Plant Archives Vol. 16 No. 2, 2016 pp. 659-666 **ISSN 0972-5210**

EFFECT OF PLANTING TECHNIQUES AND SPACING ON CORM AND CORMEL YIELD OF BUNDA (*COLOCASIA ESCULENTA* VAR. *ESCULENTA*) UNDER BASTAR PLATEAU OF CHHATTISGARH, INDIA

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Abstract

The present investigation was carried out at instructional cum Research Farm, Shaheed Gundadhoor College of Agriculture and Research Station, experimental field fo AICRP on Tuber Crops, Jagdalpur, Indira Gandhi Krishi Vishwavidhyalaya, Raipur (C.G.), during *Kharif* season 2015-16. The experiment was laid out in Factorial Randomized Block Design with three replications and two factors. First factor was planting techniques *viz.,* A_1- trench method and A_2- ridge and furrow method and second factor was spacing *e.i.* B_1- 90 × *30 cm,* B_2- *90* × 45 cm, B_3- 75 × 30 cm, B_4- 75 × 45 cm, B_5- 60 × 30 cm and B_6- 60 × 45 cm to find out the effect of different planting techniques and spacing on yield of corm and cormel yield, under Bastar Plateau of Chhattisgarh. Among various important growth characters of bunda *i.e.* plant height, number of leaves, plant girth and leaf size was significantly influenced under different planting method and spacing. In different crop growth stages, plant height, number of leaves, plant girth and leaf size was recorded highest in trench method than the ridge and furrow method and in case of spacing, 60 × 30 cm was observed maximum value among various growth stages than the 60 × 45 cm among all the spacing treatments. The length of corm was significantly higher in A_1 (25.17 cm) than the A_2 (9.86 cm) and in spacing treatment B_1 (31.80 cm) was reocrded highest corm length. In case of corm girth, A_1 was produced significanlty maximum corm girth than the A_2. Interaction between planting method × spacing was recorded non significant due to different treatment in com girth and number of corm per plant. Trench method of planting produces significantly maximum length of cormel and weight of corm per plant than the ridge and furrow planting. The highest value of corm and cormels yield was produced in planting method *i.e.* trench method than the ridge and furrow method and in case of spacing, 60 × 30 cm was recorded significantly maximum corm and cormels yield of bunda during experimentation. The weight loss percentage is not significantly affect due to different treatments and also their interaction. It may be concluded that the trench method of planting and planting spacing 60 × 30 cm was given more corm and cormel economic yield and it may be recommend to farmers of Bastar Plateau of Chhattisgarh for commercial production of Bunda.

Key words : Bunda, *Colocasia esculenta* var. *esculenta*, planting method, planting spacing, corm and cormel yield.

Introduction

Bunda (*Colocasia esculenta* var. *esculenta* L.) commonly known as *Shakhen* in Chhattisgarh and Bunda in north India. Bunda comes under the family Araceae sub-family aroideae and chromosome number is 2n=28. Bunda is an important starchy vegetable with high nutritive and medicinal value and belong to the monocotyledonous Araceae family in taro group. In India, it is grown in Uttar Pradesh, West Bengal, Bihar, Chhattisgarh, Jharkhand, Maharashtra, Gujarat and Andhra Pradesh and to a certain extent in Tamil Nadu and Kerala. In Chhattisgarh, it is grown in Bastar, Kondagaon, Jagdalpur, Surguja, Korea, Jashpur, Raigarh, Korba, Bilashpur and Balrampur. In Bunda, the side tubers may be absent and the mother tuber alone swells up to store food material. In the dasheen types of taro, the corm is cylindrical and large. It is up to 30cm long and 15cm in diameter and constitutes the main edible part of the plant. Bunda is widely grown in pacific and Caribbean Islands including Fiji, New Caledonia, New Hebrides, New Guinea and Solomon Islands.

Bunda originated in Inodo-Malayan region of South East Asia and originally cultivated in most of the states in

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India or Malaysia with diverse genetic resources; where wild forms are still found, which has been confirmed with wide variations in isozyme profiles of Asian taro from India, Indonesia and Japan (Lebot and Aradhya, 1992). Wild forms occur in various parts of South Eastern Asia (Purseglove, 1972). Colocasia spread eastwards to other regions with homogeneous equatorial climates from Southeast, Eastern Asia and the Pacific Islands. Archaeological evidence on stone mortars and pestles from the Solomon Islands suggested that Colocasia was already in use around 28,000 years ago. The first European navigators observed cultivated colocasia as far as Japan and New Zealand, and written records indicate that Captain Cook and his companion noticed colocasia in Maori plantations in 1769 (Matthews, 1995).

Two gene pools appeared with domestication occurring in Southeast Asia and with separation of the land masses of Sunda and Sahul overlapping in Indonesia (Mattews, 1990 and Kreike *et al*., 2004). Based on these genepools, Bunda have been designated *Colocasia esculenta* var. *esculenta*, commonly known as dasheen. Dasheen varieties have large central corm, with suckers or stolen, whereas eddoes have a relatively small central corm and a large number of smaller cormels (Purseglove, 1972).

Bunda is one of the starch and carbohydrage rich crop and its leaves and petiole are also used as green vegetables. The crop also has many medicinal properties and is being used in the preparation of ayurvedic medicines. Bunda corms and cormels are also good source of protein minerals like phosphorus and iron. Bunda corm is an excellent source of carbohydrate, the majority being starch of which 17-28% is amylase, and the remainder is amylopectin (Oke, 1990). Nutritional content of most of the edible aroids notwithstanding their high starch content, edible aroids have a higher content of protein and amino acids than many other tropical root crops (Kay, 1987). Bunda starch is ideal for preparation of baby food and cosmetics. The peeled corms, after -pre cooking and drying can be used to produce a flour, similar to potato flour, which is used in the preparation of soups, biscuits, bread, beverages, infant foods and puddings.

The corms and cormels are used for making curry, pickle, and also as supplementary food. The edible portion is chiefly rich in carbohydrate along with good amount of protein and mineral. In some areas bunda is grown for its tender leaves and petioles which are edible and contain 23% protein on dry weight basis (Tindall, 1986). The fresh bunda leaf lamina and petiole contain 80% and 94% moisture, respectively. Humid climate is suitable for this crop and it performs poorly under hot and dry condition. Bunda prefers moist conditions for better growth and yield. It is best suited in swampy tropical climate with a temperature range of 25°C to 30°C. A wide range of rainfall is found in bunda growing areas but annual rainfall near 1000 mm is optimum for its growth and high yield. Usually, the main corm of bunda is cut transversely into pieces of 4 to 5cm thickness; containing one to two 'buds' and weight should not be less than 50 gm. The top portion of the main corm containing apical bud is the best for sprouting. The time of planting greatly varies with region and availability of irrigation. It can be planted from February to June, but February is the best time of planting under irrigated conditions in North Bihar, parts of West Bengal and eastern U.P. as rainfed crop, it can be planted in June, where there is no frost during growing period. The major diseases of colocasia are phytopthora blight, mosaic, tuber rot and insect is aphid and beetle. In many countries bunda is being replaced by sweet potatoes and cassava largely due to pests and disease problems, which are becoming a limiting factor for bunda production (Ivancic, 1992).

In India, successful cormel tip culture of colocasia esculenta leading to the elimination of Dasheen mosaic virus has been done at CTCRI (Edison, 2006). There are several studies on the micro propagation of *Colocasia esculenta* var. *esculenta* L. Schott. In India colocasia is grown in an area of 1.6 million ha producing 11.66 million tonnes with an average production of 7.25 t ha^{-1} (FAO, 2010).

The agronomical practices, planting technique and spacing are the major factors to achieve maximum yield of the produce for any tuber crops. Generally, planting of Bunda is done by ridge and furrow method in some parts of UP, Bihar, Jharkand due to availability of sandy alluvial soil type. In the Chhattisgarh State planting of Bunda is done by trench method of planting and farmers getting more corm and cromel yield through this method as compare to ridge and furrow method.

The looking to the importance of this crop, present investigation entitled "Effect of planting techniques and spacing on corm and cormel yield of Bunda (*Colocasia esculenta* var. *esculenta*) under Bastar plateau of Chhattisgarh" is proposed to be conducted with the following objectives: To study the effect of different planting techniques of *Bunda* on corm and cormel yield, to study the effect of different plant spacing on growth and yield of *Bunda* and to find out the best planting technique and spacing for higher corm yield of *Bunda* in Bastar Plateau of Chhattisgarh.

Materials and Methods

Field experiments were conducted at the Research Farm of Shaheed Gundadhoor College of Agriculture and Research Station AICRP on Tuber crops experimental field, Kumhrawand (Jagdalpur, Indira Gandhi Krishi Vishwavidyalaya) (C.G.) during *Kharif* season (2015-16) for investigation on "Effect of planting technique and spacing on corm and cormel yield of bunda (*Colocasia esculenta* var. *esculenta*) under Bastar plateau of Chhattisgarh". The experiment was laid out in Factorial Randomized Block Design (FRBD) with two factors (A = Planting Technique: A_1 = Trench Method of Planting, A_2 = Ridge & Furrow Method of Planting and B = Plant Spacing: B_1: 90×30 cm, B_2: 90×45 cm, B_3: 75×30 cm, B_4: 75×45 cm, B_5: 60×30 cm, B_6: 60×45 cm.) with 12 treatment combinations and 3 replications. The treatment was grown randomly in each replication/block in a total of 36 plots of 4.5m × 4.5 m. Bastar plateau is one of the three agro-climatic zones of the Chhattisgarh which comes under sub-humid climatic condition. The normal average annual rainfall of the area is 1440 mm but its distribution is very erratic. Major amount of precipitation occurs between June and September (about 3-4 Months). The soil of the experimental site was silty-loam to clay-loam, which is locally known as *Mal* (midland) in the region. Field preparation involves ploughing and turning of soil followed by planting by anyone of the methods, viz., pit, mounds, trench, ridge and furrow depending on the soil type. Among these methods, 45-60 cm deep trench planting is superior to others due to better tuber growth and yield. Planting spacing 75 × 30 cm and 90 × 45 cm under practice in Chhattisgarh. Bunda is propagated vegetative mostly by corms and cormels weighing 75 g having 2-3 eyes for sprouting. The full dose of FYM 10 tonnes per hectare and Vermi compost 1 tonne per hectare has been applied in the prepared field and mix with soil properly. The fertilizer dose 80 kg N, 60 kg P_2O_5 and 80 kg K per hectare applied in the field. The planting of corms and cromels were done after treatment with fungicide. Average sizes of seed corm of bunda were planted at different planting method (Trench and Ridge-Furrow) and different spacing (90 × 30 cm, 90 × 45 cm, 75 × 30 cm, 75 × 45 cm, 60 × 30 cm, 60 × 45 cm) as per treatments. Planting materials were planted on 12th May, 2015.

The half dose of N, full P and K should be applied at the time of planting in trenches and ride and furrows. Remaining half N should be applied 60 days after planting during filling of trenches by soil with intercultural operation and earthing up. Bunda is rainfed crops but irrigation is required during early planting April-June. Irrigation was given 10-15 days interval up to June month. Earthing up was done 60 days after planting. Paddy straw mulching was done just after planting of seeds for improves soil moisture retaining capacity and suppresses weed population in Bunda filed. Observation was recorded from center rows of each plot selected sample plants in each treatment/replication and observed mean value used for statistical analysis. The data on the different growth and yield characters were collected to investigate the crop response to different treatments at different stages of crop growth at an interval of 40 days. The data for different characters under study were statistically analyzed to find out the significance of the differences among the treatments.

Results and Discussion

The results obtained over the season on various parameters are presented and discussed under following heads:

Days to emergence

There were no significant differences across the planting techniques and spacing. The interaction between planting method and spacing. Howere, planting methods affected emergence was all so not found significant effect. In trench method (A_1) tuber seeds emerged earlier than the ridge and furrow (A_2) method. It may be due to high humidity and temperature in the trench as compare to ridge and furrows.

Plant height (cm)

The data pertaining to bunda plant height at different stages of crop growth are presented in table 1. Table reveals that trench method recorded significantly tallest plant than the ridge and furrow method at 120 DAP. Whereas, in spacing, treatment B_5 (60 × 30 cm) was recorded significantly taller plant among all the treatment at all the growth stages but treatment B_6 (60 × 45 cm) was at par at 120 DAP. In case of interaction between planting method × spacing, A1 × B_5 and A_2 × B_5 was recorded significantly tallest plant at 120 DAP, but smallest plant was recorded in A_1× B_2 at 120 DAP and 120 DAP A_2 × B_4 was recorded smallest plant height, the data reveals that plant height increased progressively with advancement of crop age and reached maximum at 120 DAP. The result indicated that the plant height increased with the decrease in plant spacing. Greater plant height at closer spacing was due to more linear growth of plants as a result of higher plant density per unit area (Mastiholi and Heremath, 2009) in coleus crop. Plants in closer spacing get less sunlight and air and hence grow more vertically.

Number of leaves plant^{-1}

The results of number of leaves plant^{-1} significantly, maximum number of leaves was recorded in treatment A_2 and B_2 during experimantation. In case of interaction, $A_1 \times B_6$ and $A_2 \times B_6$ was recorded significantly higher number of leaves per plant at all growth period but at 120 DAP, $A_1 \times B_2$ was produced maximum number of leaves per plant. The number of leaves per plant was decreased slightly after 120 DAP, due to drying of lower leaves. From the results, it was observed that at maturity and the closer spacing produced higher number of leaves than the wider spacing. It might be due to the competition among the plants to achieve the required food for their growth due to the closer spacing. This result has an agreement with results of Khan *et al*. (2002) in onion crops.

Plant girth (cm)

The data on plant girth at different stages of crop growth are presented in table 1. Data shows that plant girth was significantly highest at 120 DAP, in treatment A_2 than the A_1 and in different spacing, B_6 was recorded maximum plant girth at at 120 DAP. At 120 DAP, $A_1 \times B_6$ and $A_2 \times B_6$ was recorded significantly highest plant girth and lowest plant girth was recorded with $A_1 \times B_3$ and $A_2 \times B_3$. The result indicated that the plant girth increased with the increase in row to row spacing. It may be due to more horizontal growth of plant and grow to allow more tillers per plant on wider row available space.

Petiole length (cm)

The data on petiole length at different stages of crop growth are presented in table 1. Petiole length was gradually increased and reached maximum at 120 DAP. At 120 DAP, spacing shows non significant effect. The findings revealed that interaction between planting method × spacing remained unaffected for petiole length, but it was shows comperatively higher petiole length than the spacing × ridge and furrwo method. This result indicate that the highest petiole length was recorded in closer spacing than the wider spacing in the trench method but in the ridge and furrow method wider spacing recorded higher petiole length than the closer spacing. It may be due to less completion among the plant for light, nutrient and vigorous growth in trench method of planting.

Leaf sheath length (cm)

The leaf sheath length increase with the advancement in crop age and reached maximum at 120 DAP. In case of interaction between planting mehod × spacing smaller leaf sheath was recorded with $A_2 \times B_4$. At 120 DAP, interaction between trench method × spacing, $A_1 \times B_6$ was recorded statistically longer leaf sheath among all the treatments but it was show statistically similar result with $A_1 \times B_2$, A1 × B_5, $A_1 \times B_4$ and $A_1 \times B_3$ respectively and in case of ridge and furrow method × spacing, $A_2 \times B_1$ was recorded significantly longer leaf sheath but it was on par with $A_2 \times B_6$ and $A_2 \times B_2$ and smallest leaf sheath was recorded with $A_2 \times B_2$. Remaining interaction shows non significant during experimentation. The result indicated that the closer spacing with trench method 60 × 30 cm produced the highest length of leaf sheath than the wider spacing it was probably due to more linear growth of plant as a result of higher plant density per unit area and more vertical and vigorous growth of plants.

Leaf size (cm^2)

The data reveals that leaf size increased progressively with advancement of crop are and reached maximum at 120 DAP. The data shows that the leaf size are significantly highest in planting method 120 DAP and in spacing, B_6 at 120 DAP was recorded significantly largest leaf size among all the treatments. Interaction effects of different planting method and spacing, $A_1 \times B_5$ 120 DAP recorded significantly highest leaf size in case of trench method with spacing. At 120 DAP, $A_2 \times B_1$ was recorded significantly larger leaf size among the trench method × spacing and lowest leaf size was recorded with $A_2 \times B_5$. The increase value of leaf size raltively obsrved trench method of plantig with closer spacing. It may be due to vigorous growth of plants when tuber seeds planted in the trench.

Number of suckers plant^{-1}

The data shows that A_2 recorded significantly highest number of suckers plant^{-1} than the A_1 during experimentation. In spacing, it was recorded significantly highest number of suckers in treatment B_6 at 120 DAP but it was at par with with B_5. Interaction effect of different planting method and spacing in number of suckers plant^{-1} effect was found non significant. The result indicated that the ridge and furrow method of planting gives more number of suckers as compare trench method of planting. It may be follows to suckers growth due to shallow planting depth.

Length of corm (cm), corm girth (cm) and number of corm plant^{-1}

Data recorded on length of corm, corm girth and number of corm plant^{-1} is presentned in table 3. The data reveals that the length of corm was significantly highest in A_1 than the A_2 and in case of spacing, treatment B_2 was recorded significantly more length of corm which was at par with B_1. The interaction effect of different planting method × spacing was significantly affected by length of corm. The findings revealed that interaction effect of $A_1 \times B_1$ was significantly largest corms and it was at par with $A_1 \times B_2$ and smaller corm was produced by $A_2 \times B_5$. In case of corm girth, A_1 produced significantly maximum corm girth than the A_2. Spacing and interaction between planting method × spacing was found unaffected due to different treatment. In case of number of corms plant^{-1} was recorded non significant effect due to different treatments. The maximum corm length was recorded in wider spacing and trench method of planting. It might be due to more uptakes of plant nutrient from hollow soil depth as well as dense root system it was grow more vertically. This result has an agreement with results of Hossain (2013) in elephant foot yam. The number of corm plant^{-1} increase with decrease the spacing, it might be due to less availability of nutrients and water completion of the plant. The result of our finding was similar to Saud *et al*. (2013).

Length of cormels (cm), cormel girth (cm) and number of cormel plant^{-1}

The data reveals that different planting method and spacing could not produce significant effect on length of cormel, cormel girth and number of cormel plant^{-1} during experimentation, except planting method in length of cormel. A_1 produces significantly maximum length of cormel than the A_2. The maximum corm length was recorded in wider spacing. It might be due to more uptakes of plant nutrient from soil as well as dense root system it was growth more vertically. This result has an agreement with results of Hossain (2013) in elephant foot yam. The maximum number of cormels plant^{-1} was found in wider spacing. It might be due to found highest plant spacing ensured highest vegetative growth and the ultimate results was the highest number of cormels plant^{-1}. This result was also reported by Sikder *et al*. (2014) in Mukhikachu. The increase in number of comels hill^{-1} with the increase of plant spacing was also reported by Ezumah (1973) and Pena (1978).

Total weight of corm and cormel plant^{-1} (kg), weight of corm plant^{-1} (kg) and weight of cormels plant^{-1} (kg)

The data on total corm weight, weight of corm plant^{-1} and weight of cormels are presented in table 4. The findings revealed that total corm weight and weight of corm plant^{-1} was significantly highest in A_1 than the A_2. Rest at the treatment and interactions are failed to produce significant effect. The maximum corm and cormels weight plant^{-1} was recorded at wider spacing. However, there was a trend of increase in the weight of corm and cormels plant^{-1} with the increase in plant spacing. This increase in the corm and cormels weight plant^{-1} was probably due to decreasing competition for nutrient, water and light as well as hollows soil texture created through trench diggong. The increase in corm and cormels weight plant^{-1} with increase in plant spacing was also reported by Atiquzzaman (2007) and Pena (1978).

Yield of corm and cormels tonnes ha^{-1}

Data reveals that yield of corms tonnes per hectare was significantly highest in planting method A_1 than the A_2 and in case of spacing, B_5 was recorded significantly highest yield of corm among all the treatments and significantly lowest yield was produced by B_2. Interaction was not affected significantly due to different treatments. In case of yield of cormels tonne per hectare, it was affected non significant effect due to different treatments and interaction with planting method with spacing during experimentation. The yield of corms and cormels was increased with the decrease in spacing. However, the closest spacing 60 × 30 cm showed higher yield. It was clearly indicated that the plant population in bunda per unit area is one of the main factors that determines the total yield of corm per hectare. This finding was agreed with the results to Atiquzzaman (2007) and Bhayan *et al*. (1982).

Total tuber yield (tonne ha^{-1})

Data reveals that yield of corms tonnes per hectare was significantly highest in planting method A_1 than the A_2 and in case of spacing, B_5 was recorded significantly highest yield of total tuber among all the treatments and significantly lowest yield was produced by B_2. Interaction was not affected significantly due to different treatments. The total tuber yield was increased with the decrease in spacing. However, the closest spacing 60 × 30 cm showed higher tuber yield. It was clearly indicated that the plant population in bunda per unit area is one of the main factors that determines the total tuber yield of corm and cormel per hectare. This finding was agreed with the results to Atiquzzaman (2007) and Bhayan *et al*. (1982).

Summary and Conclusion

The present study revealed that the treatments were found significant influence on yield and most of the yield contributing characters. The days to emergence was remarkably affected by the planting method. The planting method, trench method are earlier days to emergence than the ridge and furrow method. The plant height was recorded significantly affected by the planting method

Table 1 : Effect of different treatments on growth parameters.

Factors	Days to emergence			Plant height (cm)			Number of leaves plant^{-1}			Plant Girth (cm)			Petiole length (cm)		
	A_1	A_2	Mean	A_1	A_2	Mean	A_1	A_2	Mean	A_1	A_2	Mean	A_1	A_2	Mean
B_1	7.33	9.33	8.33	97.3	81.9	89.6	11.45	16.57	14.01	29.16	33.49	31.33	28.13	52.96	40.55
B_2	7.00	10.00	8.50	88.8	82.25	85.53	14.37	17.2	15.79	35.34	31.92	33.63	47.03	40.85	43.94
B_3	7.00	10.00	8.50	93	83.74	88.37	10.59	13.61	12.10	24.99	27.87	26.43	45.18	40.51	42.85
B_4	7.33	11.00	9.17	94.12	81.65	87.89	11.68	16.89	14.29	27.86	34.85	31.36	47.1	40.03	43.57
B_5	7.33	10.00	8.67	131.33	88.33	109.83	12.98	16.2	14.59	34.5	33.56	34.03	51.4	42.92	47.16
B_6	7.33	10.677	9.00	119.57	98.4	108.99	13.88	22.24	18.06	36.44	37.92	37.18	65.92	46.26	56.09
Mean	7.22	10.17	8.70	104.02	86.04	95.03	12.49	17.18	14.84	31.38	33.27	32.33	47.46	43.92	45.69
Factor	A	B	A × B	A	B	A × B	A	B	A × B	A	B	A × B	A	B	A × B
SEm±	0.19	0.32	0.45	1.07	1.87	2.64	0.33	0.57	0.81	0.48	0.83	1.17	3.25	5.63	7.97
CD (5%)	0.55	N.S.	N.S	3.17	5.48	7.74	0.97	1.68	2.37	1.4	2.43	3.44	N.S.	N.S.	N.S.

A_1 – Trench Method, A_2 – Ridge and Furrow Method, B_1 – 90 × 30 cm, B_2 – 90 × 45 cm, B_3 – 75 × 30 cm, B_4 – 75 × 45 cm, B_5 – 60 × 30 cm, B_6 – 60 × 45 cm and N.S.- Non significant

Table 2 : Effect of different treatments on growth and corm characters.

Factors	Leaf sheath length (cm)			Leaf size (cm^2)			Number of suckers plant^{-1}			Length of corm (cm)			Corm girth (cm)		
	A_1	A_2	Mean	A_1	A_2	Mean	A_1	A_2	Mean	A_1	A_2	Mean	A_1	A_2	Mean
B_1	23.22	66.44	44.83	1104.76	1360.13	1232.45	2.50	4.78	3.64	31.80	9.86	20.83	15.10	18.36	16.73
B_2	56.89	48.74	52.82	1331.85	1106.13	1218.99	3.13	4.09	3.61	28.03	10.81	19.42	14.73	18.37	16.55
B_3	49.4	46.11	47.76	1415.43	1150.57	1283.00	2.61	3.31	2.96	23.77	10.09	16.93	14.94	17.72	16.33
B_4	53.24	46.33	49.79	1059.16	863.67	961.41	2.28	4.24	3.26	22.69	9.32	16.01	16.26	17.89	17.07
B_5	54.59	46.66	50.63	1670.53	1017.62	1344.08	3.15	4.61	3.88	21.58	9.28	15.43	18.99	17.75	18.37
B_6	67.59	54.4	61.00	1538.50	1274.73	1406.62	4.26	5.78	5.02	23.18	9.83	16.50	18.64	19.77	19.21
Mean	50.82	51.45	51.14	1353.37	1128.85	1241.11	2.99	4.47	3.73	25.17	9.86	17.52	16.44	18.31	17.38
Factor	A	B	A × B	A	B	A × B	A	B	A X B	A	B	A × B	A	B	A × B
SEm±	2.57	4.44	6.29	15.48	26.81	37.92	0.25	0.43	0.61	0.63	1.09	1.55	0.43	0.75	1.05
CD (5%)	N.S.	N.S.	18.44	45.42	78.66	111.25	0.73	1.26	N.S.	1.85	3.21	4.54	1.27	N.S.	N.S.

A_1 – Trench Method, A_2 – Ridge and Furrow Method, B_1 – 90 × 30 cm, B_2 – 90 × 45 cm, B_3 – 75 × 30 cm, B_4 – 75 × 45 cm, B_5 – 60 × 30 cm, B_6 – 60 × 45 cm and N.S.- Non significant

and spacing. The plant spacing 60 × 30 cm resulted the highest plant height in the trench method, at all growth stages, and in the ridge and furrow method plant spacing 60 × 45 cm resulted in the highest plant height at all growth stages. The plant height decreased with the increase in plant spacing in the condition of different planting method. The lowest plant height was produced by 90 × 45 cm spacing in trench method, but in the ridge and furrow method the lowest plant height was produced by 90 × 30 cm spacing at all growth stages.

The number of leaves significantly maximum was recorded at 120 DAP, in treatment A_2 than A_1 during experimentation. In case of interaction, $A_1 \times B_6$ and $A_2 \times B_6$ was recorded significantly higher number of leaves per plant at all growth period. The girth of plant was significantly highest at 120 DAP, in treatment A_2 than the A_1. The Petiole length was gradually increased and reached maximum at 120 DAP and spacing also shows non significant effect.

The significantly maximum length of leaf sheat was recorded in A_1 than the A_2 at all gowth stage and B_5 was recorded significantly longest leaf sheath among all the treatments during experimention. In case of interaction between planting mehod × spacing at 120 DAP interaction between trench method × spacing $A_1 \times B_6$ was recorded statistically longer leaf sheath among all the treatments. In case of ridge and furrow method × spacing, $A_2 \times B_1$ was recorded significantly longer leaf sheath and smallest

Table 3 : Effect of different treatments on yield attributing characters.

Factors	No. of corm plant^{-1}			Length of cormel (cm)			Cormel girth (cm)			Number of cormels plant^{-1}			Weight of cormels plant^{-1} (kg)		
	A_1	A_2	Mean	A_1	A_2	Mean	A_1	A_2	Mean	A_1	A_2	Mean	A_1	A_2	Mean
B_1	1.33	1.35	1.34	14.27	7.59	10.93	4.68	6.03	5.36	3.79	4.06	3.92	0.110	0.153	0.132
B_2	1.53	1.40	1.47	16.14	8.62	12.38	5.98	6.79	6.39	5.97	4.57	5.27	0.263	0.130	0.197
B_3	1.36	1.28	1.32	12.62	6.61	9.61	5.04	5.87	5.46	2.98	3.28	3.13	0.093	0.070	0.082
B_4	1.21	1.98	1.60	11.71	6.39	9.05	4.59	6.81	5.70	3.51	3.22	3.37	0.180	0.103	0.142
B_5	1.40	1.32	1.36	12.57	7.84	10.21	6.63	6.44	6.54	3.69	3.68	3.69	0.177	0.097	0.137
B_6	1.29	2.64	1.96	15.58	6.63	11.11	7.89	6.67	7.28	4.37	4.01	4.19	0.197	0.210	0.204
Mean	1.35	1.66	1.51	13.82	7.28	10.55	5.80	6.44	6.12	4.05	3.80	3.93	0.170	0.127	0.149
Factor	**A**	**B**	**A × B**	**A**	**B**	**A × B**	**A**	**B**	**A × B**	**A**	**B**	**A × B**	A	B	A × B
SEm±	0.15	0.26	0.37	0.81	1.40	1.98	0.38	0.66	0.94	0.33	0.58	0.81	0.020	0.034	0.048
CD (5%)	N.S.	N.S.	N.S.	2.38	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

A_1 – Trench Method, A_2 – Ridge and Furrow Method, B_1 – 90 × 30 cm, B_2 – 90 × 45 cm, B_3 – 75 × 30 cm, B_4 – 75 × 45 cm, B_5 – 60 × 30 cm, B_6 – 60 × 45 cm and N.S.- Non significant

Table 4 : Effect of different treatments on yield attributing characters.

Factors	Weight of corm plant^{-1} (kg)			Total tuber weight plant^{-1} (kg)			Corm yield (tonne ha^{-1})			Yield of cormel (tonne ha^{-1})			Total tuber yield (tonne ha^{-1})		
	A_1	A_2	Mean	A_1	A_2	Mean	A_1	A_2	Mean	A_1	A_2	Mean	A_1	A_2	Mean
B_1	0.668	0.352	0.510	0.787	0.48	0.634	24.75	13.05	18.90	4.02	5.51	4.77	28.77	18.56	23.67
B_2	0.594	0.324	0.459	0.855	0.459	0.657	14.67	8.00	11.33	6.46	3.25	4.86	21.13	11.25	16.19
B_3	0.444	0.240	0.342	0.541	0.307	0.424	19.75	10.65	15.20	4.24	3.17	3.70	23.99	13.82	18.9
B_4	0.547	0.339	0.443	0.658	0.406	0.532	16.22	10.05	13.14	5.35	3.03	4.19	21.57	13.08	17.33
B_5	0.659	0.269	0.464	0.805	0.367	0.586	36.59	14.92	25.76	9.83	5.37	7.60	46.42	20.29	33.36
B_6	0.653	0.390	0.522	0.855	0.563	0.709	24.18	14.43	19.31	7.37	7.63	7.50	31.55	22.06	26.81
Mean	0.594	0.319	0.457	0.750	0.430	0.590	22.69	11.85	17.27	6.21	4.66	5.44	28.9	16.51	22.71
Factor	A	B	A × B	A	B	A × B	**A**	**B**	**A × B**	**A**	**B**	**A × B**	**A**	**B**	**A × B**
SEm±	0.032	0.055	0.078	0.844	0.076	0.108	1.10	1.91	2.70	0.69	1.19	1.68	1.10	1.91	2.70
CD (5%)	0.093	N.S.	N.S.	0.129	N.S.	N.S.	3.23	5.60	N.S.	N.S.	N.S.	N.S.	3.23	5.60	N.S.

A_1 – Trench Method, A_2 – Ridge and Furrow Method, B_1 – 90 × 30 cm, B_2 – 90 × 45 cm, B_3 – 75 × 30 cm, B_4 – 75 × 45 cm, B_5 – 60 × 30 cm, B_6 – 60 × 45 cm and N.S.- Non significant

leaf sheath was recorded with $A_2 \times B_2$. The leaf size are significantly highest in planting method *i.e.* A_1 at 120 DAP.

The number of suckers was recorded at 120 DAP in A_2 and found significantly highest number of suckers per plant than the A_1 during experimentation. In spacing, it was recorded significantly highest number of suckers in treatment B_6 at 120 DAP. Interaction effect of different planting method and spacing in number of suckers per plant effect was found non significant.

The length of corm was significantly highest in A_1 than the A_2 and in case of spacing, treatment B_2 was recorded significantly more length of corm. The interaction effect of different planting method × spacing was significantly affected by length of corm. The findings revealed that interaction effect of $A_1 \times B_1$ was significantly largest corms and smaller corm was produced by $A_2 \times B_5$. In case of corm girth, A_1 produced significantly maximum corm girth than A_2. Interaction between planting method × spacing was found unaffected due to different treatment for length of corms. In case of number of corms per plant was recorded non significant effect due to different treatments. The different planting method and spacing could not produce significant effect on length of cormel, cormel girth and number of cormel per plant during experimentation, except planting method in length of cormel. A_1 produces significantly maximum length of cormel than the A_2.

The total corm weight and weight of corm per plant was significantly highest in A_1 than the A_2. Rest at the treatment and interactions are failed to produce significant effect. The yield of corms tonnes per hectare was significantly highest in planting method A_1 than the A_2 and in case of spacing, B_5 was recorded significantly highest yield of corm among all the treatment and significantly lowest yield was produced by B_2. Interaction was not affected significantly due to different treatments. In case of yield of cormels tonne per hectare, it was observed non significant effect due to different treatments and interaction with planting method with spacing during experimentation. It is concluded that the trench method of planting and planting spacing 60 × 30 cm was given more corm and cormel economic yield.

Acknowledgement

The authors express their sincere gratitude to Dr. S. C. Mukherjee, Dean, SG CARS, Jagdalpur for the facilities provided and encouragement for undertaking this experiment at the centre. The authors express their sincere gratitude to Dr. James George, Project Coordinator, AICRP on Tuber Crops for provided facilities and budget for undertaking this experiment.

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