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Effect of foliar application of micronutrients and pre harvest bagging on growth and yield of custard apple (*Annona squamosa* L.) cv. GJCA-1

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Abstract
The present investigation entitled "effect of foliar application of micronutrients and pre harvest bagging on growth and yield of custard apple (*Annona Squamosa* L.)." was conducted at Fruit Research Station, Madhadibaug, College of Horticulture, JAU., Junagadh, Gujarat. during the year 2024. Fifteen treatment combinations comprising three level of foliar application of micronutrients at different nodes *viz*., control (M_0), multi-micronutrient grade IV @ 1% (M_1), multi-micronutrient grade IV @ 1.5% (M_2) and five level of pre harvest bagging *viz*., control (B_0), news paper bag (B_1), white paper bag (B_2), brown paper bag (B_3) and non-woven bag (B_4), were allocated in randomized block design with factorial concept in three repetition. The results revealed that growth and yield parameters were significantly influenced by the various level of micronutrients and pre harvest bagging. Multi-micronutrient grade IV @ 1% significantly increase the plant height (49 m), tree canopy spread E-W (0.46 m) and N-S (0.47 m), fruit weight (175.50 g), fruit yield per plant (14.61 kg) and yield per hectare (4.06 t). Among the pre harvest bagging treatments, brown paper bagging (B_3) significantly increase the fruit weight (177.34 g), yield per plant (14.27) and yield per hectare (3.96 t/ha). Furthermore, the interaction effect between micronutrients and pre harvest bagging found significant with parameters like; fruit weight (203.67 g), yield per plant (18.13 kg) and yield per hectare (5.03 t/ha) in treatment combination multi-micronutrient grade IV @ 1% + brown paper bagging (B_3).

Keywords: Custard apple, multi-micronutrient grade IV, bagging, yield etc.

Introduction
Custard apple (*Annona squamosa* L.) is one of the most significant dryland fruit crops in India. It is native to the West Indies and South America, from where it spread to various parts of the world. Custard apple belongs to the family Annonaceae and includes 40 genera and 120 species, of which only five are edible. Among these, custard apple (*Annona squamosa* L.) is the most valued. Other species include *Annona reticulata* (ramphal), *Annona cherimola* (laxmanphal), and *Annona atemoya* (hanumanphal). It is often referred to as the "poor man's fruit."

The common varieties of custard apple include Pink Mammoth, Balanagar, Red Sitaphal, Barbados, and British Guinea. "Sindhan" is a local variety predominantly found in the Girnar hills of the Junagadh district in Gujarat. A new variety named Gujarat Junagadh Custard Apple-1 (GJCA-1) has been developed from the Sindhan variety and released by Junagadh Agricultural University (JAU), Junagadh.

The custard apple has become established in many tropical and subtropical regions. This plant is drought-tolerant and thrives in shallow soil with minimal care. It is deciduous, shedding its leaves during the winter months. New growth appears in spring, marked by the emergence of flowers. The custard apple is valued for its nutritional benefits. The ripe fruits are primarily consumed fresh, and there is a high demand for custard apples in the preparation of ice cream and pudding. Fruit pulp contains protein (5.20 g), fat (0.50-0.60 g), carbohydrates (59.00 g), crude fibre (0.90-6.60 g), calcium (60.00 mg), phosphorus (80.00 mg), iron (105.00 mg), thiamine (0.07-0.12 mg), riboflavin (0.09-0.17 mg), ascorbic acid (15.00-44.40 mg) and nicotinic acid (0.50 mg) per 100 g of edible portion of custard apple (Nair and Agrawal, 2017) [15].

Micronutrients play a crucial role in plant nutrition and production as they are involved in various enzyme systems, each fulfilling specific functions. For example, copper, iron, and molybdenum function as electron carriers in oxidation-reduction reactions that are essential for photosynthesis and metabolic processes. Additionally, zinc and manganese help connect enzymes to their substrates (Raja, 2009) [18]. Micronutrients are generally more available to plants when applied as a foliar spray rather than through soil application. Although these nutrients are required in much smaller quantities compared to primary nutrients, they are equally essential for plant metabolism (Katyal, 2004) [8].

Micronutrients are essential for fruit production, and deficiencies can reduce yields. Foliar application of these nutrients after full bloom can improve both fruit quality and quantity. Zinc supports chlorophyll development and enzyme activation, while boron is vital for cell division and sugar movement, resulting in larger fruit. Iron boosts chlorophyll levels, enhancing leaf colour and plant health.

The impact of bagging on the red (anthocyanin) coloration of fruits shows that shading diminishes colour development in red-fleshed varieties. While bagging does not alter the coloration of non-red fruits, it promotes uniform colouring and helps prevent abnormal skin coloration, such as greening in Asian pears. Fruit bagging is a simple, safe, and eco-friendly technique that protects fruits from pathogens and insect attacks while enhancing their appearance and yield. In fact, bagging treatments can improve the skin color, making the final product more visually appealing than untreated fruits (Ali *et al.* 2021) [1].

Materials and Methods

The present investigation entitled, "Effect of foliar application of micronutrients and pre harvest bagging on growth and yield of custard apple (*Annona squamosa* L.) cv. GJCA-1" was carried out at Fruit Research Station, Madhadibaug, College of Horticulture, Junagadh Agricultural University, Junagadh (Gujarat). The experiment was laid out in Randomized Block Design with factorial concept with fifteen treatment combinations with three repetitions, consisting three levels of foliar application of micronutrient grade IV *viz*., Control (M_0), Multi-micronutrient grade IV @ 1% (M_1) and Multi-micronutrient grade IV @ 1.5% (M_2) five levels of pre harvest bagging *viz*., Control (B_0), News paper bag (B_1), White bag (B_2), Brown paper bag (B_3) and Non-woven bag (B_4). Foliar applications of each treatment were carried out twice: first at the flowering stage and again three weeks after the initial spray. After completion of the fruit set, the bagging material included. In bagging, perforations were made on both sides of the bag for proper ventilation required for fruit growth and development. All fruits are selected for bagging. The different material bags were tied with cello tape properly, so that they would not fall, and there was no open space for the entry of insects or rainwater, etc. The mature and uniformly sized fruits were harvested from each tree and observations were made regarding the fruit yield parameters.

Results and Discussion

An appraisal of data in table 1 and 2 shows the effect of micronutrients and pre harvest bagging on growth and yield parameters of custard apple.

Growth parameters

The maximum incremental plant height (0.49 m), tree canopy spread E-W (0.46 m) and N-S (0.47 m) were observed in foliar application of multi-micronutrient grade IV @ 1% (M_1). Incremental plant height and tree canopy spread E-W were at par with foliar application of multi-micronutrient grade IV @ 1.5% (M_2). While, minimum incremental plant height (0.45 m), tree canopy spread E-W (0.42 m) and N-S (0.43 m) were noted in the control treatment (M_0). This might be due to reason that the multi-micronutrient boosts canopy spread by enhancing photosynthesis and promoting balanced shoot and root growth. Foliar application of micronutrients boost photosynthetic compounds in plant tissues, promoting the synthesis of tryptophan, a precursor to indole-3-acetic acid (IAA), which enhances vegetative growth (Thirupathaiah *et al.* 2017) [24]. Similar results were observed by Ram and Bose, (2000) [19] in mandarin orange, Neware *et al.* (2017) [16] and Bhanukar *et al.* (2018) [2] in sweet orange and Mishra and Polara (2020) [14] in pomegranate. Further, with respect to pre harvest bagging and interaction effect was found non-significant.

Yield parameters

The maximum fruit weight (175.50 g) were observed in foliar application of multi-micronutrient grade IV @ 1% (M_1), which was at par with multi-micronutrient grade IV @ 1.5%. While, the minimum fruit weight (157.11 g) was recorded in control treatment (M_0). The increase in fruit weight due to micronutrients may be attributed to the enhanced mobilization of metabolites within the fruits, as well as their role in cell division and cell expansion. Additionally, there may be an increase in the volume of intercellular space within mesocarpic cells. Zinc plays a vital role in promoting starch formation, while boron is actively involved in the transportation of carbohydrates in plants. The above finding is in accordance with the result of Kumar *et al.* (2013) [10] in guava. Similar result was also found by Dutta and Dhua (2002) [4] in mango and Singh *et al.* (2017) [17] in mango which are agreement with the present findings.

Significantly the maximum yield (14.61 kg/tree) and yield per hectare (4.06 t/ha) were obtained with foliar application of multi-micronutrients grade IV @ 1% (M_1). The minimum yield (11.11 kg/tree) and yield per hectare (3.09 t/ha) were obtained under control treatment (M_0). This might be due to multi-micronutrient grade IV increase yield by supplying nutrients, which play key role in enzyme activation, chlorophyll formation, pollen viability and nutrient transport. This enhances photosynthesis, flowering and overall plant vigour, leading to improved crop productivity and yield. These findings are also supported by earlier reports of Jat and Kacha (2014) [7] in guava, Singh *et al.* (2017) [23] in mango Rathod *et al.* (2023) [20] in custard apple and Saini *et al.* (2019) [21] in fruit crops.

The effect of pre harvest bagging were also found significant and maximum fruit weight (177.34 g) was recorded with brown paper bag (B_3) which was at par with non-woven bag (B_4) and news paper bag (B_1). Significantly, minimum fruit weight (159.51 g) was noted in control (B_0). They allow proper air circulation, reduce heat build-up, enhances photosynthetic accumulation leading to better growth and increased weight. According to Dutta and Majumder (2012) [5] pre harvest improved the fruit weight

and size through the conducive effect such as increased relative humidity and consequently reduced fruit water loss. Kutiyu (2014) [11] also emphasized that change fruit weight by covering of different bags might be due to interaction between light intensity and favourable temperature and moisture regime inside the bag. Similar results were observed by Debnath *et al.* (2006) [3] and Rahman *et al.* (2018) [17] in guava and Lakshmi *et al.* (2024) [12] in custard apple.

The highest fruit yield per plant (14.27 kg/plant) and yield per hectare (3.96 t/ha) were registered in brown paper bagging (B_3), which was at par with non-woven bagging (B_4). Whereas, minimum yield per plant (11.48 kg/plant) and yield per plant (3.19 t/ha) were registered in control treatment (B_0). The increase in fruit yield of treated plants is likely due to their enhanced physiological activity, which allows for better food storage for fruit development. This creates a favorable microenvironment that improves fruit quality, colour, and marketability, resulting in a higher yield per plant. The results are in accordance with in Kireeti *et al.* (2018) [19] in mango and Sakromi *et al.* (2019) [20] in pomegranate

Interaction effect shown that the treatment combination of foliar application of multi-micronutrient grade IV @ 1% and brown paper bagging (M_1B_3) recorded highest fruit weight (203.67 g), yield per plant (18.13 kg/tree) and yield per hectare (5.05 t/ha). While the lowest fruit weight (152.97 g), yield per plant (10.62 kg/tree) and yield per hectare (2.95 t/ha) were recorded under control treatment (M_0B_0). This contributes to the increased fruit weight following pre-harvest bagging, which may also reflect the fruit's larger size and enhanced water accumulation and soluble solid deposition. The present investigation is in conformity with results reported by Jakhar and Pathak (2014) [6] in mango. Micronutrients improve photosynthesis and fruit development, while brown paper bagging reduces stress and enhances fruit uniformity, leading to healthier plants and higher marketable yields. The results are in accordance with Mishra *et al.* (2017) [13] in guava.

Table 1: Effect of foliar application of micronutrients and pre harvest bagging on incremental plant height, tree canopy spread E-W and N-S, fruit weight, fruit yield per plant and yield per hectare of custard apple

Treatment	Incremental plant height (m)	Tree canopy spread		Fruit weight (g)	Fruit yield per plant (kg/plant)	Fruit yield per hectare (t/ha)
		E-W (m)	N-S (m)			
Level of multi-micronutrient grade IV (M)						
M_0	0.45	0.42	0.43	157.11	11.11	3.09
M_1	0.49	0.46	0.47	175.50	14.61	4.06
M_2	0.47	0.45	0.44	169.04	12.71	3.53
S.Em.±	0.009	0.008	0.008	3.051	0.321	0.089
C.D. at 5%	0.03	0.02	0.02	8.84	0.93	0.26
Level of pre harvest bagging (B)						
B_0	0.46	0.43	0.44	159.51	11.48	3.19
B_1	0.46	0.45	0.43	166.17	12.64	3.51
B_2	0.47	0.44	0.46	164.91	12.52	3.48
B_3	0.48	0.45	0.45	177.34	14.27	3.96
B_4	0.47	0.45	0.44	169.67	13.15	3.65
S.Em.±	0.011	0.011	0.111	3.939	0.414	0.115
C.D. at 5%	NS	NS	NS	11.41	1.20	0.33
Interaction (M × B)						
S.Em.±	0.020	0.019	0.019	6.823	0.718	0.119
C.D. at 5%	NS	NS	NS	19.76	2.08	0.58
C.V.%	7.23	7.18	7.27	7.05	9.70	9.70

Table 2: Interaction effect of foliar application of micronutrients and pre harvest bagging on fruit weight, fruit yield per plant and yield per hectare of custard apple

Treatment Combination		Fruit weight (g)	Yield per plant (kg)	Yield per hectare (t)
M_0B_0	Control	152.97	10.62	2.95
M_0B_1	Control + News paper bag	157.28	11.17	3.11
M_0B_2	Control + White paper bag	158.59	11.10	3.08
M_0B_3	Control + Brown paper bag	158.42	11.45	3.18
M_0B_4	Control + Non-woven bag	158.33	11.20	3.11
M_1B_0	Multi-micronutrient grade IV @ 1% + Control	157.02	11.80	3.28
M_1B_1	Multi-micronutrient grade IV @ 1% + News paper bag	170.96	13.91	3.86
M_1B_2	Multi-micronutrient grade IV @ 1% + White paper bag	175.27	14.79	4.11
M_1B_3	Multi-micronutrient grade IV @ 1% + Brown paper bag	203.67	18.13	5.03
M_1B_4	Multi-micronutrient grade IV @ 1% + Non-woven bag	170.60	14.39	4.00
M_2B_0	Control + News paper bag	168.57	12.01	3.33
M_2B_1	Multi-micronutrient grade IV @ 1.5% + News paper bag	170.24	12.82	3.56
M_2B_2	Multi-micronutrient grade IV @ 1.5% + White paper bag	160.91	11.66	3.23
M_2B_3	Multi-micronutrient grade IV @ 1.5% + Brown paper bag	169.91	13.21	3.67
M_2B_4	Multi-micronutrient grade IV @ 1.5% + Non-woven bag	180.08	13.85	3.85
	S. Em.±	6.823	0.718	0.119
	C.D. at 5%	19.76	2.08	0.58
	C. V.%	7.05	9.70	9.70

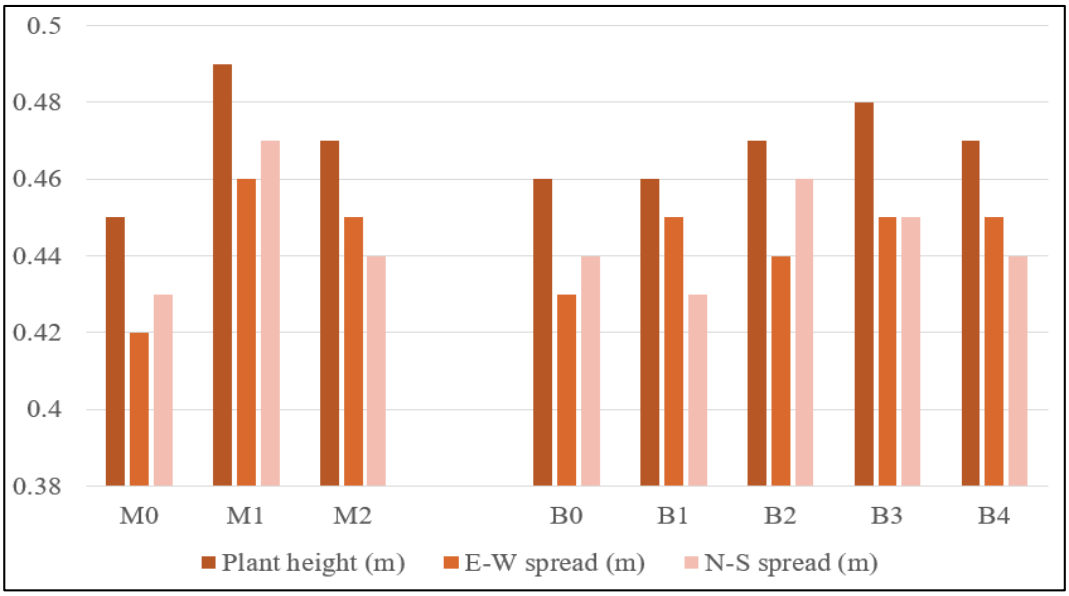

Fig 1: Effect of foliar application of micronutrients and pre harvest bagging on fruit plant height, canopy spread E-W and N-S.

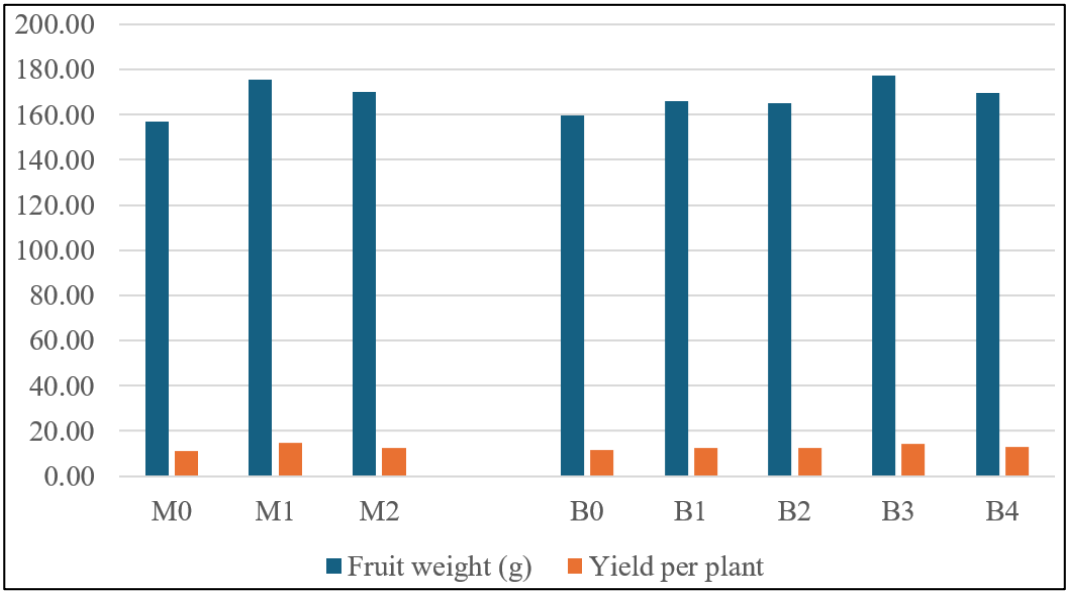

Fig 2: Effect of foliar application of micronutrients and pre harvest bagging on fruit weight and yield per plant.

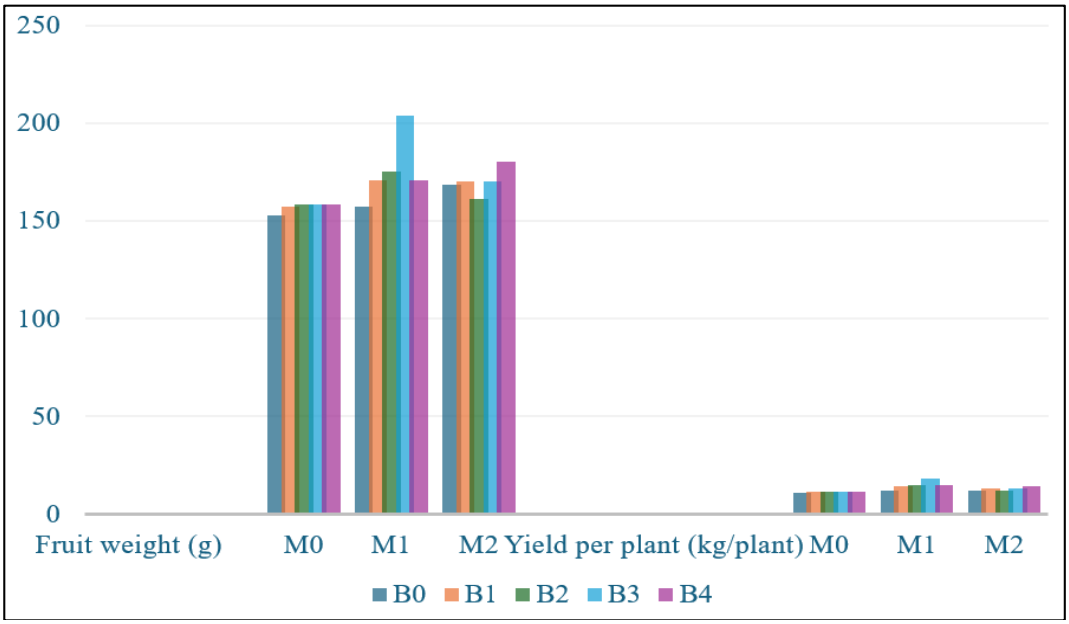

Fig 3: Interaction effect of foliar application of micronutrients and pre harvest bagging on fruit weight and yield per plant.

Conclusion

It can be concluded that applying a multi-micronutrient grade IV @ 1% significantly impacts several growth and yield parameters of custard apple plants. Specifically, it positively influenced plant height (m), canopy spread in both east-west and north-south directions (m), fruit weight (g), yield per plant (kg), and yield per hectare (t). Additionally, using a brown paper bag had a significant positive effect on fruit weight (g), yield per plant (kg), and yield per hectare (t). The combination of the multi-micronutrient grade IV at 1% and the brown paper bag treatment was found to be the most effective for enhancing fruit weight and yield-related traits.

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