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Performance of growth regulators on breaking dormancy and to induce early and uniform sprouting in elephant foot yam

R. Muthuraj*, S. Sunitha and Saravanan Raju

ICAR-Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram 695 017, Kerala, India

Abstract

Elephant foot yam [*Amorphophallus paeoniifolius* (Dennst.) Nicolson] is a popular tropical tuber crop grown for its starchy corms. It is propagated through both corms and cormels. Lack of sufficient planting materials of uniform size, non-availability of good quality planting materials and corm dormancy are the major constraints in the production of elephant foot yam. Corms are not suitable for immediate planting due to the dormancy period and also the slow development of buds which takes about 2-3 months after harvest. Field experiment was conducted at ICAR-Central Tuber Crops Research Institute (CTCRI) , Sreekariyam, Thiruvananthapuram, Kerala during crop seasons 2017-18 and 2018-19 to find out the performance of growth regulators and chemical treatments on dormancy breaking to induce uniform sprouting and enhance yield in elephant foot yam. The results revealed that the corms subjected to fumigation treatment with carbon disulphide @ 80 ml per 100 kg corm resulted in maximum uniform sprouting with 89.75%, 99.89% sprouting at 15, 40 days after planting followed by Gibberellic acid (GA_3 200 ppm). The growth parameters indicated that maximum plant height (58.75cm), pseudo stem girth (86.25cm) and canopy spread (77.65cm) were recorded in plants raised from corms fumigated with carbon disulphide @ 80 ml per 100 kg corm at 90 days after planting. The corm yield data revealed that plants raised from fumigated corms produced significantly higher corm yield (34.85 t ha^{-1}), followed by plants raised from corms treated with GA_3 (200 ppm) (29.25 t ha^{-1}), in comparison to 14.93 t ha^{-1} from plants raised from untreated corm.

Keywords : Germination, Dormancy breaking, Fumigation, Growth regulator, Corm yield

Introduction

Elephant foot yam (*Amorphophallus paeoniifolius* (Dennst.) Nicolson) is a tuber crop belonging to the Araceae family. It is notable for the large and edible underground corm. The most recognizable part of the plant is its corm which is the swollen underground stem used for food. The corm can be quite large and heavy, resembling an elephant foot and that is how the plant gets it common name (Jeeva et al., 2023; Prakash and Nayar, 2000). The corms are rich in starch and are used as staple food. The botanically modified stem (corm) is consumed as a vegetable after boiling, baking or frying. The plant has a remarkable dry matter production capacity per unit area, surpassing many other vegetables. In India, it is commercially cultivated as a food crop in Andhra Pradesh, Bihar, Odisha, West Bengal, Gujarat, Kerala, Tamil Nadu, Maharastra, Uttar Pradesh, Jharkhand, Chhattisgarh, Punjab and Northeastern states (Nedunchezhiyan and Byju, 2005; Nedunchezhiyan et al., 2006). It stands out as one of the most economically profitable tuber crops. Elephant foot yam has several medicinal properties and

*Corresponding author Email: ramanmuthuraj72@gmail.com

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found to be effective in the treatment of piles, dysentery, asthma, swelling of lungs, vomiting and gastrointestinal disorders (Raghu et al., 1999). In the realm of traditional medicine, ayurvedic practitioners highly recommend elephant foot yam for maintaining regular bowl movements (Jeeva et al., 2023). Pickle, a delicacy recipe preferred by Indians is also prepared from elephant foot yam corms (Nedunchezhiyan and Misra, 2008).

There is ample scope for its adoption as a cash crop due to its high production potential and popularity as a vegetable. Several factors affect the growth and yield of elephant foot yam is the non-availability of good quality planting materials. It has emerged as commercial crop in India with good economic returns to farmers due to its high production and export potential. Because of high market demand it is being extensively cultivated in different parts of India (Misra et al., 2001). The major problems in elephant foot yam cultivation are lack of sufficient quantity of planting materials of uniform size, non-availability of good quality planting materials and corm dormancy (Bhagavan et al., 2008). By adopting conventional method of propagation, a multiplication rate of 1:4 and by minisett technique, the multiplication rate of 1:15 could be attained (James George and Nair, 1993). Whole corms or cut corm pieces (500-750 g) having part of apical meristem is mainly used as planting materials.

About 25 percentage of the harvested produce is used as planting material for the next season. The apical buds of the cormels sprout simultaneously with the corms, irrespective of the size, once dormancy is broken. Hence, farmers separate the cormels from the corms immediately after harvest and use as seed material. It requires 5.0 to 6.0 t of corms to plant one ha area. As it is a vegetatively propagated crop, immediately after harvesting corms could not be used as planting material due to the presence of dormancy for a period of 2- 3 months. The new leaf sprout emerges from the cut corm pieces or whole corm. The time of emergence of new shoots depends on the dormancy status of the planting material. If the planting material has completed its dormancy before planting, then the new shoot sprout will emerge as soon as it is planted. Leaf emergence is delayed when the apical buds of seed corms are damaged or cut pieces of corm are planted. Leaves were found to emerge earlier when whole corms were planted, irrespective of corm size (Sen et al., 1996).

Studies reported that the corm dormancy depends mainly on intrinsic balance of abscisic acid (ABA) and Gibberellic acid (GA_3) which indicates that GA_3 has pronounced effect in regulating seed germination and dormancy. Growth regulators gibberellic acid, indole acetic acid, potassium nitrate (KNO_3) and thiourea are used to break seed dormancy and to improve seed germination in many plant species (Pallais et al., 1991; Karam and Al-Salem, 2001; Bahrani et al., 2008; Zeinalabedini et al, 2009; Deng et al., 2010; Zeng et al., 2010). Soaking bottom corm setts for 6 h in thiourea, KNO_3, gibberellic acid and Chlormequat (CCC) increased sprouting percentage and growth (Das et al., 1995; Dhua et al., 1988; Kumar et al., 1998). Dhua et al., (1988) reported that 250 g basal corm portion treated with 200 mg thiourea, 500 mg potassium nitrate, 0.02 ml CCC per litre increased the sprouting percentage of cut pieces. Ethrel or ethephon was reported to induce early sprouting in corm (Dhua et al., 1988; Bala and Indira,1992). Treating cut pieces of corms from lower half with chemicals significantly improved sprouting, subsequent growth and yield. Among the different chemicals used, thiourea, potassium nitrate and CCC were effective in promoting sprouting (Dhua et al., 1988; Kumar et al., 1998). Keeping in view of the above facts, the present investigation was undertaken to study the performance of growth regulators and chemical treatments on breaking dormancy to induce uniform sprouting and enhance yield.

Materials and Methods

The field experiment was conducted in at ICAR-Central Tuber Crops Research Institute (CTCRI), Sreekariyam, Thiruvananthapuram, Kerala, India with elephant foot yam variety, Gajendra during the crop seasons 2017-18 and 2018-19. The performance of growth regulators and chemical treatments on dormancy breaking to induce early and uniform sprouting was evaluated. The uniform corm size of 400-500 g were subjected to thirteen different treatment viz., T_1 - Gibberellic acid (100 ppm), T_2 - Gibberellic acid (200 ppm), T_3- Indole acetic acid (100 ppm), T_4 - Indole acetic acid (200 ppm), T_5 - Thiourea 0.5% ,T_6 - Thiourea (1%) , T_7 - Potassium nitrate (0.5%), T_8 - Potassium nitrate 1%, T_9 -Combination of Gibberellic acid (100 ppm) + Thiourea 0.5%, T_{10} - Carbon disulphide solution (80 ml per 100 kg corm) exposed to fumigation treatment for 14 days, T_{11} - Cow dung slurry treatment, T_{12} - Water treatment, T_{13} - Control (without any treatment). All the corms were soaked for 30 minutes. The treatments were replicated thrice during each crop season under rainfed conditions. The crop was planted in 90 × 90 cm spacing. FYM @10 t ha^{-1} and NPK @ 80:60:80 Kg ha^{-1} were applied as per the package of practices recommended by ICAR-CTCRI. The crop was harvested after 9 months, and the corm yield was recorded.

Fumigation treatment

As the harvested elephant foot yam corms possess seed dormancy, it must be treated with chemicals to break the dormancy artificially. In fumigation method, freshly harvested corm was kept in a heap (Fig. 1). Placing the fumigated chemical carbon disulphide solution @ 80 ml quintal^{-1} inside elephant foot yam seed corm heaps in bottles in four directions and then placing with paddy straw/dried leaf over the elephant foot yam corm heaps followed by covering with mud for 2 weeks treated corms storage in gunny bag for one week in dark room condition promoted uniform sprouting after 3 weeks.

Fig. 1. Fumigation treatment of elephant foot yam corms (a) Elephant foot yam corm before treatment, (b) Elephant foot yam corm under fumigation, (c) Corms with uniform sprout after fumigation (d) Single corm with sprout

Results and Discussion

Gibberallic acid is one of the major plant hormones involved in the control of mobilization of food reserves from the endosperm or cotyledons, most especially enzymatic production (Black, 1972). The physiological component of dormancy determines the dormancy level response to external gibberellic acid application (Geneve, 2003) and promotes seed germination (Baskin and Baskin, 1971). Gibberallic acid is involved in the promotion and maintenance of seed germination. It is known to obviate the requirement of seeds for various environmental cues, germination and counteract with cytokinins (Bewley and Black, 1994). If the seed dormancy is non-deep or intermediate physiological dormancy, it can be broken through cold stratification (Carpital et al., 1983), temperature (Junttila, 1973), light (Scheibe and lang, 1965), darkness (Rajendren et al., 2000) or by GA_3 (Baskin and Basin, 1971). Freshly harvested seeds exhibit physiological dormancy and required three months of storage at ambient temperature for germination (Jennings and Iilesias, 2002). The longevity of seeds to germination increased with reduced bound water (Roberts and Ellis, 1989).

In the present study, growth regulator GA_3, Indole acetic acid (IAA) treatment, fumigation treatment and water treatment were used to break dormancy and induce uniform sprouting of elephant foot yam. Performance of growth regulators significantly influenced the sprouting, corm development and corm yield in the variety Gajendra (Table 1). Among the different growth regulators, fumigation treatment with carbon disulphide @ 80 ml per 100 kg corms produced significantly higher sprouting percentage, followed by gibberellic acid (200 ppm) treatment. A significant difference was observed in the number of days to 50% and 100% sprouting in the growth regulator treatment. Thiourea (0.5%) treated corms significantly reduced the number of days for 50% and 100% sprouting than GA_3 (200 ppm and 500 ppm) and control.

Performance of growth regulator on sprouting

Among the different treatments/growth regulators, fumigation treatment with carbon disulphide @ 80 ml per 100 kg corm had better effect than the other chemicals and growth regulators. The growth regulator GA_3 (200 ppm) treated corms produced 50% sprouting in 21 days and 100% sprouting in 26 days. Carbon disulphide treated corms took significantly lesser number of days to 50% (15 days) and 100% sprouting (40 days), which was followed by gibberellic acid (100 ppm) and Indole acetic acid (100 ppm, 200 ppm). A similar trend observed by Kumar et al., (1998) reported that thiourea was the most effective in breaking dormancy of elephant foot yam corms with 92% sprouting in 75 days after harvesting compared to 18 % sprouting in the control. The results revealed that elephant foot yam corms fumigated with carbon disulphide resulted in maximum uniform sprouting with 79.75% and 99.85% sprouting at 15 and 40 days after planting (DAP), respectively. Corms treated with GA_3 (200 ppm) had 65.45%, 88.75% sprouting at 15 and 40 days after planting (DAP) respectively (Fig. 2). Carbon disulphide treatment also recorded maximum plant survival rate (99.85%), followed by GA_3 (200 ppm) treatment for 30 min (88.75%) and IAA (200 ppm) treatment (82.60%). The plant survival rate of cow dung slurry treated corms was 82.40%, whereas the untreated corm survival rate was only 74.85%.

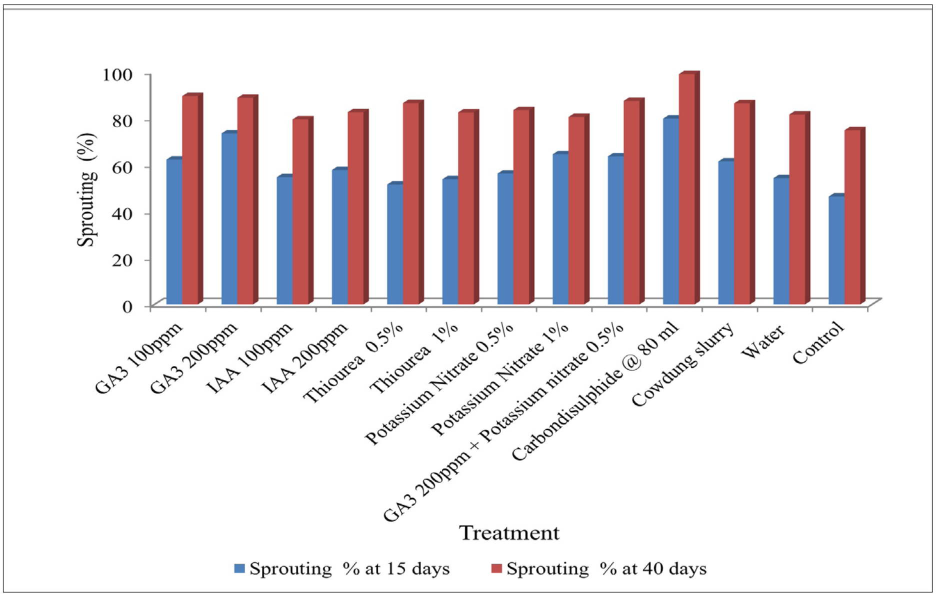

Fig. 2. Performance of growth regulator treatments on percentage sprouting

Performance of growth regulator on pseudostem length

The performance of different growth regulators and chemical treatment of corm on pseudostem length of elephant foot yam plants were assessed. The fumigation treatment with carbon disulphide 80 ml @ 100 kg corm treated corms produced significantly higher plant with pseudostem length of 86.25 cm at 90 days after planting. Corms treated with GA_3 (200 ppm) produced 79.85 cm, GA_3 @100 ppm produced shoot length of 68.78cm, The corms soaked with IAA @200 ppm for 30 min corms produced plant with pseudostem length of 75.36 cm at 90 days after planting. Similar trend reported in growth regulators gibberellic acid, potassium nitrate, thiourea were found to hasten sprouting (Bhagavan, 2005) and enhance sprouting percentage (Kumar et al., 1998; Bhagavan, 2005) in elephant foot yam. Mukherjee et al., (2009) reported that thiourea had greater influence in breaking dormancy in elephant foot yam. Whereas minimum pseudostem length 64.24 cm was recorded with thiourea treatment (0.5%) followed by thiourea 1% with pseudostem length of 62.50 cm. (Table1). The corms treated with potassium nitrate (0.5%,1%) treatment produced plant with pseudostem length 67.80 cm and 65.75 cm, respectively. Corms soaking with water for 30 minutes produced plant with pseudostem length 59.80 cm. However, control treatment resulted minimum pseudostem length of 52.40 cm as compared to other treatments.

Performance of growth regulator on canopy spread

The performance of different growth regulators and chemical treatment on canopy spread of elephant foot yam corm was assessed. Fumigation treatment with carbon disulphide 80 ml @ 100 kg corm treated corms took significantly produced plant with canopy spread of 77.65 cm at 90 days after planting. It was found that the planting material soaked in GA_3 (200 ppm) for 30 minutes produced canopy spread of 75.80cm at 90 days after planting. Whereas corms treated with thiourea (0.5%) plant produced canopy spread of 66.35cm. Whereas the minimum canopy spread (62.30 cm) was recorded in the plants raised from the treatment of cow dung slurry treatment (Table 1). The corms treated with potassium nitrate (0.5%, 1%) produced plant with canopy spread 74.40cm and 65.75 cm respectively, whereas soaking in water for 30 min resulted in plant with canopy spread 62.30 cm. The minimum canopy spread 61.25cm was recorded in control as compared to other treatments.

Performance of growth regulators on corm yield

The growth parameters indicated that maximum pseudostem length (86.25cm) and canopy spread (77.65 =cm) were recorded in plants raised from corms treated with fumigation treatment at 90 days after planting. Based on the experimental result, the corm yield data revealed that plants raised from corms treated with carbon disulphide 80 ml @ 100 kg corm treated produced significantly higher corm yield (34.50 t ha^{-1}) followed by plants raised from corms treated with GA_3

Table 1. Performance of growth regulators and chemical treatments on corms yield in elephant foot yam

Treatments	Days to 50% sprouting	Days to 100% sprouting	Plant Survival (%)	Plant height at 90 days (cm)	Psuedostem length at 90 days (cm)	Canopy spread at 90 days (cm)	Corm yield (t ha^{-1})
T_1: Gibberellic acid 100 ppm	21	26	86.50	50.20	68.78	73.85	21.47
T_2: Gibberellic acid 200 ppm	20	29	88.75	52.33	79.85	75.80	29.25
T_3: Indole acetic acid 100 ppm	19	27	79.50	48.50	73.50	72.25	26.87
T_4: Indole acetic acid 200 ppm	20	28	82.60	46.75	75.36	74.35	28.15
T_5: Thiourea 0.5%	21	27	86.50	41.85	64.24	66.35	27.20
T_6: Thiourea 1%	22	28	82.50	39.25	62.50	68.65	26.10
T_7: Potassium nitrate 0.5%	23	26	83.50	40.45	67.80	74.40	25.73
T_8: Potassium nitrate 1%	22	28	80.55	37.65	65.75	65.75	27.02
T_9: Gibberellic acid 200 ppm+ Potassium nitrate 0.5%	21	26	87.45	42.50	66.25	72.95	22.43
T_{10}: Carbon disulphate @ 80 ml	15	20	99.85	58.75	86.25	77.65	34.50
T_{11}: Cowdung slurry	18	28	82.40	43.75	62.45	65.80	26.16
T_{12}: Water Treatment	19	29	81.60	41.65	59.80	62.30	20.99
T_{13}: Control	26	34	74.85	36.85	52.40	61.25	14.93
CD (0.05)	1.42	2.10	4.34	1.92	3.74	1.38	2.85

(200 ppm) produced corm yield of 29.25 t ha^{-1}, whereas plants raised from corms treated with IAA (200 ppm) produced yield of 28.15 t ha^{-1}. Elephant foot yam corm treated with growth regulator of GA_3 200 ppm produced significantly higher corms yield and a greater number of corms (Muthuraj et al., 2021). The differences in corm yield of plants raised from corms treated with IAA (100 ppm), Thiourea (0.5%), GA_3 (500 ppm), Thiourea (0.1%) and potassium nitrate (0.5%) were statistically not significant. (Table1). The corm yield of plants raised from untreated corm was very low (14.93 t ha^{-1}). The reason for reduced seed corm dormancy, increased sprouting, maximum pseudostem growth, canopy spread, and higher corm yield due to treatment of carbon disulphide may mention. I mean probable reason for better performance of this chemical, because it is not mentioned anywhere in the manuscript. If it is mentioned it would be useful for the researchers.

Conclusion

The present study result revealed that plant raised from the carbon disulphide 80 ml @ 100 kg corm treated corms significantly produced maximum corm yield (34.50 t ha^{-1}) followed by Plant raised from GA_3 (200 ppm) treated corms produced higher corms (29.50 t ha^{-1}). Based on the experimental result, we could conclude that the fumigation treatment with carbon disulphide 80 ml @ 100 kg corm treatment more useful techniques to break the dormancy in freshly harvested corm of elephant foot yam.

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