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Morphological and yield attributing parameters of macro-propagated cultivars of banana (*Musa* spp L.)

Pamidi Suryanarayana, Chintamani Panda and Subhrajyoti Mishra

Abstract
An experiment on the field performance of different macro-propagated cultivars of banana (*Musa* spp L.) was carried out at the field of the AICRP on Tropical Fruits (Banana) located at the Horticulture Research Station, O U A T, Bhubaneswar during 2016-2017. The experiment comprised of eight treatments replicated thrice and planted at a spacing of 2×2 m following recommended package of practices. Observations on different morphological and yield attributing characters were studied critically. The result revealed that none of the genotypes was superior for all traits studied. However among the macro propagated type, performance of Grand Naine was better as compared to other genotype with regards to the maximum plant height (189.57 cm), plant girth (63.93 cm), life period of leaf (42.19), emergence of new plant (4.52), days taken from emergence to full unfurling of leaf (22.16 days), number of leaves produced till flag leaf (44.39) , number of days taken to produce flag leaf (229.62 days), length of the leaf (152.45 cm), width of leaf (61.04 cm), number of leaves present at shooting (12.30), no of fingers/hand (13.09), finger weight (133.67 g), number of hands per bunch(14.2), hand weight (1.750 kg), bunch weight (24.85 kg) and yield (49.68 t/ha). The cultivar Bantal produces the fingers at par in weight with Grand Naine (133.67) and the Champa produces highest number of fingers per bunch (15.5) whereas the bunch weight (9.8 kg) is less due to small size fingers. Hence the Grand Naine is a superior genotype under the coastal agro-climactic condition of Odisha with early bunching habits (260 days).

Keywords: Macro-propagated banana, banana (*Musa* spp L.), yield attributing characters, Grand Nain, yield, morphological characters

Introduction
Banana (*Musa spp*.) the "Apple of Paradise" belongs to the family *Musaceae* under the section *Eumusa* in the order *Zingiberales* is one of the oldest and widely grown fruits known to mankind. The cultivation of this herbaceous fruit plant dates back to 8000-5000 B.C. as per the archeological and paleo environmental evidences obtained from Papua New Guinea. It was originated in South-East Asia (Simmonds, 1966) [17]. It is used both as a staple food as well as a major export commodity for many tropical and subtropical countries. It plays a vital role in the diet of people due to its high nutritive value. It has high carbohydrate content as well as supplies a good amount of energy (100 cal per 100g), a good source of vitamins A, B_1, B_2, and C and important minerals like Ca, K, P and Fe while it contains little amount of proteins and fats.

World banana production is around 105 million tonnes annually, among which share of India remains 9.19 per cent (Ministry of Agriculture and Farmer Welfare, 2015) [10] making it the largest producer. India produces about 30,008,000 t of banana annually from an area of 880,000 ha with an average productivity of 34.1 t ha^{-1}(NHB, 2014) [11]. It is the second most important fruit crop next to mango filling about 1/3rd volume of the fruit basket of our country. The productivity ranges from 10 t ha^{-1} as in case of Kerala and Assam comparable to the highest over 65 t ha^{-1} achieved by the farmers of Maharashtra and Gujarat (NHB, 2014) [11]. Banana occupies 20 per cent area among the total fruit area in India and the varieties like Dwarf Cavendish, Robusta, Monthan, Poovan, Nendran, Red Banana, Nyali, Safed Velchi Basaraipur, Rasthali, Karpurvalli, Virupakshi and Grand Nain etc are popular. Main banana growing states are Tamil Nadu, Maharashtra, Gujarat, Andhra Pradesh and Karnataka. In Odisha Patakpura, Champa, Grand Naine, Dwarf Cavendish and Bantala are the popular cultivars. The state produces about 467.730 t of Banana from an area of 24,730 ha with an average productivity of 18.91 t ha^{-1} (NHB, 2014) [11].

Banana and plantains are propagated vegetatively through sword suckers up to a tune of 90 per

Cent and rest 5 per cent by other types of planting materials like bits, butts and peepers. Generally, a sucker had different developmental stages viz. peepers, sword suckers, maiden-sucker, Water and bull head corm and could be used as planting materials. On the other hand, peepers should not be used for establishing banana plantations because they were a little slower in development than other types.

Macro propagation is an excellent option for producing low cost quality planting material because of the ease of multiplication, low cost of production of planting material and having potential to produce 50-60 shoots per sucker in 4-5 months. Macro propagation is achieved by two methods and could be adopted either in the field conditions (*in situ*) or in the nursery (*ex situ*). It involves decapitation, decortications and hardening. Macro-propagation is one such cost effective technique where repression of apical meristem will stimulate the regeneration of lateral meristem (Kacar and Faber, 2012; Saraswathi *et al.*, 2014) [7, 15, 16]. Increased suckering rate can be achieved through complete or partial decapitation on a field grown plant or detached corm technique (Baiyeri and Aba, 2002) [1].

Banana in India is mostly a crop of marginal framers with little affordability to tissue culture plants which are 4-8 times higher than the suckers cost. Hence a simple and framer friendly method has been developed to bridge the gap in supply of healthy planting material with an affordable cost through macro-propagation. Macro-propagation method generates plantlets from sword sucker, so framers can adopt this especially to enhance the planting material production of traditional cultivars. By choosing a healthy mother plant, macro-propagation can produce healthy planting material to replace the diseased plant of the same variety in a short span of time. It can produce 50-60 plantlets within 4-5 months as against 6-10 suckers by a mother plant. Macro propagation provides cheap, simple and relatively rapid techniques for vegetative multiplication of *Musa* species that could be amenable to the low income, unskilled, small and medium scale farmers who are the major's growers of banana and plantains in the humid tropics. This experiment was under taken in order to establish the superiority of macro propagated planting materials over the conventional planting material i.e. sword suckers.

Materials and Methods

A field experiment was conducted on different macro-propagated cultivars of banana (*Musa* spp L.) planted at a spacing of 2×2 m at AICRP on Fruits (Banana), Horticultural Research Station, Department of Fruit Science and Horticulture Technology, O.U.A.T., Bhubaneswar during 2016-17. The experimental site comes under the eighteenth agro climatic region of the country i.e. "Eastern Coastal Plain'' and is termed as sub humid. The climate here is warm, humid with distinct summer, rainy and winter seasons. Geographically the site is delineated at 20^0.15 N latitude and 85^0.52 E longitudes at an altitude of 25.5 m above MSL. The design used in the present experiment was Completely Randomized Block Design (RBD) having 8 treatments each replicated thrice. The experiment was done on 4 varieties of banana Bantal, Patakapura, Champa, and Grand Naine.

Preparation of planting materials

Old rhizomes were obtained from the field of AICRP on Banana, Horticulture Research Station, OUAT, BBSR. Using a sharp scalpel and small knife, each plantlet was separated carefully so as to retain at least 2-3 roots. Excess roots were removed and remaining roots were trimmed to 2-3 cm length. Hardenings were done individually in poly bags. A media mixture of Red soil: Sand: Farmyard manure in 1:1:1 ratio is filled in poly bags with drainage holes. Bundles of plantlets were dipped in IBA (0.25%) for 15 min and shifted directly for secondary hardening by planting in poly bags to facilitate better rooting and regeneration. Plantlets were watered sufficiently and maintained under shade for 45 days and to make ready for field planting.

Planting of suckers

Healthy, disease free and uniform sized sword suckers of 3 months age were selected and treatment was done by dipping paired suckers with cut leaves and pseudostem in solution containing Monocrotophos @ 2.5ml/ liter and Copper oxy-chloride (COC) @ 5g/ liter. Later, the suckers were planted in the pits. Before planting, 50g of phosphorus in the form of SSP was applied to each pit as basal dressing.

Fertilization

A fertilizer schedule of 200-50-200g N-P-K/ plant was followed. Phosphorus was applied as basal and nitrogen and potassium were applied in 4 splits (45 DAP, 90 DAP, 135 DAP and 180 DAP) starting from 45 days after planting. Fertilizer was applied in split dose for better growth of the plant i.e. 50g urea, 50g SSP and 100g MOP was applied as basal at the time of planting. Another 50g urea was applied each at three months and six months after planting. Then at nine month of planting rest 50gm urea and 100 gm MOP was applied.

Irrigation

The plants of experimental plot were irrigated through drip irrigation every week for a period of 3-4 hours to ensure availability of moisture at the active root zone. Good drainage condition was provided without any water logging.

Plant protection measures

Furadon 3G was applied @ 10g per plant for protection against nematodes infestation and was repeated three times each at two month interval. To control termites attack, Cholopyriphos @ 2ml/ lit was applied at the base of the plant.

Biometrical and yield observations

The plant height was measured using a ruler up to the end of the last leaf petiole and expressed in centimetres. The pseudostem plant girth at base, middle, top was measured in centimeters and average was recorded as the plant girth. The number of suckers arising from the base of the plant was counted from time to time were recorded up to shooting of the plant. The total number of functional leaves produced on the pseudostem when flag leaf emerges was counted and recorded by tagging. The intervals between the full emergences of leaf up to its senescence was measured periodically by tagging the individual leaves and expressed in days. The interval between first appearance of the leaf and it's full unfurling which is measured in days and expressed in the same unit. The length and width of the leaf was measured from the base of petiole to the leaf tip using a ruler and expressed in centimeter. The duration between date of planting and emergence of inflorescence was recorded as days to shooting. The total numbers of leaves per plant present at shooting were counted and were expressed in number. The number of days from

planting to harvesting period between appearance of first fertile hand (female) and first male hand to recorded the observations. Number of hands per bunch, bunch weight, hand weight, number of fingers per hand and finger weight from second hand was obtained by proper methods and the average of treatments were recorded immediately after harvest. Average of bunch weight of selected plants in each treatment multiplied by 80 per cent of population can be used to record the yield of individual population.

Results and Discussion

Vegetative Characters

The plant height (Table 1) and plant girth was recorded highest in the variety Bantal and Grand Naine all throughout the growth period under the study up to shooting. This may be due to the resultant effect of the genetic makeup of the variety interacted with the environment. Hence the cultivar Bantal is tallest (242.62) followed by Champa (239.43 cm) and Patkapura (234.91 cm) whereas the Grand Naine (188.42 cm) exhibited dwarfism. So far as the effected of methods of propagation on plant height is concerned all most all the genotypes produced more height in macro propagated planting in comparison to suckers. This may be due to the ageing effect as the formers are more aged as they are planted maintaining at 45 days from poly nursery. This corroborates the finding of Wong *et al*, (2002), Singh *et al*, (2011) [18].

Table 1: Plant Height in Different Banana Genotypes Studied Under Coastal Zone of Odisha

Treatments Treatments	30 DAP	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP	At shooting stage
T_1- Champa (M)	33.58	57.68	68.26	84.11	108.99	125.47	239.43
T_2- Champa (S)	0.00	53.03	55.23	75.97	96.59	115.37	237.28
T_3- Bantal (M)	37.18	61.60	72.87	92.17	114.28	132.49	242.62
T_4- Bantal (S)	0.00	54.01	60.17	83.07	103.74	124.36	241.96
T_5- Patkapura (M)	35.97	58.77	69.25	90.87	108.15	122.40	234.91
T_6- Patkapura (S)	0.00	54.83	61.31	83.97	100.07	117.20	232.55
T_7- Gran Naine (M)	29.89	51.84	61.97	76.91	95.99	119.89	189.57
T_8- Grand Naine (S)	0.00	47.69	52.15	68.21	90.03	112.99	188.42
SE (m)±	1.02	1.19	1.34	2.71	2.14	1.43	2.26
CD 5%	3.08	3.61	4.14	5.55	6.48	4.32	5.24

M- Macro propagation, S- Sucker

Plant girth

There was tremendous increase in plant girth starting from 30 DAS after planting up to shooting after that it remains constant (Table 2). The maximum plant girth was attained by the macro propagated Grand Naine (63.93 cm) cultivar followed by the macro propagated Bantal (59.25 cm). The plant girth was recorded at three point of the pseudo stem i.e. base, middle and top and it was averaged this may attributed to the better growth in Grand Naine cultivars than others.

Table 2: Plant Girth in Different Banana Genotypes Studied Under Coastal Zone of Odisha

Treatments	30 DAP	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP	At shooting stage
T_1- Champa (M)	9.00	18.57	25.48	34.86	42.65	51.26	56.13
T_2- Champa (S)	0.00	10.49	19.51	25.39	37.20	45.14	51.97
T_3- Bantal (M)	8.23	20.77	30.15	38.61	46.30	55.08	59.25
T_4- Bantal (S)	0.00	11.21	25.74	32.22	40.10	47.66	50.08
T_5- Patkapura (M)	7.41	18.93	28.66	35.99	41.92	52.09	54.12
T_6- Patkapura (S)	0.00	9.74	23.88	29.68	38.54	53.40	55.07
T_7- Grand Naine (M)	10.10	22.58	34.26	41.32	50.95	61.88	63.93
T_8- Grand Naine (S)	0.00	10.61	27.74	37.81	42.79	52.87	54.68
SE (m)±	0.26	1.05	1.62	1.52	1.20	2.02	1.11
CD 5%	0.81	3.19	4.89	4.59	3.64	6.24	3.37

M- Macro propagation, S- Sucker

Emergence of suckers

It was noticed that the sucker production is highest in Grand Naine (4.52) macro propagated treatment on all the dates (Table 3). It may be due to treatment of mother corms in IBA 2500 ppm after excising. This triggers more sprouts production stimulating the dormant eyes of the corm which later on transformed to suckers. This corroborates the finding of (Ogero, 2012, Faturori *et al*, 2002, and Joab 2004) [12, 6].

Number of leaves and their life period

So far as the total number of leaves produced per plant including the flag leaf is concerned there is significant difference among the eight treatment combinations (Table 4). The variety Bantal exhibited highest number of leaves (45.83) than any other variety followed by Grand Naine (44.39) which indicates the intrinsic genetical potential for the trait. However there is no difference among the propagating methods adopted confirming the assumption .The genetic makeup of culinary type of Banana (plantain) is different to that of desert types. It is agreed by Baskaran *et al.*, (2014) [2], Kahangi *et al*, (2002) [8], Lopez (1994) [9].

But considering the life period of individual leaves which were ear marked from their emergence up to final senescence the revealed that, it is highest in Bantal (49.53) variety followed by Champa (44.71). It indicates that, this character is fully expressed by the heredity and not influenced by any environmental factors.

Table 3: Emergence of new plant in different Banana genotypes studied under coastal zone of Odisha

Treatments	90 DAP	120 DAP	150 DAP	180 DAP	210 DAP	240 DAP	Harvesting stage
T_1- Champa (M)	3.11	3.55	3.87	3.90	2.78	2.56	4.30
T_2- Champa (S)	2.51	3.28	4.69	3.23	3.23	2.36	3.96
T_3- Bantal (M)	3.40	4.32	3.82	3.95	3.52	3.28	4.77
T_4- Bantal (S)	3.31	4.24	5.15	4.79	3.79	2.45	4.60
T_5- Patkapura (M)	4.51	4.43	4.40	3.69	3.16	3.06	2.77
T_6- Patkapura (S)	3.14	3.24	4.37	4.41	3.40	3.36	2.37
T_7-GrandNaine (M)	4.63	5.43	5.51	4.35	4.09	3.71	4.52
T_8-GrandNaine (S)	3.74	4.26	5.40	3.14	3.13	3.10	3.71
SE (m)±	0.23	0.13	0.34	0.26	0.26	0.35	0.21
CD 5%	0.71	0.40	1.04	0.81	0.80	1.06	0.65

M- Macro propagation, S- Sucker

Leaf size and other leaf characters

The time period interval between the appearance of a leaf and its full unfurling was recorded (Table 4). It was found that, there is any significant difference neither among the varieties, propagating methods nor their interactions. However Bantal genotype takes the highest days for full opening (25.46) followed by Grand Naine (22.16) which indicate this trait to be genetically controlled without any external environmental impact .This corroborates the findings of Dayarani *et al*,(2013) [3] Robinson and Davilliers (2007) [14].

But so far as the leaf size is concerned both length (Table 5) and breadth (Table 6) which was being recorded in every month by tagging the individual leaves, it shows an increasing trend from the initial period up to shooting after which the length and breadth of the leaves remained constant .The maximum leaf length and width was obtained from Grand Naine (152.45) followed by Champa (139.18) irrespective of the propagation methods.

Appearance of flag leaf in banana indicates the sign of bunch appearance. It is the last leaf produced by the pseudo stem which is easily distinguishable from its size. Different varieties take different gestation period to produce the flag leaf.

In the present investigation it was found that irrespective of the propagating material Bantal consumed highest time period of 256.29 days followed by Patkapura (255.83) and Grand Naine (245.62) is the lowest .This indicates the earliness of the variety which is fully controlled by the inherent genetic makeup.

Undeniably the leaves produce photosynthates which are utilized to develop the reproductive parts as a site of storage for future perpetuation. In banana plant the number of leaves present at the time of shooting decides the bunch size, bunch weight and the finger characteristics. It appeared that the cultivar Bantal (13.68) and Grand Naine (13.68) are at par in this trait producing about 14 leaves at the time of shooting which was lowest in Patkapura (9.86). Further the method of propagation has no significant effect on this character as it is completely a genetical one.

The number of days taken for shooting after the flag leaf emergence indicates the growth rate of the plant (Table 4). It was observed highest in Patkapura (51.84) followed by Bantal (44.34) and Grand Naine (32.54) being the lowest which indicates the rate of growth in the later is more. This agrees with the findings of Joab (2014) [6] and Ogero (2012) [12].

Yield Attributing Characters

The pseudostem of banana bears an inflorescence terminally which is a once- in- life cycle event (monocarpic) of that plant. The yield attributing characters which are mostly genetically determined decides the economic yield of the crop (Table 7). The number of hands in a bunch and number of fingers in a hand together constitute the total bunch weight. Agreeably Grand Naine fingers (133.76g) are more weight than Bantal (132.0g). In desert type Patkapura (74.79g) followed by Bantal. The number of finger in hand is highest in Macro-propagated Champa (15.5) followed by Sucker Champa (15.2) and Grand Naine (13.09) but the number of hands near bunch is highest in Grand Naine (14.2) followed by Champa (12.35). Culinary types Bantal (10.08) is with less number of fingers per hand and less number of hands per bunch (9.4). The individual finger weight and the corresponding hand weight together contribute towards the bunch weight as well as final yield. Accordingly the hand weight is highest in Grand Naine genotype along with the bunch weight (24.85Kg) followed by Bantal (13.28Kg). Hence per hectare yield is highest in Grand Naine (49.68t) followed by Bantal (26.56t) and the Patkapura (15.45t) being the lowest. The method of propagation appears to have least effect on the bunch yield and other yield attributing characters indicating that it is genetically controlled trait. The findings are in line with Rashed (2003), Baiyeri and Aba (2005) [11], Gitonga *et al*, (2010) [12], Sajith *et al*, *(*2014) [15].

Table 4: Number of leaves produced till flag leaf, life period of a leaf, days taken for emergence to full unfurlinging of leaf, number of days taken to produce flag leaf, number of days taken for shooting after the flag leaf emergence and number of leaves present at shooting in different Banana genotypes studied under coastal zone of Odisha

Treatments	Number of leaves produced till flag leaf	Life period of a leaf	Days taken for emergence to full unfurlinging of leaf	Number of days taken to produce flag leaf	No of days taken for shooting after the flag leaf emergence	Number of leaves present at shooting
T_1- Champa (M)	41.71	44.71	20.52	240.30	39.03	12.84
T_2- Champa (S)	41.82	41.48	20.11	242.94	31.28	12.16
T_3- Bantal (M)	45.23	49.53	25.46	255.29	44.34	11.57
T_4- Bantal (S)	45.63	47.27	22.49	252.16	47.32	13.68
T_5- Patkapura M)	42.53	43.15	20.07	256.83	51.84	11.11
T_6- Patkapura (S)	42.12	42.07	21.34	260.86	48.05	9.86
T_7- Grand Naine	43.27	40.84	22.16	232.62	32.54	12.32
T_8- Grand Naine (S)	44.39	42.19	21.21	231.57	31.97	13.65
SE (m)±	0.55	1.17	0.67	2.19	2.41	0.26
CD 5%	1.52	3.53	2.02	3.89	4.86	0.78

M- Macro propagation, S- Sucker

Table 5: Leaf length of banana genotypes studied under coastal zone of Odisha

Treatments	30DAP	60DAP	90DAP	120DAP	150 DAP	180DAP	At shooting stage
T_1- Champa (M)	31.55	50.39	73.21	98.87	111.07	129.63	139.18
T_2- Champa (S)	0.00	33.00	63.04	89.94	101.84	124.34	137.08
T_3- Bantal (M)	31.65	51.11	71.61	95.66	110.07	125.05	134.85
T_4- Bantal (S)	0.00	27.83	68.21	84.57	99.95	124.64	133.59
T_5- Patkapura (M)	31.61	50.31	69.76	90.20	108.21	121.92	136.99
T_6- Patkapura (S)	0.00	33.18	60.12	87.75	97.41	118.26	136.12
T_7- Grand Naine (M)	27.17	52.32	79.11	99.47	115.73	134.91	152.45
T_8- Grand Naine (S)	0.00	37.27	71.58	90.27	110.72	131.69	151.16
SE (m)±	0.87	0.66	1.37	0.67	1.16	1.18	1.49
CD 5%	2.63	2.04	4.15	2.02	3.52	2.06	3.40

M- Macro propagation, S- Sucker

Table 6: leaf width of banana genotypes studied under coastal zone of Odisha

Treatments	30DAP	60DAP	90DAP	120DAP	150DAP	180DAP	At Shooting stage
T_1- Champa (M)	13.63	20.04	25.49	33.58	42.18	50.24	56.27
T_2- Champa (S)	0.00	17.83	20.72	28.16	40.98	50.01	55.01
T_3- Bantal (M)	14.77	20.59	27.05	35.46	43.44	49.85	54.29
T_4- Bantal (S)	0.00	18.04	21.77	32.36	42.10	48.25	53.19
T_5- Patkapura (M)	15.70	20.33	27.26	32.07	40.32	45.55	53.72
T_6- Patkapura (S)	0.00	19.78	21.68	29.95	38.45	43.35	53.05
T_7- Grand Naine (M)	15.10	21.84	28.64	37.37	45.02	53.61	61.04
T_8- Grand Naine (S)	0.00	18.13	21.63	34.15	43.20	52.05	60.48
SE (m)±	0.34	0.37	0.90	0.93	0.71	0.68	1.17
CD 5%	1.04	1.13	2.73	2.82	2.16	2.12	3.54

M- Macro propagation, S- Sucker

Table 7: Yield and yield attributing characters of banana genotypes studied under coastal zone of Odisha

Characters / Treatments	No of fingers /hand	Finger weight (g)	No of hands /Bunch	Hand weight (Kg)	Bunch weight (Kg)	Yield/ ha (t)
T_1- Champa (M)	15.5	51.42	12.35	0.797	9.842	19.68
T_2- Champa (S)	15.2	50.34	11.68	0.765	8.93	17.86
T_3- Bantal (M)	10.48	132.00	9.6	1.384	13.28	26.56
T_4- Bantal (S)	10.8	129.3	9.4	1.396	13.12	26.24
T_5- Patkapura (M)	10.8	74.79	10.28	0.807	8.31	16.60
T_6- Patkapura (S)	10.5	72.30	10.17	0.759	7.72	15.45
T_7- Grand Nain (M)	13.09	133.67	14.2	1.750	24.85	49.68
T_8- Grand Nain (S)	12.81	126.74	13.92	1.624	22.5	45.19
SE (m)±	0.04	1.13	0.70	0.46	2.37	2.17
CD 5%	0.12	3.42	2.17	1.39	4.03	6.57

M- Macro propagation, S- Sucker

Conclusion

Considering the results and discussion it can be concluded that, as suckers are not plentily available in banana we can use the macro-propagated plants for raising a successful crop. It is a rapid mass multiplication method without substantial loss in yield. Among all the genotypes tested the cultivar "Grand Naine" a desert type banana is best among all with short gestation period (247 days) and highest yield (49.68t/ ha).

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