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Effect of Fertilizer Application and Spacing on the Growth and Yield of Taro [*Colocasia esculenta* (L.) Schott.]

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A B S T R A C T

An investigation was carried out to see the effect of fertilizer and spacing on the growth and yield of taro at research field of Department of Horticulture, College of Agriculture, RVSKVV, Gwalior during two consecutive *kharif* seasons of 2017 and 2018. Three levels of fertilizer dose viz., F_1 = full FYM (10t/ha.) + recommended dose of NPK (80:60:60 kg/ha), F_2 = full FYM (10t/ha.) +75% of recommended dose of NPK (60:45:45 kg/ha), F_3 = full FYM (10t/ha.) +125% of recommended dose of NPK (100:75:75 kg/ha) and three levels of spacing viz., 0.60m x 0.30m, 0.60m x 0.45m and 0.60m x 0.60m were used as treatment variables. The experiments were laid out in factorial randomized block design with three replications. The growth attributes of taro viz., plant height, number of leaves per plant, petiole length, number of petioles per plant, and number of side shoots per plant were significantly increased by the application of F_3 [full FYM (10 t/ha) + 125% recommended dose of NPK (100:75:75 kg/ha)]. The yield attribute and yield of taro viz., number of corms per plant, number of cormels per plant, cormel length, cormel diameter, average corm weight and yield per plant and yield per hectare were significantly increased by the application of F_3 [full FYM (10 t/ha) + 125% recommended dose of NPK (100:75:75 kg/ha)]. Plant spacing showed positive influences on the height of plant, number of leaves per plant, petiole length, number of petioles per plant, number of side shoots per plant, number of corms per plant, number of cormel per plant, cormel length, cormel diameter, average corm weight, average cormel weight, yield per plant and yield per hectare. The highest yield (7.98 t/ha and 7.92 t/ha) was obtained from the fertilizer application of F_3, respectively in both the year 2017 and 2018. Yield per hectare was increased with the lower plant spacing up to 0.60m x 0.30m. The highest yield (9.06 t/ha 8.94 t/ha) was obtained from the spacing of 0.60m x 0.30m, respectively in both the year 2017 and 2018.

Introduction

Taro (*Colocasia esculenta* L. Schott) commonly known as arbi, tarul, dasheen, champadhumpa and eddoe. It is an important staple food crop grown throughout many Pacific island countries, parts of Africa, Asia and the Caribbean and is thought to have originated in North Eastern India and Asia (Kuruvilla and Singh, 1981; Ivancic, 1992) and gradually spread worldwide by settlers. It is widely grown as a rainfed crop in the valley and *Jhum* area in entire North Eastern States of India. *Colocasia esculenta* is an herbaceous, perennial root crop that has the character of being an underground stem. It is different from yam as it is not a tuber but a corm. Taro leaves are heart shaped which are 5.0-7.6 cm long and 2.5-5.0cm across on 7.6cm long petioles that all emanate from an upright tuberous rootstock, called a corm. The petioles are thick and succulent, which attaches near the centre of the leaf. The corm is shaped like a top with rough ridges, lumps and spindly roots, and skin of corm and cormels are brown with white or pink color flesh. Colocasia produces smaller corms or "cormels" which grow off the sides of the main corm.

The crop of colocasia has a triple value in that the stem may be used as salads, the tubers provide easily digested starch, while the leaves are used as a green vegetable. The major economic parts are corm and cormels which have a nutritional value comparable to sweet potato, while the young leaves used for food

contains about 23% protein on a dry weight basis. It is also rich in calcium, phosphorus, iron, vitamin C, thiamine, riboflavin and niacin, which are important constituents of human diets. Corms and cormels possess a high nutritional value. The corm is a rich source of carbohydrate, the majority being starch. Taro corms and cormels have a high economic value in urban markets.

The taro industry provides valuable employment to a large number of people, mostly in rural areas. There are considerable opportunities for diversification and utilization of taro crop. From a global view, taro will be increasingly used in processed form of food, feed and starch derived products.

Nutrient management and spacing are the major regulating factors to get the maximum yield and quality of any crop. Sensible and suitable use of nutrients and spacing are essential to improve yield and quality of produce. The present experiment was therefore, carried out to find out suitable plant spacing and optimum fertilizer dose for better growth and higher yield of taro.

Materials and Methods

Field experiments were carried out in the research field of Department of Horticulture, College of Agriculture, RVSKVV, Gwalior during two consecutive *kharif* seasons of 2017 and 2018 on taro [*Colocasia esculenta* (L.) Schott.]. Three levels of fertilizer dose i.e. F_1 = full FYM (10t/ha.) + recommended dose of NPK (80:60:60 kg/ha), F_2 = full FYM (10t/ha.) +75% of recommended dose of NPK (60:45:45 kg/ha), F_3 = full FYM (10t/ha.) +125% of recommended dose of NPK (100:75:75 kg/ha) and three levels of spacing i.e. S_1 = (0.60m x 0.30m), S_2 = (0.60m x 0.45m) and S_3 = (0.60m x 0.60m) were used as treatment variables in the present study. The experiments were conducted in a factorial randomized block design with three replications. The unit plot size was 3.6 m x 3.6 m. The variety used in the experiment was “Narendra Arbi-1”. The crop was fertilized with as per treatment. Intercultural operations were done as and when required. Observations on five plant growth characters viz. height of plant (cm), number of leaves per plant, petiole length (cm), number of petioles per plant and number of side shoots per plant and yield and yield attributes namely number of corms per plant, number of cormels per plant, corm length (mm), cormel length (mm), corm diameter (mm), cormel diameter (mm), Average corm weight (g), Average cormel weight (g), Yield per plant (g) and Yield (t/ha) were recorded. Ten plants were randomly selected from each plot for recording yield contributing characters. The growth and yield data was recorded from an area of 12.96m^2 in each plot and per hectare yield was calculated. Corms and cormels were considered to calculate yield data which were mentioned as edible yield. The experimental data recorded were subjected to statistical analysis using analysis of variance technique suggested by Panse and Sukhatme (1967) and presented in Table 1 and 2. The critical differences for the treatments comparison were worked out, wherever the "F" test was found significant at 5% level of significance.

Results and Discussion

The results of present investigation showed significant differences for the growth stages (Table 1).

Height of plant

Different fertilizer level showed significant variations in the plant height of taro. Fertilizer level had significant effect on the height of plant. The maximum plant height (88.85 cm and 88.57 cm) was noticed in treatment F_3 followed by F_1. While the lowest plant height (66.71 cm and 68.23 cm) was recorded in treatment F_2, respectively in both the year 2017 and 2018. Plant spacing had significant effect on the height of plant. In 2017, the plant spacing of S_3 (0.60m x 0.60m) produced the maximum plant height (80.22 cm) and the minimum plant height (73.41 cm) was obtained in the plant spacing of S_1 (0.60m x 0.30m). While, the plant spacing S_3 was statistically at par with the spacing of S_2 during the year 2017. In 2018, the plant spacing of S_3 (0.60m x 0.60m) produced the maximum plant height (82.08 cm). The minimum plant height (75.12 cm) was obtained in the plant spacing of S_1 (0.60m x 0.30m). While, the plant spacing S_1 and S_3 was statistically at par with the spacing of S_2 during the year 2018. The result indicated that the plant height increased with the decrease in spacings and the results is agreed upon with Purewall and Daragan (1957).

Number of leaves per plant

The highest number of leaves per plant (5.48 and 5.38) was observed in the treatment F_3 and the lowest number of leaves per plant (4.18 and 4.16) was recorded in $F_{2,}$ respectively in both the year 2017 and 2018. Plant spacing had significant effect on the number of leaves of taro. The highest number of leaves per plant (5.33 and 5.28) was obtained in S_3 (0.60m x 0.60m) spacing and the lowest number of leaves per plant (4.51 and 4.41) was noticed in S_1 (0.60m x 0.30m), which was statistically similar with the S_2 (0.60m x 0.45m), respectively in both the year 2017 and 2018.

Petiole length

The highest petiole length (86.95cm and 87.25cm) was recorded in the treatment F_3. However, the lowest petiole length (67.52cm and 66.35cm) was recorded in $F_{2,}$ respectively in both the year 2017 and 2018. The highest petiole length (78.07cm and 80.37cm) was obtained in S_3 (0.60m x 0.60m) spacing and the lowest petiole length was noticed in S_1 (0.60m x 0.30m). However, plant spacing S_3 was statistically at par with S_2 respectively during both the year 2017 and 2018.

Number of petiole per plant

The highest number of petiole per plant (5.66 and 6.53) was observed in the treatment F_3 and the lowest number of petioles per plant (4.25 and 4.39) was recorded in $F_{2,}$ respectively in both the year 2017 and 2018. Plant spacing had significant effect on the number of petiole per plant of taro (Table 1). The plant spacing i.e. S_3 (0.60m x 0.60m) produced the maximum number of petiole per plant (5.25 and 5.82) and the minimum number of petiole per plant (4.70 and 4.89) was obtained in the spacing of S_1 (0.60m x 0.30m). However, plant spacing of S_1 were statistically at par with S_2, during the year 2017 only. This result was found in agreement with that of Dhar (1989).

Number of side shoots per plant

In 2017, the minimum number of side shoots per plant (2.51) was recorded in F_2 and the maximum number of side shoots per plant (3.01) recorded in F_3, which was statistically similar with F_1. In 2018, the minimum number of side shoots per plant (2.61) was recorded in F_2 and the maximum number of side shoots per plant (3.22), recorded in F_3. The variation in the number of side shoots due to plant spacing was found to be significant. There was a significant increase in the number of side shoots per plant with the increase in plant spacing. In 2017, the plant spacing of S_3 (0.60m x 0.60m) produced the maximum number of side shoots per plant (2.97), which was at par with S_2 (0.60m x 0.45m) and the minimum number of side shoots per plant (2.68) was obtained in the plant spacing of S_1 (0.60m x 0.30m). In 2018, the plant spacing of S_3 (0.60m x 0.60m) produced the maximum number of side shoots per plant (3.12) and the minimum number of side shoots per plant (2.81) was obtained in the plant spacing of S_1 (0.60m x 0.30m) which was statistically at par with S_2 (0.60m x 0.45m).

Number of corms per plant

The highest number of corms per plant (2.08 and 1.98) was observed in the treatment F_3 followed by treatment of F_1. However, the lowest number of corms per plant (1.40 and 1.29) was recorded in F_2, respectively in both the year 2017 and 2018. The variation in the number of corms due to plant spacing was found to be significant (Table 2). The plant spacing of S_1 (0.60m x 0.30m) produced the minimum number of corms per plant (1.59 and 1.49) and the maximum number of corms per plant (1.89 and 1.76) was obtained in the plant spacing of S_3 (0.60m x 0.60m), which was at par with plant spacing of S_2 (0.60m x 0.45m), respectively in both the year 2017 and 2018.

Number of cormel per plant

In 2017, the minimum number of cormels per plant (9.45) was recorded in F_2, which were at par with treatment F_1 (9.97) and the maximum number of cormels per plant (11.55) was recorded in F_3. In 2018, the minimum number of cormels per plant (9.73) was recorded in F_2, which statistically similar with treatment F_1 (10.39) and the maximum number of cormels per plant (12.01) was recorded in F_3. The variation in the number of cormels per plant due to plant spacing was found to be significant (Table 2). In 2017, the minimum number of cormels per plant (9.69) was observed in the plant spacing of S_1 (0.60m x 0.30m) and the maximum number of cormels per plant (10.92) was obtained in the plant spacing of S_3 (0.60m x 0.60m) which was significantly higher than rest of the all other treatments. While, the plant spacing S_1 and S_3 was statistically at par with plant spacing of S_2 (0.60m x 0.45m) made for each other. In 2018, the plant spacing of S_1 (0.60m x 0.30m) produced the minimum number of cormels per plant (10.19) and the maximum number of cormels per plant (11.27) was obtained in the plant spacing of S_3 (0.60m x 0.60m). While, the plant spacing S_1 and S_3 was statistically at par with plant spacing of S_2 (0.60m x 0.45m) made for each other during the year 2018. The increase in number of cormel per plant with decrease of plant spacing was also reported by Mannan *et al.,* (1988) and Dhar (1989).

Corm length

In 2017, the lowest corm length (47.93 mm) was recorded in F_2 which was significantly inferior to rest of the treatments, and the highest corm length (57.16 mm) was recorded in F_3, which was statistically similar with the F_1 (56.98 mm). In 2018, the minimum corm length (45.45 mm) was observed in F_2, followed by F_1 and the maximum corm length (59.06 mm) was noticed in F_3. The variation in the corm length due to plant spacing was found to be significant. The plant spacing of S_1 (0.60m x 0.30m) produced the lowest corm length (51.29mm x 49.59mm) and the highest corm length (55.90mm x 56.00 mm) was obtained in the plant spacing of S_3 (0.60m x 0.60m) which was statistically similar with plant spacing of S_2 (54.87mm and 53.58mm).

Cormel length

The highest cormel length (50.19 mm and 50.34 mm) was observed in the treatment F_3 followed by treatment F_1. However, the lowest cormel length (34.13 mm and 34.40 mm) was recorded in F_2, respectively in both the year 2017 and 2018. The variation in the cormel length due to plant spacing was found to be significant. In 2017, the lowest cormel length (40.09 mm) was obtained in plant spacing of S_1 (0.60m x 0.30m) and the highest cormel length (44.92 mm) was obtained in the plant spacing of S_3 (0.60m x 0.60m) which was at par with spacing of S_2 (42.62 mm). In 2018, the plant spacing of S_1 (0.60m x 0.30m) produced the minimum cormel length (39.73 mm) and the maximum cormel length (46.70 mm) was obtained in the plant spacing of S_3 (0.60m x 0.60m).

Table.1 Effect of spacing and fertilizer on growth characters of taro in *kharif* 2017 and 2018

Treatments	Plant height (cm)		No. of leaves/plant		Petiole length (cm)		No. of petioles/plant		No. of side shoots/plant	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
Fertilizer levels										
F1	75.95	78.96	5.06	4.91	73.93	77.22	4.96	5.32	2.96	3.05
F2	66.71	68.23	4.18	4.16	67.52	66.35	4.25	4.39	2.51	2.61
F3	88.85	88.57	5.48	5.38	86.95	87.25	5.66	6.53	3.01	3.22
S.E.(m)	**1.392**	**1.513**	**0.147**	**0.155**	**2.052**	**1.283**	**0.143**	**0.148**	**0.047**	**0.050**
C.D. (at 5%)	**4.174**	**4.537**	**0.442**	**0.464**	**6.152**	**3.846**	**0.429**	**0.445**	**0.141**	**0.150**
Plant spacing										
S1	73.41	75.12	4.51	4.41	71.38	73.50	4.70	4.89	2.68	2.81
S2	77.87	78.57	4.88	4.76	78.95	76.95	4.92	5.53	2.83	2.94
S3	80.22	82.08	5.33	5.28	78.07	80.37	5.25	5.82	2.97	3.12
S.E.(m)	**1.392**	**1.513**	**0.147**	**0.155**	**2.052**	**1.283**	**0.143**	**0.148**	**0.047**	**0.050**
C.D. (at 5%)	**4.174**	**4.537**	**0.442**	**0.464**	**6.152**	**3.846**	**0.429**	**0.445**	**0.141**	**0.150**

F_1 = full FYM (10 t/ha)+ recommended dose of NPK (80:60:60 kg/ha), F_2 = full FYM (10 t/ha) +75% of recommended dose of NPK (60:45:45 kg/ha), F_3 = Full FYM (10 t/ha)+125% of recommended dose of NPK (100:75:75 kg/ha), S_1 = (0.60m x 0.30m), S_2 = (0.60m x 0.45m), S_3 = (0.60m x 0.60m)

Table.2 Effect of spacing and fertilizer on yield contributing characters of taro in *kharif* 2017 and 2018

Treatments	No. of corms/plant		No. of cormel / plant		Corm length (mm)		Cormel length (mm)		Corm diameter (mm)		Cormel diameter (mm)		Avg. corm weight (g)		Avg. cormel weight (g)		Yield/ plant (g)		Yield (t/ha)	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
Fertilizer levels																				
F1	1.73	1.62	9.97	10.39	56.98	54.67	43.32	43.91	46.33	44.15	21.51	20.63	49.70	50.40	12.76	13.29	165.98	165.75	6.56	6.61
F2	1.40	1.29	9.45	9.73	47.93	45.45	34.13	34.40	35.20	35.36	18.43	19.05	44.41	45.76	10.08	10.53	140.32	141.10	5.56	5.49
F3	2.08	1.98	11.55	12.01	57.16	59.06	50.19	50.34	50.27	49.58	26.26	24.77	53.24	53.27	14.62	15.16	201.34	199.79	7.98	7.92
S.E.(m)	**0.056**	**0.051**	**0.225**	**0.254**	**0.925**	**1.367**	**0.784**	**0.827**	**0.747**	**0.794**	**0.438**	**0.480**	**0.860**	**0.876**	**0.274**	**0.284**	**2.839**	**3.415**	**0.112**	**0.156**
C.D. (at 5%)	**0.168**	**0.154**	**0.674**	**0.761**	**2.772**	**4.098**	**2.349**	**2.479**	**2.239**	**2.380**	**1.314**	**1.439**	**2.577**	**2.626**	**0.823**	**0.850**	**8.511**	**10.239**	**0.336**	**0.468**
Plant spacing																				
S1	1.59	1.49	9.69	10.19	51.29	49.59	40.09	39.73	42.20	40.63	20.17	19.84	46.65	47.86	11.71	12.08	164.23	160.56	9.06	8.94
S2	1.73	1.62	10.36	10.67	54.87	53.58	42.62	42.22	43.83	42.91	22.26	21.35	49.68	50.16	12.08	12.99	167.44	171.09	6.17	6.30
S3	1.89	1.76	10.92	11.27	55.90	56.00	44.92	46.70	45.77	45.55	23.77	23.26	51.02	51.41	13.67	13.91	175.97	174.99	4.87	4.78
S.E.(m)	**0.056**	**0.051**	**0.225**	**0.254**	**0.925**	**1.367**	**0.784**	**0.827**	**0.747**	**0.794**	**0.438**	**0.480**	**0.860**	**0.876**	**0.274**	**0.284**	**2.839**	**3.415**	**0.112**	**0.156**
C.D. (at 5%)	**0.168**	**0.154**	**0.674**	**0.761**	**2.772**	**4.098**	**2.349**	**2.479**	**2.239**	**2.380**	**1.314**	**1.439**	**2.577**	**2.626**	**0.823**	**0.850**	**8.511**	**10.239**	**0.336**	**0.468**

F_1 = full FYM (10 t/ha)+ recommended dose of NPK (80:60:60 kg/ha), F_2 = full FYM (10 t/ha) +75% of recommended dose of NPK (60:45:45 kg/ha), F_3 = Full FYM (10 t/ha)+125% of recommended dose of NPK (100:75:75 kg/ha), S_1 = (0.60m x 0.30m), S_2 = (0.60m x 0.45m), S_1 = (0.60m x 0.60m)

Corm diameter

Minimum corm diameter (35.20 mm and 35.36 mm) was recorded in F_2 followed by F_1 and the maximum corm diameter (50.27 mm and 49.58 mm) recorded in F_3, respectively in both the year of 2017 and 2018. The variation in the cormel diameter due to plant spacing was found to be significant. In 2017, the plant spacing of S_1 (0.60m x 0.30m) produced the minimum corm diameter (42.20 mm) and the maximum corm diameter (45.77 mm) was obtained in the plant spacing of S_3 (0.60m x 0.60m). While, the plant spacing S_1 and S_3 was statistically at par with plant spacing of S_2 (0.60m x 0.45m) made for each other. In 2018, the plant spacing of S_1 (0.60m x 0.30m) produced the minimum corm diameter (40.63 mm), which was statistically similar with plant spacing of S_2 (0.60m x 0.45m) and the maximum corm diameter (45.55 mm) was obtained in the plant spacing of S_3 (0.60m x 0.60m).

Cormel diameter

Minimum cormel diameter (18.43 mm and 19.05 mm) was recorded from F_2 followed by F_1 and the maximum cormel diameter (26.26 mm and 24.77 mm) was recorded in F_3, respectively in both the year 2017 and 2018. The variation in the cormel diameter due to plant spacing was found to be significant. The plant spacing of S_1 (0.60m x 0.30m) produced the minimum cormel diameter (20.17 mm and 19.84 mm) and the maximum cormel diameter (23.77 mm and 23.26 mm) was obtained in the plant spacing of S_3 (0.60m x 0.60m), respectively in both the year 2017 and 2018.

Average corm weight (g)

The highest average corm weight (53.24 g and 53.27 g) was recorded in the treatment F_3. However, the lowest average corm weight (44.41 g and 45.76 g) was recorded in treatment F_2, respectively in both the year 2017 and 2018. The average weight of corms was recorded at harvest. A significant variation in the average weight of corms due to plant spacing was observed (Table 2). In 2017, the minimum average corm weight (46.65 mm) was observed in the plant spacing of S_1 (0.60m x 0.30m) and the maximum average corm weight (51.02 mm) was obtained in the plant spacing of S_3 (0.60m x 0.60m) which was identical with spacing of S_2 (0.60m x 0.45m). In 2018, the plant spacing of S_1 (0.60m x 0.30m) produced the minimum average corm weight (47.86 mm) and the maximum average corm weight (51.41 mm) was obtained in the plant spacing of S_3 (0.60m x 0.60m) which was at par with S_2 (0.60m x 0.45m) made for each other. All the treatments of various spacings were significantly superior with each other during 2017 & 2018. As incase of number of corms per plant the plant spacing of 0.60m x 0.30m resulted in the highest average weight of corms and the lowest from the closest one. However, there was a trend of decrease in the average weight of corms with the increase in plant spacing. The increase in corm average weight with decrease spacing was also reported by Dhar (1989).

Average cormel weight (g)

The highest average cormel weight (14.62 g and 15.16 g) was recorded in the treatment F_3 followed by F_1. However, the lowest average cormel weight (10.08 g and 10.53 g) was recorded in treatment F_2, respectively in both the year 2017 and 2018. The average weight of cormel was recorded at harvest. A significant variation in the average weight of cormel due to plant spacing was observed (Table 2). In 2017, the minimum average cormel weight (11.71 mm) was observed in the plant spacing of S_1 (0.60m x 0.30m) and it was at par with spacing of S_2 (0.60m x 0.45m) and the maximum average cormel weight (13.67 mm) was obtained in the plant spacing of S_3 (0.60m x 0.60m). In 2018, the plant spacing of S_1 (0.60m x 0.30m) produced the minimum average cormel weight (12.08 mm) and the maximum average cormel weight (13.91 mm) was obtained in the plant spacing of S_3 (0.60m x 0.60m) followed by S_2 (0.60m x 0.45m).

Yield per plant (g)

The economic yield per plant (201.34g and 199.79g) was highest in treatment F_3 followed by F_1 i.e., 165.98g and 165.75g. The lowest yield (140.32g and 141.10g) were recorded in the treatment F_2, respectively in both the year 2017 and 2018. In 2017, the minimum yield per plant (164.23 g) was recorded in the plant spacing of S_1 (0.60m x 0.30m) which was statistically at par with plant spacing of S_2 (0.60m x 0.45m) and the maximum yield per plant (175.97 g) was obtained in the plant spacing of S_3 (0.60m x 0.60m). In 2018, the plant spacing of S_1 (0.60m x 0.30m) produced the minimum yield per plant (160.56 g) and the maximum yield per plant (174.99 g) was obtained in the plant spacing of S_3 (0.60m x 0.60m) which was statistically at par with plant spacing of S_2 (171.09 g).

Yield (t/ha)

The economic yield (7.98 t/ha and 7.92 t/ha) was highest in treatment F_3 followed by F_2 i.e., 6.56 t/ha and 6.61 t/ha. The lowest yield (5.56 t/ha and 5.49 t/ha) were recorded in the treatment F_2, respectively in both the year 2017 and 2018. The plant spacing resulted in significant variation in the yield per hectare. The highest yield (9.06 t/ha and 8.94 t/ha) was obtained from the spacing of S_1 (0.60m x 0.30m) and the lowest yield (4.87 t/ha and 4.78 t/ha) in the plant spacing of S_3 (0.60m x 0.60m) respectively both in the year 2017 and 2018. This finding is in agreement with the results of Mannan *et al.,* (1988), Basak *et al.*, (1999), and Akther *et al.,* (2016).

The results of the experiment led to the conclusion that the further study might be suggested to use the full FYM (10 t/ha) + 125% recommended dose of NPK (100:75:75 kg/ha) and plant spacing S_1 (0.60m x 0.30m) for growth and yield of taro.

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