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# Effect of media and corm preparation methods on banana macro-propagation

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**Abstract**
The experiment was conducted to study the effectiveness of banana macro-propagation using three methods of corm preparation; whole corm, ½ split corms and ¼ split corms in five types of media; soil, sand, cocopeat, soil + sand and sawdust. Were laid out in a 2-factor factorial completely randomized design. Various parameters were studied and data were analyzed at 5% level of significance. The result were reveal that least number of days was recorded in sand 21.0 days, sawdust 22.00 days, and soil 22.40 days as compared to soil + sand 23.70 days and cocopeat 29.80 days. Highest number of plantlets was generated from ¼ split corms (29.49), followed by ½ split corms (27.84) and whole corm (25.24). The quality parameters of plantlets with respect to highest plant vigour was obtained from the whole corm followed by those obtained from ½ split corms and ¼ split corms while whole corm and ½ split corms were more vigorous plantlet when planted in sawdust, sand and cocopeat. From the results of the current study, it could be recommended to use ½ split corms as propagules, which met both higher number as well as quality of planting materials. Further, sawdust, sand and cocopeat can be recommended in that order of priority depending on availability in a particular area.

**Keywords:** Banana, Grand Naine, corm, decapitation, macropropagation, plantlets

## Introduction
Banana (Musa *spp*.) is herbaceous monocotyledonous evergreen fruit crop widely cultivated in humid tropic and subtropical regions. Musa *spp*. which includes banana and plantains belong to family Musaceae and originated from South East Asia. Reported to have originated from crosses of two wild species of *Musa acuminata* and *Musa balbisiana* [1]. Banana has many uses, edible as ripe fruit, cooked (plantains), vegetables, chips, processed into powder, soft drinks, beer, jam and baby foods.The pseudo-stem for making textile fibre; fresh leaves as food plates and animal feed.

Banana and plantains are grown in an area 5.16 million ha with production of 116.78 million tonnes in the world while in India area under banana production was 0.866 million ha was 30.46 million tonnes [2]. The largest producersof bananas are India, China, Indonesia, Brazil, Ecuador, Philippines, Mexico, Guatemala, Angola, Tanzania, and Colombia [3]. In India major producing states are Tamil Nadu, Maharashtra, Gujarat, Andhra Pradesh, Karnataka, Madhya Pradesh, Bihar, Uttar Pradesh, West Bengal and Assam. The estimated area in India was 0.898 million ha with production of 31.75 million tonnes [2].

In the production system the major constraints faced by banana farmers include limited availability of good quality planting materials, rising production costs, low prices, downward influence on prices by international and leading retail chains [3, 4]. The quality banana planting materials of improved cultivars could enhance banana productivity and incomes [5-7]. The demand for good banana planting materials in India was estimated at 125 million per annum while 20 companies were available to supply 2 to 5 million plantlets (4%) of the demand through tissue culture [8] while the 96% of the required planting materials were sourced by collecting suckers from existing plantations posing high risk of pests and disease transmission to the new plantations [9].

Grand Naine is a cultivar of *Musa acuminata* included in Cavendish group and was introduced to India from Israel. It is shorter than the Giant Cavendish and taller than the Dwarf Cavendish cultivars; it is a variety with high international acceptance due to its good quality fruits. Producers prefer Grand Naine due to high yielding of 200 to 220 fruits (i.e fingers) per bunch, long cylindrical bunch weighing 25 kg to 35 kg, bearing 8 to10 hands. On an average, fruit length and girth vary from 15 to 21 cm and 12 to13 cm respectively.

Other commercially important varieties include Robusta, Dwarf Cavendish, Red Banana and Nendran [10, 1, 11].

Edible bananas are propagated vegetatively using suckers which are produced through tissue culture, macro-propagation and suckers from the field [12]. Sword suckers are preferred since they are vigorous as reported by [1]. Tissue culture requires high technology for mass production of disease-free plantlets. However, such tissue culture facility and plants produced are not affordable by small holder farmers who are collectively major producers of banana. The sword sucker, rhizome and rhizome bits are used as start-up materials in banana macro-propagation. The number and quality of plantlets generated varies with type of media, variety, method of corm preparation, health of plant and treatment with hormones [13].

Macro-propagation is employed to produce relatively good quality plantlets to meet the demand of planting materials for the banana farmers. This experiment was conducted to come up with best corm preparation method and type of media that resulted into a greater number of good quality planting materials through macro-propagation. In terms of quality plantlets, macro-propagation is considered intermediate between tissue culture and field suckers, since the technique can produce ranges from 10 to 40 relatively good quality planting materials from single corm as compared to 3 to 6 suckers from natural regeneration. The current experiment sought to test the effectiveness of five types of media and three methods of corm preparation in the banana macropropagation.

## Materials And Methods

The present experiment was carried out in at Fruit Science Nursery, Department of Fruit Science, College of Horticulture and Forestry, CAU, Pasighat -791102, Arunachal Pradesh in North East India; during March through October 2020. The experiment conducted propagation of whole corm, ½ split corms and ¼ split corms in five types of media. The experiment was laid out in a two-factor factorial CRD in which effect of media, corm preparation method, and their combined effect were studied. Factor A included five (5) types of media; soil, sand, cocopeat, sand + soil, and sawdust, while factor B. The three (3) levels of corm preparation methods; Whole corm, ½ split corms (2 equal parts), and ¼ split corms (4 equal parts). There were fifteen (15) treatment combinations that were replicated three times, a total of forty-five (45) plots Table 1. There were two corms per replication and the total number of corms used was 45 x 2 = 90 corms Figure 1.

Five (5) humidity chambers of equal dimensions were set up, each measuring 3 m long, 1 m wide and 1 m height (3 m X 1 m X 1 m) and covered with greenhouse polyethylene sheet (200-micron). Five propagation beds were prepared on well levelled ground by digging pits of dimensions 2.9 m long, 0.9 m wide and 0.45 m deep. Pits were filled with one type of media each to the ground level and demarcated by marking into 9 equal plots to which different treatments were assigned. The suckers were washed and then pared off the root portion by removing the outer layer with sharp knife to eliminate possible incidences of nematodes and other soil borne infections. Leaf sheaths were pared off one by one from base to expose lateral buds on the corm. The apical meristem was removed by screwing with sharp knife to eliminate apical dominance to encourage sprouting of lateral buds. Crosswise incisions were made on exposed lateral buds to induce multiple primary shoots from single bud.

The three methods of corm preparation were thirty (30) corms kept as whole corms; another thirty (30) corms were longitudinally split into 2 equal parts and the third group of 30 corms were longitudinally split into 4 equal parts. The corms were treated with fungicides and placed under shade for 24 hours. Benzoic aminopurine (BAP) was sprayed to the buds at the rate of 40 ppm before planting in respective media and covered with 5 cm thick media and irrigated adequately. The humidity chambers remained closed at all time to maintain humidity except when carrying out intercultural operations inside the chamber. Irrigation was provided 4 to 6 days interval based on moisture level in the initiation media to ensure adequate moisture at all time Figure 2. Fungicides were applied at 6 weeks interval as a precaution against building up of fungi in the humidity chambers. The decapitation of the shoots was performed when shoots attained two leaf stages by cutting off pseudostem 2 cm above the small corm. The cross wise incision was made on the meristematic point allowing development of at least 2 new shoots from single plantlet decapitated. The decapitation of primary shoots resulted into secondary shoots, with same procedure repeated on secondary and tertiary shoots. The cut portion was then treated with fungicides before covering again with the initiation media. The plantlets that were generated after decapitation of tertiary shoots were transferred to the growth media in polythene bags that was prepared by mixing 1:1:1 ratio of soil, sand and FYM for hardening. The potted plants were placed under partial shade and irrigated at 3 to 5 days interval depending on the prevailing weather condition. The observations recorded were; number of days to sprouting, shoots per corm (primary, secondary, and tertiary), plantlets harvested per corm, survivability percentage (%), pseudostem girth (mm), height of plantlet (cm), number of roots, root girth (mm), root length(cm), fresh and dry weight of plantlets.

## Results And Discussion

### Number of days to sprouting

The whole process from planting of corms in media to end of hardening took 7 months (29 weeks) Table 2, the shortest duration to primary shoot emergence was recorded in sand (21.0 days) at par with sawdust (22.0 days) and soil (22.4 days) and significantly different from soil + sand (23.7 days), while longest duration was recorded in cocopeat (29.8 days). The shortest duration was recorded in the ¼ split corms (21.9 days) significantly different from ½ split corms (24.7 days) and whole corm (24.8 days). Similar results were also reported by [14] when they used sawdust treated with biofertilizers; while [15] reported 40.5 days in sawdust.

### Number of plantlets harvested per corm

The data in table 2 show the highest number of shoots harvested from sawdust (31.61) and sand (29.28) followed by soil + sand (26.14) and soil (25.64) while cocopeat (24.93) was very significantly lower than sawdust. The lower number of plantlets in cocopeat could be attributed to the delayed shoot initiation thereby reducing chances of producing more shoots. Similar results were reported by [16, 17] when whole corms were planted in sawdust. The highest number of plantlets per corm was produced in ¼ split corms (29.49) and ½ split corms (27.84) while whole corm produced significantly lower number of plantlets (24.93). This could be attributed to the difference in severity of injury employed in

different methods of corm preparation. The trend in this experiment had shown that the more the injury caused to the corm the more the plantlets were generated. However, there was no assessment in this experiment of whether the level injury to the corm influenced changes in hormonal levels (auxins and cytokinins) which regulate plant regeneration. This phenomenon was backed by [18-20] who suggested that tissue wounding in plant regeneration enhances biosynthesis of auxins and cytokinin which in turn increases cell proliferation, callus formation and activation of signaling pathways leading to organogenesis.

**Survival percentage (%) at the end of hardening**

The higher survival rate observed in sawdust 91.78% (74.77%), sand 90.89% (73.91%) and cocopeat 90.00% (72.47%). These three types of media were found to have good drainage and loose enough to accommodate rooting than soil and soil + sand. Lower survival percentage was recorded in soil 79.33% (63.15); and soil + sand 81.33% (64.75%) as shown in table 2. The whole corm produced plantlets that had higher survival rate while the lowest survival rate was observed in plantlets from ¼ split corms. The plantlets generated from ½ split and had moderate survival rate. This trend could be attributed to the relatively smaller plants generated from ¼ split corms [21] reported poor root development at time of detaching plantlets from mother corm as one of the factors leading to reduced survival rate.

**Number of primary, secondary, and tertiary shoots generated and decapitated per corm.**

Table 3 had shown that media, corm preparation method and decapitation influenced the increase in number of shoots generated per corm. Corm splitting resulted into a greater number of shoots than whole corm.The highest number of primary shoots was recorded from corms planted in soil (3.41) statistically at par with those planted in sawdust (3.28) and soil + sand (3.16). number of secondary shoots was higher in sawdust (8.92) and sand (8.34 shoots). The higher number of tertiary shoots produced in ¼ split corms (17.27), at par with ½ split corms (16.67) while significantly lower number of shoots was produced from whole corm (14.03). Similar results were reported by [14, 22]. The lower number of primary shoots was recorded in corms planted in sand (2.78) and cocopeat (2.60). The number of shoots per corm was highest in ¼ split corm (3.53), followed by ½ split corms (3.01) and whole corm (2.60). The number of shoots per corm was observed to increase with severity of corm splitting. The combined effect had shown that the higher number of primary shoots per corm was in treatments combining ¼ split corms, with each of the media except cocopeat which delayed in sprouting.

**Number of secondary shoots generated and decapitated.**

Data presented in table 3 show the higher number of secondary shoots per corm recorded in sawdust (8.92) and sand (8.34 shoots) significantly higher than soil (7.07), soil + sand (7.42); while cocopeat was the least. The ¼ split corms produced higher number of shoots (8.76) significantly higher than ½ split corms (7.71) and whole corm (7.19). Similar results were also reported by [23] when whole corm was planted in sawdust.

**Number of tertiary shoots generated and decapitated**

The highest number of tertiary shoots was generated and decapitated from sawdust, sand. Soil and soil + sand produced lower number of shoots and it was also observed that workability was poor with soil media and soil + sand thereby making it unconducive for removing some part of media and perform shoot decapitation. The higher number of tertiary shoots produced in ¼ split corms (17.27), at par with ½ split corms (16.67) while significantly lower number of shoots was produced from whole corm (14.03). These findings were similar to those reported by [14, 24, 23, 25].

**Pseudostem girth (mm) after 30 days of hardening**

The higher pseudostem girth (mm) was recorded in plantlets generated in sand (42.06 mm), sawdust (41.04 mm), cocopeat (40.73 mm) and soil + sand (38.24 mm). Whole corm and ½ split corms produced plantlets with higher pseudostem girth as compared to ¼ split corms. The treatment combinations had shown no significant differences except T11 (soil + sand + ½ split corm) and T3 (soil + ¼ split corm) which recorded significantly lower stem girth. These results were in agreement with findings reported by [26].

**Pseudostem girth (mm) after 60 days of hardening**

After 60 days, sawdust sand and cocopeat derived plantlets recorded higher girth. Whole corm and ½ split corms were at par while ¼ split corms recorded lower pseudostem girth.

**Pseudostem girth (mm) after 90 days of hardening**

The data in table 4 show higher pseudostem girth of plantlets generated from sawdust (65.47 mm), sand (63.18 mm) and cocopeat (61.88 mm); while lower girth was recorded in soil + sand (59.14 mm) and soil (54.42) mm. It was observed that plantlets that had higher pseudostem girth also recorded higher root girth and plant height. Whole corm (63.07 mm) and ½ split corms (62.05 mm) gave higher pseudostem girth in sawdust, sand, cocopeat and sand + soil. While ¼ split corms registered best results in sawdust, sand and cocopeat. Similar trend was reported by [27] who observed that corms that were split into 4 fragments produced plantlets with smaller girth (32.0 mm) as compared to plantlets generated from whole corm (39.0 – 47.0 mm). The highest pseudostem girth was 68.20 mm recorded in T13 (sawdust + whole corm) and was at par with 10 other treatments except four treatments which were 55.83 mm in T1 (soil + whole corm), 54.77 mm in T2 (soil + ½ split corm), 54.43 mm in T12 (soil + sand + ¼ split corm), and 52.67 mm in T3 (soil + ¼ split corm).

**Height of plantlet (cm) after 30 days of hardening**

The significantly taller plantlets were produced from corms panted in sawdust (19.2 cm), sand (19.0 cm) and cocopeat (18.2 cm) as compared to those resulted from corms planted in soil (15.5 cm) and soil + sand (15.8 cm). Among the 15 treatment combinations the highest mean was 21.5 cm observed in T13 (sawdust + whole corm), and it was at par with 21.3 cm in T4 (sand + whole corm), 19.8 cm in T14 (sawdust + ½ split corm), 19.5 cm in (cocopeat + whole corm), 19.3 cm in T5 (sand + ½ split corm), and 18.4 cm in T8 (cocopeat + ½ split corm). The lowest plant height was 14.4 cm in T12 (soil + sand + ¼ split corm). The data in table 3 show that significantly taller plantlets were generated from whole corm and ½ split corms which were significantly different from ¼ split corms table 5.

**Height of plantlet (cm) after 60 days of hardening**

Sawdust (23.3 cm), sand (21.6 cm) and cocopeat (21.2 cm) produced taller plantlets as per the plant height recorded in

table 4. The higher growth rate in terms of plant height could be attributed to quick establishment of plantlets after transferring to polythene bags. The whole corm (21.7 cm) and ½ split corms (20.4 cm) came out superior to those resulted from ¼ split corms (18.4 cm). Similar results were reported by [28]. The treatment combinations of whole corm, ½ split corms with sawdust, cocopeat, sand gave better results in terms of plant height. In case of ¼ split corms better results were observed in sawdust as initiation media. Highest mean height was 24.5 cm in T13 (sawdust + whole corm), and was at par with 23.7 cm in T4 (sand + whole corm), 22.9 cm in T7 (cocopeat + whole corm), 22.8 cm in T14 (sawdust + ½ split corm), 22.4 in T15 (sawdust + ¼ split corm), 22.3 cm in T5 (sand + ½ split corm), 21.5 cm in T8 (cocopeat + ½ split corm). The lowest was 15.8 cm in T12 (soil + sand + ¼ split corm) table 5.

**Height of plantlet (cm) after 90 days of hardening**

After 90 days of hardening plant height was observed ton be higher in plantlets produced from sawdust, sand, and cocopeat; and were significantly higher compared to soil and soil + sand. Similar findings were reported by [23] when whole corm was planted in sawdust. The reason for such difference could be attributed to quick establishment in polythene bags due to good root development at the time of detachment from mother corms. The combined effect of whole corm and ½ split corms produced better results in sawdust, sand and cocopeat as presented in table 5.

**Average leaf area (cm2) after 30 days**

Highest leaf area was recorded from plants that were generated from sawdust (118.3 cm2) and was significantly different from cocopeat (104.4 cm2). The soil (87.6 cm2) and sand (82.1 cm2) were statistically at par, while the lowest leaf area was recorded in soil + sand (80.6 cm2). Whole corm and ½ split corms gave higher leaf area in sawdust, cocopeat and soil while ¼ split corms had better performance in sawdust. The combined effected had shown highest leaf area of 125.1 cm2 in T13 (sawdust + whole corm), at par with 116.0 cm2 in T15 (sawdust + ¼ split corm) and 113.7 cm2 in T14 (sawdust + ½ split corm); these were followed by 109.9 cm2 in T7 (cocopeat + whole corm), 105.0 cm2 in T8 (cocopeat + ½ split corm) and 101.6 cm2 T1 (soil + whole corm). The lowest leaf area (72.1 cm2) was recorded from plantlets generated from T12 (soil + sand + ¼ split corm) table 6.

**Average leaf area (cm2) after 60 days**

Higher leaf area was recorded from plantlets generated from sawdust, and cocopeat followed by sand. it was observed that all treatment combinations performed better except ¼ split corms in soil table 6.

**Average leaf area (cm2) after 90 days**

The average leaf area recorded at the end of 90 days showed that sawdust (222.2 cm2), sand (214.0 cm2) and cocopeat (210.8 cm2) were at par significantly higher than soil (186.2 cm2) and soil + sand (196.8 cm2). Whole corm resulted in plantlets with largest leaf area followed by ½ split corms and ¼ split corms. Similar results were reported by [23] while [8] reported higher leaf area of 328.40 to 370.35 cm2 table 6.

**Number of roots per plantlet**

The higher number of roots was recorded in plantlets produced from sawdust, soil and cocopeat significantly higher than sand and soil + sand. The ¼ split corms produced higher number of roots (11.4) which were smaller and thinner than those plantlets raised from whole corm (8.8) which produced fewer but thicker roots. Similar findings were reported by [8] when whole corm was used in sawdust. [28] had reported the higher number of roots (9.89 to 36.07) per plantlets and such a difference could be due to harvesting of primary shoots without decapitation. While [29] reported significant positive correlations of plantlet root development and the plant establishment when out planted in field table 7.

**Root girth (mm)**

The highest girth was recorded in plantlets generated in sawdust (22.6 mm) followed by those raised in cocopeat (20.7 mm), soil (19.8), sand (19.2 mm) and soil + sand (17.6 mm). The whole corm produced plantlets with higher root girth (21.5 mm) while ½ split and ¼ split corms had lower root girth of 19.1 and 19.2 mm respectively. It was observed that the root girth was inversely correlated to number of roots per corm. Whole corms produced plantlets with comparatively lower number of roots, however the root girth was higher. While ¼ split corms registered a greater number of roots with lower girth. [30] reported that organic substrates used as macro-propagation media have higher advantage over top soil table 7.

**Root length (cm).**

The highest root length was recorded plantlets raised in sawdust (38.44 cm) and sand (34.78 cm) followed by those plantlets raised in cocopeat (33.89 cm) while significantly lower root length was from plantlets raised in soil (31.89 cm) and soil + sand (30.33 cm). Similar results were reported by [8] when whole corm of Grand Naine was regenerated in sawdust. The results obtained in plantlets raised from whole corm was at par with those raised from ½ split corm and but significantly different as compared to plantlets raised from ¼ split corm. Root length was observed to be directly correlated with the plant height, and inversely correlated with the number of roots per plantlet table 7.

**Fresh weight of plantlet**

The highest fresh weight was recorded from plantlets that were generated from sawdust (59.33 g), cocopeat (57.11 g) and sand (55.11 g). Plantlets generated from whole corm recorded highest fresh weight (57.1 g) and was at par with those raised from ½ split corm (54.87 g). It was observed that whole corm produced more vigorous corms as compared to ¼ split corm (49.8 g). The difference could be attributed to the higher competition resulted from more shoots per corm generated from ¼ split corms in comparison to the lower number of shoots per corm generated from whole corm as shown in table 8.

The observation on the combined effect of media and corm revealed that the higher fresh weight was obtained where whole corm or ½ split corm, were planted in sawdust, cocopeat and sand. [31] found that the vigorous banana plants were comprised of 90 – 91% water and 9 – 10% dry matter.

**Dry weight of plantlet (g)**

The data in table 8 show that sawdust produced plantlets with higher dry weight (6.40 g) at par with cocopeat (6.38 g) and sand (5.81 g). Whole corm produced plantlets that had higher dry weight (6.26 g) ½ split corms (5.62 g), and ¼ split corms (5.21 g).

The treatment combination T13 (sawdust + whole corm) where 7.19 g and at par with T13 were T7 (6.84 g), T4 (6.64 g), and T14 (6.30 g) which were comprising whole corm and half split corm. It was noted from the results that cocopeat (T9 = 6.02 g) and Sawdust (T15 = 5.75 g) were the only media which produced plantlets at par with T13 when ¼ split corm was used. It was observed that the more the number of shoots generated per corm the smaller the plantlets and the lower the dry weight. This could be as a result of the competition for the nutrients provided by the mother corm due to the fact that in macro-propagation mother corm is the main source of food materials to support the plantlets generated. This phenomenon was also reported by Robson and Saúco (2010) that rather than initiation media, mother corm was the main source of nutrients for all the developing shoots.

## Conclusion

According to the results of the experiment it could be concluded that the five different types of media had influence on the production of banana plantlets through macro-propagation. Almost all the parameters tested proved that sawdust, sand and cocopeat were more outstanding over soil and soil + sand. Corm preparation methods had a bearing on the number and quality of the plant produced. The aim was to find out the best way of corm preparation that produces higher number and quality planting materials. The highest number of plantlets was produced by using ¼ split corms > ½ split corms >whole corm while highest quality was obtained from whole corm > ½ split corms > ¼ split corms.

This study therefore recommends use of ½ split corms that was at par with ¼ split corms in terms of higher number of plantlets per corm; the quality of planting materials was similar to whole corm. The study recommends that three out of five types of media sawdust, sand and cocopeat which resulted in higher number and quality of plantlets and could be selected in that order of priority depending on availability in a particular area.

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## Competing Interests

Authors have declared that no competing interests exist.

**Table 1:** Treatment details

| Treatments | Treatment details combinations | Treatments | Treatment details combinations |
|---|---|---|---|
| T1 | Soil + Whole Corm | T9 | Cocopeat + ¼ Split corms |
| T2 | Soil + ½ Split corms | T10 | Soil + Sand + Whole Corm |
| T3 | Soil + ¼ Split corms | T11 | Soil + Sand + ½ Split corms |
| T4 | Sand + Whole Corm | T12 | Soil + Sand + ¼ Split corms |
| T5 | Sand + ½ Split corms | T13 | Sawdust + Whole Corm |
| T6 | Sand + ¼ Split corms | T14 | Sawdust + ½ Split corms |
| T7 | Cocopeat + Whole Corm | T15 | Sawdust + ¼ Split corms |
| T8 | Cocopeat + ½ Split corms | | |

**Table 2:** Number of days to sprouting, plantlets harvested per corms and survival percentage (%)

| | Number of days to sprouting | | | | Plantlets harvested per corm | | | | Survival percentage (%) at the end of hardening | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Factors** | **Whole corm** | **½ split corm** | **¼ split corm** | **Mean (Media)** | **Whole corm** | **½ split corm** | **¼ split corm** | **Mean (Media)** | **Whole corm** | **½ split corm** | **¼ split corm** | **Mean (Media)** |
| Soil | 25.70 | 23.00 | 18.70 | 22.40 | 23.90 | 26.03 | 27.00 | 25.64 | 81.00 (64.32) | 80.67 (63.96) | 76.33 (61.16) | 79.33 (63.15) |
| Sand | 22.70 | 20.70 | 19.70 | 21.00 | 27.33 | 29.73 | 30.77 | 29.28 | 93.67 (77.99) | 92.33 (74.77) | 86.67 (68.98) | 90.89 (73.91) |
| Cocopeat | 27.70 | 30.30 | 31.30 | 29.80 | 24.00 | 23.67 | 27.13 | 24.93 | 95.67 (78.67) | 88.67 (70.44) | 85.67 (68.29) | 90.00 (72.47) |
| Soil + Sand | 24.30 | 26.00 | 20.70 | 23.70 | 21.67 | 27.47 | 29.30 | 26.14 | 84.00 (66.59) | 82.33 (65.3) | 77.67 (62.35) | 81.33 (64.75) |
| Sawdust | 23.70 | 23.30 | 19.00 | 22.00 | 29.30 | 32.30 | 33.23 | 31.61 | 97.00 (81.81) | 90.33 (71.99) | 88.00 (69.87) | 91.78 (74.55) |
| Mean (Corm) | 24.80 | 24.70 | 21.90 | | 25.24 | 27.84 | 29.49 | | 90.27 (73.88) | 86.87 (69.29) | 82.87 (66.13) | |
| | | | | | | | | | | | | |
| | Media | Corm | M X C | | Media | Corm | M X C | | Media | Corm | M X C | |
| SEm ± | 1.56 | 0.96 | 1.00 | | 1.26 | 1.24 | 0.86 | | 2.41 | 2.25 | 1.61 | |
| C.D. $_{0.05}$ | 2.55 | 1.98 | 4.42 | | 3.29 | 2.55 | 5.70 | | 5.47 | 4.23 | 9.47 | |

**Table 3:** Number of primary, secondary and tertiary shoots generated and decapitated per corm

| | Number of shoots generated and decapitated per corm | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Primary shoots | | | | Secondary shoots | | | | Tertiary shoots | | | |
| **Factors** | **Whole corm** | **½ split corm** | **¼ split corm** | **Mean (Media)** | **Whole corm** | **½ split corm** | **¼ split corm** | **Mean (Media)** | **Whole corm** | **½ split corm** | **¼ split corm** | **Mean (Media)** |
| Soil | 3.00 | 3.33 | 3.90 | 3.41 | 6.53 | 6.93 | 7.73 | 7.07 | 13.40 | 15.10 | 14.97 | 14.49 |
| Sand | 2.17 | 2.90 | 3.27 | 2.78 | 7.30 | 8.23 | 9.50 | 8.34 | 14.23 | 18.37 | 18.77 | 17.12 |
| Cocopeat | 2.20 | 2.37 | 3.23 | 2.60 | 7.27 | 7.60 | 8.17 | 7.68 | 13.67 | 15.90 | 16.53 | 15.37 |
| Soil + Sand | 2.97 | 3.10 | 3.40 | 3.16 | 7.03 | 7.30 | 7.93 | 7.42 | 13.70 | 15.27 | 16.23 | 15.07 |
| Sawdust | 2.67 | 3.33 | 3.83 | 3.28 | 7.80 | 8.50 | 10.47 | 8.92 | 15.17 | 18.70 | 19.83 | 17.90 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean (Corm) | 2.60 | 3.01 | 3.53 | | 7.19 | 7.71 | 8.76 | | 14.03 | 16.67 | 17.27 | |
| | Media | Corm | M X C | | Media | Corm | M X C | | Media | Corm | M X C | |
| SEm ± | 0.15 | 0.27 | 0.14 | | 0.33 | 0.46 | 0.26 | | 0.65 | 0.99 | 0.53 | |
| C.D. $_{0.05}$ | 0.43 | 0.33 | 0.75 | | 1.05 | 0.82 | 1.82 | | 1.85 | 1.43 | 3.20 | |

**Table 4:** Pseudostem girth (mm) after 30 days, 60 days, and 90 days of hardening.

| | **Pseudostem girth (mm) at 30 days** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **After 30 days** | | | | **After 60 days** | | | | **After 90 days** | | | |
| **Factors** | **Whole corm** | **½ split corm** | **¼ split corm** | **Mean (Media)** | **Whole corm** | **½ split corm** | **¼ split corm** | **Mean (Media)** | **Whole corm** | **½ split corm** | **¼ split corm** | **Mean (Media)** |
| Soil | 39.93 | 38.47 | 36.33 | 38.24 | 48.33 | 46.40 | 44.10 | 46.28 | 55.83 | 54.77 | 52.67 | 54.42 |
| Sand | 43.87 | 43.97 | 38.33 | 42.06 | 55.20 | 51.80 | 48.90 | 51.97 | 67.00 | 63.43 | 59.10 | 63.18 |
| Cocopeat | 42.23 | 41.67 | 38.30 | 40.73 | 54.13 | 50.87 | 48.97 | 51.32 | 64.73 | 62.10 | 58.80 | 61.88 |
| Soil + Sand | 41.07 | 37.47 | 38.20 | 38.91 | 48.90 | 46.87 | 45.03 | 46.93 | 59.60 | 63.40 | 54.43 | 59.14 |
| Sawdust | 44.03 | 41.53 | 37.57 | 41.04 | 55.77 | 53.17 | 47.67 | 52.20 | 68.20 | 66.57 | 61.63 | 65.47 |
| Mean(Corm) | 42.23 | 40.62 | 37.75 | | 52.47 | 49.82 | 46.93 | | 63.07 | 62.05 | 57.33 | |
| | Media | Corm | M X C | | Media | Corm | M X C | | Media | Corm | M X C | |
| SEm ± | 0.71 | 1.31 | 0.67 | | 1.29 | 1.60 | 0.94 | | 1.90 | 1.77 | 1.26 | |
| C.D. $_{0.05}$ | 3.74 | 2.89 | 6.47 | | 3.91 | 3.03 | 6.78 | | 5.96 | 4.61 | 10.32 | |

**Table 5:** Height of plantlet (cm) at 30 days, 60 days, and 90 days

| | **Height of plantlets (cm)** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **After 30 days** | | | | **After 60 days** | | | | **After 90 days** | | | |
| **Factors** | **Whole corm** | **½ split corm** | **¼ split corm** | **Mean (Media)** | **Whole corm** | **½ split corm** | **¼ split corm** | **Mean (Media)** | **Whole corm** | **½ split corm** | **¼ split corm** | **Mean (Media)** |
| Soil | 16.2 | 15.4 | 14.8 | 15.5 | 18.4 | 17.3 | 16.1 | 17.3 | 23.7 | 22.9 | 19.7 | 22.1 |
| Sand | 21.3 | 19.3 | 16.4 | 19.0 | 23.7 | 22.3 | 18.8 | 21.6 | 28.7 | 27.2 | 23.4 | 26.4 |
| Cocopeat | 19.5 | 18.4 | 16.8 | 18.2 | 22.9 | 21.5 | 19.0 | 21.2 | 27.3 | 26.4 | 22.1 | 25.3 |
| Soil + Sand | 16.9 | 16.1 | 14.4 | 15.8 | 19.1 | 18.1 | 15.8 | 17.7 | 25.3 | 23.6 | 21.5 | 23.5 |
| Sawdust | 21.5 | 19.8 | 16.5 | 19.2 | 24.5 | 22.8 | 22.4 | 23.3 | 30.4 | 28.0 | 23.9 | 27.4 |
| Mean (Corm) | 19.1 | 17.8 | 15.8 | | 21.7 | 20.4 | 18.4 | | 27.1 | 25.6 | 22.1 | |
| | Media | Corm | M X C | | Media | Corm | M X C | | Media | Corm | M X C | |
| SEm ± | 0.80 | 0.96 | 0.58 | | 1.16 | 0.95 | 0.73 | | 0.97 | 1.48 | 0.77 | |
| C.D. $_{0.05}$ | 2.18 | 1.69 | 3.78 | | 2.57 | 1.99 | 4.44 | | 3.63 | 2.81 | 6.28 | |

**Table 6:** Average leaf area ($cm^2$) after 30 days, 60 days, and 90 days

| | **Average leaf area ($cm^2$) after 30 days** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **30 days** | | | | **60 days** | | | | **90 days** | | | |
| **Factors** | **Whole corm** | **½ split corm** | **¼ split corm** | **Mean (Media)** | **Whole corm** | **½ split corm** | **¼ split corm** | **Mean (Media)** | **Whole corm** | **½ split corm** | **¼ split corm** | **Mean (Media)** |
| Soil | 101.6 | 84.1 | 77.0 | 87.6 | 125.6 | 114.0 | 106.4 | 115.3 | 204.1 | 182.3 | 163.1 | 183.2 |
| Sand | 90.3 | 80.7 | 75.2 | 82.1 | 171.1 | 147.1 | 139.8 | 152.7 | 236.7 | 206.5 | 198.9 | 214.0 |
| Cocopeat | 109.7 | 105.0 | 97.7 | 104.1 | 175.4 | 165.6 | 159.7 | 166.9 | 230.7 | 202.9 | 198.9 | 210.8 |
| Soil + Sand | 91.3 | 78.3 | 72.1 | 80.6 | 131.6 | 118.7 | 112.3 | 120.9 | 205.2 | 196.3 | 188.9 | 196.8 |
| Sawdust | 125.1 | 113.7 | 116 | 118.3 | 188.6 | 170.9 | 160.9 | 173.5 | 240.9 | 218.7 | 207.5 | 222.3 |
| Mean (Corm) | 103.6 | 92.4 | 87.6 | | 158.5 | 143.2 | 135.8 | | 223.5 | 201.3 | 191.4 | |
| | Media | Corm | M X C | | Media | Corm | M X C | | Media | Corm | M X C | |
| SEm ± | 7.26 | 4.74 | 4.33 | | 11.85 | 6.66 | 6.85 | | 6.92 | 9.49 | 5.27 | |
| C.D. $_{0.05}$ | 7.43 | 5.76 | 12.87 | | 16.06 | 12.44 | 27.82 | | 23.45 | 18.17 | 40.62 | |

**Table 7:** Number of roots per plantlet, root length (cm), and root girth (mm) after 90 days of hardening

| | **Number, length (cm), and girth (mm) of roots after 90 days of hardening** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Number of roots per plantlet** | | | | **Root length (cm** | | | | **Root girth (mm)** | | | |
| **Factors** | **Whole corm** | **½ split corm** | **¼ split corm** | **Mean (Media)** | **Whole corm** | **½ split corm** | **¼ split corm** | **Mean (Media)** | **Whole corm** | **½ split corm** | **¼ split corm** | **Mean (Media)** |
| Soil | 9.0 | 10.7 | 11.3 | 10.3 | 22.0 | 18.7 | 18.7 | 19.8 | 36.0 | 31.0 | 28.7 | 31.9 |
| Sand | 9.0 | 9.7 | 9.7 | 9.4 | 21.7 | 17.3 | 18.7 | 19.2 | 42.0 | 32.3 | 30.0 | 34.8 |
| Cocopeat | 8.7 | 10.3 | 11.7 | 10.2 | 22.3 | 19.0 | 20.7 | 20.7 | 37.0 | 33.3 | 31.3 | 33.9 |
| Soil + Sand | 8.0 | 9.7 | 10.3 | 9.3 | 18.7 | 17.3 | 16.7 | 17.6 | 35.3 | 29.7 | 26.0 | 30.3 |
| Sawdust | 9.3 | 11.7 | 13.3 | 11.4 | 23.0 | 23.3 | 21.3 | 22.6 | 43.3 | 39.7 | 32.3 | 38.4 |
| Mean (Corm) | 8.8 | 10.4 | 11.3 | | 21.5 | 19.1 | 19.2 | | 38.7 | 33.2 | 29.7 | |
| | Media | Corm | M X C | | Media | Corm | M X C | | Media | Corm | M X C | |
| SEm ± | 0.38 | 0.72 | 0.36 | | 0.83 | 0.79 | 0.57 | | 1.38 | 2.64 | 1.29 | |
| C.D. $_{0.05}$ | 1.33 | 1.03 | 2.30 | | 2.55 | 1.97 | 4.42 | | 3.78 | 2.93 | 6.54 | |

**Table 7:** Fresh and dry weight of plantlets (g) after 90 days of hardening

| | Fresh weight (g) | | | | Dry weight (g) | | | |
|---|---|---|---|---|---|---|---|---|
| **Factors** | **Whole corm** | **½ split corm** | **¼ split corm** | **Mean (Media)** | **Whole corm** | **½ split corm** | **¼ split corm** | **Mean (Media)** |
| Soil | 51.3 | 46.3 | 42.7 | 46.8 | 5.4 | 4.5 | 4.4 | 4.8 |
| Sand | 59.7 | 57.7 | 48.0 | 55.1 | 6.6 | 5.7 | 5.1 | 5.8 |
| Cocopeat | 59.0 | 58.3 | 54.0 | 57.1 | 6.8 | 6.3 | 6.0 | 6.4 |
| Soil + Sand | 53.0 | 52.0 | 49.0 | 51.3 | 5.2 | 5.3 | 4.8 | 5.1 |
| Sawdust | 62.67 | 60.0 | 55.3 | 59.3 | 7.2 | 6.3 | 5.8 | 6.4 |
| Mean (Corm) | 57.1 | 54.9 | 49.8 | | 6.3 | 5.6 | 5.2 | |
| | Media | Corm | M X C | | Media | Corm | M X C | |
| SEm ± | 2.22 | 2.17 | 1.48 | | 0.33 | 0.3 | 0.22 | |
| C.D. 0.05 | 5.63 | 4.36 | 9.76 | | 0.85 | 0.66 | 1.48 | |

A. B. C. D.

E. F. G

**Fig 1:** Corm preparation method: Paring of leaf sheath to expose lateral buds (A); Corms after scooping off apical meristem (B); whole corm (C); ½ split corm (D); ¼ split corm (E); treatment of corms with fungicide (F); placing treated corms on raised platform to drip overnight (G).

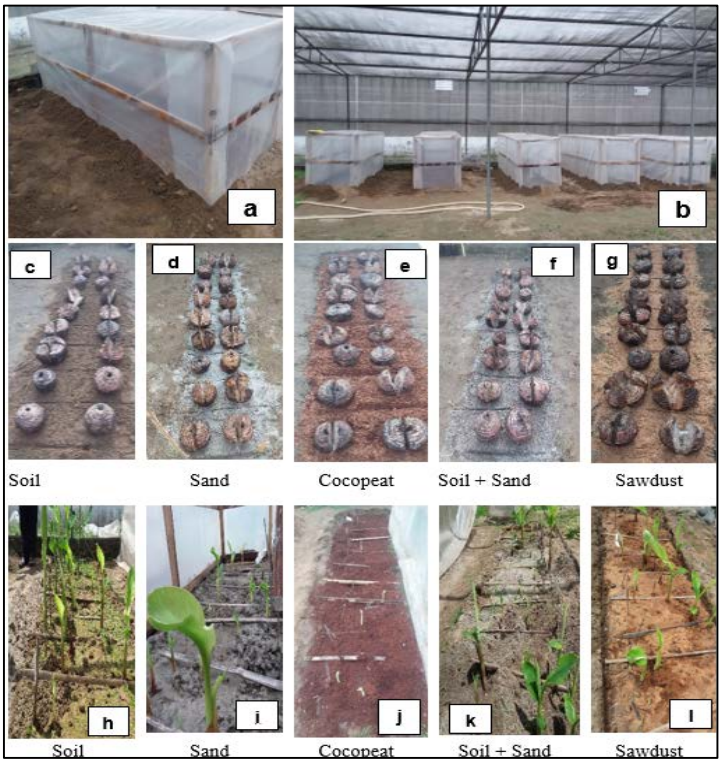


**Fig 2:** Humidity Chamber placement of in media and shoot initiation**:** The humidity chambers (a) and (b). The placement of corms in media, soil (c), sand (d), cocopeat (e), soil + sand (f), and sawdust (g). Primary shoot initiation in soil (h), sand (i), cocopeat (j) soil + sand (k) and sawdust (l).


**Fig 3:** Decapitation and plantlets produced per corm: Decapitation of shoots (m); decapitated shoot with cross wise incision (n); Shoots emerge after tertiary shoot decapitation (o); Plantlets ready for transferring to polythene bags (p and q); Root zone cleaned of media for easy detachment from mother corm (r); shoots generated form generated from a quarter portion of corm (s); and shoots generated from ½ split corm (t)

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