Biological Forum – An International Journal **14(4a): 755-760(2022)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Impact of Denavelling and Bunch Feeding on Yield, Yield Attributing Characters and Shelf-life in Banana *cv.* Champa

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(Received 16 August 2022, Accepted 10 October, 2022)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Bananas are heavy feeders of nutrients and thus need balanced nutrition for optimum growth and fruit production and in turn obtain potential yields. Any deviation in the supply of nutrients at this crucial stage affects the bunch size and quality. During fruit development, soil application of nutrient uninhibited flow of nutrients to the developing bunch influence the poor filling, development and quality of fingers. Soil characters may cause considerable loss to the soil applied nutrients leading to insufficient supply of nutrient after shooting to meet the nutrient demand of developing bunch. Hence, bunch feeding of nutrients provides a considerable scope not only for the effective utilization of nutrients as source to a sink but also to safeguard the economy of the farmer by improving the uniformity in bunch shape, yield and quality. A field experiment was conducted to study the effect of denavelling and bunch feeding of nutrients on the bunch cum finger parameters of banana cv. Champa (AAB) at AICRP on fruits, Horticulture Research Station, Odisha University of Agriculture and Technology (OUAT) Bhubaneswar during the year 2019. The experiment was laid out in Randomized Block Design (RBD) with 3 replications and 9 treatments including untreated check. The results revealed that the bunch feeding of nutrient along with cowdung slurry significantly influenced the bunch character, yield and post-harvest quality. The treatment T_5 (denavelling + bunch feeding with cow dung slurry and K_2SO_4 @15 g/plant) significantly increased yield and yield attributing characters *viz.*, bunch length (63.66cm), bunch girth (86.78cm), hand weight (1.61kg), bunch weight (13.36kg), yield (32.74 t/ha) and finger parameters *viz.*, finger weight (86.28g), finger length (15.32cm), finger girth (14.77cm), pulp to peel ratio (4.86) and rind thickness (3.45mm) which was closely followed by T_4 (denavelling + bunch feeding with cow dung slurry and K_2SO_4 @ 7.5g/plant) for all the above mentioned characters. The post-harvest parameters such as TSS (22.57^0B), Total sugar (20.23%) and shelf life (16.91 days) were found maximum in T_5 followed by T_4 the above treatment. Thus, the study clearly indicates that denavelling combined with nutrient support in the form of bunch feeding i.e., T_5: denavelling + bunch feeding with cow dung slurry and K_2SO_4 @15 g/plant) is a beneficial operation to boost the yield of Champa banana which is widely cultivated in Odisha.

Keywords: Denavelling, bunch feeding, Champa Banana.

INTRODUCTION

Banana (*Musa* spp.) is one of the major commercial fruit crops cultivated in the tropics and sub tropics of all over the world. India leads the world in banana cultivation with an area of 8.80 lakh ha distributed in almost all states with a production of nearly 32.45 mt. The corresponding figures for Odisha is 23.62 thousand ha and 502.84 thousand mt (Annon, 2022). It is considered as one of the most energy producing food, cheap, highly nutritious and easily digestible. Banana is the most affordable fruits in the market and available all-round the year. Irrespective of rich and poor, almost all people utilize banana for table purposes and also in every auspicious occasions. Banana is an excellent source of potassium, which benefits the muscle spasms (Millik *et al.*, 2018).

Nutrients play a significant role in the production of high yield of good quality fruits (Ramesh and Kumar 2007). Providing appropriate quantities of nutrients at the right proportion when needed most is the essence of management of nutrients in successful banana cultivation. Banana takes up major nutrients in great quantities during peak growth phase and after shooting the rate of nutrient uptake slows down (Venkata and Swamy 2017). Nitrogen and Potassium are the most used nutrient elements in plant growth and development which play an essential role in high yield and fruit quality. Potassium is the key element in banana nutrition. Potassium is known to influence fruit yield in general and fruit quality in particular (Millik *et al.*, 2017). Bunch

is the most drastically affected organ if potassium is insufficiently supplied (Sreekanta *et al*., 2017). Earlier studies revealed that banana takes up major nutrients in sufficient quantities during peak growth phase (Kurian *et al.,* 1999). Potassium stimulates early shooting and significantly shortens the time required for fruit maturity. Usually after shooting the rate of nutrient uptake from the soil decreases hence there is a less scope for soil application of nutrients after shooting, therefore direct application of nutrients through distal stalk and direct bunch spraying may help in increasing the yield and quality of banana. However, the uptake and utilization of nutrients by banana plants is inadequate resulting in poor growth of the bunch as well as fingers at the distal end (Turner and Barkus 1980). It affects both total weight as well as overall appearance leading to lower profitability. Not only is the selection of the essential nutrients but its time and method of application at the appropriate stage of the plant equally important to derive maximum benefits from banana cultivation. Even though K is abundant in many banana growing soils, the bulk of soil K is unavailable to plants due to both plant and environmental factors therefore additional application through bunch feeding has been found beneficial. In high value crop like banana quality standards have become the most important factor influencing yield and farmer's income (Shira *et al.,* 2013). Unfortunately, scanty information is available and no systematic investigation has yet been explored under coastal agro-climatic conditions of Odisha. Keeping this in view the present experiment was carried out to study the impact of denavelling practice along with bunch feeding on finger and bunch characters, yield and shelf life of Banana.

MATERIAL AND METHODS

The field experiment was carried out during 2019 in the All India Coordinated Research Project on Fruits (Banana), Horticulture Research Station, OUAT, Bhubaneswar which is situated at 20°16′N Latitude, 85°47′E Longitude and altitude of 25.5 m above MSL. The soil of the experimental field is well drained, sandy loam, strongly acidic in reaction and had low organic carbon (<0.5%). The most popular banana cultivar Champa was planted at a distance of 2m × 2m spacing in well-prepared plots and manured with FYM @ 5 t/ha. Recommended package of practices were adopted for the crop. The experiment was laid out in Randomized Block Design (RBD) with 3 replications and 9 treatments including untreated check. Rachis at the distal end of the bunch was excised along with male bud giving a slant cut (denavelling) at 60^0 angle by excision of rachis 15 cm after the last hand. This operation was done immediately after the fruit bunch formation and shedding at 7-8 flower bracts. A fresh slurry of cowdung was prepared by blending the fertilizers dissolved in 250ml of water with 500g fresh cowdung for imposing to the selected Champa banana bunches after denavelling. The slurry was placed in plastic bags (200 gauge of size 15 cm × 15cm) and firmly tying the bags with a strong thread in such a way that about 8-10 cm of the distal end of the rachis will remain immersed in the slurry. The observations were recorded on yield and yield attributing characters such as length of bunch, girth of bunch, length of finger, girth of finger, finger weight, hand weight, internodal length, pulp to peel ratio, bunch weight and yield. The quality parameters such as TSS, total sugar content, physiological loss in weight and shelf life were recorded. The treated stalk was cut at the time of final harvest. The treatments imposed in the study are as follows:

T_1: Control (No Denavelling + No nutrient application)
T_2: Denavelling (D) + No nutrient application
T_3: Denavelling + Cow dung slurry(C)
T_4: D + C + K_2SO_4 @7.5g/plant
T_5: D + C + K_2SO_4@15g/plant
T_6: D + C + KNO_3 @10g/plant
T_7: D + C + KNO_3@20g/plant
T_8: D + C + KH_2PO_4 @10g/plant
T_9: D + C + KH_2PO_4@15g/plant

RESULT AND DISCUSSION

A. Effect of denavelling and bunch feeding on finger characters

Exogenous application of nitrogen and potassium as bunch feeding alongwith cow dung slurry and denavelling improved the finger weight to varying degrees as compared to untreated check. The data presented on finger weight (Table1) revealed that significantly maximum finger weight (86.28g) was recorded in T_5 (denavelling + bunch feeding with cow dung slurry and K_2SO_4 @15 g/plant) which is superior to rest of the treatments. The minimum value (68.74g) was noticed in T_1 (control). The increase in fruit weight might be due to the removal of flower bud after formation of bunch which helped in the conservation and utilization of photosynthates in the more efficient way. Increase in finger weight of the hand might be attributed to the application of potassium which indirectly improved utilization of nitrogen and protein formation and thereby increasing the size and weight. Potassium helped to increase the overall fruit weight as well as starch and sugar contents in the fruits. In the present study, application of K_2SO_4 improved finger weight and the findings are in accordance with the results of Pandey and Sinha (1999) who reported that the increase in weight of the finger, hand, bunch and yield per hectare were due to sulphur present in the sulphate of potash that might be responsible for the formation of iron-sulphur and protein in plants by activating the catalase and peroxidase enzymes.

Bunch feeding also exhibited significant influence on finger girth (Table 1). Significantly highest (14.77cm) finger girth was recorded in T_5 (denavelling + bunch feeding with cow dung slurry and K_2SO_4 @15 g/plant) closely followed by T_4 (denavelling + bunch feeding

with cow dung slurry and K_2SO_4 @7.5 g/plant). The lowest (10.34 cm) finger girth was recorded in T_1 (control). The increase in girth of the finger clearly indicated that potassium acted as a catalyst in cell enlargement. The increase in finger circumference in T_5 might be due to exogenous potassium supply that acted as an activator of several enzymes. Potassium appeared to have role in synthesizing the chlorophyll pigments. According to Mustaffa and Kumar (2012); Kumar *et al*., (2008); Nandan *et al.* (2011) presence of sulphur in K_2SO_4 exhibited a synergistic effect with zinc which is essential for carbon dioxide absorption and utilization, synthesis of RNA and auxin which increases the size of fruit.

The pulp to peel ratio in banana as influenced by bunch feeding has been presented in Table 1. Highest pulp to peel ratio (4.86) was recorded in T_5 (denavelling + bunch feeding with cow dung slurry and K_2SO_4 @15 g/plant) which was at par with T_4 (4.69). Lowest (3.62) pulp to peel ratio was recorded in T_1. Kumar *et al*. (2008) in Robusta and Nandan *et al.* (2011) reported that higher pulp and less rind weight in the fingers was due to the beneficial role of potassium for better pulp recovery and less physiological loss in weight of fruits and thereby increasing the pulp weight and good pulp recovery.

The data related to the rind thickness (Table 1) revealed that there is no significant variation observed among the treatments. Such result might be due to insufficient availability of nutrients in control treatment.

Table 1: Effect of denavelling and bunch feeding on finger characters.

Treatments	Finger weight (g)	Finger length (cm)	Finger grith (cm)	Pulp to peel ratio	Rind thickness (mm)
T_1: Control (No Denavelling + No nutrient application)	68.74	11.68	10.34	3.62	2.82
T_2: Denavelling (D) + No nutrient application	71.91	12.35	10.89	3.88	3.03
T_3: Denavelling + Cow dung slurry(C)	75.07	13.30	12.08	4.01	3.09
T_4: D + C + K_2SO_4 @7.5g/plant	82.70	14.88	14.24	4.69	3.36
T_5: D + C + K_2SO_4 @15g/plant	86.28	15.32	14.77	4.86	3.45
T_6: D + C + KNO_3 @10g/plant	78.19	13.73	13.24	4.25	3.22
T_7: D + C + KNO_3@20g/plant	78.94	14.02	13.62	4.45	3.16
T_8: D + C + KH_2PO_4@10g/plant	76.92	13.23	12.35	4.39	3.08
T_9: D + C + KH_2PO_4@15g/plant	76.57	12.51	11.76	4.12	3.25
SE(m)+	1.17	0.40	0.37	0.13	0.26
CD (0.05)	**3.51**	**1.21**	**1.12**	**0.38**	**NS**

B. Effect of denavelling and bunch feeding on bunch character and yield of banana

The bunch parameters were significantly influenced by the different treatments (Table 2). The highest bunch length of 63.66 cm was observed in treatment T_5 (denavelling + bunch feeding with cow dung slurry and K_2SO_4 @15 g/plant) which was at par with T_4: denavelling + bunch feeding with cow dung slurry and K_2SO_4 @ 7.5 g/plant (62.16cm). Whereas, the lowest bunch length of 54.06 cm was noticed in T_1 (control). The increased bunch length might be due to the additional supply of potassium that might helped in cell division and its expansion by treatment effect on RNA and DNA synthesis. The present results are in conformity with the findings of Nalina and Kumar (2007).

The girth of the bunch varies from 72.21 cm to 86.78 cm in different treatments. The bunch girth was found maximum (86.78 cm) and in the treatment T_5 (denavelling + bunch feeding with cow dung slurry and K_2SO_4 @15 g/plant) which was comparable with that of T_4(83.38cm) (Table 2). The reason behind increased in bunch girth might be due to K_2SO_4 triggered with the maximum nitrate reductase in the active growth stages. Since nitrate reductase is the key enzyme of nitrate assimilation, the maintenance of the high rate of enzyme activity is imperative for enhanced protein content of the plants as reported by Evans and Sorger (1966).

The maximum internodal length of 13.37 cm between hands of bunches were recorded in T_7 (denavelling + bunch feeding with cow dung slurry and KNO_3@15 g/plant) was at par with T_6: (denavelling + bunch feeding with the of cow dung slurry and KNO_3@10 g/plant (13.08cm). The increase in internodal length might be due to additional supply of nitrogen combination with potassium that helped in cell division and cell expansion by stimulating RNA and DNA synthesis as reported by Mustaffa *et al.* (2012). The results of the present investigation are in conformity with the findings of Geetha *et al*. (2015); Ramesh Kumar and Kumar (2008).

The hand weight significantly varied between 1.17 kg and 1.61 kg in different treatments (Table 2). The results revealed that maximum hand weight of 1.61 kg was recorded in T_5(denavelling + bunch feeding with cow dung slurry and K_2SO_4 @15 g/plant) closely followed by T_4 (1.5kg). Increase in the weight of hand was due to sulphur present in the K_2SO_4. It might be responsible for the formation of ferridoxin (Iron - sulphur protein) in plants by activating the catalase and peroxidase enzymes. Presence of sulphur in K_2SO_4 had a synergistic effect with zinc, which is essential for carbon dioxide absorption, utilization and synthesis of RNA and auxin.

Sulphur increased the absorption of potassium by reacting with nitrogen Farrag *et al*. (1990). As per Evans *et al.* (1975) soluble protein was considered as an indirect measure of Ribulose-1, 5-bisphosphate RuBP carboxylase activity as the enzyme constituted more than 60 per cent of the soluble protein content by serving as an indicator of the photosynthetic rate. According to Noggle and Fritz (1986) RuBP carboxylase, the prime enzyme of carbon fixation is dominant in the soluble protein fraction of leaves and therefore, is known as the most abundant protein in the world. Increase in bunch weight is also reported by Alagarsamy and Neelakandan (2008) in *cv*. Robusta, Ramesh and Kumar (2007) in *cv*. Neypoovan and Ramesh *et al.* (2008) in *cv*. Robusta.

The difference among the treatments was highly significant in respect to bunch weight. It was revealed from the data in Table 2 that denavelling along with the bunch feeding increased the bunch yield in almost all the treatments. Significantly highest bunch weight of 13.36 kg/plant was recorded in T_5 (denavelling + bunch feeding with cow dung slurry and K_2SO_4 @15 g/plant) closely followed by T_4: denavelling + bunch feeding with cow dung slurry and K_2SO_4 @ 7.5 g/plant 13.05kg). Lowest bunch weight was recorded in T_1 (9.92 kg/ plant). This might be due to conservation and utilization of energy received from nutrients for finger development which might have otherwise lost for opening of the rest of the flowers. The Sulphur present in K_2SO_4 created a favorable impact on bunch weight that might be attributed to the more accumulation of dry matter and starch.

The banana yield per hectare varied from 23.56 to 32.74t /ha in different treatments. Highest yield of 32.74t/ha was obtained from T_5 (denavelling + bunch feeding with cow dung slurry and K_2SO_4 @15 g/plant) closely followed by T_4: denavelling + bunch feeding with the of cow dung slurry and K_2SO_4 @15 g/plant(30.14t/ha). The lowest yield (23.56t/ha) was recorded in T_1 where no denavelling and no nutrients were supplemented. The application of sulphate of potash improves bunch weight as well as yield per hectare. The present finding is in corroboration with the results of Pandey and Sinha (1999), who reported that the increase in weight of the bunch and yield per hectare are mainly due to sulphur present in the K_2SO_4 which might be responsible for the formation of ferredoxin (iron-sulphur protein) in plants with a direct impact in activating the catalase and peroxidase enzymes. Sulphur application increased the yield since it is a constituent of amino acid and protein production reported by Ahmed *et al.* (1998). Similar findings were reported of Sandhya *et al.* (2016) in banana cv. Grand Naine. The influence of sulphur in enhancing fruit yield in banana was traced by Lahav and Turner (1983) who reported that the sulphur helps in energy transformation and activation of enzymes in carbohydrate metabolism and subsequently greater partitioning in photosynthates.

Table 2: Effect of denavelling and bunch feeding on bunch growth and yield.

Treatments	Bunch length (cm)	Bunch girth (cm)	Inter-nodal length (cm)	Hand weight (kg)	Bunch weight (kg)	Yield (t/ha)
T_1: Control (No Denavelling + No nutrient application)	54.06	72.21	9.32	1.17	9.92	23.56
T_2: Denavelling (D) + No nutrient application	55.94	74.98	9.97	1.32	10.60	26.53
T_3: Denavelling + Cow dung slurry(C)	58.42	78.09	11.56	1.40	11.21	28.02
T_4: D + C + K_2SO_4 @7.5g/plant	62.16	83.38	12.20	1.50	13.05	30.94
T_5: D + C + K_2SO_4 @15g/plant	63.66	86.78	12.59	1.61	13.36	32.74
T_6: D + C + KNO_3 @10g/plant	60.10	80.07	13.08	1.42	11.44	28.6
T_7: D + C + KNO_3@20g/plant	60.88	81.71	13.37	1.47	12.08	29.46
T_8: D + C + KH_2PO_4@10g/plant	58.33	78.47	11.11	1.42	11.28	28.19
T_9: D + C + KH_2PO_4@15g/plant	57.07	77.13	10.41	1.37	10.99	27.47
SE(m)+	0.86	1.43	0.146	0.054	0.40	0.95
CD (0.05)	**2.597**	**4.296**	**0.437**	**0.162**	**1.223**	**2.858**

C. Effect of denavelling and bunch feeding on post-harvest fruit quality and shelf life of banana

The physiological loss in weight (PLW) was significantly influenced by different treatments. The minimum PLW **(**10.50 %) was observed in T_5 (denavelling + bunch feeding with cow dung slurry and K_2SO_4 @15 g/plant) which was at par with T_4 and T_7. This might be due to increase in peel thickness of the fruits, which resulted in better development of the firmness of fruits. According to Soumya *et al.* (2018) reduced PLW might be due to the improvement in number of phloem layers and a greater number of crystals in phloem cells and scattered starch granules throughout the parenchyma, which reduced the rate of transpiration. The reduction in transpiration was helpful in improving the storability by decreasing weight loss (Ravichandran *et al.*, 2011). The weight loss from harvested fruits i.e. PLW, especially under tropical

conditions causes severe economic loss to the producer and seller which also leading quality deterioration with low consumer preference (Swietlik and Faust 1984). The present study is in corroboration with the findings of Ramesh Kumar *et al.* (2008) in cv. Robusta (AAA-Cavendish).

The total soluble solids (TSS) varied from 18.11°B to 22.57°B in different treatments. The TSS content was significantly higher in T_5 (22.57°B) followed by T_4, T_6 and T_7. The lowest TSS of 18.11°B was recorded in T_1. Nandan *et al.* (2011) reported that sulphate of potash when supplied exogenously increased the flow of plant assimilates into the developing fruits and thereby increase the TSS. The findings are in conformity with Ramesh and Kumar (2007) in *cv*. Neypoovan and Ramesh *et al.* (2007) in *cv*. Robusta (Table 3).

The number of days required from harvesting of fruits to spoilage is designated as the shelf life. The longest shelf life (16.91days) was recorded in T_5: denavelling + bunch feeding with cow dung slurry and K_2SO_4 @15 g/plant which was at par with T_4 (16.38 days). Lowest shelf life was observed in T_6 (12.12 days) and T_7 (12.89 days) respectively. This might be due to application of nitrogen combination impacting less shelf life or early advocate to spoilage. According to Mengel and Kirkby (1987) potassium nutrient supplied through bunch feeding enhanced storage and shipping quality of bananas and also extends their shelf life. The findings are agreement with Nandan *et al.* (2011) cv. Nanjangudu and Sateeshkumar and Bangaruswamy (2006) in cv. Rasthali The data presented in Table 3 indicated that there is significant variation among the treatments. The maximum total sugar (20.23%) was recorded in T_5: denavelling + bunch feeding with cow dung slurry and K_2SO_4 @15 g/plant which was closely followed by T_4, T_6, and T_7. The present findings is in agreement with that of the reports of Tisdale and Nelson (1966). Potassium is involved in phloem loading and unloading of sucrose and amino acids which stores in the developing fruits in the form of starch as reported by Mengel and Kirkby (1987). Application of K_2SO_4 was found to be good in increasing sugar percent as potassium plays a major role in synthesis of carbohydrate and protein, breakdown and translocation of organic acids. The potassium when supplied in the form of K_2 SO_4 favors conversion of starch into simple sugars during ripening of fruits by activating the sucrose synthetase enzyme, thus resulting in higher sugar percentage.

Table 3: Effect of bunch feeding on post-harvest parameters of banana cv Champa.

Treatments	PLW (%)	TSS(°B)	Shelf life (days)	Total sugar(%)
T_1: Control (No Denavelling + No nutrient application)	13.80	18.11	14.08	15.89
T_2: Denavelling (D) + No nutrient application	13.40	19.20	14.94	16.11
T_3: Denavelling + Cow dung slurry(C)	12.60	19.74	15.46	17.23
T_4: D + C + K_2SO_4 @7.5g/plant	10.90	22.02	16.38	20.12
T_5: D + C + K_2SO_4 @15g/plant	10.50	22.57	16.91	20.23
T_6: D + C + KNO_3 @10g/plant	12.40	20.79	12.12	19.25
T_7: D + C + KNO_3@20g/plant	11.80	20.81	12.89	19.67
T_8: D + C + KH_2PO_4@10g/plant	11.90	20.07	15.66	18.28
T_9: D + C + KH_2PO_4@15g/plant	12.70	19.82	15.05	18.07
SE(m)+	**0.32**	**0.63**	**0.41**	**0.53**
CD (0.05)	**0.97**	**1.88**	**1.23**	**1.60**

CONCLUSIONS

Denavelling along with bunch feeding through cow dung slurry was found effective increasing in bunch parameters, finger parameter, fruit quality and shelf-life in banana cv. Champa. The results clearly indicated that supplementing sulphate of potash application through bunch feeding along with cow dung slurry increased bunch parameters such as bunch length (63.66cm), bunch girth (86.78cm), bunch weight (13.36kg), hand weight (1.61kg), yield (32.74 t/ha) and finger parameter *viz.*, finger weight (86.28g), finger girth (14.77cm), finger length (15.32cm), pulp to peel ratio (4.86) rind thickness (3.45mm). The postharvest parameters such as TSS (22.57°B), total sugar (20.23%) significantly and responded positively to nutrient supplements after denavelling. Hence, the present investigation shows the banana bunch weight can be enhanced by the direct feeding of nutrients to the bunch.

FUTURE SCOPE

Need to study the response of other nutrients to bunch feeding of banana on growth, yield and post-harvest life of banana.

Acknowledgement. I express my sincere gratitude to Dr. S.N. Dash, Dr. Sunil Samal, Dr. Subash Ch. Swain, Dr. Saudamini Swain, Dr. Rabindra Kumar Nayak, Dr. Antaryami Mishra and all other faculty members of Department of Fruit Science and Horticulture Technology and Department of Soil Science, OUAT, Bhubaneswar for support and guidance to carry out this research study.

Conflict of Interest. None.

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How to cite this article: Shefalika Nayak, Sunil Samal, Subash Ch. Swain and Saudamini Swain (2022). Impact of Denavelling and Bunch Feeding on Yield, Yield Attributing Characters and Shelf-life in Banana *cv.* Champa. *Biological Forum – An International Journal*, *14*(4a): 755-760.