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Yield Attributing Traits and Economic Efficacy of Pineapple as Influenced by Plant Growth Regulators and Micronutrients

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ABSTRACT: An experiment was conducted to study the influence of growth regulators and micronutrients on yield attributing traits and economic efficacy of pineapple (*Ananas comosus* L.) cv. MD-2. Challenges faced by pineapple growing farmers are not getting optimum and uniform-sized fruits required for high yield which leads to fetching lesser prices in the market and the fruits are also of no export standards. Therefore, the study was conducted during 2020-21 and 2021-22 to find out the effective concentration of plant growth regulators and micronutrients as well as their combination for obtaining a high yield of pineapple fruits. In the present study, it was observed that the application of growth regulators and micronutrients at the flower initiation stage was found beneficial for increasing the yield of pineapple fruits. While the combined spraying of NAA 200 mg L^{-1} along with boron 100 mg L^{-1} and zinc 100 mg L^{-1} at the flower initiation stage was beneficial for getting higher fruit yield (35.98 ton ha^{-1}) and maximizing the gross return (₹ 8.16 lakhs ha^{-1}) as well as net return (₹ 4.57 lakhs ha^{-1}) with a high benefit-cost ratio (2.33) of pineapple cv.MD-2.

Keywords: Plant growth regulators, micronutrients, NAA (naphthalene acetic acid), GA (gibberellic acid), BR (brassinosteroid), boron, zinc, yield, economics, pineapple, MD-2.

INTRODUCTION

In the Bromeliaceae family, the pineapple (*Ananas comosus* L.) is one of the most important commercial fruits in the world and is believed to have originated in Brazil (Sharma *et al.*, 2022). India is the fifth largest producer of pineapple with 0.11 MHA hectares area and 17.99 mt productions with productivity of 16.8 t ha^{-1} (Anonymous, 2020). It is cost-effective to use plant growth regulators due to their effectiveness at very low concentrations. The importance of growth regulators in regulating plant growth and development is now widely acknowledged. The plant growth regulator such as naphthalene acetic acid (NAA), gibberellic acid (GA), and brassinosteroids (BR) are useful to increase fruit weight and ultimately increase fruit yield (Singh and Chohan 1984; Shinde *et al.*, 2008; Pal *et al.*, 2010; Li *et al.*, 2011; Li and Sun, 2010). Apart from PGRs, micronutrients also play a vital role in crop yield and the quality of pineapple. According to Prof. R.K. Nayak (Associate Professor, Soil Science, OUAT), the soil of Odisha suffers from micronutrient deficiency especially boron and zinc (Rout, 2019). There is no doubt elements like nitrogen, phosphorus, and potash play a vital role in promoting plant vigour and production but micronutrients like Fe, Zn, Mn, Cu, and B are also equally important, despite their requirement in micro quantities (Yadav and Solanki 2015). A sufficient amount of micronutrient application is necessary for better plant growth which ultimately results in a higher yield, better flowering, and higher fruit set (Ram and Bose 2000) whereas its deficiency leads to a reduction in the productivity of fruit crops (Kumar 2002; Zagade *et al.*, 2017). Hence, an attempt has been made to modify the growth in terms of fruit weight and size by use of appropriate plant growth regulators and micronutrients with proper doses in pineapple to increase yield with economic benefit.

MATERIAL AND METHODS

A field trial on pineapple cv. MD-2 was conducted at Central Horticultural Experiment Station, Aignia, Bhubaneswar, India during 2020-21 and 2021-22. Pineapple was planted in a double-row system of planting (60 × 70 × 90 cm). The experiment consisted of 14 treatments, and foliar application of the plant growth regulators and micronutrients was done at the flower initiation stage. The experiment was arranged in a randomized completed block design (RBCD) with three replications using 25 plants per replication. The treatments were comprised of T_1 – control; T_2 – B 100 mg L^{-1}, T_3 - NAA 100 mg L^{-1}; T_4 - NAA 200 mg L^{-1}; T_5 - NAA 200 + B 100 + Zn 100 mg L^{-1}; T_6 - NAA 200 + B 100 + Zn 100 mg L^{-1}; T_7 – GA 50 mg L^{-1}; T_8 - GA 100 mg L^{-1}; T_9 – GA 50 + B 100 + Zn 100 mg L^{-1}; T_{10} – GA 100 + B 100 + Zn 100 mg L^{-1}; T_{11} – BR 2 mg L^{-1}; T_{12} - BR 4 mg L^{-1}; T_{13} – BR 2 + B 100 + Zn 100 mg L^{-1}; T_{14} – BR 4 + B 100 + Zn 100 mg L^{-1}. The cost of production was calculated considering labour charges, cost of manures, fertilizers, growth regulators, micronutrients, suckers, and other inputs used for raising the crops. The net return was computed as the difference between the gross return and the cost of production. The benefit-cost ratio was calculated by dividing the gross return by the cost of production.

RESULTS AND DISCUSSION

Table 1 reveals that yield of pineapple was significantly influenced by the application of growth regulators and micronutrients. In the main crop, the maximum fruit yield (40.97 ton ha^{-1}) was recorded under treatment T6 (NAA 200 + B 100 + Zn 100 mg L^{-1}) followed by treatment T_5 (NAA 200 + B 100 + Zn 100 mg L^{-1}) *i.e.* 38.01 ton ha^{-1}, whereas, the minimum yield of 29.83 ton ha^{-1} was observed in T_1 (control). A similar pattern was observed in the ratoon crop, where the maximum fruit yield (30.99 ton ha^{-1}) was recorded under treatment T_6 (NAA 200 + B 100 + Zn 100 mgL^{-1}) followed by treatment T_5 (NAA 200 + B 100 + Zn 100 mg L^{-1}) *i.e.* 29.96 ton ha^{-1}, whereas, the minimum yield of 22.38 ton ha^{-1} was observed in T_1 (control). Therefore, from the mean data, it was observed that the maximum yield (35.98 ton ha^{-1}) was recorded in treatment T_6 followed by treatment T_5 (29.96 ton ha^{-1}), and the minimum yield was recorded in treatment T_1 (26.11 ton ha^{-1}). This might be due to the effect of NAA attributed to the increase in cell division and cell elongation through the enlargement of vacuoles and the loosening of cell walls after increasing the plasticity of the cell wall which results in bigger fruits ultimately increasing the fruit yield (Ranjan *et al*., 2003; Agrawal and Dikshit 2008). These findings are in accordance with the results obtained by Nkansah *et al*. (2012) in mango, Srivastava *et al*. (2009) in aonla, Yadav *et al*. (2021) in ber, and Prajapati *et al*. (2016) in custard apple. Spraying of micronutrients such as zinc along with NAA might have also increased the fruit weight and it is evident that zinc increases the biosynthesis of auxin (Mašev and Kutáˇcek, 1966; Malik *et al*., 2000). According to Shireen *et al*. (2018), boron also plays a vital role in increasing fruit size which might be due to the increase in cell division and carbohydrate metabolism. Therefore, it may be concluded that the combined role of NAA, boron, and zinc might be the reason for increasing the fruit size which results in higher fruit yield in pineapple. A similar observation was reported by Kumari and Deb (2018) who reported that there is an increase in fruit weight when pineapple fruits are treated with a combined formulation of zinc and boron. These findings were supported by Amorim *et al*. (2013); Yong-hong lin and Jen-hshuan chen (2011) in pineapple, Baiea *et al*. (2015) in mango, Ghanta *et al.* (1992) as well as Pant and Lavania (1998) in papaya.

The data (Table 2) of the main crop (2021) revealed that the highest cost of production (₹ 4.87 lakhs ha^{-1}) was recorded in the treatment T_{10} (GA 100 + B 100 + Zn 100 mg L^{-1}) followed by the treatment T_8 (GA 100 mg L^{-1}) *i.e.* ₹ 4.85 lakhs ha^{-1}, and T_9 (GA 50 + B 100 + Zn 100 mg L^{-1}) *i.e.* ₹ 4.65 lakhs ha^{-1}. While the lowest cost of cultivation (₹ 4.33 lakhs ha^{-1}) was recorded in control (T_1). Similarly, in the case of the ratoon crop (2022), the highest cost of production was recorded in T_{10} *i.e.* ₹ 3.13 lakhs ha^{-1} followed by T_8 *i.e.* ₹ 3.11 lakhs $ha^{-1,}$ and T_9 *i.e.* ₹ 2.91 lakhs ha^{-1} and lowest in fruits with no treatment or control (T_1) *i.e.* ₹ 2.59 lakhs ha^{-1}. Therefore, the mean data for two years presented in Table 2 reveals that the highest cost of production was recorded in T_{10} (GA 100 + B 100 + Zn 100 mg L^{-1}) *i.e.* ₹ 4.00 lakhs ha^{-1} followed by the treatment T_8 (GA 100 mg L^{-1}) *i.e.* ₹ 3.98 lakhs ha^{-1}, and T_9 (GA 50 + B 100 + Zn 100 mg L^{-1}) *i.e.* ₹ 3.78 lakhs ha^{-1} and the lowest cost of cultivation was recorded in control (T_1) *i.e.* ₹ 3.46 lakhs ha^{-1}.

The gross return of the treatments influenced by plant growth regulators and micronutrients is present in Table 2. In the main crop (2021), the highest gross return per hectare *i.e.* ₹ 9.29 lakhs ha^{-1} was obtained in treatment T_6 (NAA 200 + B 100 + Zn 100 mg L^{-1}) followed by treatment T_5 (NAA 100 + B 100 + Zn 100 mg L^{-1}) *i.e.* ₹ 8.62 lakhs ha^{-1}. While the lowest gross return was recorded in control (T_{10}) *i.e.* ₹ 6.77 lakhs ha^{-1}. Similarly in the ratoon crops (2022), the highest gross return was observed in T_6 (NAA 200 + B 100 + Zn 100 mg L^{-1}) *i.e.* ₹ 7.03 lakhs ha^{-1} followed by T_5 (NAA 100 + B 100 + Zn 100 mg L^{-1}) *i.e.* ₹ 6.80 lakhs ha^{-1} and the lowest was observed in T_1 (control) *i.e.* ₹ 5.08 lakhs ha^{-1}. Therefore, the mean data reveals that the highest gross return was recorded in T_6 (NAA 200 + B 100 + Zn 100 mg L^{-1}) *i.e.* ₹ 8.16 lakhs ha^{-1} followed by T_5 (NAA 100 + B 100 + Zn 100 mg L^{-1}) *i.e.* ₹ 7.71 lakhs ha^{-1} and the lowest was observed in T_1 (control) *i.e.* ₹ 5.92 lakhs ha^{-1}.

The most important aspect of economics is the net return and the benefit/cost (B/C) ratio is presented in Table 2. In the main crop (2021), it is observed that maximum net return *i.e.* ₹ 4.83 lakhs ha^{-1}, and B/C ratio *i.e.* 2.08 was obtained in treatment T_6 (NAA 200 + B 100 + Zn 100 mg L^{-1}) followed by T_5 (NAA 100 + B 100 + Zn 100 mg L^{-1}) with a net return of ₹ 4.18 lakhs ha^{-1} and B/C ratio of 1.94. While the lowest net return and B/C ratio were recorded in T_{11} (BR 2 mg L^{-1}) *i.e.* ₹ 2.40 lakhs ha^{-1} and 1.54 respectively. Similarly in the ratoon crops (2022), maximum net return *i.e.* ₹ 4.31 lakhs ha^{-1}, and B/C ratio *i.e.* 2.58 was obtained in treatment T_6 (NAA 200 + B 100 + Zn 100 mg L^{-1}) followed by T_5 (NAA 100 + B 100 + Zn 100 mg L^{-1}) with a net return of ₹ 4.09 lakhs ha^{-1} and B/C ratio of 2.51. While the lowest net return and B/C ratio were recorded in T_{11} (BR 2 mg L^{-1}) *i.e.* ₹ 2.44 lakhs ha^{-1} and 1.90 respectively. Therefore in mean data, the highest net return and B/C ratio was recorded in T_6 (NAA 200 + B 100 + Zn 100 mg L^{-1}) *i.e.* ₹ 4.57 lakhs ha^{-1} and 2.33 respectively followed by T_5 (NAA 100 + B 100 + Zn 100 mg L^{-1}) *i.e.* ₹ 4.13 lakhs ha^{-1} of net return with B/C ratio of 2.23 and the lowest was observed in T_{11} (BR 2 mg L^{-1}) *i.e.* ₹ 2.42 lakhs ha^{-1} with B/C ratio of 1.72. It is clearly observed that fruits treated with NAA 200 + B 100 + Zn 100 mg L^{-1} showed maximum gross return and net return which resulted in a high B/C ratio. It might be due to the increase in fruit weight due to the interaction effect of NAA, boron, and zinc as discussed earlier in this paper. The results confirm the findings of Sarkar *et al.* (2022), Prajapati *et al.* (2016), and Thorat *et al.* (2018). It is observed that the lowest net return and B/C ratio was observed in fruits treated with brassinosteroid 2 mg L^{-1}, it is due to the high cost of brassinosteroid and no significant increase in fruit weight compared to control.

Table 1: Influence of PGRs and micronutrients on yield (tons ha^{-1}) of pineapple.

Treatments (mg L^{-1})	Yield (tons ha^{-1}) 2021	2022	Mean
T_1 - Control	29.83	22.38	26.11
T_2 - B 100 + Zn 100	31.32	23.98	27.65
T_3 – NAA 100	34.82	26.11	30.47
T_4 – NAA 200	36.30	28.56	32.43
T_5 – NAA 100 + B 100 + Zn 100	38.01	29.96	33.99
T_6– NAA 200 + B 100 + Zn 100	40.97	30.99	35.98
T_7 – GA 50	33.90	25.55	29.72
T_8 – GA 100	34.10	25.64	29.87
T_9 – GA 50 + B 100 + Zn 100	36.51	28.83	32.67
T_{10} – GA 100 + B 100 + Zn 100	36.82	29.06	32.94
T_{11} – BR 2	30.17	22.67	26.42
T_{12} – BR 4	30.42	23.13	26.78
T_{13} – BR 2 + B 100 + Zn 100	31.81	24.28	28.04
T_{14} – BR 4 + B 100 + Zn 100	32.27	24.82	28.54
SEm (±)	0.345	0.351	0.348
CD (5%)	1.00	1.02	1.01

Table 2: Influence of PGRs and micronutrients on cost of production, gross return, net return, and benefit cost ratio of pineapple.

Treatments (mg L^{-1})	CP (₹ in lakhs)			GR (₹ in lakhs)			NR (₹ in lakhs)			B/C ratio		
	2021	2022	Mean	2021	2022	Mean	2021	2022	Mean	2021	2022	Mean
T_1 : Control	4.33	2.59	3.46	6.77	5.08	5.92	2.43	2.48	2.46	1.56	1.96	1.76
T_2 : B 100 + Zn 100	4.43	2.69	3.56	7.10	5.44	6.27	2.67	2.75	2.71	1.60	2.02	1.81
T_3 : NAA 100	4.42	2.68	3.55	7.90	5.92	6.91	3.47	3.24	3.36	1.79	2.21	2.00
T_4 : NAA 200	4.44	2.70	3.57	8.23	6.48	7.35	3.79	3.78	3.79	1.86	2.40	2.13
T_5 : NAA 100 + B 100 + Zn 100	4.44	2.70	3.57	8.62	6.80	7.71	4.18	4.09	4.13	1.94	2.51	2.23
T_6 : NAA 200 + B 100 + Zn 100	4.46	2.72	3.59	9.29	7.03	8.16	4.83	4.31	4.57	2.08	2.58	2.33
T_7 : GA 50	4.63	2.89	3.76	7.69	5.80	6.74	3.06	2.91	2.98	1.66	2.01	1.83
T_8 : GA 100	4.85	3.11	3.98	7.73	5.82	6.78	2.88	2.71	2.80	1.59	1.87	1.73
T_9 : GA 50 + B 100 + Zn 100	4.65	2.91	3.78	8.28	6.54	7.41	3.63	3.63	3.63	1.78	2.25	2.01
T_{10} : GA 100 + B 100 + Zn 100	4.87	3.13	4.00	8.35	6.59	7.47	3.48	3.46	3.47	1.71	2.10	1.91
T_{11} : BR 2	4.44	2.70	3.57	6.84	5.14	5.99	2.40	2.44	2.42	1.54	1.90	1.72
T_{12} : BR 4	4.48	2.74	3.61	6.90	5.25	6.07	2.42	2.51	2.47	1.54	1.92	1.73
T_{13} : BR 2 + B 100 + Zn 100	4.46	2.72	3.59	7.21	5.51	6.36	2.75	2.78	2.77	1.62	2.02	1.82
T_{14} : BR 4 + B 100 + Zn 100	4.50	2.76	3.63	7.32	5.63	6.47	2.82	2.87	2.84	1.63	2.04	1.83
SEm (±)	-	-	-	0.078	0.080	0.079	0.078	0.080	0.079	0.017	0.029	0.023
CD (5%)	-	-	-	0.23	0.23	0.23	0.23	0.23	0.23	0.05	0.08	0.07

*GR – Gross return, CP – Cost of production, NR - Net return, 2021 – Main crop, 2022 – Ratoon crop; *Selling price – Rs. 25/kg

CONCLUSION

Based on the finding of the investigation it may be concluded that application with NAA 200 mg L^{-1} along with boron 100 mg L^{-1} and zinc 100 mg L^{-1} at the flower initiation stage is beneficial for getting optimum sized fruits which results in higher fruit yield as well as higher net return with high benefit to cost ratio of pineapple. It is also observed that the application of brassinosteroid showed the lowest benefit-to-cost ratio as the price of brassinosteroid is much higher compared to other plant growth regulators and produced comparatively lesser yield which is not profitable. Hence the application of NAA along with boron and zinc is profitable in pineapple fruit when compared to other treatments.

FUTURE SCOPE

There is a need to evaluate the combination of different plant growth regulators on pineapple fruits. Synthetic growth regulators should also be examined in pineapple fruits. There is a need to explore other new-generation plant growth regulators such as jasmonic acid, salicylic acid, polyamines, etc on pineapple.

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Conflict of Interest: None.

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