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Enhancing yield and economics of banana cultivar Rasthali (Silk-AAB) through bunch spray of growth regulators and nutrients

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Abstract

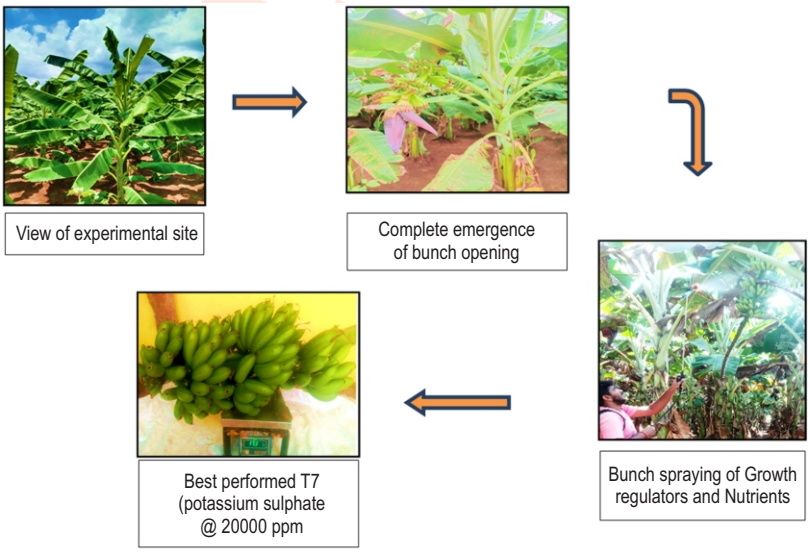
Aim: Poor finger filling is often observed in Rasthali bananas, which results in low fruit yield. Hence, different growth regulators and nutrients were sprayed at various concentrations to enhance the yield and economics of Rasthali banana.

Methodology: The experiment was conducted at Dharumathupatti village, Dindigul district, Tamil Nadu during 2022 and 2023 in a Randomized Block Design with eight treatments, replicated thrice. The treatments included Gibberellic acid @ 50 ppm (T_1), NAA @ 50 ppm (T_2), 2,4-D @ 25 ppm (T_3), Ethephon @ 100 ppm (T_4), Urea @ 10000 ppm (T_5), Potassium nitrate @ 10000 ppm (T_6), Potassium sulphate @ 20000 ppm (T_7) and Control (T_8). The spraying was done twice; the first spray at emergence of the last hand and the second, one month after the first spray. The observations on various growth, bunch and finger parameters as well as the benefit: cost ratio (B:C ratio) were recorded.

Results: T_7 treatment produced the highest number of leaves (8.97) whereas T_4 treatment registered the minimum number of days taken from last hand opening to harvest (98.67). The highest bunch, finger parameters and benefit-to-cost ratio were also recorded in T_7 treatment.

Interpretation: Potassium sulphate (20000 ppm) effectively enhanced the growth, yield and economics of Rasthali banana.

Key words: Banana cultivar, Bunch spray, Growth regulator, Potassium, Yield



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Introduction

The banana, a perennial herbaceous fruit crop of tropical importance, is a member of Musaceae family within the Scitamineae order. Humid subtropical and tropical conditions are ideal for its growth. It has the medicinal value as it contain oligosaccharides such as fructo oligosaccharide and polyphenols like catechin, epicatechin, epigallocatechin, and gallic acid. Besides, they are also useful for treating intestinal disorders, preventing colon cancer, diabetes and muscles contraction (Bantayehu, 2017). India is a home for diverse array of banana cultivars, with Rasthali, the most popular and extensively cultivated genome of AAB genome, being among the most renowned and extensively cultivated. It is also called Martaman. Owing to several desired quality attributes, it fetches premium price in the market among different cultivars. The fruits are medium-sized, attractively colored and have a distinctive flavor with well-balanced acidity. This table-purpose variety is a fantastic choice for many people and being a nutrient-loving crop, its yield and productivity depend on steady supply of nutrients at critical stages of development.

Even though balanced nutrition is rendered to crops for higher yield, quality and resistance to stresses, the actual prerequisite is not fully met by the crop, especially during its reproductive stage, such as shooting and bunch development stages. Moreover, climatic fluctuation during crop production program in bananas reflect poor bunch filling, improper finger development, poor quality *etc.* After seven months of planting, the banana crop receives its final fertilizer dosage to supply the nutritional requirements from shooting to harvest. According to Patil *et al.* (2018), any restriction in the nutrition supply at this stage causes poor finger filling and development, and a decline in bunch size and quality. However, due to consumption of nutrients during the finger development period, it is not advisable to apply fertilizers to the soil at this time. According to Rajni *et al.* (2017), foliar application of growth regulators and nutrients during these crucial stages improve the quality and production. Sandhya *et al.* (2018) reported that nutrients are absorbed through leaves more rapidly than roots. Post shoot spraying with various nutrients during the fruit growth stage enhances fruit production and nutritional value of bananas.

Wagle *et al.* (2022), in banana variety Grand Naine,the post shoot bunch spray of sulphate of potash (SOP) @1.5% and GA3 @100 ppm had significantly increased the yield and quality. Sathish *et al.* (2021) reported that bunch spray of 2, 4-D (30 ppm) along with bunch feeding of urea and sulphate of potash had increased the yield and cost economics of tissue cultured banana cv. Neypoovan. Deepa *et al.* (2023) found that spraying a mixture of Sulphate of Potash (1%), calcium nitrate (0.3%), magnesium sulphate (0.2 %) and borax (0.2 %) in banana cv. Grand Naine enhanced the overall yield and productivity. Findings of Sree *et al.* (2020) revealed that bunch weight and total yield of banana cv. Grand Naine had increased due to bunch spray with sulphate of potash (2 %) and Arka banana special mixture (0.5 %). Most of the previous research have been carried out on other banana cultivars. As Rasthali is a unique cultivar of Tamil Nadu and is facing the problem of poor fruit filling, this study was undertaken to assess the effect of bioregulators and nutrients on bunch characteristics, yield, and quality of banana cultivar Rasthali (Silk-AAB) through pre-harvest spraying.

Materials and Methods

A field trial with banana cultivar Rasthali (Silk-AAB) was conducted at farmer's field in Dharumathupatti village, Dindigul District of Tamil Nadu during 2022 and 2023. The field lies 300 m above mean sea level at 10.50°N latitude and 77.49°E longitude. The plant spacing in the experimental field was 2 m × 2 m. Two rounds of spraying were carried out: the first after the final hand had completely opened, and the second a month later to first spray. The experiment was conducted in a randomized block design with three replications. The treatments included: T_1- GA3 at 50 ppm, T_2- NAA at 50 ppm, T_3-2,4-D at 25 ppm, T_4-Ethephon at 100 ppm, T_5-Urea at 10,000 ppm, T_6-Potassium nitrate at 10,000 ppm, T_7-Potassium sulphate at 20,000 ppm T_8 and Control (Water spray).

The following growth and yield parameters were monitored: The total number of green leaves per plant at 60 days after the last hand opening was counted and recorded; Time interval between the last hand opening until harvest was counted in days and expressed as duration between the last hand opening to harvest (days); the bunch length was measured from the first hand scar point on the peduncle to the final hand scar using a measuring tape and recorded in centimeter; the bunch circumference was measured at the middle by using a measuring tape and then the value was stated in centimeter; Weight of bunches was weighed by using a computerized weighing balance, after the bunch was severed from the mother plant above the first hand scar mark, and the result was recorded in kilogram; Finger length was measured on the convex side of the finger that extended from the base of the pedicle to the fruit tip;finger circumference was measured by using a thread at the midpoint of the finger's diameter and recorded in centimeter; the weight of the pulp and peel was weighed separately and expressed gram; the pulp to peel ratio was worked out; the weight of second-hand was weighed in using a using a computerized weighing balance and expressed in kilogram; yield of fruits h^{-1} was derived by multiplying the individual bunch weight and number of plants h^{-1} and was expressed in metric tons. The benefit-cost ratio (BCR) h^{-1} was calculated by the formula given below, encompassing expenditures for diverse field activities ranging from field preparation to harvest. Additionally, the gross income and net return were computed.

$$BCR = \frac{\text{Gross return (Rs. ha}^{-1}\text{)}}{\text{Total cost of cultivation (Rs. ha}^{-1}\text{)}}$$

All recorded as well as calculated growth and yield parameters were normalized before analysis, and the Fisher's variance analysis was applied for randomized block design. The procedures outlined by Panse *et al.* (1985) were employed to

interpret the data, and significant treatments were analyzed. P-values of 0.05 were employed in the 'F' and't' tests to denote significance. Critical difference values were calculated where the 'F' test yielded significant results.

Results and Discussion

Different growth regulators and nutrients significantly affected the growth parameter, *viz.,* the number of leaves on the 60th day of bunch opening in banana cv. Rasthali. Treatment T_7 (8.97) recorded the highest number of leaves, followed by T_5 (8.60 d). T_5, T_6, T_2 and T_4, treatments were on par with T_7. The lowest number of leaves was recorded in T_8 (6.87 d). Application of various growth regulators and nutrients significantly affected the days from last hand opening to harvest. Plants applied with ethephon 100 ppm (T_4), the minimum number of days taken from last hand opening to harvest was registered (98.67 days), followed by T_7 (100.0 days). T_1 treatment, recorded the longest duration (106.0 days), followed by T_8 (105.3 days).

Retaining a high number of photosynthetically active and functional leaves at the bunch development stage in bananas is always beneficial. In the present study, the foliar application of different nutrients atthe fruit filling stage resulted in a higher rate of leaf retention, which would have helped increase the fruit yield. It was noted that the bananas responded well to foliar treatments of potassium and nitrogen (Sandhya *et al.,* 2018). The transport and storage of carbohydrates in plants, as well as water interaction, depend heavily on potassium. Banana enhance its vigor when given an appropriate amount of potassium (Gad El-Kareem *et al.,* 2021). Protein, nucleic acid, nucleotide, amino acid, and chlorophyll require nitrogen. It is crucial for the synthesis of auxin. In general, the post-shooting nutrition spray increased the leaf longevity compared to control i.e., water spray. Retaining more green leaves during the post-flowering period of a determinate crop, such as bananas, helps the vegetative sink absorb a significant amount of newly developed assimilates during current photosynthesis. This is especially true when the assimilating flow from other plant parts is limited. Likewise, the leaf adds its assimilated reserves to the sink as it ages (Kumar and Kumar, 2007).

The low level of potassium concentration significantly shortened the leaf life expectancy of bananas, which was caused by more significant movement of potassium from old leaves to other regions. In bananas, bunch size and yield are influenced by the accumulation of additional photosynthates in the bunches due to preservation of greater levels of chlorophyll pigment throughout the post-shooting period (Kumar and Kumar, 2008), i.e., the effectiveness of photosynthesis is reflected in the greater chlorophyll concentration observed on leaves and growing fruits. When nutrients were sprayed after shooting, chlorophyll in the leaves increased significantly. This result is consistent with the findings of Chandrakumar *et al.* (2001), who noted improved plant development characteristics due to enhanced potassium levels. Among the treatments, application of ethephon @100 ppm, facilitated reduction in the number of days taken from the last hand opening to harvest (98.67 d) and fruit ripening. Currently, ethylene is considered as a primary phytohormone involved in ripening, this may had been caused by the rapid ripening behavior and accelerated actions of hydrolytic enzymes, which were linked to high metabolic modification in fruits (Singh *et al.,* 2018).

This resulted in the conversion of organic acids and complex polysaccharides into simple sugars through advanced respiration and carbon assimilation processes occurring in fruits and plant reactions that were formerly attributed to auxins are now thought to be caused by induced ethylene synthesis. Furthermore, it has been shown that ethylene significantly impacts fruit ripening and maturity. Similar results were obtained by Patel *et al.* (2011) and Shrestha *et al.* (2024) in bananas. The influence of growth regulators and nutrients significantly affected the bunch length in banana cultivar Rasthali (Table 1). Treatment T_7 recorded the highest bunch length (73.20 cm), significantly different from other treatments. The least bunch length was produced by T_8 (64.13

Table 1: Impact of bunch spray of growth regulators and nutrients on growth and bunch characters of banana cv. Rasthali

Treatments	No. of leaves@ 60th day of last hand opening	Duration between the last hand opening to harvest (days)	Bunch length (cm)	Bunch girth (cm)	Second hand weight (kg)	Bunch weight (kg)	Fruit yield (t ha^{-1})
T_1	7.47	106.0	67.93	100.33	1.90	16.50	41.26
T_2	8.30	103.3	68.93	101.33	1.92	16.55	41.36
T_3	7.37	104.0	67.27	97.00	1.88	16.76	41.89
T_4	8.17	98.67	71.03	103.00	1.97	18.14	43.69
T_5	8.60	102.3	69.27	98.00	1.74	15.74	39.34
T_6	8.40	101.0	69.67	103.67	1.96	17.11	42.77
T_7	8.97	100.0	73.20	105.00	2.27	18.44	46.17
T_8	6.87	105.3	64.13	95.33	1.62	14.98	37.45
CV (%)	7.65	1.78	1.64	1.87	2.78	3.02	3.34
SE(d)	0.50	1.49	0.92	1.54	0.04	0.41	1.14
CD at 5%	1.04	3.19	1.97	3.30	0.08	0.87	2.44

Table 2: Impact of bunch spray of growth regulators and nutrients on finger characters of banana cv. Rasthali

Treatments	Finger length (cm)	Finger girth (cm)	Finger weight (g)	Pulp weight (g)	Peel weight (g)	Pulp and peel ratio
T_1	15.83	12.20	118.65	86.17	32.29	3.20
T_2	13.50	12.80	102.61	64.30	34.46	3.07
T_3	13.87	14.03	106.75	73.07	33.66	3.30
T_4	11.10	14.13	139.44	105.33	33.61	3.12
T_5	15.67	12.40	121.42	89.07	32.40	3.47
T_6	14.40	13.47	151.36	114.67	32.43	3.77
T_7	15.37	14.47	154.95	124.67	30.90	4.21
T_8	12.23	11.10	100.50	72.03	35.93	2.52
CV (%)	2.84	2.98	1.18	2.53	4.83	8.18
SE(d)	0.32	0.32	1.20	1.88	1.31	0.22
CD at 5%	0.68	0.68	2.57	4.03	2.80	0.47

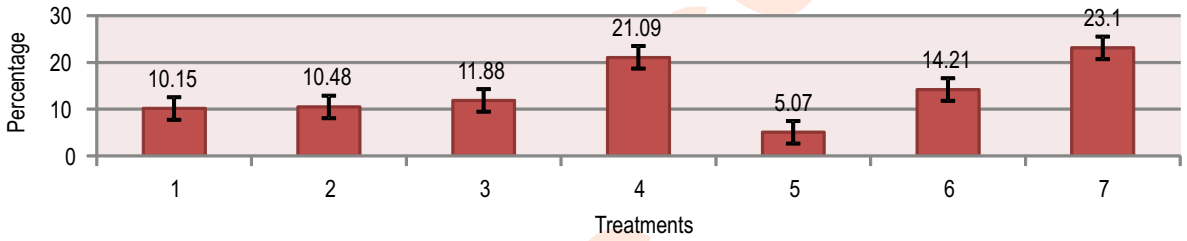

Fig.1: Percentage of bunch weight increase over control.

cm), followed by T_3 (67.27 cm). Application of growth regulators and nutrients at shooting stage significantly affected the bunch circumference in banana cv. Rasthali. The results showed that T_7 treatment recorded the highest bunch circumference (105 cm). The next best bunch circumference was registered by T_6 treatment (103.67 cm). The lowest bunch circumference was recorded in control (95.33 cm). There was a significant increase in the weight of the second-hand of banana cv. Rasthali due to the application of growth regulators and nutrients. The outcomes showed that the uppermost second-hand weight of the bunch was recorded in T_7 (2.27 kg), which was on par with T_4, followed by T_6 (1.96 kg). The lowest hand weight was recorded in control T_8 (1.62 kg).

A foliar spray of growth regulators and nutrients to Rasthali banana plants significantly affected impacted the bunch weight. The of bunch of Rasthali banana showed increase in bunch weight in T_7 treatment (18.44 kg), which was on par with T_4 (18.14 kg), followed by T_6 (17.11 kg). Lesser bunch weight was recorded in T_8 (14.98 kg), followed by T_5 (15.74 kg). Overall, T_7 recorded a 23.10 percent increase in bunch weight over control and 21.09 percent by T_4 (Fig. 1). A similar trend was noticed for total fruit yield ha^{-1} of banana cv. Rasthali. The experimental findings vividly indicated that the treatment T_7 recorded the highest fruit yield ha^{-1} (46.17 t ha^{-1}), followed by T_4 (43.69 t ha^{-1}). The treatment T_8 recorded the lowest fruit yield ha^{-1} (37.45 t ha^{-1}), followed by T_1 (41.26 t ha^{-1}) which was on par with T_2 (41.36 t ha^{-1}) (Table 1). Sree *et al.* (2020) reported that the weight gain of the bunch was attributed to sulphur content present in sulphate of potash. This sulphur content potentially induces the synthesis of a protein known as ferredoxin, which directly activates peroxidase and catalase enzymes. The application of growth regulators and nutrients significantly affected the finger length of banana cultivar Rasthali. The treatment T_1 (15.83 cm) recorded the highest fruit length, followed by T_7 (15.37 cm) and were found to be on par.

The lowest finger length was recorded in T_4 the treatment (11.10 cm), followed by T_8 (12.23 cm) (Table 2). A significant difference was observed in the finger girth due to application of various growth regulators and nutrients. Among the various treatments, the maximum finger girth was recorded in T_7 (14.47 cm), followed by T_4 (14.13cm) and both were on par. The tiniest circumference of finger was noted in T_8 (11.10 cm). There was a significant increase in fruit weight upon application of different growth regulators and nutrients. The results showed that the enhanced fruit weight was recorded in T_7 (154.95 g), followed by T_6 (151.36 g). Lesser fruit weight was recorded in T_8 (100.5 g), followed by T_2 (102.61 g) (Table 2). A perceptible difference in pulp weight was observed when different growth regulators and

Table 3: Influence of growth regulators and nutrients on of cultivation cost, gross income, net income, benefit-cost ratio in banana cv. Rasthali (Silk-AAB)

Treatments	Cost of cultivation (Rs. ha^{-1})	Gross income (Rs. ha^{-1})	Net income (Rs. ha^{-1})	Benefit-cost ratio
T_1	335000	1094000	759000	3.26
T_2	320000	1034000	714000	3.23
T_3	315000	1047250	732250	3.32
T_4	312000	1092250	780250	3.50
T_5	305000	983500	678500	3.22
T_6	307500	1069250	761750	3.47
T_7	315000	1133750	818750	3.59
T_8	300000	936250	636250	3.12

nutrients were applied. Among the various treatments, the maximum weight of pulp was recorded in T_7 (124.67 g), trailed by T_6 (114.67 g). In T_8, the lower pulp weight (72.03 g) was documented. Foliar spray of various growth regulators and nutrients significantly affected the peel weight of banana cv. Rasthali. The treatment T_7 recorded the minimum peel weight (30.90 g), followed by T_1 (32.29 g), which was on par with T_5 (32.40 g). The treatment T_8 (35.93 g) showed maximum peel weight, followed by T_2 (34.46 g), which was on par with T_3 (33.66g) and T_4 (33.61 g). The growth regulators and application of nutrients significantly affected the finger characteristics of Rasthali. Among the various treatments, the maximum pulp: peel ratio was recorded in T_7 (4.21), which was on par with T_6 (3.77), followed by T_5 treatment (3.47). The minimum pulp: peel ratio was recorded in T_8 (2.52), followed by the treatment T_2 (3.07) (Table 2).

The current investigation examines the significant effects that various growth regulators and nutrients have on fruit yield attributes, including bunch length, bunch circumference, hand weight, fruit length, fruit girth, fruit weight, pulp and peel weight as well as their ratio, bunch weightand fruit yield ha^{-1}. T_7, which consisted of a foliar spray of 20,000 ppm potassium sulphate applied twice, the first time at the last hand opening of the bunch and the second time 30 days after the initial spray, resulted in the following measurements: bunch length (73.20cm), bunch circumference (105 cm), hand weight (2.27 kg), fruit length (15.37 cm), fruit girth (14.47 cm), finger weight (154.95 g), pulp weight (124.67 g), peel weight (30.90 g), fruit yield (46.17) ha^{-1}, among the various treatments evaluated. The current investigation revealed that applying sulphate of potash increased bunch weight. These results align with the findings of Geetha *et al.* (2015); Millik *et al.* (2018) and Garasangi *et al.* (2018) who reported that utilization of sulfur resulted in a higher yield due to its presence in synthesizing amino acids and proteins. As an all-around metabolic activator, potassium stimulates photosynthesis and respiration. Thus, further administration of potassium via foliar spray accelerated bunch development.

A greater weight of the group results from the convergence of all favorable characteristics that thrive in ideal circumstances, such as a well-balanced diet. Potassium is responsible for improved sugar translocation into fruit tissues, increased sugar formation, or sugar synthesis from organic acids. Organic acid neutralization brought on by a high potassium content in the tissue (Kumar *et al.,* 2017). The application of growth regulators and nutrients in bunch spray significantly influenced various finger characters of Rasthali banana. An observed difference in the weight of third-hand finger (154.95 g) and finger girth (14.47 cm), as well as the weight of the pulp (124.67 g), peel (30.90 g), and pulp: peel ratio (4.01), is attributed to the application of potassium sulphate (20000 ppm). Similar findings were documented by Mustaffa *et al.* (2004) in cultivar Nendran. They found that the bunch weight of Nendran banana was enhanced by potassium sulphate application. According to Kumar and Kumar (2007), the finger weight of Neypoovan banana had been increased by applying sulphate of potash.

The favorable outcomes can be attributed to the facilitation of fruit girth and fruit weight by potassium, which operates via accelerated cell division and enlargement. As a result of activating numerous enzymes, the exogenous potassium supply might have contributed to the increase in finger circumference. Sulfur (present in SOP) and zinc interact positively, promoting fruit development by facilitating RNA synthesis auxin and the assimilation and utilization of carbon dioxide. Potassium, is an essential element for cellular elongation, collaborates with sulphate to enhance cellular permeability to water and other osmotic solutes.

In addition to the growth-promoting effects of potassium sulphate, auxin and gibberellins were found to have encouraging effects on the overall enhancement of yield. Nandankumar *et al*. (2011) reported that in banana cv. Nanjangudu Rasabale the bunch weight increased on applying gibberellic acid and sulphate of potash. Sathappan *et al.* (2019) found the pronounced influence of spraying of sulphate of potash in elevating the yield in hill banana var. Sirumalai; Shetty *et al*. (2015) obtained the massive bunches through combined spray of SOP and urea in banana var. Grand Naine. Similarly, the highest yield in banana cv. Matti was recorded by Rajarathinam *et al.* (2023) and Taram *et*

al. (2023). Kumaran *et al.* (2019) reported that the impact of potassium on cell division and growth can be attributed to the augmentation of finger circumference and length. According to Wagle *et al.* (2022), at the stage of finger development, there was a significant increase in potash availability, which enhanced the fruit growing till harvest. Ensuring nutrition at this stage has a favorable impact on fruit yield metrics. When the nutrients and growth regulators are retained during the fruit-developing stage, the fruit bunch photosynthesis accumulates, which in turn increases the fruit size.

Cost economics

The cost economics of foliar spraying of various growth regulators and nutrients on banana cultivar Rasthali at the post-shooting stage varied significantly, as measured by the total income, net income and benefit-cost ratio. The treatment T_7, which received a 20000-ppm potassium sulphate spray, produced the highest total income per hectare (Rs. 11,33750), followed by the group treated with 500 ppm ethephon (Rs. 10,92250). The increased total and net income generated for each treatment was reflected in the benefit-to-cost ratio. T_7 exhibited the highest benefit-to-cost ratio (3.59), with T_4 following suit at 3.50. T_8 exhibited the lowest benefit-cost ratio at 3.12, with T5 following suit at 3.22 (Table 3). Gross profit, the benefit-to-cost ratio and net profit are all components of cost economics. The variety T_7, containing 20,000 ppm potassium sulphate, yielded the most significant gross profit of 11,33750 Rs. ha^{-1}, the highest net profit of 8,18750 Rs. ha^{-1}, and the highest benefit-to-cost ratio of 3.59. This phenomenon may be attributed to lower cost and higher yield under potassium sulphate spray (Table 3). These results align with those of Jagadeesha *et al.* (2015); Patil *et al.* (2018) and Nethravathi *et al.* (2021).

Conclusion: The banana cultivar Rasthali (Silk-AAB) had shown remarkably positive results on various growth and yield indices when different growth regulators and nutrients were sprayed on the foliage after shooting. The findings suggest that applying a foliar spray of 20,000 ppm potassium sulphate twice, once at the opening of the last hand and again one month after the initial spray promisingly improved the number of leaves, reduced the number of days between the opening of last hand and harvest, increased the weight of the bunch, widened the fingers, and increased the percentage of yield. Furthermore, this treatment improved the cost-effectiveness of banana cultivar Rasthali, thereby ensuring the highest possible profit for the farmers.

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