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Influence of Corm Size and Planting Density on Growth and Yield Attributes of Elephant Foot Yam [*Amorphophallus paeoniifolius* (Dennst.) Nicolson]

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Abstract

An investigation was conducted at Vegetable Research Farm, CSK HPKV, Palampur, to study the effects of corm size and spacing on growth and yield attributes of elephant foot yam. Eight treatment combinations comprising two spacings of 60 × 60 cm and 75 × 75 cm and four corm sizes of 200, 300, 400 and 500g were studied on variety 'Gajendra' following a Factorial Randomised Block Design with three replications during *kharif* 2022. The results revealed that plant growth parameters, i.e. corm sprout emergence, pseudostem height and girth, leaf area index, canopy spread and harvest index, increased with large seed corms of size 500 g planted at wider spacing of 75 × 75 cm. Similarly, corm yield per plant was also highest with large corms planted at wider spacing, whereas yield per hectare (567.50 q/ha) was found maximum when large seed corm of size 500 g was planted at closer spacing of 60 × 60 cm.

Keywords: Elephant Foot Yam, Gajendra, Corm Size, Spacing, Yield

Tuber crops have been known since ancient times to save mankind from food crises and have a significant impact on the nutritional preferences of those who live in tropical regions. These crops are recognised for their high calorific value and ability to survive even under unfavourable soil and climatic conditions[1]. After cereals and legumes, tuber crops are the third most significant group of food crops that serve as staple or subsidiary food for almost one-fifth of the world's population. These crops can serve as a "Safety Net" during food scarcity and are a rich source of micronutrients[2]. These crops are the main source of calories for a substantial part of the rural population in many sub-Saharan countries and are also an important part of the urban diet in several countries[3]. Apart from food, these crops can also be used as an important source of animal feed and raw materials for many agro-based industries[4]. Due to their high production potential, higher biological efficiency, acceptable culinary features, medicinal utility and therapeutic value, they are highly lucrative crops and are becoming more popular among farmers as a cash crop.

Elephant foot yam [*Amorphophallus paeoniifolius* (Dennst.) Nicolson] locally called as zimikand or suran, belongs to the family Araceae, is a widely cultivated member of edible aroids. Its plant comprises large dissected tripartite leaves with flourishing outspreading crown-like foliage, borne on a thick single erect stem called a pseudo stem. It is a perennial, herbaceous and C_3 crop[5,6]. Due to its higher yield potential, culinary

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properties, medicinal utility and therapeutic value, it is called the 'King of tuber crops'[7]. Among tuber crops, elephant foot yam is highly nutritious, requires less input, and provides food and nutritional security. Being a nutritionally rich crop, hundred gram fresh weight of fresh corms contain energy (330 KJ), protein (1.7-5.0 per cent), fat (0.2-0.4 per cent), carbohydrate (18-24 per cent), fibre (0.6-0.8 per cent), ash (0.7-1.3 per cent), calcium (30-56 mg), iron (0.6-2.0 mg), phosphorous (20-30 mg), vitamin A (260-434 IU), thiamine (0.04-0.06 mg), riboflavin (0.05-0.08 mg 100), niacin (0.7-0.75 mg) and ascorbic acid (3 mg) as reported by Singh *et al*[8]. Its corms are used as vegetables, pickles and in the preparation of curries, and are also used for curing piles, dysentery, asthma, swelling of the lungs, vomiting, abdominal pain, fatigue, constipation, inflammation, tumors, rheumatism and as blood purifiers. It is a good source of carbohydrates, calcium, phosphorus, iron and vitamins, and helps maintain hormonal levels in the body. It is also a good source of essential fatty acids (Omega-3) and fibre, which decrease cholesterol levels[9].

It is primarily grown as a summer-rainy season crop and takes approximately 8 to 9 months to complete its life cycle. As a tropical tuber crop, it thrives in hot (25-35 °C), humid (80-90 per cent RH) and evenly distributed annual rainfall of approximately 1000-1500 mm[10]. It cannot tolerate frost, and its growth is adversely affected at temperatures below 20°C. The plants proliferate well in well-aerated soils that are medium to light in weight, that is, coarse-textured sandy soils[11]. In India, it is cultivated over an area of 29,000 hectares, with a production of 816,000 mt [12]. It is cultivated mainly in Andhra Pradesh, Gujarat, Maharashtra, West Bengal, northeastern states, Kerala, Bihar and Uttar Pradesh[9]. In Himachal Pradesh, elephant foot yam is emerging as a lucrative crop, especially in the low and mid-hill areas of the state. Data pertaining to the area and production of this crop in the state are not available. According to revenue records, the area under this crop is approximately 150 hectares in the Bilaspur district of Himachal Pradesh[13].

In India, Gajendra, Sree Padma, Bidan Kusum, NDA-9 and Sree Athira are some of the high-yielding varieties released for cultivation to obtain better quality corms and higher yields. Himachal Pradesh has a comparative advantage in cultivating many vegetables, and elephant foot yam is one of the remunerative and new emerging cash crops. Furthermore, this crop has become a viable alternative in areas impacted by monkeys. It is cultivated through corms/cormels, with size varying from 200 to 500 g; accordingly, the spacing will also vary. To maintain optimum plant population on a per-hectare basis and to ultimately increase its production potential, standardisation of corm size and spacing is of utmost importance. Since it is an emerging crop in the state, investigations on planting whole corms have been conducted irrespective of corm size/weight. Considering these facts, the present investigation was planned by planting the 'Gajendra' variety to study the effect of corm size and spacing on growth and yield attributes of elephant foot yam.

MATERIALS AND METHODS

The study was conducted during the *kharif* season of 2022 at the Research Farm of the Department of Vegetable Science and Floriculture, CSKHPKV, Palampur, India (31.12°N, 76.53°E; 1,300 m asl). The region has a humid subtropical climate, dominated by monsoonal rainfall from June to September. The mean temperature ranges from 5.7 to 34.2°C. The actual mean weekly meteorological records were obtained from the on-campus Agro-meteorological Observatory. Elephant foot yam cv. 'Gajendra' served as the plant material, which is the most popular variety in our country for commercial use and was released from a local selection from the Kovvur region of Andhra Pradesh, India. Its corms are non-acrid, well-shaped and generally devoid of cormels. The experiment was arranged in a factorial randomised block design with three replicates. Treatments comprised two plant spacing (60 × 60 cm and 75 × 75 cm) and four seed corm weight classes (200, 300, 400 and 500 g). Each

plot measured 3 × 3 m and five plants per plot were tagged for detailed measurements.

The field was prepared using conventional tillage, and planting was performed on May 14, 2022. FYM (30 t ha^{-1}) and NPK @ 100:60:80 kg ha^{-1} were applied; half of the nitrogen and the full dose of P and K were incorporated as a basal dose, and the remaining N was top-dressed in two equal splits. Pendimethalin was applied pre-emergence, followed by hand weeding as required. Mulching was used for moisture conservation purposes. Harvesting was performed at physiological maturity, defined as more than 50% foliage senescence. The observations on growth and yield traits, *viz.*, days to 50% sprout emergence, days to maturity, leaf area index, pseudo stem height and girth, canopy spread, harvest index and corm yield were recorded. The data collected for various attributes were subjected to statistical analysis using the Gomez and Gomez[14] method of analysis of variance. The values of significant differences were determined using an error probability of 5%. Critical Difference (CD) values were calculated for the comparison between the treatment means in cases where the variance ratio (F value) was significant.

RESULTS AND DISCUSSION

Sprout emergence in elephant foot yam is a desired trait that helps the plant roots to absorb nutrients from a larger area of the root zone, which ultimately increases corm yield. The results of the observation are presented in Table 1, which revealed that seed corm planted at 75 cm × 75 cm took significantly fewer days (32.00 days) for sprout emergence as compared to seed corm planted at 60 cm × 60 cm (35.41 days). As far as planting different seed corm sizes is concerned, seed corm of 500 g size resulted in early sprout emergence (27.66 days), followed by 400 g, 300 g and 200 g, showing each treatment varying significantly from one another. These results are also supported by Santosa and Sugiyama[15], who reported similar results while working on whole and sectioned corms. According to Hossain *et al.*[16], larger corms/cormels sprout earlier than smaller ones because of higher food reserves, which might have favoured the initial growth of sprouts. Wider spacing provides more space for plants to derive nutrients from the soil and reduces competition between plants for light, water and nutrients.

The data pertaining to the days taken for the maturity of the elephant foot yam corm showed that different plant spacings had a non-significant effect on crop maturity, whereas seed corm size had a significant effect on the maturity of the crop. The 500 g seed corm took the maximum number of days (185.66 days) for crop maturity, which was similar to that of the 400 g seed corm (184.00 days). This indicates that with an increase in seed corm size, the crop took more days to mature than smaller corms. This might be due to the presence of more food material in the larger seed corms. These results are similar to those of Hossain *et al.*[16]. The Leaf Area Index (LAI) is defined as the total leaf area per unit ground area, and it helps assess the growth and vigour of the plant. It is an indicator of canopy health, as it affects how light moves through the canopy. The data pertaining to the leaf area index are shown in Table 1. It was observed from the data that a significantly higher value of leaf area index (1.89) was recorded with wider spacing, *i.e.*, 75 cm × 75 cm, as compared to closer spacing (1.76), *i.e.*, 60 cm × 60 cm. The maximum leaf area index (2.00) was recorded when seed corms weighing 500 g were used for planting, followed by 400, 300 and 200 g in that order, with each seed corm size varying significantly from one another.

The pseudo stem height is an important parameter in elephant foot yam as it contributes to photosynthetic activity and plant spread, which ultimately contributes to corm yield. The data pertaining to pseudo stem height at 60, 90 and 120 Days After Planting (DAP) showed significant influence on pseudo stem height at all growth stages. The maximum value of pseudo stem height (80.40 cm at 120 DAP) was recorded with

wider spacing of 75 cm × 75 cm as compared to closer spacing of 60 cm × 60 cm (75.24 cm at 120 DAP). It was also observed from the data that seed corm size had a significant effect on pseudo stem height at all growth stages. A significant increase in pseudo stem height was recorded at 60, 90 and 120 DAP. Among the different seed corm sizes, the 500 g seed corm had significantly higher pseudo stem height (82.52 cm at 120 DAP), followed by 400 g, 300 g and 200 g. In the same manner, each treatment was significantly different from the other. This indicates that with an increase in seed corm size and spacing, the height of the pseudo stem increases. Similar results were also reported by Nath *et al.*[17] and Ravi *et al.*[11] who suggested that this was due to the early sprouting of corms and better root ramifications.

The data pertaining to pseudo stem girth were recorded at 90 and 120 DAP, and the result showed a significant effect at 90 and 120 DAP. The maximum value of pseudo stem girth (15.50 cm at 120 DAP) was recorded with wider spacing of 75 cm × 75 cm as compared to closer spacing of 60 cm × 60 cm (14.86 cm at 120 DAP). This is because wider spacing provides more space to derive nutrients from the soil and reduces competition between plants for nutrients, water and light. The data revealed that seed corm size had a significant effect on pseudo stem girth at both

Table 1. Effect of plant spacing and seed corm size on growth and yield parameters of elephant foot yam

Treatments	50% sprout emergence (days)	Days to maturity	Leaf area index	Pseudo stem height (cm)			Pseudo stem girth (cm)		Canopy spread (cm)		Harvest index	Corm yield (kg/ plant)	Corm yield (q/ ha)
				60 DAP	90 DAP	120 DAP	90 DAP	120 DAP	90 DAP	120 DAP			
Plant spacing in cm (S)													
S_1: 60 x 60	35.41	182.33	1.76	24.45	46.29	75.24	12.02	14.86	58.09	77.60	81.53	1.17	428.75
S_2: 75 x 75	32.00	181.91	1.89	25.90	50.88	80.40	12.48	15.50	60.57	79.90	85.86	2.14	344.71
SE(m) ±	0.22	0.51	0.01	0.28	0.16	0.13	0.12	0.16	0.60	0.61	0.88	0.04	1.53
CD (P=0.05)	0.67	NS	0.02	0.85	0.49	0.39	0.39	0.51	NS	NS	2.72	0.15	4.71
Seed corm size in g (C)													
C_1: 200	38.66	177.66	1.63	21.88	43.31	72.87	10.99	14.07	53.41	73.82	80.03	1.26	254.28
C_2: 300	36.66	181.16	1.77	24.46	46.41	76.51	11.78	14.72	56.25	75.54	83.65	1.55	313.74
C_3: 400	31.83	184.00	1.90	26.26	50.26	79.37	12.85	15.57	61.92	80.88	84.48	2.24	450.08
C_4: 500	27.66	185.66	2.00	28.10	54.37	82.52	13.38	16.34	65.75	84.76	86.67	2.66	528.83
SE(m) ±	0.31	0.72	0.01	0.39	0.22	0.18	0.18	0.23	0.86	0.86	1.25	0.06	2.17
CD (P=0.05)	0.96	2.23	0.03	1.21	0.70	0.56	0.55	0.73	2.63	2.65	3.84	0.21	6.66

DAP: Days after planting, S: Spacing, C: Corm size

Table 2. Interaction effect of different plant spacing and seed corm size on corm yield of elephant foot yam

Sub-plot	Main plot			
	C_1: 200 g	C_1: 300 g	C_1: 400 g	C_1: 500 g
Corm yield (kg/plant)				
S_1: 60 x 60 cm	1.16	1.43	2.00	2.77
S_2: 75 x 75 cm	1.36	1.68	2.49	3.05
SE(m) ±				0.09
CD (P=0.05)				0.29
Corm yield (q/ha)				
S_1: 60 x 60 cm	290.00	357.50	500.00	567.50
S_2: 75 x 75 cm	218.56	269.99	400.16	490.16
SE(m) ±				3.07
CD (P=0.05)				9.42

S: Spacing, C: Corm size

growth stages. At 90 DAP, the 500 g seed corm had significantly higher pseudo stem girth (13.38 cm) as compared to the 400, 300 and 200 g corms. However, it was statistically similar to that of the 400 g seed corm (12.85 cm at 90 DAP). Similar results were also recorded at 120 DAP, and it was found that the 500 g seed corm had the highest pseudo stem girth (16.34 cm), followed by 400 g (15.57 cm), 300 g (14.72 cm) and 200 g (14.07 cm). The data indicated that as the seed corm size increased, the girth of the pseudo stem also increased. The results are in close conformity with the work done by earlier workers Nath *et al.*[17] and Chattopadhyay *et al.*[18].

Canopy spread is an important parameter for transpiration, respiration and photosynthesis. The data revealed that plant spacing had a non-significant effect on the canopy spread of elephant foot yam at 90 and 120 DAP. However, seed corm size had a significant effect on canopy spread at all crop growth stages. The seed corm size of 500 g had significantly maximum canopy spread (65.75 cm at 90 DAP and 84.76 cm at 120 DAP) as compared to 400 g, 300 g and 200 g at 90 and 120 DAP. Similarly, all treatments significantly varied from each other at 90 and 120 DAP. The results are in agreement with the findings of Nath *et al.*[16] and Ravi *et al.*[11]. The data related to the harvest index (Table 1) showed that plant spacing had a significant effect on the harvest index. The seed corms planted at a spacing of 75 cm × 75 cm had a significantly higher harvest index (85.86) than those planted at a closer spacing of 60 cm × 60 cm (81.53). The 500 g seed corm resulted in a significantly higher harvest index (86.67), which was similar to that of the 400 g (84.48) and 300 g (83.65) seed corms. The interaction effect between plant spacing and seed corm size for all the above parameters was found to be non-significant.

The corm yield was significantly impacted by the plant spacing as well as seed corm size used for planting, and the data showed that closer spacing of 60 cm × 60 cm recorded significantly higher corm yield (428.75 q/ha) than the wider spacing of 75 cm × 75 cm (344.71 q/ha). Although the corm yield per plant was higher with wider spacing of 75 cm × 75 cm (2.14 kg/plant), the corm yield per hectare was significantly higher with the closer spacing of 60 cm × 60 cm, which was due to the greater number of plants, that is, 25000 plants/ha, whereas the number of plants was reduced to 16071/ha when the spacing was increased to 75 cm

× 75 cm. Significantly higher corm yields (528.83 q/ha) were observed when seed corms weighing 500 g were used for planting, followed by corms weighing 400, 300 and 200 g, with all sizes varying significantly from each other. This was due to the higher amount of food reserves in large seed corms, which resulted in the production of large-sized corms of elephant foot yam and, therefore, an increase in corm yield. The results are similar to those of Santosa and Sugiyama. The interaction between plant spacing and seed corm size significantly influenced the corm yield per plant and per hectare as presented in Table 2. It was observed that significantly higher corm yield per plant (3.05 kg/plant) was recorded when 500 g seed corm was planted at a wider spacing of 75 cm × 75 cm, while lowest value (1.16 kg/plant) was observed when the smallest size of 200 g seed corm was planted at a closer spacing of 60 cm × 60 cm though this treatment was at par with planting of 200 g and 300 g seed corm at a spacing of 75 cm × 75 cm. It was also observed that the highest corm yield per hectare (567.50 q/ha) was recorded when the largest seed corm size of 500 g was planted at a closer spacing of 60 cm × 60 cm, while the lowest corm yield per hectare (218.56 q/ha) was recorded when the smallest seed corm size of 200 g was planted at a wider spacing of 75 cm × 75 cm.

CONCLUSION

The present investigation concluded that plant growth parameters, such as corm sprout emergence, pseudo stem height and girth, leaf area index, canopy spread and harvest index of the 'Gajendra' variety of elephant foot yam, increased with an increase in seed corm size and spacing. The corm yield per plant was maximum (3.05 kg/plant) when large seed corms (500 g) were planted at wider spacing (75 cm × 75 cm), while the corm yield per hectare was maximum (567.50 q/ha) when large seed corms of 500 g were planted at closer spacing of 60 cm × 60 cm.

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AUTHORS CONTRIBUTION

DK: Conducted the experiment and analyzed the data. NS: Wrote the original manuscript and revised final submission. SN: Compiled literature RS: Finalized the research programme, methodology, provided resources and edited the manuscript.