Indian Journal of Ecology (2025) 52(1): 177-183
DOI: https://doi.org/10.55362/IJE/2025/4475

Manuscript Number: 4475
NAAS Rating: 5.38

Elimination of Hard Lumps in Malbhog Banana (*Musa*, AAB) by Application of Growth Regulators and Micronutrients

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Abstract: Combined effect of different plant growth regulators and micronutrients on incidence of hard lump of Malbhog banana was observed at Uttar Banga Krishi Vishwavidyalaya, Pundibari, West Bengal for main and ratoon crop. Combinations of GA_3 (@0, 50, 100 ppm) and 2,4-D (@ 0, 50, 100 ppm) as foliar spray along with borax (soil application @ 0, 1, 2 g/plant; foliar application @ 0, 0.25, 0.50 %) and zinc sulphate heptahydrate (soil application @ 0, 2, 4 g/plant and foliar application @ 0, 0.25, 0.50 %) were used as the sources of boron and zinc respectively at 3rd, 5th and 7th months after planting. The hard lumps separated from the ripe banana fruits to record different observations. Colourless or brownish coloured, large sized lumps were detected with high fruit pressure from most of the control treatments (no growth regulators and micronutrients). Most soft fruits with minimum or no lumps recorded in GA_3 and 2,4-D (both @100ppm). Among the soil application of micronutrients 1g borax with 2g zinc sulphate/plant application and foliar application of both the borax and zinc sulphate @ 0.25% resulted best with respect to fruit pressure and less incidence of lumps.

Keywords: GA_3, 2,4-D, Boron, Zinc, Hard lump, Malbhog banana

Banana (*Musa* sp.) is one of the most important commercial fruit crops of India cultivated in 959 thousand ha area is under banana cultivation and producing the yield of 35131 thousand MT during the year 2021-22 (Keelery 2023). Dwarf Cavendish, Kabuli, Marthaman, Champa, Kanthalie are most important varieties which are cultivated throughout India (Amini et al., 2019; Deb and Sinha 2024). Malbhog or Rashthali (*Musa*, AAB) is one of the popular cultivars of northern part of West Bengal and North East India (Kumar et al., 2020, Subba et al., 2024).

The wide range of banana cultivation is being attempted by the growers of Bengal, especially of Terai region with the increasing trend Terai soils are acidic in reaction (pH 4.8-6.5) and is having high rainfall, leading to high leaching loss of nutrients. Therefore, important micronutrients are not available to the plants according to their requirement (Bhowmick et al., 2017). Among different cultivation problems formation of hard lumps within the fruit pulp is one of the serious problems of Malbhog banana, the choicest banana variety of northern part of West Bengal. Very fresh and healthy fruits may also contain fair proportion of hard lumps within the fruit pulp due to which the ripe fruits become unsuitable for consumption. Hard lumps are the dry mass of cells often mixed with pulp which results the banana fruit not suitable for consumption in severe cases. This problem is supposed to be associated with imbalance of plant growth hormones and micronutrients during the finger development and maturity within the fruit tissue (Gonmei et al., 2022) which is very similar to dead tissue development in many other fruits (Basra 2000, Davies 2013) and uneven growth of tissues in same organ (Singh et al., 2021). However, no information on elimination of hard lump formation in Malbhog banana is lacking. The current research aimed to study the impact of application of some growth regulators and micronutrients on hard lumps of formation of Malbhog banana.

MATERIAL AND METHODS

Location site: The experiment was conducted at the Farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal. The site is located 26°19' N latitude and 89°29' E longitude and having an attitude of 43 meters above mean sea level. The soil of the experimental field was sandy loam in nature, coarse in texture having poor water holding capacity with low pH (5.23). The climatic condition of the terai zone is characterized by high rainfall (above 3000 mm annually), high humidity, moderate temperature, prolonged winter with high residual soil moisture.

Planting and after care: Sword suckers of banana plants (variety Malbhog) having average weight of 2.5 kg were planted in well prepared field with spacing of 2 x 2 m during April' 2021. 150 kg nitrogen, 150 kg P_2O_5 and 200 kg K_2O per ha were applied in three split doses. Need based application of pesticides and fungicides was followed for main crop as well as ratoon crop.

Experimental details: The treatment combinations of growth regulators (GA_3 and 2,4-D) and micronutrients (borax i.e. $Na_2B_4O_7$, 10 H_2O) as source of boron and zinc sulphate i.e. $ZnSO_4$, $7H_2O$ as source of zinc) were used (Table 1, 2). The experiment was laid out in randomized block design (RBD) with 9 treatments of growth regulators and micronutrient combinations each replicated thrice. Soil and foliar application of micronutrients were combined with foliar application of growth regulators.

Application of growth regulators and micronutrients: Growth regulators (GA_3 and 2,4-D) were applied separately (keeping 2-3 days interval) at 5 and 7months after planting and after flowering during the morning hours of sunny days in an amount of 500 ml/plant in respective doses. Micronutrients were applied separately (keeping 2-3 days interval) for foliar application adjusting the pH 7.0 at 3, 5 and 7months after planting during the morning hours of sunny days in an amount of 500 ml/plant in respective doses. But in case of soil application both micronutrients were applied on same day.

Observations: Harvesting of fruit was done at fully mature stage and fruits were brought to the laboratory (Department of Horticulture and Postharvest Technology, Institute of Agriculture, Visva-Bharati) After ripening, fruits were peeled out and smashed lightly with two fingers to find out the lumps. Incidence of lumps were expressed in percentage. Three different coloured of lumps were observed under different treatments like brownish, yellow and self-colored (colour of pulp). Positions of lumps were classified according to placental region, inner mesocarp and outer mesocarp. The length of separated lumps were measured with a centimeter scale. The weights of separated lumps were measured in gram. Toughness or texture of ripe fruit was measured with the help of fruit pressure tester (penetrometer) using the penetration ring nut radius of 4.0 mm. Calibration was expressed in terms of kg per square centimeter.

Statistical analysis: Data collected from the field experiment were subjected to statistical analysis using Statistical Package for Social Sciences (IBM SPSS Version 27.0).

RESULTS AND DISCUSSION

Incidence of hard lump formation: Incidence of hard lump formation (Table 3) was highest (27.9 and 24.1 % in soil and foliar application of micronutrients, respectively) under T_1 (control or having no growth regulators and micronutrients) whereas it is minimum as 5.5 and 5.6 % under E_1T_8 (GA_3 and 2,4-D both @100ppm along with soil application of borax @

Table 1. Treatment combinations of growth regulators with soil application of micronutrients for first set of experiment (E_1)

Treatments	Growth regulators	Micro nutrients used (per plant)
E_1T_1	No application (Control)	No application (Control)
E_1T_2	No application	Borax @ 1g + Zinc sulphate @ 2g
E_1T_3	No application	Borax @ 2g + Zinc sulphate @ 4g
E_1T_4	GA_3 @ 50ppm + 2,4-D @ 50ppm	No application
E_1T_5	GA_3 @ 50ppm + 2,4-D @ 50ppm	Borax @ 1g + Zinc sulphate @ 2g
E_1T_6	GA_3 @ 50ppm + 2,4-D @ 50ppm	Borax @ 2g + Zinc sulphate @ 4g
E_1T_7	GA_3 @ 100ppm + 2,4-D @ 100ppm	No application
E_1T_8	GA_3 @ 100ppm + 2,4-D @ 100ppm	Borax @ 1g + Zinc sulphate @ 2g
E_1T_9	GA_3 @ 100ppm + 2,4-D @ 100ppm	Borax @ 2g + Zinc sulphate @ 4g

Table 2. Treatment combinations of growth regulators with foliar application of micronutrients for second set of experiment (E_2)

Treatments	Growth regulators used	Micro nutrients used
E_2T_1	No application (Control)	No application (Control)
E_2T_2	No application	Borax @ 0.25 % + Zinc sulphate @ 0.25 %
E_2T_3	No application	Borax @ 0.50 % + Zinc sulphate @ 0.50 %
E_2T_4	GA_3 @ 50ppm + 2,4-D @ 50ppm	No application
E_2T_5	GA_3 @ 50ppm + 2,4-D @ 50ppm	Borax @ 0.25 % + Zinc sulphate @ 0.25 %
E_2T_6	GA_3 @ 50ppm + 2,4-D @ 50ppm	Borax @ 0.50 % + Zinc sulphate @ 0.50 %
E_2T_7	GA_3 @ 100ppm + 2,4-D @ 100ppm	No application
E_2T_8	GA_3 @ 100ppm + 2,4-D @ 100ppm	Borax @ 0.25 % + Zinc sulphate @ 0.25 %
E_2T_9	GA_3 @ 100ppm + 2,4-D @ 100ppm	Borax @ 0.50 % + Zinc sulphate @ 0.50 %

1g and Zinc sulphate @2g/plant) and E_2T_8 (GA_3 and 2,4-D @100ppm and foliar application of borax @ 0.25 % + Zinc sulphate @ 0.25 %). The formation of hard lumps was decreased with increased in the dose of growth regulators. In both the cases of soil and foliar application of micronutrients, moderate dose (Borax @ 0.25 % + Zinc sulphate @ 0.25 %) resulted better in terms of lesser incidence of hard lumps. Combination of both the growth regulators and micronutrients resulted lesser incidence of hard lumps in the banana fruit pulp rather it is higher in solo application of growth regulators or micro nutrients. But lowest rate of formation of hard lumps was observed in E_2T_8 (growth regulators with foliar application of micronutrients). Growth regulators probably played a role in uniformity of cell division and growth of cells within the fruit tissue due to which there was minimum lumps. Besides micronutrients might have helped in better translocation of nutrients to the developing fruit (Gonmei et al, 2022). Lee (2003) revealed that micronutrients particularly zinc and boron have positive role in auxin distribution and proper tissue development in growing fruits, respectively. This might be the cause of the pattern of hard lump formation in the treatments without zinc application. Additionally, incidents of hard lump were lower in ratoon crop than in main crop across the treatments. This might be attributed to the result of application of micronutrients as well as growth regulators which impacted the proper growth and nutrient storage of mother rhizome from which the ratoon plant arisen.

Colour of hard lumps: The colour of lumps become lighter from brown to yellow and ultimately self-colored (*i.e*., the colour of fruit pulp) with increasing the dose of growth regulators (Table 4). There were no such changes in colour with the increase of the doses of micronutrients. But higher doses of growth regulators played a great role in reducing the intensity of the colour of hard lumps. Growth regulators along with micronutrients might have reduced the formation of narrow minute patches of dead cells within the living cells of fruit tissues which reduced the intensity of the colour of hard lumps in the present experiment (Bauri et al, 2014). Davies (2013) observed that the imbalance in growth regulator distribution may cause the cell death in patches in soft growing tissues and this support present findings. Escalante et al (2018) mentioned the colour variation of banana pulp and browning may be due to imbalance of physiological process.

Position of hard lumps: Different positions of hard lumps in ripe banana fruits have been observed in the present experiment (Table 5). The hard lumps have different

Table 4. Colour of hard lumps in the ripe banana fruits under different treatment combinations of growth regulators and micronutrients

Treatments	Growth regulators with soil application of micronutrients
E_1T_1, E_2T_1	Brown
E_1T_2 ,E_2T_2	Brown
E_1T_3	Yellow
E_1T_4	Yellow
E_1T_5	Yellow
E_1T_6	Yellow, Self-coloured
E_1T_7	Self-coloured
E_1T_8	Self-coloured
E_1T_9	Self-coloured

Table 3. Incidence of hard lumps in the ripe banana fruits under different treatment combinations of growth regulators and micronutrients (%)

Treatments	Growth regulators with soil application of micronutrients			Treatments	Growth regulators with foliar application of micronutrients		
	Main crop	Ratoon crop	Pooled		Main crop	Ratoon crop	Pooled
E_1T_1	28.6	27.3	27.9	E_2T_1	25.5	23.7	24.1
E_1T_2	24.9	25.4	25.1	E_2T_2	23.2	20.6	21.9
E_1T_3	18.3	17.7	18.0	E_2T_3	16.7	13.9	15.3
E_1T_4	17.2	14.3	15.7	E_2T_4	14.2	12.0	13.1
E_1T_5	13.8	14.5	14.1	E_2T_5	11.3	12.7	12.0
E_1T_6	14.7	12.3	13.5	E_2T_6	10.5	9.0	9.7
E_1T_7	11.3	9.5	10.4	E_2T_7	6.7	7.8	7.2
E_1T_8	5.8	5.3	5.5	E_2T_8	5.1	6.2	5.6
E_1T_9	8.7	6.9	7.8	E_2T_9	7.9	6.3	7.1
CD (p=0.05)	2.65	2.06	2.31	CD (p=0.05)	2.42	2.34	1.87

positions like core of the placenta, whole placenta, inner mesocarp, outer mesocarp etc. The hard lumps in banana fruits exhibited that the application of growth regulators reduced the scattering of hard lumps. With the increase in the dose of growth regulators resulted in concentric position of lumps near to the placental core of the banana fruits. The control treatment resulted the most scattered position of hard lumps in entire mesocarp and placental core. Growth regulators might have direct effect of proper connective tissues throughout the fruits and entire mesocarp which resulted no such occurrence of hard lumps in the fruit mesocarp.

Length of hard lumps: Significantly higher length of hard lumps (Table 6) was inT_1 of both soil and foliar application of micronutrients (2.10 and 2.15 cm, respectively no application of growth regulators and micronutrients (Table 6). E_1T_1 and E_2T_1 have resulted increased growth of hard lumps and thus highest length of lumps have been attained. Conversely, shortest length of hard lumps was observed under T_8 in both the soil and foliar application of micronutrients (0.78 cm and 0.80 cm, respectively in E_1T_8 and E_2T_8). Both the soil and foliar application of micronutrients have shown similar trend and moderate dose of micronutrients has resulted lowest length of hard lumps while the higher dose and no application of micronutrients exhibited greater length of hard lumps. The deficiency of micronutrients as well as profuse use might cause physiological abnormalities that resulted higher length of hard lumps.

Average weight of hard lumps: Average weight of hard lumps of banana fruits was maximum (6.07g and 5.65g respectively) in E_1T_1 (growth regulators with soil application of micronutrients) and E_2T_1 (growth regulators with foliar application of micronutrients) though weight of hard lumps were slightly lower under foliar application (*i.e.* second set of experiment or E_2) (Table 7). Minimum weight of hard lumps was in E_1T_8 and E_2T_8 (0.94 and 1.01g in soil and foliar

Table 5. Position of hard lumps in the ripe banana fruits under different treatment combinations of growth regulators and micronutrients

Treatments	Growth regulators with soil application of micronutrients	Treatments	Growth regulators with foliar application of micronutrients
E_1T_1	Placenta, outer and inner mesocarp	E_2T_1	Placenta, outer and inner mesocarp
E_1T_2	Placenta, outer and inner mesocarp	E_2T_2	Outer and inner mesocarp
E_1T_3	Outer and inner mesocarp	E_2T_3	Outer and inner mesocarp
E_1T_4	Outer and inner mesocarp	E_2T_4	Outer mesocarp
E_1T_5	Inner mesocarp	E_2T_5	Outer mesocarp
E_1T_6	Inner mesocarp	E_2T_6	Inner mesocarp
E_1T_7	Total placenta	E_2T_7	Core of placenta
E_1T_8	Core of placenta	E_2T_8	Core of placenta
E_1T_9	Core of placenta	E_2T_9	Core of placenta

Table 6. Length of hard lumps in the ripe banana fruits under different treatment combinations of growth regulators and micronutrients

Treatments	Growth regulators with soil application of micronutrients			Treatments	Growth regulators with foliar application of micronutrients		
	Main crop	Ratoon crop	Pooled		Main crop	Ratoon crop	Pooled
E_1T_1	2.16	2.05	2.10	E_2T_1	2.21	2.09	2.15
E_1T_2	1.85	1.92	1.88	E_2T_2	1.80	1.83	1.81
E_1T_3	1.53	1.45	1.69	E_2T_3	1.62	1.53	1.57
E_1T_4	1.95	1.98	1.96	E_2T_4	1.61	1.66	1.63
E_1T_5	1.21	1.03	1.12	E_2T_5	1.12	0.98	1.05
E_1T_6	1.21	1.32	1.26	E_2T_6	1.05	1.12	1.08
E_1T_7	1.07	0.96	1.02	E_2T_7	0.78	0.89	0.83
E_1T_8	0.81	0.75	0.78	E_2T_8	0.77	0.83	0.80
E_1T_9	0.96	0.88	0.92	E_2T_9	0.93	1.11	1.02
CD (p=0.05)	0.18	0.17	0.18	CD (p=0.05)	0.20	0.21	0.19

application of micronutrients with growth regulators respectively). Higher doses of growth regulators decreased the total amount of lumps in banana fruits. Medium dose of micronutrients (soil application of borax @ 1g and zinc sulphate @2g/plant or foliar application of borax @ 0.25 % and zinc sulphate @ 0.25 %) resulted lower average weight of lumps when no growth regulators were applied while both the medium and high dose of micronutrients resulted more or less similar weight of lumps in banana fruits. Comparing the results of treatment combinations, indicate that addition of micronutrients with growth regulators have markedly reduced the lump weight. The positive role of gibberellic acid and auxins including the synthetic auxins (like 2,4-D) on proper growth of the fruit pulps during growth and development might have reduced the chances of physiological disorder like hardening of fruit pulp (Basra 2000). Application of micronutrients like zinc might have caused higher synthesis of auxin within the developing fruits that resulted into reduced size of lumps in banana fruit pulp. The reduced weight of lumps by application of gibberellin and 2,4-D as well as the micronutrients is supported by the report of Basra (2000).

Fruit pressure (kg/cm^2): Fruit pressure was statistically maximum (2.81 and 2.82 kg/cm^2) under both the E_1T_1 and E_2T_1 with no application of growth regulators and micronutrients in both set of experiments (Table 8). Application of micronutrients significantly reduced incidence as well as size of the lumps in the banana caused reduced hardness of the banana fruits. Thus the higher dose of growth regulators and medium dose of micronutrients under both the soil and foliar application of micronutrients i.e. E_1T_8 (GA_3 and 2,4-D both @100ppm along with soil application of borax @

Table 7. Average weight (g) of hard lumps in the ripe banana fruits under different treatment combinations of growth regulators and micronutrients

Treatments	Growth regulators with soil application of micronutrients			Treatments	Growth regulators with foliar application of micronutrients		
	Main crop	Ratoon crop	Pooled		Main crop	Ratoon crop	Pooled
E_1T_1	6.15	6.00	6.07	E_2T_1	5.28	6.03	5.65
E_1T_2	5.27	5.03	5.15	E_2T_2	2.77	2.89	2.83
E_1T_3	4.20	4.32	4.26	E_2T_3	3.94	4.16	4.05
E_1T_4	4.76	4.51	4.63	E_2T_4	3.82	3.65	3.73
E_1T_5	2.11	1.93	2.02	E_2T_5	2.02	1.86	1.94
E_1T_6	3.23	3.36	3.29	E_2T_6	2.93	3.14	3.03
E_1T_7	2.81	2.70	2.75	E_2T_7	2.22	2.41	2.32
E_1T_8	0.90	0.99	0.94	E_2T_8	1.10	0.92	1.01
E_1T_9	1.36	1.48	1.42	E_2T_9	1.27	1.35	1.31
CD (p=0.05)	0.41	0.38	0.39	CD (p=0.05)	0.44	0.37	0.42

Table 8. Fruit pressure of ripe banana fruits under different treatment combinations of growth regulators and micronutrients (kg/cm^2)

Treatments	Growth regulators with soil application of micronutrients			Treatments	Growth regulators with foliar application of micronutrients		
	Main crop	Ratoon crop	Pooled		Main crop	Ratoon crop	Pooled
E_1T_1	2.78	2.84	2.81	E_2T_1	2.80	2.84	2.82
E_1T_2	2.66	2.70	2.68	E_2T_2	2.73	2.65	2.69
E_1T_3	2.67	2.71	2.69	E_2T_3	2.62	2.67	2.64
E_1T_4	2.44	2.39	2.41	E_2T_4	2.46	2.36	2.41
E_1T_5	2.32	2.28	2.30	E_2T_5	2.32	2.50	2.41
E_1T_6	2.53	2.46	2.50	E_2T_6	2.03	2.15	2.09
E_1T_7	1.90	1.95	1.92	E_2T_7	1.89	1.81	1.85
E_1T_8	1.69	1.60	1.65	E_2T_8	1.62	1.75	1.69
E_1T_9	1.68	1.74	1.71	E_2T_9	1.83	1.88	1.84
CD (p=0.05)	0.15	0.17	0.14	CD (p=0.05)	0.16	0.18	0.15

1g and Zinc sulphate @2g/plant) and E_2T_8 (GA_3 and 2,4-D @100ppm and foliar application of borax @ 0.25 % + Zinc sulphate @ 0.25 %) showed the minimum fruit pressure (1.65 and 1.69 kg/cm^2). The fruit pressure was decreased with increment in the dose of growth regulators and micronutrients. As growth regulators and micronutrients reduced the size and weight of the hard lumps fruit pressure also decreased that mean fruits become softer. Singh *et al*. (2021) has described the positive influence of gibberellins and auxins in proper tissue development during sexual growth in plants and deficiency of such growth regulators may also cause reduced growth by hardening the tissues and dead patch formation. Thus, the deficiency of growth regulators in the present experiment caused increased hardness of lumps in banana fruits under treatments having no growth regulators (control treatments; E_1T_1 and E_2T_1). This has consonance with the statement of Singh et al (2021). Antonio and Augusto (2020) and Wang et al (2024) have also reported higher fruit pressure in banana due to improper physiological advancement of growth and ripening for imbalance of growth regulators and micronutrients.

Sarma et al (2001) reported that pulp hardiness might be reduced by application of 2,4-D in higher dose after harvesting in *Musa* (AAB group) cv. Malbhog. The softer pulp of banana free mostly free from hard lumps in the present experiment with the application of growth regulators and micronutrients was due to proper availability of different growth regulators and micronutrients for the fruit pulp tissue development in banana. Banana fruits with no application of micronutrients in the present study exhibited comparatively hard fruits than the micronutrient applied fruits. The present research has also similarity with the findings of Matsumoto et al (2009). Gonçalves and Vitória (2011) reported the deficiency of zinc and boron in papaya caused pulp hardiness. McMenemy (2014) described hard lumps in flesh of avocado fruit due to nutritional deficiency and micronutrients in particular.

CONCLUSIONS

Colourless or brownish, large sized lumps were detected in the banana fruits with higher fruit pressure from most of the control treatments (i.e. having no growth regulators and micronutrient application). Most soft fruits with minimum or no lumps have been recorded under maximum doses of growth regulators. Among the soil application of micronutrients, 1g borax with 2g zinc sulphate per plant application resulted best in respect to fruit pressure and less occurrence of hard lumps in banana. But 0.25% of both the borax and zinc sulphate as foliar application has also shown better result with respect to less occurrence of hard lumps and softer fruits. Hence, to get banana fruits with minimum hard lumps, GA_3 and 2,4-D (both @100ppm) with borax and zinc sulphate (@1 and 2g/plant as soil application, respectively or 0.25% foliar application of both) can be followed.

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Received 04 October, 2024; Accepted 24 January, 2025