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Impact of pre- harvest foliar spray of nutrients and agrochemicals on fruit yield and quality of ber (*Zizyphus mauritiana*)

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Abstract

A field experiment was conducted to find out the impact of pre- harvest foliar spray of nutrients and agrochemicals on fruit yield and quality parameters of ber (*Zizyphus mauritiana* Lamk) during 2022-23 and 2023-24 at SKN College of Agriculture, Jobner, Rajasthan. Among nutrients and agrochemicals, application of T_{11} ($ZnSO_4$ @ 4g/L + $CaCl_2$ @ 2g/L + chitosan @ 1.5g/L +salicylic acid @ 1g/L) to individual plants was significantly superior to all other treatments, but it was on a par with T_9 ($CaCl_2$ @ 2g/L + salicylic acid @ 1g/L), T_7 ($ZnSo_4$ @ 4g/L + salicylic acid @ 1g/L) and T_5 ($ZnSO_4$ @ 4g/L + $CaCl_2$ @ 2g/L). In treatment T_{11} ($ZnSo_4$ @ 4g/L + $CaCl_2$ @ 2g/L + chitosan @ 1.5g/L + salicylic acid @ 1g/L), an increase in days taken to first harvesting (137.00 days), days taken to complete harvesting (57.11 days), fruit weight (18.51 g), diameter of fruits (3.59 cm), fruit yield (38.01 kg/tree), fruit yield (105.68 q/ha), maximum TSS% (19.05 ^{0}Brix) and minimum titratable acidity (0.415 %) were recorded.

Key words: Agrochemicals, Nutrients, Spray, Fruit yield.

Indian jujube or ber (*Zizyphus mauritiana* Lamk) is one of the most common fruit, indigenous to an area joined from India to china. Cultivation of ber requires the least input and care (Pareek, 1983). It has a remarkable adaptability enabling it to grow in a wide range of agro-climatic situations and soils (Rana *et al.* 1979). Its fruits are palatable and delicious with a good amount of vitamin A, C, B complex and minerals (Pareek, 2002). In India, ber is being cultivated on an area of about 51.73 ha with a total production of 548.27 tonnes and productivity of 10.53 tonnes (MAFW, 2023-24). In Rajasthan, it is grown in an area of 11000 ha with a total production of 95900 tonnes and productivity of 8.71 tonnes (MAFW, 2023-24) in ber macro as well as micro nutrients improves the quality and quantity of production. Furthermore, zinc and calcium are very important nutrients required for its growth and development. The agrochemicals like chitosan and salicylic are needed for growth and development of plants, hence an experiment was conducted.

Materials and Methods

A field experiment was conducted at SKN College of Agriculture, Jobner, cv. Gola during 2022-23 and 2023-24. It consists of 12 nutrients and agrochemical treatments along with the control, T_0 (control), T_1 (zinc sulphate @ 4 g / L), T_2 (calcium chloride @ 2 g / L), T_3 (chitosan @ 1.5 g / L, T_4 salicylic acid @ 1 g / L), T_5 (zinc sulphate @ 4 g / L + calcium chloride @ 2 g / L), T_6 (zinc sulphate @ 4 g / L + chitosan @ 1.5 g / L), T_7 (zinc sulphate @ 4 g / L + salicylic acid @ 1 g / L), T_8 (calcium chloride @ 2 g / L + chitosan @ 1.5 g / L), T_9 (calcium chloride @ 2 g / L + salicylic acid @ 1 g / L), T_{10} (chitosan @ 1.5 g / L + salicylic acid @ 1 g / L) and T_{11} (zinc sulphate @ 4 g / L + calcium chloride @ 2 g / L + chitosan @ 1.5 g / L + salicylic acid @ 1 g / L) laid out in factorial randomized block design with three replications.

The treatments were applied during first week of November 2022-23 and 2023-24 after recording initial (base) yield attributing parameters of plants and observations were noted. For the measurement of number days taken to first harvesting of fruits was counted from the initiation of flowering to first harvesting of fruits and averages were computed. Days taken to complete harvesting the numbers of days taken from date of first harvesting of fruits to last date of harvesting of fruits constituted duration of harvesting. Number of days for each replication were recorded. Weight of fruit twenty fruits from each treatment were selected at random in each picking during both the years and weighed separately on electronic balance and average fruit weight in gram was calculated.

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The fruit diameter was measured at fruit maturity/ harvesting stage. The fruit size *i.e.* length and breadth were measured in centimeters with the help of calibrated Vernier Calipers. The volume of fruits was recorded by water displacement method with the help of measuring cylinder and volume of displaced water was expressed in cubic centimeter. The number of fruits/ plant were counted at each picking and total numbers of fruits were recorded for each treatment individually. Ripen fruits were harvested periodically and then weight was recorded with the help of single pan balance. Thereafter total fruit yield was calculated by summing up the total weight of fruits at different pickings obtained during harvesting period from each experimental plant.

$$\text{Yield (q/ha)} = \frac{\text{Yield/ plant (kg)}}{100} \times 278 \text{ (plant/ha)}$$

The data were statistically analyzed as per analysis of variance technique as suggested Panse *et al.* (1995). The significance of treatments was tested through F test at 5 per cent level of significance. The critical difference CD was calculated to assess the significance of difference among different treatments.

Results and Discussion

Application of nutrients and agrochemicals had significant effect on fruit yield and quality parameters of ber fruits. The earliest first harvesting (137.00 days after initiation of flowering) was recorded with the application of treatment T_{11} ($ZnSo_4$ @ 4g/L + $CaCl_2$ @ 2g/L + chitosan @ 1.5g/L + salicylic acid @ 1g/L), which was found significantly superior over rest of the treatments except treatments T_9 ($CaCl_2$ @ 2g/L + salicylic acid @ 1g/L), days, T_7 ($ZnSo_4$ @ 4g/L + salicylic acid @ 1g/L), days and T_5 ($ZnSo_4$ @ 4g/L + $CaCl_2$ @ 2g/L) days during both the years and pooled mean. However, maximum days taken to first harvesting after initiation of flowering (152.33 days) was noted under the control. Similarly, maximum days taken to complete harvesting (195.72) days after flowering was noted treatment T_{11} followed by T_9 (192.94) days, T_7 (191.33) days and T_5 (190.06) days minimum of (179.11) days taken to complete harvesting was noted under control T_0 treatment (Table 1).

The maximum fruit weight (18.51 g) was recorded with the application of treatment T_{11} ($ZnSo_4$ @ 4g/L + $CaCl_2$ @ 2g/L + chitosan @ 1.5g/L + salicylic acid @ 1g/L). This treatment was found statistically at par with treatment T_9 ($CaCl_2$ @ 2g/L + salicylic acid @ 1g/L 18.20 g), T_7 ($ZnSo_4$ @ 4g/L + salicylic acid @ 1g/L 18.02 g), T_5 ($ZnSo_4$ @ 4g/L + $CaCl_2$ @ 2g/L 17.85 g) and minimum fruit weight of (15.59g) was noted under the control. Maximum diameter of fruit of (3.63) was noted treatment T_{11} followed T_9 (3.55 cm), T_7 (3.49cm), T_5 (3.44cm) minimum diameter of fruit (2.83cm) was noted under control T_0 treatment (Table 2).

The highest volume of fruit of (18.83 cc) was recorded with the application of treatment T_{11} ($ZnSo_4$ @ 4g/L + $CaCl_2$ @ 2g/L + chitosan @ 1.5g/L + salicylic acid @ 1g/L). followed treatment T_9 ($CaCl_2$ @ 2g/L + salicylic acid @ 1g/L 18.54 cc), T_7 ($ZnSo_4$ @ 4g/L + salicylic acid @ 1g/L18.36cc), T_5 ($ZnSo_4$ @ 4g/L + $CaCl_2$ @ 2g/L18.18cc) and minimum volume of fruit (16.10cc) noted under the control. Similarly, treatment T_{11} ($ZnSo_4$ @ 4g/L + $CaCl_2$ @ 2g/L + chitosan @ 1.5g/L + salicylic acid @ 1g/L) registered maximum number of (2236.06 fruits/plant).

This treatment was found significantly superior over rest of the treatments except treatment T_9 (2214.10 fruits/plant), T_7 (2202.84 fruits/plant), T_5 ($ZnSo_4$ @ 4g/L + $CaCl_2$ @ 2g/L 2193.58 fruits/ plant) minimum number of (1822.13 fruits/ plant) were noted under the control treatment (Table 3). Maximum fruit yield (38.01 kg/tree) during both the years and pooled mean, respectively was recorded with the application of treatment T_{11} ($ZnSo_4$ @ 4g/L + $CaCl_2$ @ 2g/L + chitosan @ 1.5g/L + salicylic acid @ 1g/L). followed by this treatment T_9 ($CaCl_2$ @ 2g/L + salicylic acid @ 1g/L 37.12 kg/tree), T_7 ($ZnSo_4$ @ 4g/L + salicylic acid @ 1g/L 36.98 kg/tree), T_5 ($ZnSo_4$ @ 4g/L + $CaCl_2$ @ 2g/L 36.77 kg/tree) and minimum fruit yield of 31.28 kg/tree was noted under the control.

Treatment T_{11} was recorded maximum fruit yield q/ha of (105.68) q/ha during both the years and pooled mean, respectively, which was found statistically at par with T_9 (103.20 q/ha), T_7 (102.80 q/ha), T_5 (102.22 q/ha) and minimum fruit yield of (86.95 q/ha) were noted under the control (Table 1).

Maximum TSS content of (19.05^0 Brix) during both the years and pooled mean, respectively was recorded in fruits with treatment T_{11} ($ZnSo_4$ @ 4g/L + $CaCl_2$ @ 2g/L + chitosan @ 1.5g/L + salicylic acid @ 1g/L). This treatment was significantly superior over rest of the treatments except treatment T_9 ($CaCl_2$ @ 2g/L + salicylic acid @ 1g/L 18.90^0 Brix), T_7 ($ZnSo_4$ @ 4g/L +salicylic acid @ 1g/L 18.33 Brix), T_5 ($ZnSo_4$ @ 4g/L + $CaCl_2$ @ 2g/L 18.69^0 Brix and minimum TSS content (16.80^0 Brix)

Table 1. Effect of Pre-Harvest Foliar Spray of Nutrients and Agrochemicals on Days taken to First Harvesting and Days taken to Complete Harvesting of Ber fruits.

Treatment	Days taken to First Harvesting			Days taken to Complete Harvesting		
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
Nutrients and agrochemicals						
T_0 Control	152.44	152.22	152.33	25.44	28.11	26.78
T_1 $ZnSO_4$	151.89	148.00	149.94	28.56	35.44	32.00
T_2 $CaCl_2$	149.33	147.89	148.61	29.89	34.33	32.11
T_3 Chitosan	146.89	146.22	146.56	28.33	34.22	31.28
T_4 Salicylic acid	146.33	145.44	145.89	34.00	37.89	35.94
T_5 $ZnSO_4$ + $CaCl_2$	142.33	141.22	141.78	45.11	51.44	48.28
T_6 $ZnSO_4$ + Chitosan	149.78	147.44	148.61	31.00	36.33	33.67
T_7 $ZnSO_4$ + Salicylic acid	139.44	139.44	139.44	49.44	54.33	51.89
T_8 $CaCl_2$ + Chitosan	145.00	144.22	144.61	35.11	38.89	37.00
T_9 $CaCl_2$ + Salicylic acid	138.89	137.89	138.39	52.11	57.00	54.56
T_{10} Chitosan+ Salicylic acid	148.00	147.11	147.56	35.56	39.44	37.50
T_{11} $ZnSO_4$ + $CaCl_2$ + Chitosan + SA	137.44	136.56	137.00	54.33	59.89	57.11
SEm±	**3.07**	**3.10**	**2.18**	**4.86**	**4.26**	**3.23**
CD (P = 0.05)	**8.65**	**8.73**	**6.09**	**13.72**	**12.01**	**9.04**
Different Stage of Foliar Spray						
S_1	144.86	144.14	144.50	41.61	43.42	42.51
S_2	150.47	148.31	149.39	27.94	34.78	31.36
S_3	141.61	140.97	141.29	42.67	48.64	45.65
SEm±	**1.53**	**1.55**	**1.09**	**2.43**	**2.13**	**1.62**
CD (P = 0.05)	**4.32**	**4.37**	**3.05**	**6.86**	**6.00**	**4.52**

was noted under control. However minimum acidity (0.415 %) was recorded under treatment T_{11} followed by this treatment T_9 (0.417%), T_7 (0.418), T_5 (0.421%) and maximum titratable acidity (0.469%) was recorded in control at the time of completion of experiment (Table 2).

Application of zinc sulphate, calcium chloride, salicylic acid and chitosan enhanced the yield and yield parameters of ber when applied either alone or in combinations. Zinc sulphate application reduced maturity duration could be attributed to enhancing effect of $ZnSO_4$ in enzymatic reaction, cell division as well as in growth (Supriya and Bhattacharya, 1993). The enhancement in weight, diameter and volume of fruits with foliar spray of salicylic acid may be due to the high content of starch and plant hormones, especially cytokines, which play a vital role in enhancing cell division and expansion, ultimately leading to increased volume (Uthairatanakij *et al.,* 2007). Application of salicylic acid at pea size stage showed a maximum increase in fruit weight, diameter and volume of fruits because at this time, stone fruit undergoes through the cell elongation stage (Kassem *et al.,* 2011). During this stage, cells absorb water from adjacent cells or xylem, which can cause turgidity of the cells and elongation of the fruit cells, activation of some essential enzymes and supply of more plant hormone for the growth and development of fruit which increases volume and diameter of fruits (Valero *et al.,* 2002).

The increase in number of ber fruits by application of foliar application of nutrients and agrochemicals (calcium, zinc, salicylic acid and chitosan) treatment

Table 2. Effect of Pre-Harvest Foliar Spray of Nutrients and Agrochemicals on fruit weight and diameter of fruits on ber fruit.

Treatments	Fruit weight			Diameter of fruits		
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
Nutrients and agrochemicals						
T_0 Control	15.29	15.90	15.59	2.69	2.96	2.83
T_1 $ZnSO_4$	16.51	17.09	16.80	2.87	3.11	2.99
T_2 $CaCl_2$	16.48	17.15	16.82	2.80	3.07	2.94
T_3 Chitosan	16.46	17.07	16.77	2.74	3.02	2.88
T_4 Salicylic acid	16.42	17.03	16.73	2.87	3.11	2.99
T_5 $ZnSO_4$ + $CaCl_2$	17.54	18.15	17.85	3.40	3.50	3.45
T_6 $ZnSO_4$ + Chitosan	16.98	17.59	17.28	3.12	3.22	3.17
T_7 $ZnSO_4$ + Salicylic acid	17.71	18.32	18.02	3.41	3.56	3.49
T_8 $CaCl_2$ + Chitosan	16.92	17.53	17.22	3.26	3.29	3.27
T_9 $CaCl_2$ + Salicylic acid	17.89	18.50	18.20	3.46	3.64	3.55
T_{10} Chitosan+ Salicylic acid	16.89	17.50	17.19	3.31	3.42	3.36
T_{11} $ZnSO_4$ + $CaCl_2$ + Chitosan + SA	18.12	18.89	18.51	3.56	3.62	3.59
SEm±	**0.38**	**0.43**	**0.29**	**0.11**	**0.18**	**0.10**
CD (P = 0.05)	**1.09**	**1.21**	**0.80**	**0.30**	**0.49**	**0.29**
Different Stage of Foliar Spray						
S_1	17.03	17.66	17.35	3.14	3.32	3.23
S_2	16.48	17.04	16.76	2.97	3.06	3.01
S_3	17.29	17.99	17.64	3.27	3.50	3.38
SEm±	**0.19**	**0.21**	**0.14**	**0.05**	**0.09**	**0.05**
CD (P = 0.05)	**0.54**	**0.60**	**0.40**	**0.15**	**0.25**	**0.14**

may be due to increased fruit set and reduced fruit drop due to that these nutrients play important role in biosynthesis of IAA (Alloway, 2008). As a result of spray of these nutrients could give higher number of fruits and consequently yield. Further, increase in fruit yield in treated plant may be attributed to reason that plants remain physiologically more active to build up sufficient food stock for developing fruits ultimately leading the higher yield. The increase in percentage of total soluble solid when spraying calcium may be due to the role of these elements in increasing activity of vegetative growth, then absorb nutrients (Badway *et al.*, 2019).

An increase in TSS: acid ratio is due to increase in TSS content and the decreased acidity Abdelrhman *et al.,* (2017). The present results are in conformity with the findings of Singh and Maurya (2004) in mango, Singh *et al.* (2005) in papaya, Rajkumar *et al.* (2014) in guava, Goswami *et al.* (2014) in guava, Yadav *et al.* (2018) in guava, Yadav *et al.* (2018) in pomegranate, Ajender and Chawla (2019) in apple and Gami *et al.* (2019) in ber.

Conclusion

Thus, it may be concluded that application of T_{11} ($ZnSo_4$ @ 4g/L + $CaCl_2$ @ 2g/L + chitosan @ 1.5g/L + salicylic acid @ 1g/L).) had its better effect on fruit yield and quality of ber plants. The (($ZnSo_4$ @ 4g/L + $CaCl_2$ @ 2g/L + chitosan @ 1.5g/L + salicylic acid @ 1g/L) emerged better in its effectivity on fruit yield and quality attributes.

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