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Optimization of Flowering and Fruit Development in Ber (*Ziziphus mauritiana* L.) cv. Umran using Fertilizers, Micronutrients, and Bioregulators

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

In order to investigate the effect of fertilizers, micronutrients and bioregulators on flowering and fruit growth and developments on ber (*Ziziphus mauritiana* L.) cv. Umran, an experiment was carried out during 2019/2020 cropping season at the Fruit Research Station, Imalia, Department of

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Horticulture JNKVV Jabalpur. The study used a factorial design using randomized complete block design (RCBD), with three replications and a total of twelve treatment combinations that included bioregulators, micronutrients, and fertilizers either separately or in various combinations. The application of treatment T4 [RDF (N:P:K)+Foliar spray of GA3 + NAA (50 ppm+50 ppm)] was found to be significantly superior as compared to other treatments for flowering parameter in respect to induce early flower bud formation, based on the results obtained in this study. It takes 22 days to induce the earliest flowering after spray, and it takes 8.67 days to achieve 50% flowering. The earliest date of flower bud initiation was found with the T11 [RDF (N:P:K)+ NPK -18:18:18 (1.0%) + ZnSO4 (0.5%) + Borax (0.3%)] which showed to be the best for fruit growth and development characteristics, including specific gravity (1.047), fruit weight (36.52 g), fruit volume (36.56 ml), fruit length (4.53 cm), and fruit diameter (3.50 cm).With regard to practically every fruit growth and development attribute, the treatment T10 was found to be the second best.

Keywords: Bioregulators; flowering; fruit growth; flowering treatments; fertilizers; micronutrients; foliar nutrients.

1. INTRODUCTION

The Indian jujube, commonly known as ber, is a member of the Rhamnaceae family. It is often referred to as the "King of arid-zone fruits" or the "poor man's apple." The genus *Ziziphus* gets its name from the Arabic word "Zizaif," which is the name of the fruit. The Rhamnaceae family itself comprises approximately 50 genera and more than 600 species that are distributed across tropical and sub-tropical regions in the northern hemisphere [1]. There are various species of Zizyphus genus which are now widely distributed across tropical and sub-tropical regions of Asia, Europe and America. However, the fruit is originated in tropical and tropical regions of northern hemisphere [2].

The ber fruit stands out as a fruit crop that can yield favourable returns even when grown under rainfed conditions. This is attributed to its remarkable adaptability to a wide range of soils, varying water availability conditions, and diverse climates, although it is sensitive to heavy frosts. It thrives particularly well in arid and semi-arid regions. This adaptability makes it a resilient and economically viable option for cultivation in areas with challenging environmental conditions [3-7].

The ber fruit boasts a spongy, sweet, and delicious pulp that is not only flavourful but also packed with essential nutrients. It is known to be an excellent source of vitamins, including vitamin C, vitamin A, and various B vitamins [8].

High degree of immature fruits drop during initial stage of fruit growth and development experiences in all over India may be due to various factors like hormonal imbalance, abortion of embryo and inclement weather [9,10,11], nutrition [12], moisture stress [13] and quality deterioration which makes ber cultivation non-profitable.

Chemical nutrients and bio-regulators, even in small quantities, play a crucial role in promoting the growth and development of plants, ultimately influencing both yield and quality. These substances can bring about changes in plant metabolism by altering the nutritional and hormonal status of the plant [14-17]. 1-Naphthaleneacetic acid (NAA) is an important plant hormone reported to enhance the fruit set, growth, retention, yield and market price of some fruit species also delayed in fruit ripening as well as enhancing fruit formation through cell division and elongation [18-21]. Gibberellins are reported to increase fruit set, size, retention and yield as well as improve fruit physico-chemical characteristics and ripening [22]. In addition to plant hormones, micronutrients such as boron (B) and zinc (Zn) have proven to be beneficial in ber fruit cultivation, [23] demonstrated that these micronutrients can positively impact fruit set, yield, fruit quality, and the storage life [23,24,25]. Considering above facts in mind, the present study entitled “Studies on response of ber (*Ziziphus mauritiana* L.) cv. Umran to fertilizers, micronutrients and bioregulators on growth, yield and quality” attributes of ber cv. ‘Umran’ was undertaken with following objectives: -

1. To study the effect of fertilizers, micronutrients and bioregulators on flowering and fruit growth and developments attributes
2. To find out the best combination and dose of fertilizers, micronutrients and bioregulators on flowering and fruit growth and developments attributes. You need to state the problems and objectives of the

study. And also, the significance of this study.

2. MATERIALS AND METHODS

2.1 Study Area and Experimental Design

The present investigation was carried out under Kymore plateau and Satpura hill regions during 2019-20 at Fruit Research Station Imalia, Department of Horticulture, College of Agriculture JNKVV Jabalpur, Madhya Pradesh, on Ber cv. Umran and the trees were maintained under a uniform cultural schedule. The experiment was laid out in RBD (Randomized block design) comprising 12 treatment combinations and was replicated thrice. Treatments were given twice i.e., first, before flowering and second, at fruit setting stage. The following treatment combinations are as follows: T_0: Control, T_1: RDF (N:P:K) (500:250: 250) – Soil application, T_2: RDF(N:P:K) + Foliar spray of GA_3 (50 ppm), T_3: RDF(N:P:K) + Foliar spray of NAA (50 ppm), T_4: RDF(N:P:K) + Foliar spray of GA3 + NAA (50 ppm + 50 ppm), T_5: RDF (N:P:K) + Foliar spray of KNO3 (1.0 %), T_6: RDF (N:P:K) +Urea (1.5 %) + $ZnSO_4$ (0.50%), T_7: RDF (N:P:K) + Urea (1.5 %) + $ZnSO_4$(0.50%) + Borax(0.50%), T_8: RDF (N:P:K)+ Urea (1.5%)+ZnSO4 (0.5%)+ Borax (0.5%)+CuSO4 (0.3%), T_9: RDF (N:P:K) + NPK – 18:18:18 (1.0 %), T_{10}: RDF (N:P:K) + NPK - 18:18:18 (0.5%) + ZnSO4 (0.5%) + Borax (0.5%) and T_{11}: RDF (N:P:K) + NPK -18:18:18 (1.0%) + ZnSO4 (0.5%) + Borax (0.3%).

Preparation of Solutions: Solutions of NPK, KNO_3, Urea, $ZnSO_4$, and Borax were prepared by dissolving them in distilled water to obtain the required concentration as mentioned above. GA_3 and NAA solutions were prepared in distilled water after dissolving them in the required amount of alcohol.

2.2 Application of Treatments

Prior to flowering, the first sprayings were applied during the RDF treatment. When the fruit was starting to set, a second spraying was applied. A foot sprayer was used to apply the spray.

2.3 Data Collection

2.3.1 Flowering parameters

1. Date of Flower Bud Initiation: Five uniform branches around each tree were selected and tagged. The date of flower bud initiation was noted in each tagged branch from the date of foliar application of treatments.

2. Days Taken for Flowering (50%): Days taken to 50 % flowering in each treatment were counted after the first flowering in the tagged shoots based on visual observation on all four tagged branches of different direction of each treated plant.

2.4 Fruit growth and Development Attributes

1. Fruit length (cm): The length of each fruit from stalk end to stylar end was measured with the help of vernier calipers at 60, 90,120,150 days after the fruit set and the average length of fruit was calculated.

2. Fruit diameter (cm): The diameter of each fruit was measured at the maximum thickness of the fruit by vernier calipers at 60, 90,120,150 days after the fruit set, and the average diameter of the fruit was worked out.

3. Fruit weight (g): The average weight of the fruit was calculated after the final picking as per the formula given below:

Average fruit weight = Total weight of fruits (g) / Number of fruits

4. Fruit volume (ml): Fruits were placed in measuring cylinders of 1-liter capacity filled with water. The replaced water was measured, and the data were recorded as the volume of fruits in ml, then the average value was computed.

5. Specific gravity: The specific gravity of the fruit was determined by weighing fruits from each treatment of each replication in top pan balance and then recording displaced water after sinking the fruits in water. The specific gravity was calculated by dividing the weight of the fruit by the volume of the fruit.

Please you need to state the statistical analysis used for this study.

3. RESULTS AND DISCUSSION

3.1 Flowering Parameters

The result about the Date of flower bud initiation and the number of days required for 50% flowering under various treatments is shown in Table 1. The studies showed that this attribute has been significantly impacted by the different treatments.

The earliest date of flower bud initiation (11.09.2019) and days taken to induce earliest

flowering after spray is (22 days) and the minimum days to 50% flowering (8.33 days) were recorded in treatment T_4 [RDF (N:P:K)+Foliar spray of GA_3 + NAA (50 ppm + 50 ppm)] followed by treatment T_{11} [RDF (N:P:K) + NPK -18:18:18 (1.0%) + $ZnSO_4$ (0.5%) + Borax (0.3%)], whereas the maximum day taken for flower bud initiation (19.09.2019) and the maximum days (13.67 days) to 50% flowering was recorded in T_0 (Control).

The early onset of flowering may be attributed to the influence of GA_3, which enhances leaf production and encourages vegetative growth. This boosts photosynthetic rates, leading to increased carbohydrate accumulation and ultimately the initiation of flower development, as indicated by Ujjwal et al. [26]. Additionally, NAA may contribute to the enlargement of cells, further supporting this process. These finding are in line with, Karole and Tiwari, [27], Parouss et al. [28], Kacha et al. [29].

3.2 Fruit Growth and Development Attributes

Fruit growth and development characteristics, such as fruit length, fruit breadth, fruit weight, fruit volume, and stone length, stone diameter, and stone weight, were measured and recorded under different conditions. The results of the studies showed how much the different treatments affected this attribute.

The maximum fruit length (2.94 cm), (3.59 cm), (3.84 cm), (4.53 cm) at 60, 90, 120, 150, days respectively after the fruit set presented in Table 2, the maximum fruit diameter (1.85 cm), (2.30 cm), (3.36 cm), (3.50cm), at 60, 90, 120, 150 days respectively after fruit set presented in Table 3, maximum fruit weight (36.52 g), fruit volume (36.56 ml) and specific gravity (1.047) presented in Table 4 were recorded with the application of treatment T_{11} [RDF (N:P:K) + NPK -18:18:18 (1.0%) + $ZnSO_4$ (0.5%) + Borax (0.3%)].The minimum values of fruit length (2.62 cm), (3.18 cm), (3.52 cm), (3.83 cm) at 60, 90, 120, 150 days respectively after fruit set, fruit diameter (1.56 cm), (1.93 cm), (2.85 cm), (2.99 cm) at 60,90,120,150 days respectively after fruit set, minimum fruit weight (27.50 g), fruit volume (27.22 ml), and specific gravity (0.899 gm/ml) was observed under control T_0, which was at par with treatments T_{10}, T_8, T_7, T_6, T_4, and T_2. This phenomenon may be explained by the stimulation of chlorophyll production and the enhancement of photosynthetic activity by nitrogen, phosphorus, and potash. According to research by Jat and Kacha [30], this ultimately results in higher food material storage in the tissue and larger fruit. Prasad [31], Dalal et al. [32], Dhayal et al. (2011), Mishra et al. [33], and Gill and Singh (2011) are all in agreement with these findings.

Boron boosts nitrogen uptake, facilitating photosynthesis and leading to carbohydrate accumulation, ultimately resulting in increased fruit size, as reported by Kamble et al. [34], Sharma et al. [35], Kamble et al. [34], Kumar and Shukla [36], Singh et al. [37], Nehete et al. [38].

Table 1. Effect of fertilizers, micronutrients and bio regulators on Date of flower bud initiation, Days to (50%) flowering, initial fruit set percentage and fruit retention percentage

Treatments	Date of flower bud initiation	Days to flowering 50 %
T0	19.09.2019	13.67
T1	17.09.2019	11.67
T2	14.09.2019	10.67
T3	12.09.2019	9.00
T4	11.09.2019	8.33
T5	15.09.2019	11.67
T6	13.09.2019	10.33
T7	13.09.2019	9.67
T8	12.09.2019	9.33
T9	15.09.2019	11.33
T10	11.09.2019	9.00
T11	11.09.2019	8.67
SEm±	0.79	0.59
C.D. at 5%	2.30	1.71

Table 2. Effect of fertilizers, micronutrients, and bio regulators on fruit length (cm) at different days of growth and development period at (60, 90,120,150 days)

Treatments	Fruit length (cm) at different days			
	60 days	90 days	120 days	150 days
T0	2.62	3.18	3.52	3.83
T1	2.65	3.22	3.55	3.87
T2	2.80	3.37	3.70	4.15
T3	2.78	3.34	3.68	4.12
T4	2.82	3.40	3.72	4.22
T5	2.73	3.32	3.63	4.09
T6	2.84	3.43	3.75	4.25
T7	2.85	3.49	3.78	4.29
T8	2.87	3.53	3.79	4.46
T9	2.70	3.29	3.59	4.05
T10	2.89	3.56	3.81	4.49
T11	2.94	3.59	3.84	4.53
SEm±	**0.05**	**0.077**	**0.04**	**0.11**
CD at 5%	**0.15**	**0.22**	**0.14**	**0.34**

Table 3. Effect of fertilizers, micronutrients and bioregulators on fruit Diameter at different days of growth and development period at (60, 90,120,150 days)

Treatments	Fruit Diameter (cm) at different days			
	60	90	120	150
T0	1.56	1.93	2.85	2.99
T1	1.59	1.84	2.98	3.12
T2	1.71	2.13	3.18	3.32
T3	1.68	2.10	3.15	3.19
T4	1.72	2.16	3.20	3.34
T5	1.65	2.05	3.12	3.26
T6	1.74	2.20	3.23	3.37
T7	1.77	2.23	3.25	3.41
T8	1.78	2.25	3.30	3.44
T9	1.62	2.02	3.10	3.24
T10	1.82	2.26	3.34	3.48
T11	1.85	2.30	3.36	3.50
SEm±	0.037	0.049	0.10	0.09
CD at 5%	0.10	0.144	0.29	0.26

Table 4. Effect of fertilizers, micronutrients and bioregulators on fruit weight, fruit volume and specific gravity

Treatments	Fruit weight (gm)	Fruit volume (ml)	Specific gravity(gm/ml)
T0	27.30	27.22	0.899
T1	29.30	28.23	0.923
T2	31.85	32.99	0.965
T3	31.28	32.36	0.966
T4	32.00	34.19	0.935
T5	30.72	31.82	0.965
T6	32.70	35.01	0.934
T7	33.90	35.06	0.966
T8	33.98	35.12	0.967
T9	29.88	30.32	0.929
T10	34.48	35.62	0.998
T11	36.52	36.56	1.047
SEm±	**1.05**	**1.04**	**0.022**
CD at 5%	**3.04**	**3.03**	**0.065**

Moreover, Zinc enhances fruit size by stimulating auxin production and improving sugar metabolism. It increases fruit length, diameter, fruit weight and specific gravity possibly through cell wall regulation, leading to larger and heavier fruits. Zinc maintains elevated auxin levels in fruit parts, and its role in auxin production is well-established. This results in greater fruit width and length due to enhanced water uptake, as reported by Pippal et al. [39]. These findings are in line with Joon et al. [40], Kamble et al. [34], Singh and Vashistha [41], Kamble et al. [34], Sharma et al. [35], Sharma et al. (2011), Pandey et al. [42], Nehete et al. [38], Chandra and Singh [43], Gami et al. [44].

4. CONCLUSION

On the basis of result obtained in present investigation, it is concluded that the application of treatment T4 [RDF (N:P:K)+Foliar spray of GA3 + NAA (50 ppm+50 ppm)] was found significantly superior as compared to other treatments for flowering parameter (viz., days of flower bud initiation, days to 50% flowering), whereas, treatment T11 [RDF (N:P:K) + NPK - 18:18:18 (1.0%) + ZnSO4 (0.5%) + Borax (0.3%)].was proved significantly superior as compared to other treatments for fruit growth and development attributes (viz., length of fruit (cm) and diameter of fruit (cm) at 60,90,120, and 150 DAFs, average weight of fruit (g), fruit volume, specific gravity.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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