 2%, zinc sulphate @ 0.8% and their interaction (urea @ 2% x zinc sulphate@ 0.8%), respectively. The spray of urea @ 2% resulted in canopy spread E-W and N-S direction (0.89 m and 0.86 m), reducing sugar (5.90 %),non reducing sugar (4.15%), the maximum no. of fruit/ tree (238.57), fruit weight (178.50 g), yield per tree (42.19 kg), while spray of zinc sulphate @ 0.8 % resulted in canopy spread E-W and N-S direction (0.86 m and 0.86 m), reducing sugar (5.84%), non-reducing sugar (4.06%), the maximum number of fruit/ tree (234.52), fruit weight (175.25g) and fruit yield/ tree (40.92 kg), respectively**.** The treatment having foliar spray 1.5% urea and 0.6 % zinc sulphate proved the second best in respect of these parameters.

Keywords- Guava, Foliar spray, Urea, Zinc sulphate, Plant growth, Fruit yield and quality.

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Introduction

Guava (*Psidium guajava* L.), is one of the most important fruit crop. It is one of the most common and important tropical/ sub-tropical fruit, because of its high nutritive value and possibilities of cultivation even under adverse conditions. Guava belongs to the family Myrtaceae. It's classified under genus Psidium, which contains 150 species, but only (*Psidium guajava* L.) has been exploited commercially. It was introduced in India during 17th century and its commercial cultivation is done in Maharashtra, U.P., M.P. and Bihar. However, Maharashtra is the pioneer in guava cultivation. In India, guava covers total area about 205 thousands ha, with an annual production of 2462 thousands Metric tons. The average productivity of guava is 12.0 MT/ha. However, Maharashtra has the largest area covering about 36.0 thousands ha. Maharashtra produces 311.0 thousands MT annually followed by M.P. (280.8 thousands MT) and U.P (241.4 thousands MT). The average productivity is highest in M.P. with 29.0 MT/ha [1]. The applications of mineral nutrients like urea and zinc sulphate are known to play a vital role in growth, development, yield and quality of fruits. Commercially, guava produced in Allahabad region of U.P. is best in the world. Guava is one of the rich and cheapest sources of vitamin C and pectin. Guava fruit contains about 82.50 per cent water, 2.45 per cent reducing sugar, 2.23 per cent non-reducing sugar, 9.73 per cent total soluble solids, 0.48 per cent ash and 260 mg Vitamin C per 100 gm of fruit pulp as well as good amount of iron, calcium and phosphorus respectively [27]. The foliar feeding of fruit trees has gained much importance in recent years, as nutrients applied through soil are needed in higher quantities due to leaching losses and also due to unavailability to the plant because of complex soil reaction. Regular foliar spray of nutrients is beneficial to increase fruit yield.

Material and Method

The experiment was conducted on seven year old guava tree *cv.* Apple Colour at the Department of Fruit Science, K.N.K. College of Horticulture, Mandsaur during 2012-13. The experiment was laid out in factorial randomized block design with three replications. The treatment consist sixteen foliar application of urea and zinc sulphate. These were: T_0 control (water spray), T_1 (zinc sulphate 0.3%), T_2 (zinc sulphate 0.6%), T_3 (zinc sulphate 0.8%), T_4 (urea 1 %), T_5 (urea 1 % + zinc sulphate 0.3 %), T_6 (urea 1 % + zinc sulphate 0.6 %), T_7 (urea 1 % + zinc sulphate 0.8 %), T_8 (urea 1.5 %), T_9 (urea 1.5 % + zinc sulphate 0.3 %), T_{10} (urea 1.5 % + zinc sulphate 0.6 %), T_{11} (urea 1.5 % + zinc sulphate 0.8 %), T_{12} (urea 2 %), T_{13} (urea 2 % + zinc sulphate 0.3 %), T_{14} (urea 2 % + zinc sulphate 0.6 %) and T_{15} (urea 2 % + zinc sulphate 0.8 %). The treatments were imposed at two times. First foliar spray of urea and zinc sulphate on crop was done on 16 August 2012 and same spray was repeated after 30 days. For recording various growth parameters of fruit *viz.* canopy spread, canopy height. The plant canopy spread was measured with the help of measuring device at the time of foliar application and at harvest and calculation of increase in plant canopy spread during the experimental period was calculated. While reproductive parameters were calculated by following formulas:

Fruit setting (%) = (Number of set fruits/ Number of flowers) x 100

$$\text{Fruit drop (\%)} = \frac{\text{Total no. of fruit set} - \text{Total no. of fruits at harvest time}}{\text{Total number of fruit set}}$$

Fruit retention (%) = Number of fruits at harvest/ initial number of fruit set x 100

For determination of chemical parameters of fruit *viz.* sugars (total, reducing and non-reducing sugars) and pectin content, four healthy fruits were selected randomly from each tree at full maturity stage. Sugars in fruit juice were estimated

by the method as suggested by [15].

Results

Morphological parameters

Plant height (m)

Data presented in [Table-1] revealed that the maximum plant height was significantly increased with the spray of urea over the control. The maximum plant height (0.42 m) was recorded under the urea @ 2.00 % (U_3) followed by (0.38 m) under urea @ 1.5% (U_2), while the minimum plant height (0.24 m) was recorded under control. The data on effect of foliar spray of zinc sulphate are presented in [Table-1] revealed that the plant height was significantly increased with the spray of zinc sulphate over the control. The maximum plant height (0.39 m) was recorded under the $ZnSO_4$ @ 0.8% (Z_3), followed by $ZnSO_4$ @ 0.6% (Z_2), while the minimum plant height recorded (11.28 cm) under control. Plant height was significantly influenced due to combined spray of urea and zinc sulphate over the control [Table-1]. The maximum plant height (0.48 m) was recorded under T_{15} (urea @ 2.00 % & $ZnSO_4$ @ 0.8 %) followed by the treatments of T_{14}, T_{13}, T_{11} and T_{10}, (urea @ 2.0 % and $ZnSO_4$ @ 0.6 %) and (urea @ 2.0 % & $ZnSO_4$ @ 0.3%), (urea @ 1.5 % & $ZnSO_4$ @ 0.8%) and (urea @ 1.5 % & $ZnSO_4$ @ 0.6%), while minimum plant height (0.21 m) under the control.

Table-1 *Effect of foliar sprays of urea, zinc sulphate and their interaction on plant height canopy spread, fruit drop, fruit retention, no. of fruit/ tree, average fruit weight, yield of fruit, and reducing and non-reducing sugar of guava.*

Treatments	Plant Height (m)	Canopy spread (m)		Fruit Drop (%)	Fruit Retention (%)	No. of fruits/ tree	Average fruit weight (g)	Yield/ tree (kg)	Reducing sugar (%)	Non-reducing sugar (%)	Total sugar (%)
		E-W	N-S								
Urea											
U_0 0.0 %	0.24	0.28	0.29	22.48	39.54	201.55	155.00	31.41	5.37	3.70	9.07
U_1 1.0 %	0.34	0.56	0.57	20.03	45.52	218.91	167.75	37.05	5.65	3.89	9.54
U_2 1.5 %	0.38	0.60	0.61	18.39	49.68	232.59	175.25	40.41	5.76	4.03	9.79
U_3 2.0 %	0.42	0.66	0.66	17.62	51.92	238.57	178.50	42.19	5.90	4.15	10.05
S.Em.±	0.002	0.003	0.006	0.06	0.37	0.75	0.89	0.007	0.02	0.01	0.024
C.D. at 5%	0.006	0.010	0.017	0.18	1.06	2.17	2.56	0.019	0.05	0.03	0.070
$ZnSO_4$											
Z_0 0.0%	0.30	0.40	0.41	21.40	42.00	207.02	161.50	33.65	5.46	3.79	9.25
Z_1 0.3%	0.33	0.52	0.53	20.07	45.96	220.28	167.00	36.98	5.63	3.90	9.53
Z_2 0.6%	0.37	0.57	0.57	18.93	48.15	229.81	172.75	39.51	5.75	4.02	9.76
Z_3 0.8%	0.39	0.62	0.62	18.10	50.56	234.52	175.25	40.92	5.84	4.06	9.90
S.Em.±	0.002	0.003	0.006	0.06	0.37	0.75	0.89	0.007	0.02	0.01	0.024
C.D. at 5%	0.006	0.010	0.017	0.18	1.06	2.17	2.56	0.019	0.05	0.03	0.070
Interaction (UXZ)											
$T_{(0)}$ U_0Z_0	0.17	0.25	0.26	23.35	35.40	179.25	152.00	27.15	5.02	3.61	8.63
$T_{(1)}$ U_0Z_1	0.19	0.27	0.28	22.85	39.66	205.45	154.00	31.64	5.45	3.68	9.13
$T_{(2)}$ U_0Z_2	0.21	0.29	0.30	22.38	40.20	208.54	156.00	32.53	5.47	3.75	9.22
$T_{(3)}$ U_0Z_3	0.22	0.31	0.31	21.33	42.89	212.97	158.00	34.32	5.53	3.75	9.28
$T_{(4)}$ U_1Z_0	0.27	0.48	0.49	21.88	42.49	211.98	161.00	33.65	5.54	3.79	9.33
$T_{(5)}$ U_1Z_1	0.28	0.53	0.55	20.75	44.39	213.16	163.00	35.45	5.58	3.84	9.42
$T_{(6)}$ U_1Z_2	0.29	0.61	0.60	19.40	46.16	222.37	171.00	38.83	5.67	3.92	9.59
$T_{(7)}$ U_1Z_3	0.32	0.63	0.62	18.08	49.06	228.15	176.00	40.25	5.80	4.01	9.81
$T_{(8)}$ U_2Z_0	0.28	0.47	0.48	20.53	44.67	217.48	165.00	36.25	5.63	3.85	9.48
$T_{(9)}$ U_2Z_1	0.30	0.62	0.62	18.72	48.50	227.19	173.00	39.47	5.69	3.98	9.67
$T_{(10)}$ U_2Z_2	0.34	0.65	0.66	17.34	51.34	241.58	181.00	42.48	5.84	4.11	9.95
$T_{(11)}$ U_2Z_3	0.35	0.68	0.67	16.96	54.20	244.11	182.00	43.45	5.89	4.17	10.06
$T_{(12)}$ U_3Z_0	0.29	0.42	0.41	19.85	45.44	219.35	168.00	37.55	5.64	3.91	9.55
$T_{(13)}$ U_3Z_1	0.34	0.64	0.65	17.96	51.28	235.33	178.00	41.35	5.81	4.08	9.89
$T_{(14)}$ U_3Z_2	0.38	0.73	0.71	16.61	54.89	246.75	183.00	44.21	6.01	4.28	10.29
$T_{(15)}$ U_3Z_3	0.41	0.85	0.86	16.04	56.07	252.85	185.00	45.65	6.14	4.31	10.45
S.Em.±	0.004	0.007	0.012	0.13	0.74	1.50	1.77	0.013	0.04	0.02	0.049
C.D. at 5%	0.011	0.020	0.034	0.37	2.13	4.34	5.12	0.039	0.11	0.06	0.140

Canopy spread (m)

East-West (E-W) direction

Data presented in [Table-1] reveals that the canopy spread (E-W) was significantly increased with the spray of urea over the control. The maximum canopy spread E-W (0.66 m) was recorded under the urea @ 2.0 (U_3) and urea @ 1.5% (U_2), while the minimum canopy spread E-W (0.28 m) was recorded under control. The data on effect of foliar spray of zinc sulphate are presented in [Table-1] revealed that the canopy spread (E-W) was significantly increased with the spray of zinc sulphate over the control. The mean maximum canopy spread in the direction of east-west (0.62 m) was recorded under the $ZnSO_4$ @ 0.8% (Z_3), while the minimum canopy spread E-W direction (0.40 m) was recorded under control. The interaction effect of foliar application of urea and zinc sulphate on canopy spread (E-W) was significantly influenced due to combined spray of urea and zinc sulphate over the control [Table-1]. The maximum canopy spread in the direction of E-W (0.85 m) was recorded under T_{15} (urea @ 2.00 % & $ZnSO_4$ @ 0.8 %), followed by treatment T_{14} (urea @ 2.0% & $ZnSO_4$ @ 0.6%), whereas the minimum canopy spread E-W direction (0.25 m) was recorded under the control.

North-South (N-S) direction

Effect of foliar spray of urea on guava tree is presented in [Table-1] revealed that the canopy spread (N-S) was significantly increased with the spray of urea over the control. The mean maximum canopy spread in the direction of N-S (0.66 m) was recorded under the treatment (urea @ 2.0 %, followed by the urea @ 1.5 %); while the minimum canopy spread N-S direction (0.29 m) was recorded under control. Data presented in [Table-1] reveals that the canopy spread (N-S) was significantly increased with the spray of zinc sulphate over the control. The mean maximum canopy spread in the direction of N-S (0.62 m) was recorded under the treatment ($ZnSO_4$ @ 0.8%) followed by in the treatment of ($ZnSO_4$ @ 0.6%), while the minimum canopy spread N-S direction (0.41 m) was recorded under control. However the interaction effect of urea and zinc sulphate canopy spread N-S direction was significantly influenced by the combined spray of urea and zinc sulphate over the control [Table-1]. The maximum canopy spread in direction of N-S (0.86 m) was recorded under T_{15} (urea @ 2.00 % & $ZnSO_4$ @ 0.8%) followed by T_{14} (urea @ 2.00 % & $ZnSO_4$ @ 0.6%) and T_{11} (urea @ 1.5 & $ZnSO_4$ @ 0.3%), (0.71 m and 0.67 m) is the best compare the other treatments respectively, whereas the minimum (0.26 m) Canopy spread N-S direction was recorded under

the control.

Fruit drop (%)

Foliar spray of urea on fruit drop percentage was significantly influenced by the foliar spray of urea over the control. [Table-1]. The minimum fruit drop (17.62%) was observed with U_3 (urea @ 2.0%, followed by treatment U_2 (urea @ 1.5%) (18.39%) and U_1 (urea @ 1.0%) (20.03%), while the maximum fruit drop (22.48%) was found under the control. The fruit drop percentage was significantly influenced by the foliar spray of zinc sulphate over the control. [Table-1]. The minimum fruit drop (18.10%) was found with the application of Z_3 ($ZnSO_4$ @ 0.8%), followed by Z_2 ($ZnSO_4$ @ 0.6%) and Z_1 ($ZnSO_4$ @ 0.3%), while the maximum fruit drop (21.40%) was found under the control. The Interaction effect of combined spray of urea and zinc sulphate over the control, [Table-1]. The minimum fruit drop percentage (16.04%) under the treatment T_{15} (urea @ 2.0% & $ZnSO_4$ @ 0.8%), followed by T_{14} (urea @ 0% & $ZnSO_4$ @ 0.6%) and T_{11} (urea @ 1.5%% & $ZnSO_4$ @ 0.8% respectively), whereas maximum fruit drop (23.35%) was recorded under the control.

Fruit retention (%)

The fruit retention percentage was significantly influenced by the foliar spray of urea over the control. [Table-1]. The maximum fruit retention (51.92%) was found with the application of urea U_3 (urea @ 2.0%) followed by (U_2) urea @ 1.5%, while the minim um fruit retention (39.54%) recorded under the control. The fruit retention percentage was significantly influenced by the foliar spray of zinc sulphate over the control. [Table-1]. The maximum fruit retention (50.56%) was found with the treatment of Z_3 ($ZnSO_4$ @ 0.8 %) followed by Z_2 ($ZnSO_4$ @ 0.6%), however, the minimum fruit retention (42.00%) was found under the treatment control. The fruit retention percentage was significantly influenced due to combined spray of urea and zinc sulphate over the control, [Table-1]. The maximum retention percentage (56.07%) was recorded under the treatment T_{15} (urea @ 2.00 % & $ZnSO_4$ @ 0.8 %), followed by T_{14} (urea @ 2.00 % & $ZnSO_4$ @ 0.6 %), T_{11} (urea @ 1.5 % & $ZnSO_4$ @ 0.8 %) and T_{10} (urea @ 1.5 % & $ZnSO_4$ @ 0.6 %), respectively, while the minimum fruit setting (35.40 %) was noticed under the control.

Yield parameters

Number of fruits per plant

Data presented in [Table-1] revealed that the number of fruits per plant was significantly increased due to the foliar spray of urea over the control. The mean maximum (238.57) number of fruits per plant was obtained under the treatment U_3 (urea@ 0.8%), followed by U_2 (urea@ 0.6% 232.59) and U_1 (urea@ 0.3% 218.91), while the minimum (201.55) number of fruits per plant was obtained under control. Data presented in [Table-1] revealed that the number of fruits per plant was significantly increased with the foliar spray of zinc sulphate over the control. The maximum number of fruits (234.52) per plant was obtained under the treatment Z_3 ($ZnSO_4$ @ 0.8%) which was significantly superior to other levels of Z_2 and Z_1 ($ZnSO_4$ @ 0.6% 229.81 and $ZnSO_4$ @ 0.3% 220.28 respectively), while the minimum (207.02) number of fruits per plant was noted in control. The interaction effect of urea and zinc sulphate was significant which increased the number of fruit over the control [Table-1]. The maximum (252.85) number of fruit was recorded under treatment T_{15} (urea @ 2.0% & $ZnSO_4$ @ 0.8%) followed by other treatment T_{14}, T_{11} and T_{10}, whereas the minimum (179.25) was recorded under the control.

Average fruit weight (g)

Data presented in [Table-1] revealed that the weight of fruit was significantly increased with the foliar spray of urea over the control. The mean maximum weight per fruit (178.50 g) was obtained under the treatment U_3 (urea @ 0.8%), which was significantly superior to the other levels of U_1, and U_2 (urea @1.0%, and urea @ 1.5%) respectively), while the minimum weight of fruit (155.00 g) was noted under control. Data presented in [Table-1] showed that the weight per guava fruit was significantly increased with the spray of zinc sulphate over the control. The maximum weight of fruit (175.25g) was obtained under the treatment Z_3 ($ZnSO_4$ @ 0.8%), which was statistically superior to the other levels of Z_1 and, Z_2 ($ZnSO_4$ @ 0.3%, and $ZnSO_4$ @ 0.6%) respectively), while the minimum weight of fruit (161.50 g) was obtained under control. The guava fruit weight was significantly influenced by the combined spray of urea and zinc sulphate over the control [Table-1]. The mean maximum weight per guava fruit (185.00 g) was obtained under treatment T_{15} (urea 2.0% & $ZnSO_4$ @ 0.8%), which was at par with the treatment T_{14}, T_{11}& T_{10} while the minimum fruit weight of guava (152.00 g) obtained under control.

Yield per plant (kg)

Data presented in [Table-1] showed that the yield per plant was significantly increased with the foliar spray of urea over the control. The mean maximum (42.19 kg) yield per plant was obtained under the treatment U_3 (urea @ 2.0%), which was significantly superior to the other levels of U_1, and U_2 (urea 1.0% 37.05 kg and urea 1.5% 40.41 kg respectively), while the minimum yield per plant (31.41 kg) was obtained under control. The data presented in [Table-1] revealed that the yield per plant was significantly increased with the spray of urea and zinc sulphate over the control. The maximum (40.92 kg) yield per plant was obtained under the treatment Z_3 ($ZnSO_4$ @ 0.8%), which was significantly superior to the spray of other levels of Z_1 and, Z_2 ($ZnSO_4$ @ 0.3% 36.98 kg and $ZnSO_4$ @ 0.6% 39.51 kg, respectively), while the minimum yield per plant (32.43 kg) was obtained under control. The combined spray of urea and zinc sulphate were significant which influenced the yield per plant over the control [Table-1]. The maximum yield per plant (45.65 kg) was obtained under treatment T_{15} (urea 2.0% & $ZnSO_4$ 0.8%) followed by T_{14} (urea 2.0% & $ZnSO_4$ 0.6% 44.21 kg), T_{11} (urea 1.5% & $ZnSO_4$ 0.8% 43.45kg) & T_{10} (urea 1.5% $ZnSO_4$ 0.6% 42.48kg respectively), whereas the minimum (30.15 kg), yield obtained under the control.

Chemical parameters

Reducing sugar (%)

Data presented in [Table-1] revealed that the reducing sugar was significantly influenced with the foliar spray of urea over the control. The maximum reducing sugar (5.90%) was recorded under the treatment U_3 (urea @ 2.0%) which was significantly superior to the other levels of U_1, and U_2 (urea 1.0% and urea 1.5% respectively), while the minimum reducing sugar (5.37%) was recorded under control. The Data presented in [Table-1] revealed that the reducing sugar was significantly influenced with the foliar spray of zinc sulphate over the control. The mean maximum reducing sugar (5.84%) was recorded under the Z_3 ($ZnSO_4$ @ 0.8%). which was significantly superior to the other levels of Z_1, and Z_2 ($ZnSO_4$ 0.3% and $ZnSO_4$ 0.6% 5.72% and 5.51%, respectively), while the minimum reducing sugar (5.46%) was recorded under control. The interaction effect of urea and zinc sulphate was significant which influenced the reducing sugar over the control [Table-1]. The maximum reducing sugar (6.14%) was recorded under treatment T_{15} (urea 2.0% & $ZnSO_4$ @ 0.8%), followed by T_{14} (urea 1.5% & $ZnSO_4$ 0.6%), while the minimum (5.02%), was recorded under the control.

Non-reducing sugar (%)

Data presented in [Table-1] showed that the non-reducing sugar was significantly influenced with the spray of urea over the control. The maximum non-reducing sugar (4.15%) was recorded under U_3 (urea 2.0%), followed by urea @ 1.5% (4.03%), while the minimum non-reducing sugar (3.70%) was recorded under control. The data presented in [Table-1] revealed that the non-reducing sugar was significantly influenced by the foliar spray of zinc sulphate over the control. The maximum non-reducing sugar (4.06%) was recorded under Z_3 ($ZnSO_4$ @ 0.8%), followed by Z_2 ($ZnSO_4$ @ 0.6%), while the minimum non-reducing sugar (3.79%) was recorded under control. The interaction effect of urea and zinc sulphate was significant which influenced the reducing sugar over the control [Table-1] The maximum non-reducing sugar (4.31%) was recorded under treatment T_{15} (urea 2.0% & $ZnSO_4$ @ 0.8%), followed by T_{14} (urea 2.0% & $ZnSO_4$ 0.6%) and T_{11} (urea 1.5% & $ZnSO_4$ 0.8%), while the minimum non-reducing sugar (3.61%) was recorded under control.

Total sugar (%)

Data depicted in [Table-1] revealed that the total sugar was significantly increased with the foliar spray of urea over the control. The maximum total sugar (10.05%) was obtained under U_3 (urea @ 2.0%), followed by U_2 and U_1 (urea @ 1.5% and urea @ 1.0% respectively), while minimum total sugar (9.07%) was recorded under control. The total sugar was significantly influenced by the foliar spray of zinc sulphate over the control. The maximum total sugar (9.90%) was recorded under Z_3 ($ZnSO_4$ @ 0.8%), which was at par with Z_2 ($ZnSO_4$ @ 0.6%), while the minimum (9.49%) total sugar was recorded under the control. The total sugar was statistically increased with the combined spray of urea and zinc sulphate over the control [Table-1]. The maximum total sugar (10.45%) was recorded under the treatment T_{15} (urea 2.0% & $ZnSO_4$ 0.8%), followed by the treatment T_{14} (urea 2.0% & $ZnSO_4$ 0.6%) and T_{11} (urea 1.5% & $ZnSO_4$ 0.8% respectively), whereas the minimum (8.63%) total sugar was obtained under the control.

Discussion

Morphological characters of trees

Effect of urea

The morphological parameters of the guava plant were significantly improved by the sprays of urea over the control. The maximum plant height (0.42 m) was recorded under U_3 (urea @ 2.0%) whereas the minimum plant height (0.24 cm) noticed under control. The maximum canopy spread (E-W and N-S direction, 0.66 and 0.66 m, respectively) was recorded under the treatment U_3 (urea @ 2.0%), whereas the minimum canopy spread (E-W and N-S direction, 0.28 and 0.29 m respectively) was noticed under control. It is quite clear from the findings of the present study that urea brought betterment may be due to stimulatory effect of urea on plant metabolism in guava. [7] Also reported that were increased the growth parameters in guava.

Reproductive parameters

The reproductive parameters of guava fruits were significantly improved by the sprays of urea. The maximum fruit setting percentage (71.15), the minimum fruit drop (17.62%) and the maximum fruit retention (51.92) percentage was recorded under the treatment U_3 (urea @ 2.0%), while the maximum fruit drop (22.03%) and the minimum fruit retention (39.54) percentage was recorded under the control. However, concentration beyond 2% urea proved to be auto-inhibitory for most reproductive characters. The obtained results are in harmony with the finding find by [18, 22].

Yield attributing Parameters

The data pertaining to various yield attributing parameters of the guava plant *viz*; number of fruits per plant, average weight per fruit and yield per plant (kg) were significantly improved by the spray of urea. The maximum number of fruits per plant (238.57), weight per fruit (178.50 g) and yield per plant (42.19 kg) were recorded under the treatment U_3 (urea @ 2.0%), which were significantly superior to other levels of urea (urea @ 1.5%, and urea @ 1.0%), while the minimum number of fruits per plant (201.55), weight per fruit (155.00 g), and yield per plant (31.41 kg), were noticed under control. It is quite clear from the findings of the present study that urea brought betterment in both growth and yield attributes may be due to stimulatory effect of urea on plant metabolism [5]. The increasing trend in most of parameters with the increase in urea concentration up to 2% may be due to better absorption of urea (nitrogen) by foliage part and its supply to different plant parts which ultimately contributed to higher yield over the control. Similar yield improvements with urea application were observed by [9]. They reported leaf burning of Sardar guava above 5% urea, which ultimately effected yield. [22] had also reported depressing effect on growth and yield in guava *cv*. Allahabad Safeda at urea concentration beyond 3%.

Chemical Parameters of fruits

The chemical parameters of guava fruits were significantly influenced by the sprays of urea. The maximum reducing sugar (5.90%), non-reducing sugar (4.15%) and total sugar (10.05%), was recorded under the treatment U_3 (urea @ 2.0 %) while minimum reducing sugar (5.37%), non-reducing sugar (3.70%) and total sugar (9.07%) was recorded under the control. The beneficial effect of urea in increasing total soluble solids, reducing sugar, total sugar, T.S.S./acid ratio and ascorbic acid content in guava fruit were also reported by [12, 16].

Morphological characters of trees

Effect of zinc sulphate

The morphological parameters of the guava plant were significantly influenced by the different concentration of zinc sulphate over the control. The mean maximum plant height (0.39 m) and canopy spread (E-W and N-S direction, 0.62 and 0.62 m respectively) were recorded under Z_3 ($ZnSO_4$ @ 0.8%), whereas the minimum plant height (0.30 m), canopy spread (E-W and N –S direction, 0.40 and 0.41 m respectively) were recorded under control. Zinc plays important role in fundamental processes involved in the cellular mechanism and respiration [19]. The presence of zinc in chloroplast cell was also considered the possible causes of increased growth of plants [25]. Improvement in vegetative growth was observed earlier with zinc by several workers; [5, 9, 11, 12, 21] in guava.

Reproductive parameters

The reproductive parameters of guava fruits were significantly improved by the sprays of zinc sulphate. The minimum fruit drop (18.10%) and maximum fruit retention (50.56%) was recorded under the treatment U_3(urea @ 2.0%), while the maximum fruit drop (21.40%) and the minimum fruit retention (42.00) percentage was recorded under the control. [26], reported that the zinc sulphate which plays an important role in translocation of carbohydrates and auxin synthesis to the sink and increased pollen viability and fertilization. The present results are also supported by [5, 6, 16, 20, 21] in guava.

Yield attributing Parameters

The data pertaining to various yield attributing parameters of the guava plant *viz;* number of fruits per plant, average weight per fruit, and yield per plant (kg) were significantly increased by the various sprays of zinc sulphate. The maximum number of fruits per plant (234.52), maximum weight of fruit (174.25 g) and the maximum fruit yield per plant (40.92 kg) were recorded under the treatment Z_3 ($ZnSO_4$ @ 0.8%), which were the significantly superior to the other levels of zinc sulphate whereas, the minimum number of fruits per plant (207.02), average weight of fruit (161.50 g) and yield per plant (33.65 kg) were recorded under control. The increase in fruit yield due to the increased growth and yield parameters may be due to the increased auxin production. Zinc acts as catalyst in the oxidation and reduction processes and it is also of great importance in the sugar metabolism, which might have improved the physical characters of guava fruit and thus increased the yield per tree. The increase in the fruit weight by zinc spray was due to the significant increase in the fruit width and length. The increase in the yield under the effect of zinc sprays might be due to the fact that zinc is universally claimed to be an essential micro nutrient and it is considered indispensable for the growth of all organism. [13], reported that foliar spray of zinc at 0.5 and 1.0 per cent concentrations increased fruit set, reduced pre-harvest abscission and increased yield; at picking time fruit characters were good. Effects of zinc spray on yield have earlier been also reported by [3, 14, 23, 24] in guava.

Chemical Parameters of fruits

The chemical parameters of guava fruits were significantly improved by the spray of zinc sulphate. The maximum reducing sugar (5.84%), the maximum non-reducing sugar (4.06) and maximum total sugar (9.90%) were recorded under treatment Z_3 ($ZnSO_4$@ 0.8%), whereas the minimum reducing sugar (5.46%), the minimum non-reducing sugar (3.79%) and the minimum total sugar (9.25) were obtained under the control. The enhanced chemical parameters of guava fruits may be due to the fact that zinc acts as catalyst in the oxidation and reduction processes and it is also of great importance in sugar metabolism. [20], recorded significant increase in reducing sugar content in 'Mrig-bahar' guava pulp with foliar spray of 0.4 per cent zinc sulphate solution over control. Increase in sugar by zinc might be due to the active enzymatic reaction like transformation of carbohydrates, activity of hexokinase and formation of cellulose. This present investigation finds support from [8, 16, 18] in guava.

Interaction effect of urea and zinc sulphate

Morphological characters of trees

The interaction effect of urea and zinc sulphate was significant which improved the morphological parameters of guava plant. The maximum plant height (0.48 m) and maximum canopy spread (E-W - 0.85m & N-S - 0.86 m respectively) was recorded under the treatment T_{15} (urea @ 2.0% & $ZnSO_4$ @ 0.8%), whereas the minimum plant height (0.21 m) and minimum canopy spread (E-W - 0.25 m & N-S - 0.26 m) direction were recorded under control. The foliar sprays of urea and zinc sulphate might have induced the synthesis of chlorophyll and thus lead to increase in chlorophyll content which in turn resulted in higher vegetative growth [21]. The increase in number of leaves per shoot with Zn and urea spray may be because Zn has an obvious affect on photosynthesis. A sure a is indispensable for photosynthesis .Improvements in vegetative growth of the present findings also are in conformity with several workers, [6, 9, 13] in guava.

Reproductive parameters

The reproductive parameters of guava fruits were significantly improved by the combined sprays of urea and zinc sulphate over the control. The maximum (74.76) fruit setting percentage, minimum (16.04 %) fruit drop and maximum (56.07) fruit retention percentage were recorded under the treatment T_{15} (urea @ 2.0% & $ZnSO_4$ @ 0.8%), while the minimum (59.34) fruit setting percentage, the maximum (23.35) fruit drop percentage and the minimum (35.40) fruit retention percentage was recorded under the control. Response of zinc application towards fruit retention is in agreement with finding of [2] in guava.

Yield attributing Parameters

The combined sprays of urea and zinc sulphate showed great improvement in yield attributing characters of guava. The maximum number (252.85) of fruits was obtained under T_{15} (urea @ 2.0% & $ZnSO_4$ @ 0.8%), followed by treatment of T_{14}, T_{11} and T_{10}, whereas the minimum number (179.25) of fruits were obtained under control. The higher average weight (185g) per fruit was under treatment T_{15} (urea @ 2.0% & $ZnSO_4$ @ 0.8%), followed by treatment of T_{14} T_{11} and T_{10} while the lowest average weight (152 g) per fruit was observed under control. The maximum yield per plant (45.65 kg) were obtained under T_{15} (urea @ 2.0% & $ZnSO_4$ @ 0.8%), followed by T_{14} (urea @ 2.0% & $ZnSO_4$ @ 0.6%), T_{11} (urea @ 1.5% & $ZnSO_4$ @ 0.8%) and T_{10} (urea @ 1.5% & $ZnSO_4$ @ 0.6%), 44.21 kg, 43.45 kg, and 42.48 kg respectively), whereas the minimum yield per plant (27.15 kg) was obtained under control. This might be due to more vegetative growth, which might be augmented photosynthesis, respiration and synthesis of more carbohydrates required for growth and development of guava plant. [4], obtained significant higher yield in terms of number and weight of fruit per tree as level of nitrogen increased in guava. The yield in terms of number and weight of fruit by zinc application has been reported by [8] and [9] in guava which supports results of present study.

Chemical Parameters of fruits

The chemical parameters of guava fruits were significantly improved by the combined spray of urea and zinc sulphate over the control. The maximum reducing sugar (6.14%) was observed under the treatment of T_{15} (urea 2.0 % & $ZnSO_4$ 0.8%) followed by the treatment, T_{14} (urea 2.0 % & $ZnSO_4$ 0.6%) and T_{11} (urea 1.5 % & $ZnSO_4$ 0.8%), whereas the minimum (5.02%) reducing sugar was observed under the control. The maximum non-reducing sugar (4.31%) was observed under the treatment T_{15} (urea @ 2.0% & $ZnSO_4$ @ 0.8%) followed by treatment T_{14} (urea @ 2.0% & $ZnSO_4$ @ 0.6%) and T_{11} (urea @ 1.5% & $ZnSO_4$ @ 0.8%), while the minimum non-reducing sugar (3.61%) was recorded under the control. The maximum total sugar (10.45%) was observed under the treatment T_{15} (urea @ 2.0% & $ZnSO_4$ @ 0.8%) followed by treatment T_{14} (urea @ 2.0% & $ZnSO_4$ @ 0.6%) and T_{11} (urea @ 1.5% & $ZnSO_4$ @ 0.8%), whereas the minimum total sugar (8.63%) was obtained under the control. Different fractions of sugar under the influence of urea and zinc sulphate might be due to hydrolysis of complex polysaccharides into simple sugars, synthesis of metabolites and rapid translocation of photosynthetic products and minerals from other parts of plant to developing fruits. [9], also observed similar results. Results find supports from the work of [10, 17] in guava.

Conclusion

It is concluded that foliar spray of urea and zinc sulphate and their interaction had significantly improved the vegetative growth, yield and quality parameters ofguava. Individual spray of urea i.e., U_3 (Urea @ 2% /plant) followed by U_2 (Urea @ 1.5%/ plant), and individual spray of zinc sulphate i.e., Z_3 ($ZnSO_4$ @ 0.8 %) followed by Z_2 ($ZnSO_4$ @ 0.6 %) were found to be the best treatments for almost vegetative, yield and quality parameters of guava plant. In the interaction effect of urea and zinc sulphate, the treatment U_3 X Z_3 (Urea @ 2%/ plant & $ZnSO_4$ @ 0.8%) followed by U_2 X Z_2 (Urea@ 1.5% / plant & $ZnSO_4$@ 0.6 %) were found to be the best treatments for almost vegetative, yield and quality parameters of guava plant.

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Abbreviations

cm	: Centimeter
cv.	: Cultivar
et al.	: And others
ha	: Hectare
g	: Gram (s)
i.e.	: That is
kg	: Kilogram
m	: Meter
/	: Per
%	: Per cent
spp.	: Species
TSS	: Total soluble solids
Viz.	: Namely

Conflict of Interest: None declared

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