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Response of NAA and enriched vermiwash on flowering and fruiting of Ber (*Zizyphus mauritiana* L.) in South Western Rajasthan

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Abstract
The investigation was carried out to study the entitled **"**Response of NAA and Enriched Vermiwash on Flowering and Fruiting of Ber (*Zizyphus mauritiana* L.) in South Western Rajasthan" was conducted at a farmer's field in Gangrar, Chittorgarh, Rajasthan during the Rabi season of 2024-25 to evaluate the effect of different concentrations of NAA (0, 30, and 40 ppm) and enriched vermiwash (0%, 10%, and 20%) on flowering and fruiting, of Ber variety 'Thai Apple'. The experiment was laid out in a Factorial Randomized Block Design (FRBD). NAA was applied in four sprays: before flowering, after flowering, at 50% flowering, and at the fruit development stage, while enriched vermiwash was prepared using botanicals like Datura, Neem, and Calotropis and applied at different concentrations. Observations were recorded on key flowering (initiation, 50% flowering, fruit bloom), fruiting (fruit set, drop, retention, fruit number, and diameter), and biochemical parameters (TSS, acidity, TSS:acid ratio, and ascorbic acid). The study aimed to identify the most effective treatment combination for improving flowering behavior and fruit yield, in Ber under the arid conditions of South Rajasthan.

Keywords: Ber, vermiwash, NAA, fruiting

1. Introduction
The Indian jujube (*Ziziphus mauritiana* L.) is grown mainly for its fruits which may be eaten fresh, dried or canned, smoked and pickled or used in drinks. Besides, Ber fruits also can be used for making several products like chutney, squash or juice, murabba, jam and dehydrated or dried products, (Viswanath *et al.* 2018) [15].

India ranks first among the Ber growing countries of the world with an area of 50,000 ha and annual production of 5.13 lakh MT (Anonymous, NHB Database, 2021-22). In India the major growing regions are Rajasthan, Madhya Pradesh, Uttar Pradesh, Haryana, Punjab, Gujarat, Bihar, Maharashtra, Andhra Pradesh and Tamil Nadu. The foliar application of PGRs is comparatively more effective than soil application. The beneficial effect of foliar application of PGRs is based on the fact that the nutrients reach directly to leaves, buds, petioles and flowers etc which are the sites of metabolism. It would be therefore worthwhile to improve the yield and quality of fruit crops by foliar application of PGRs. Among various plant growth regulators, Naphthalic Acetic Acid (NAA) is a synthetic plant hormone in the auxin group and an organic compound $C_{12}H_{10}O_2$. This is colourless solid and soluble in organic solvents only. NAA has been shown to greatly increase formation of cellulose fibre in plants. NAA spray was found useful in increasing fruit yield and quality (Arora and Singh 2014) [2]. Enriched vermiwash is a type of another organic liquid fertilizer that is produced by passing water through a column of earthworms. The wash is a collection of excretory products and excess secretions of earthworms along with micro nutrients from soil organic molecules (Yuvaraj *et al.*, 2007) [16]. The earthworms help to break down organic matter in the soil and create a nutrient-rich liquid that is high in beneficial microorganisms and enzymes. It is a coelomic fluid extraction which contains a mixture of enzymes, including proteases, amylases, urease, and phosphatase, plant growth stimulating hormones like cytokinin, gibberellins and vitamins along with nutrients as nitrogen in the form of mucus, nitrogenous excretory substances.

Vermiwash contains 0.50 percent nitrogen, 0.39 percent phosphorus and 0.46 percent potassium. It also increases the disease resistant power of crop. Vermiwash has great growth promoting as well as pest killing properties (Sinha *et al.* 2010) [13].

2. Materials and Methods

A lab experiment was conducted during February to May of 2024-25 at Post Harvest and Value Addition Laboratory, Department of Agriculture (Horticulture) Fruit Science, Faculty of Agriculture and Veterinary Sciences, Mewar University Gangrar, Chittorgarh (Rajasthan). The experiment was laid out in FCRD (Factorial Completely Randomized Design) with two factors, Factor-I-Enriched, Enriched Enriched Vermiwash 0%, Enriched Vermiwash 10%, Vermiwash 20% and Factor-II:-NAA-0 ppm, NAA-30 ppm, NAA-40 ppm. The method for biochemical properties analysis is followed standard method of particular parameters at different duration like 0, 30 and 60 days of storage. The data were analyzed by appropriate statistical method. The total 9 combination and tree replication in which total 27 plots in experimentation.

3. Results and Discussion

The earliest flowering initiation was observed in treatment V2N2 (Enriched Vermiwash 20% + NAA 40 ppm), which recorded flowering at 9.0 days after spray. This was followed closely by V2N1 (10.0 days) and V1N2 (13.0 days), indicating a synergistic effect of higher concentrations of both NAA and enriched vermiwash in promoting early flowering. Among the NAA levels, the mean initiation of flowering was 12.3 days for NAA at 40 ppm (N2), 14.3 days for NAA at 30 ppm (N1), and 18.0 days in the control (N0), showing a consistent decrease in days to flowering with increasing NAA levels. Among the treatments, the minimum number of days taken to 50% flowering (20.0 days) was recorded in the treatment T_9 (Enriched Vermiwash 20% + NAA 40 ppm), which was found significantly superior over rest of the treatments. It was followed by T8 (Vermiwash 20% + NAA 30 ppm) and T6 (Vermiwash 10% + NAA 40 ppm), which recorded 21.0 and 20.0 days respectively. The maximum number of days to 50% flowering (30.0 days) was observed in the control treatment T0 (No Vermiwash + No NAA). This indicates that application of NAA and enriched vermiwash had a positive effect in reducing the flowering time in Ber. The mean value showed that NAA at 40 ppm (21.0 days) was more effective in reducing flowering days compared to 30 ppm (22.8 days) and control (27.0 days). Similarly, among the vermiwash levels, 20% enriched vermiwash recorded the lowest average (21.3 days) compared to 10% (23.0 days) and 0% (26.4 days). Similar result also reported by Khachi *et al.* (2015) [9], Bhat *et al.* (2017) [4], Awadh *et al.* (2021) [3] and Priyaranjan *et al.* (2022) [11].

The highest fruit retention (44.3%) was observed in the treatment T_9 (Enriched Vermiwash 20% + NAA 40 ppm), which was significantly superior to all other treatments. This was closely followed by T8 (Vermiwash 20% + NAA 30 ppm) and T6 (Vermiwash 10% + NAA 40 ppm) with 41.9% and 39.5% fruit retention, respectively. The lowest fruit retention (27.8%) was recorded in the control treatment (T0) where no NAA or vermiwash was applied. This underlines the importance of growth regulator (NAA) and organic inputs (enriched vermiwash) in enhancing the physiological mechanisms responsible for fruit retention. Among the individual factors, the application of 40 ppm NAA recorded the highest mean fruit retention (39.5%), followed by 30 ppm NAA (36.8%), and the lowest in control (32.7%). Similarly, among enriched vermiwash levels, 20% vermiwash showed significantly higher average fruit retention (41.1%), followed by 10% (36.5%) and the lowest in 0% vermiwash (31.5%). The maximum number of fruits per plant (2290) was recorded in the treatment T_9 (Enriched Vermiwash 20% + NAA 40 ppm), followed closely by T8 (Enriched Vermiwash 20% + NAA 30 ppm) and T6 (Enriched Vermiwash 10% + NAA 40 ppm) with 2275 and 2265 fruits per plant, respectively. On the other hand, the minimum number of fruits per plant (2205) was observed in the control treatment (T0) which did not receive any application of NAA or vermiwash. This reveals the beneficial role of both plant growth regulators (NAA) and organic biostimulants (enriched vermiwash) in improving reproductive performance of Ber trees. Among individual treatments, 40 ppm NAA recorded the highest mean fruit count (2265 fruits/plant) followed by 30 ppm NAA (2250 fruits/plant) and the lowest (2227 fruits/plant) was observed in the control (0 ppm NAA). Similarly, among vermiwash levels, 20% enriched vermiwash resulted in the highest average fruit count (2270 fruits/plant), followed by 10% (2248 fruits/plant) and 0% (2223 fruits/plant). Among the different treatment combinations, the largest fruit diameter (4.73 cm) was recorded in T_9 (Enriched Vermiwash 20% + NAA 40 ppm), which was significantly superior to all other treatments. This was followed by T8 (Vermiwash 20% + NAA 30 ppm) and T6 (Vermiwash 10% + NAA 40 ppm) with fruit diameters of 4.65 cm and 4.60 cm, respectively. The lowest fruit diameter (3.90 cm) was observed in the control treatment (T0), where no application of NAA or vermiwash was made, indicating the positive impact of plant growth regulators and organic biostimulants on fruit development. Among NAA levels, 40 ppm showed the highest mean fruit diameter (4.54 cm), followed by 30 ppm (4.38 cm) and the lowest in control (4.13 cm). Similarly, the application of 20% enriched vermiwash recorded the highest average fruit diameter (4.56 cm), followed by 10% (4.40 cm) and the lowest in 0% (4.10 cm). Same result also reported by, Singh *et al.* (2017) [12], Jangid *et al.* (2018) [8], Chaudhary *et al.* (2018) [7], Chauhan *et al.* (2019) [5] and Tripathi and Badal (2022) [14].

Table 1: The effect of different levels of NAA and enriched vermiwash on initiation of flowering (days after spray) in Ber

Initiation of flowering (Days after spray)				
NAA / Enriched Vermiwash	**N_0 (NAA 0ppm)**	**N_1 (NAA 30 ppm)**	**N_2 (NAA 40 ppm)**	**Mean**
V_0: Enriched Vermiwash 0%	22.0	19.0	15.0	18.7
V_1: Enriched Vermiwash 10%	17.0	14.0	13.0	14.7
V_2: Enriched Vermiwash 20%	15.0	10.0	9.0	11.3
Mean	18.0	14.3	12.3	
	S.Em	CD		
V (Enriched Vermiwash)	0.086	0.257		
B (NAA TSS)	0.099	0.297		
B (Enriched Vermiwash) × N (NAA)	0.171	0.629		

Table 2: The effect of different levels of NAA and enriched vermiwash on days to 50% flowering in Ber

Days to 50% flowering				
NAA / Enriched Vermiwash	**N_0 (NAA 0ppm)**	**N_1 (NAA 30 ppm)**	**N_2 (NAA 40 ppm)**	**Mean**
V_0: Enriched Vermiwash 0%	30.0	26.3	23.0	26.4
V_1: Enriched Vermiwash 10%	28.0	21.0	20.0	23.0
V_2: Enriched Vermiwash 20%	23.0	21.0	20.0	21.3
Mean	27.0	22.8	21.0	
	S.Em	CD		
V (Enriched Vermiwash)	0.133	0.399		
B (NAA TSS)	0.154	0.461		
B (Enriched Vermiwash) × N (NAA)	0.266	0.978		

Table 3: The effect of different levels of NAA and enriched vermiwash on days to fruit bloom in Ber

Days to fruit bloom				
NAA / Enriched Vermiwash	**N_0 (NAA 0ppm)**	**N_1 (NAA 30 ppm)**	**N_2 (NAA 40 ppm)**	**Mean**
V_0: Enriched Vermiwash 0%	34.0	32.0	30.0	32.0
V_1: Enriched Vermiwash 10%	32.0	29.0	27.0	29.3
V_2: Enriched Vermiwash 20%	30.0	26.0	25.0	27.0
Mean	32.0	29.0	27.3	
	S.Em	CD		
V (Enriched Vermiwash)	0.100	0.299		
B (NAA TSS)	0.115	0.345		
B (Enriched Vermiwash) × N (NAA)	0.199	0.732		

Table 4: The effect of different levels of NAA and enriched vermiwash on fruit set (%) in Ber

Fruit set (%)				
NAA / Enriched Vermiwash	**N_0 (NAA 0ppm)**	**N_1 (NAA 30 ppm)**	**N_2 (NAA 40 ppm)**	**Mean**
V_0: Enriched Vermiwash 0%	48.2	52.5	54.8	51.8
V_1: Enriched Vermiwash 10%	51.2	57.9	60.4	56.5
V_2: Enriched Vermiwash 20%	56.3	62.7	65.5	61.5
Mean	51.9	57.7	60.2	
	S.Em	CD		
V (Enriched Vermiwash)	0.201	0.601		
B (NAA TSS)	0.232	0.694		
B (Enriched Vermiwash) × N (NAA)	0.401	1.473		

Table 5: The effect of different levels of NAA and enriched vermiwash on fruit drop (%) in Ber

Fruit drop (%)				
NAA / Enriched Vermiwash	**N_0 (NAA 0ppm)**	**N_1 (NAA 30 ppm)**	**N_2 (NAA 40 ppm)**	**Mean**
V_0: Enriched Vermiwash 0%	42.5	39.3	36.5	39.4
V_1: Enriched Vermiwash 10%	38.0	35.2	32.0	35.1
V_2: Enriched Vermiwash 20%	34.0	30.8	28.2	31.0
Mean	38.2	35.1	32.2	
	S.Em	CD		
V (Enriched Vermiwash)	0.040	0.119		
B (NAA TSS)	0.046	0.137		
B (Enriched Vermiwash) × N (NAA)	0.079	0.291		

Table 6: The effect of different levels of NAA and enriched vermiwash on fruit retention (%) in Ber

Fruit retention (%)				
NAA / Enriched Vermiwash	**N_0 (NAA 0ppm)**	**N_1 (NAA 30 ppm)**	**N_2 (NAA 40 ppm)**	**Mean**
V_0: Enriched Vermiwash 0%	27.8	31.9	34.7	31.5
V_1: Enriched Vermiwash 10%	33.2	36.7	39.5	36.5
V_2: Enriched Vermiwash 20%	37.1	41.9	44.3	41.1
Mean	32.7	36.8	39.5	
	S.Em	CD		
V (Enriched Vermiwash)	0.048	0.143		
B (NAA TSS)	0.055	0.165		
B (Enriched Vermiwash) × N (NAA)	0.095	0.350		

Table 7: The effect of different levels of NAA and enriched vermiwash on fruit diameter (cm) in Ber

Fruit diameter (cm)				
NAA / Enriched Vermiwash	**N_0 (NAA 0ppm)**	**N_1 (NAA 30 ppm)**	**N_2 (NAA 40 ppm)**	**Mean**
V_0: Enriched Vermiwash 0%	3.90	4.10	4.30	4.10
V_1: Enriched Vermiwash 10%	4.20	4.40	4.60	4.40
V_2: Enriched Vermiwash 20%	4.30	4.65	4.73	4.56
Mean	4.13	4.38	4.54	
	S.Em	CD		
V (Enriched Vermiwash)	0.008	0.025		
B (NAA TSS)	0.009	0.028		
B (Enriched Vermiwash) × N (NAA)	0.016	0.060		

4. Conclusion

The present investigation on *"*Response of NAA and Enriched Vermiwash on Flowering and Fruiting of Ber (*Ziziphus mauritiana* L.) in South Western Rajasthan*"* clearly revealed that the combined application of NAA at 40 ppm and enriched vermiwash at 20% (T_9: V_2N_2) significantly improved flowering and fruiting attributes of ber under field conditions. This treatment led to the earliest initiation of flowering, reduced days to 50% flowering and fruit bloom, and recorded the highest fruit set percentage, fruit retention, and number of fruits per plant. Therefore, the combination of NAA 40 ppm + enriched vermiwash 20% can be recommended as a sustainable and effective practice for improving yield and quality of Ber fruit in the arid region of South Western Rajasthan.

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