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Effect of Different Spacing Level and Growth Stages of Chekkurmanis (*Sauropus androgynus* L.) on Plant Growth

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ABSTRACT

Background: Chekkurmanis, is a shrubby glabrous perennial green leafy vegetable, extensively grown in warm humid tropics. It is called as “Multivitamin / Multigreen” plant. Micronutrient deficiency has spread all over the world and it is termed as “Hidden Hunger”. In this regard, chekkurmanis is the chief source of many minerals and nutrients is help to eradicate these deficiencies. The yield enhancement and improvement on plant growth characters could be manipulated by adopting optimized cultural practices, especially plant spacing and stage of harvest. With the background, present study was taken up to examine the variations in morphologically; under different spacing’s in relation to different growth stages were assessed and discussed.

Methods: The research study was carried during 2019-2020. The healthy rooted cuttings collected from Orchard, Agricultural College and Research Institute, Madurai, Tamil Nadu. The research trial consisted of two factors different spacing’s (Factor I) and specific days interval (Factor II).

Result: Based on the results, it can be suggested that growth characters *i.e.* plant height, number of branches, number of leaves per plant and petiole length parameters were significantly higher under closer spacing at 180 days after planting (S_1D_3). While, Maximum leaf length, leaf breadth and plant spread were recorded under wider spacing at 180 days after planting (S_5D_3).

Keywords: Chekkurmanis, Growth character, Spacing, Stages of growth.

INTRODUCTION

Chekkurmanis (*Sauropus androgynus* L.), the vernacular names of the crop are Katuk, Star gooseberry and Sweet leaf bush, belongs to the family ‘Euphorbiaceae’, is a shrubby glabrous perennial green leafy vegetable, extensively grown in warm humid tropics with ample rainfall. It is congenital to South and South East Asian region due to its therapeutic properties as stated by Padmavathi and Rao (1990). On account of its primary nutritive value, being an abundant source of micronutrients and affordable supply of dietary protein, it is called as “Multivitamin / Multigreen” plant. Chekkurmanis is a popular green leaf vegetable with high level of carbohydrate, thiamine, vitamin A, vitamin B, vitamin C, calcium, iron, potassium, phosphorous and protein (Paul and Anto, 2011).

Micronutrient deficiency has spread all over the world and it is termed as “Hidden Hunger”. In this regard, chekkurmanis is the chief source of many minerals and nutrients as compared to any other green leafy vegetables and products at nominal cost will also help to eradicate these deficiencies. In this regard, chekkurmanis is the chief source of many minerals and nutrients as compared to any other green leafy vegetables. Mineral deficiency and its correlated diseases can be controlled by supplement of leafy vegetables in advised proportion. A required quantity of vitamins, minerals and phytochemicals are essential for typical performance of human metabolic activities. So, yield enhancement and improvement on plant growth characters could be manipulated by adopting optimized cultural practices. Amid the cultural practices, especially plant spacing and stage of harvest are the most salient attributes, which improves growth and development of leafy vegetables. With the background of above factors, present study was taken up to standardized the spacing and stages of harvest, under different spacings in relation to different growth stages of *Sauropus androgynous* were assessed and standardized.

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MATERIALS AND METHODS

The research study was carried out by planting *Sauropus androgynus* plants (rooted cuttings) in the western block farm, Field No. 26, which is located at 80° East longitude, 11° North latitude, at an altitude of 300 M above mean sea level,

Department of Vegetable Science, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Periyakulam, Tamil Nadu, India, during 2019-2020. The nature of soil in the experimental field is sandy loam. This area receives rainfall from both South East (172.70 mm) and North East Monsoon (375.59 mm) with an average rainfall of 791.20 mm. The weather data recorded during crop growing period (Aug 2019-Apr 2020). The healthy and disease free rooted cuttings of *Sauropus androgynus* collected from Orchard, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai, Tamil Nadu, were used as planting materials for the present study.

The research trial consisted of two factors *viz.*, the rooted cuttings of *Sauropus androgynus* were planted different spacings (Factor I) and observations on growth parameters were recorded on specific days interval (Factor II). An uniform plot size of 80 m^2 was taken up for accommodating the five different spacing. The experiment was laid out with fifteen treatments in factorial randomized block design with four replications. From every treatment, five plants were randomly selected for recording observations on growth parameters and calculate the average value.

Treatment details

Factor I: Spacing (S)

Five different spacings were adopted in planting of chekkurmanis plants to carry out the research study *viz.,* S_1= 60 × 60 cm, S_2 = 90 × 90 cm, S_3= 60 × 90 cm, S_4 = 90 × 120 cm and S_5= 120 × 120 cm.

Factor II: Interval of days after planting (D)

Observations on morphological characters of the chekkurmanis plants were recorded at the following three different growth stages are D_1 = 60 days after planting (DAP), D_2 = 120 days after planting (DAP) and D_3 = 180 days after planting (DAP).

Totally there are fifteen treatmental combinations with various spacing and observation recorded on specific day intervals are furnished below:

Sl. no	Treatmental combination	Treatmental details Spacing (S) + Days of recording observation on growth parameter, (DAP- Days after planting)
1	S_1D_1	60×60 cm (S1) + 60 DAP (D1)
2	S_2D_1	90×90 cm (S2) + 60 DAP (D1)
3	S_3D_1	60×90 cm (S3)+ 60 DAP (D)
4	S_4D_1	90×120 cm (S4) + 60 DAP (D1)
5	S_5D_1	120×120 cm (S5) + 60 DAP (D1)
6	S_1D_2	60×60 cm (S1) + 90 DAP (D2)
7	S_2D_2	90×90 cm (S2) + 90 DAP (D2)
8	S_3D_2	60×90 cm (S3) + 90 DAP (D2)
9	S_4D_2	90×120 cm (S4) + 90 DAP (D2)
10	S_5D_2	120×120 cm (S5) + 90 DAP (D2)
11	S_1D_3	60×60 cm (S1) + 120 DAP (D3)
12	S_2D_3	90×90 cm (S2) + 120 DAP (D3)
13	S_3D_3	60×90 cm (S3) + 120 DAP (D3)
14	S_4D_3	90×120 cm (S4) + 120 DAP (D3)
15	S_5D_3	120×120 cm (S5) + 120 DAP (D3)

Field planting and observation

Experimental field was prepared by two ploughings. The stones and stubbles were removed and brought into fine tilth. Pits (45×45 cm^2) were formed with 45 cm depth in 5 different spacings *viz.*, 60×60cm (S_1), 90×90cm (S_2), 120×120cm (S_3), 90×120cm (S_4), 60×90cm (S_5). Observations recorded were plant height (cm) during 60 (D_1), 120 (D_2), 180 (D_3) days after planting, number of branches per plant from the main stem was counted on 60,120, 180 days after planting and the mean values were expressed in numbers, number of leaves per plant (Nos), petiole length (cm), leaf length (cm), leaf breadth (cm) and plant spread (cm^2).

RESULTS AND DISCUSSION

Influence of spacing and days after planting

Plant height

Plant growth in relation to vigour, growth rate and stand of the crop nourishes the crop productivity, specifically height of the plants plays a prominent role. Plant height greatly influence the number of primary branches and number of nodes per plant Shukla and Singh (2003). The plant height had significant influence due to plant spacing adopted and days after planting with values ranged from 83.52 to 165.74 cm (Table 1).

Among the various spacings, 60×60 cm (S_1) registered the maximum plant height (137.44 cm), while the height of the plant was the least (112.42 cm) in wider spacing of 120×120 cm (S_5). Plants grown under closer spacing produced virtuous plant height when compared to widely spaced plants. The spacing of 60×60 cm (S_1) produced significantly maximum height of the plant than other spacing. This might be due to the fact that the densely grown plants apparently grow taller with response to more conflict for penetration of light, space, air and other growth promoting factors. Intensified plant density efficiently aggravates the growth rate that consequently helps better cellular elongation either increment in internodal length or number of nodes or both. Increased plant height may also contribute for more production of leaves and hence branched sparsely.

As number of plants increased per unit area, there was less space available for lateral growth, correspondingly each and every plant attained vertical development. These results are in accordance with the findings of Ekwu and Nwokwu (2012) indicating that closer spacing recorded preferable performance over other spacing by cause of intra specific competition.

Result on effect of days after planting showed highly significant effect on plant height and the maximum height of 157.43 cm was recorded on 180 DAP (D_3), followed by D_2: 120 DAP (119.30 cm). An increasing trend was observed till the study periods of 180 DAP for plant. It is in agreement with observation in cabbage by Islam *et al.* (2017); Aini *et al.* (2020) in chilli. The interaction effect of spacing and days after planting represented significant variations. The plant height under different spacing expressed increasing trend

upon the days after planting. The maximum plant height was obtained in 60×60 cm at 180 DAP (S_1D_3) with the height of 165.74 cm, followed by S_2D_3 (162.88 cm) 90×90 cm at 180 DAP and the minimum height of 83.52 cm was observed under 120×120 cm at 60 DAP (S_5D_1).

Number of branches per plant

The number of branches implies the appearance of a plant and it is directly correlated with number of leaves per plant. Different plant spacing had significant influence on branches per plant and the individual plants grown under spacing of 60×60 cm (S_1) imparted prolific branches in comparison to sparsely spaced 120×120 cm (S_5) plants. In the present study, result on influence of spacing and days after planting on number of branches per plant is furnished in Table 1. Among the spacing levels, 60×60 cm (S_1) produced significantly higher number of branches (11.82), followed by 90×90 cm (S_2) with 10.04 branches and lesser under wider spacing 120×120 cm (S_5), which recorded 5.93 branches. Under closer and wider spacings adopted significant variation was observed on number of branches per plant. The result suggests that number of branches generally increased with respect to decreased plant spacing. This result is in close conformity with previous works of Essilfie *et al.* (2017) in chilli and Singh and Singh (2021) in pegion pea. In spite of this, number of branches statistically differed with days after planting. In this study, D_3 (180 DAP) showed superior mean value (11.85), followed by D_2 (120 DAP) and D_1 (60 DAP) with the value of 8.44 and 5.31 branches respectively. However rapid increase on this character was noted from 120 DAP (D_1) to 60 DAP (D_2). It was observed that the number of branches improved with increasing age of the plant. Similar increasing trend on number of branches was also obtained previously by Iwuagwu *et al.* (2019) in *Solanum melongena* Neethu *et al*. (2022) in French bean.

The combination of spacing and days after planting revealed significant difference. The number of branches was higher (14.87) in 60×60 cm spacing on 180 DAP (S_1D_3), followed by S_2D_3 which had 13.00 branches, while lesser in widely spaced plants 120×120 cm on 60 DAP (S_5D_1) which had 3.15 branches.

Number of leaves per plant

In the present study, spacing and days after planting exhibited preferably significant variations on number of leaves per plant are presented in Table 1. Among the three spacings adopted, 60×60 cm (S_1) showed the maximum number of leaves (145.86), followed by 90×90 cm (S_2) which showed 137.62 leaves, while the widest spacing of 120×120 cm (S_5) expressed the minimum number of leaves (98.50). Number of leaves per plant increased as plant spacing decreased from 120×120 cm (S_5) to 60×60 cm (S_1). The results of the present experiment is in accordance with the findings of Ekwu and Nwokwu (2012) in *Abelmoschus esculentus*, who observed that closer spacing provided higher number of leaves than their counterparts. In addition to that, high number of leaves in closer spacing, perhaps the reason of enhanced growth tends in quest for sunlight, space and several other factors needed for growth. This is in harmonious with study of Falodun and Ogedegbe (2016) in bhendi.

Number of leaves per plant was observed on three different days after planting, which showed an increasing tendency towards maturity of the crop. Significant variation in leaf number was noticed on 180 DAP (D_3) which registered more number of leaves (177.39), followed by 120 DAP (D_2) with 123.30 leaves and lesser leaf number of 70.87 was observed at 60 DAP (D_1). The result on this character reveals that, when number of days after planting increases, leaves per plant also improved. Same sequence of improvement was noted by Sokoto and Johnbosco (2017) in amaranthus.

The interaction between spacing and days after planting on number of leaves per plant was found to be statistically significant. The maximum number of leaves per plant (201.44) was observed under 60×60 cm at 180 DAP (S_1D_3), followed by 194.13 leaves at 90×90 cm on 180 DAP (S_2D_3). The least value of 48.42 leaves was obtained in 120×120 cm on 60 DAP (S_5D_1).

Petiole length

It is also one of the most essential character of crop. The result on petiole length is evidently seen in Table 2. The variation between spacing showed significant difference and the variation among days after planting also found to be significant. The three spacings adopted had a propitious

Table 1: Effect of spacing and days after planting on plant height, number of branches per plants and number of leaves per plant.

Treatments	Plant height (cm)				Number of branches per plant				Number of leaves per plant			
	D_1 (60 DAP)	D_2 (120 DAP)	D^3 (180 DAP)	Mean	D_1 (60 DAP)	D_2 (120 DAP)	D_3 (180 DAP)	Mean	D_1 (60 DAP)	D_2 (120 DAP)	D_3 (180 DAP)	Mean
S_1 (60×60 cm)	108.30	138.00	165.74	137.44	8.10	12.50	14.87	11.82	86.44	149.69	201.44	145.86
S_2 (90×90 cm)	97.41	126.21	162.88	128.83	6.90	10.24	13.00	10.04	81.09	137.63	194.13	137.62
S_3 (60×90 cm)	94.28	119.92	157.33	123.61	4.10	7.86	11.74	7.9	72.08	124.55	176.9	124.53
S_4 (90×120 cm)	89.65	108.85	151.41	116.63	4.29	7.67	10.95	7.63	66.34	108.13	163.84	112.77
S_5 (120×120 cm)	83.52	103.92	149.82	112.42	3.15	5.96	8.70	5.93	48.42	95.5	150.6	98.5
Mean	94.63	119.3	157.43	123.79	5.31	8.84	11.85	8.67	70.87	123.3	177.39	123.85
Factors	**S**	**D**	**S×D**		**S**	**D**	**S×D**		**S**	**D**	**S×D**	
SE (d)	1.15	0.89	2.00		0.08	0.06	0.15		1.43	1.11	2.48	
CD (0.05)	2.33**	1.80**	4.04**		0.17**	0.13**	0.30**		2.89**	2.24**	5.01**	

Table 2: Effect of spacing and days after planting on petiole length, leaf length and leaf breadth.

Treatments	Petiole length (cm)				Leaf length (cm)				Leaf breadth (cm)			
	D_1 (60 DAP)	D_2 (120 DAP)	D_3 (180 DAP)	Mean	D_1 (60 DAP)	D_2 (120 DAP)	D_3 (180 DAP)	Mean	D_1 (60 DAP)	D_2 (120 DAP)	D_3 (180 DAP)	Mean
S_1 (60×60 cm)	0.4	0.87	1.22	0.83	2.47	4.61	5.26	4.11	1.61	2.15	3.20	2.32
S_2 (90×90 cm)	0.35	0.86	1.12	0.77	2.51	4.8	5.75	4.35	1.68	2.25	3.47	2.46
S_3 (60×90 cm)	0.38	0.74	1.02	0.71	2.64	4.86	5.52	4.34	1.73	2.36	3.32	2.47
S_4 (90×120 cm)	0.27	0.66	0.93	0.62	3.78	4.97	6.34	5.03	1.80	2.53	3.60	2.64
S_5 (120×120 cm)	0.20	0.49	0.90	0.53	4.11	5.00	6.63	5.24	1.92	2.60	3.78	2.76
Mean	0.32	0.72	1.04	0.69	3.1	4.85	5.9	4.61	1.74	2.37	3.47	2.53
Factors	**S**	**D**	**S×D**		**S**	**D**	**S×D**		**S**	**D**	**S×D**	
SE (d)	0	0	0.01		0.04	0.03	0.08		0.02	0.01	0.04	
CD (0.05)	0.01**	0.01**	0.02**		0.09**	0.07**	0.16**		0.04**	0.03**	0.08**	

influence on petiole length. It was clear that, closer spacing produced the maximum petiole length than wider spacing. The spacing of 60×60 cm (S_1) recorded higher petiole length of 0.83 cm, which was followed by (S_2) which registered 0.77 cm and lesser value of 0.53 cm was obtained under 120×120 cm (S_5). The longer petiole length determined notable number of leaves on the stem Kanthaswamy (2006).

As consistent to number of leaves, days after planting had favorable association with petiole length. Petiole length of the plant at days after planting showed a phenomenal increase with age of the crop and the increment was marginal. At 180 DAP (D_3), the maximum value 1.04 cm was observed, whereas 60 DAP (D_1) expressed the least value of 0.32 cm. This may be due to the fact that when plant advanced with age, length of the petiole endures the increasing habit. Similar trend on this parameter well supported by Kanthaswamy (2006) in amaranthus that significant prominent performance of growth characters at different intervals of crop maturity. It observed increasing approach in petiole length towards age enhancement of crop. The interaction between the three different spacings and three different days after planting was significant. The highest petiole length of 1.22 cm was registered under 60×60 cm spacing on 180 DAP (S_1D_3), which was on par with S_2D_3 which had 1.12 cm. The wider spacing of 120×120 cm had lesser petiole length of 0.20 cm at 60 DAP (S_5D_1).

Leaf length

The data pertaining to the effect of spacing and days after planting are presented in Table 2. The result showed that length of the leaf was higher under 120×120 cm (S_5) with an average of 5.24 cm, while it was lesser under 60×60 cm (S_1) which recorded 4.11 cm. The difference among the spacing was found to be significant. Leaf length increased as the spacing becomes wider and wider. A possible reason is that, the advantage of efficient utilization of space, photosynthesis and more interception of light for improved growth and development. This is in congruence with the result of Hasan *et al.* (2017) in lettuce.

Length of the leaf gently increased at various stages of crop growth, which was identified to have inherent potential to contribute yield (Dehariya *et al.,* 2019). Leaf length gradually increased from 60 to 180 DAP and the peak leaf length (5.90 cm) was observed in this study at 180 DAP (D_3), followed by D_2 (4.85 cm) and D_1 (3.10 cm). As number of days after planting increases, progressive elongation on leaf length was observed. Among the stages, the peak leaf length was noticed at 180 DAP (D_3). Harmonic pattern of growth was found by Jha *et al.* (2018) in okra and Kumar *et al.* (2022) in palak, which indicated that improving trend on growth of this character at various levels of growth. Interaction effect between spacing and days after planting was found to be significant. The plants grown under 120×120 cm on 180 DAP (S_5D_3) obtained higher leaf length (6.63 cm) and the least leaf length of 2.47 cm was obtained under 60×60 cm on 60 DAP (S_1D_1).

Leaf breadth

It is directly congruous with leaf production and expansion, as well as positive relationship with leaf length (Diwan *et al.,* 2017). Both spacing and days after planting significantly influenced the breadth of the leaf. The result on this morphological character is furnished in Table 2.

Within the spacings adopted, average leaf breadth was significantly highest (2.76 cm) under 120×120 cm (S_5), while plants grown in a spacing of 60×60 cm (S_1) registered the lowest leaf breadth (2.32 cm). This study implies that widely spaced plants sustained ample space to widen its leaves, received more water and nutrients for vegetative growth and also slighter competition among the plants which assists incremental tendency on this parameter. The result indicated that general improvement in growth of leaf breadth was highly significant at wider spacing in comparison to closer spacing. This result was well supported by work of Zemichael *et al.* (2017) in lettuce.

With respect to days after planting, 180 DAP (D_3) registered significantly maximum leaf breadth (3.47 cm), followed by D_2 (2.37 cm) and D_1(1.74 cm). As plant grows, leaf breadth increased which elicited high photosynthesis. Identically, increasing progression on this trait towards stages of growth were registered in bhendi (Jha *et al.,* 2018).

Interaction effect of plant spacing and days after planting were found to be significant. Among the effect of interaction,

Table 3: Effect of spacing and days after planting on plant spread.

Treatments	Plant spread (cm^2)			
	D_1 (60 DAP)	D_2 (120 DAP)	D_3 (180 DAP)	Mean
S_1 (60×60 cm)	306.45	680.07	902.59	629.7
S_2 (90×90 cm)	311.73	755.82	978.25	681.93
S_3 (60×90 cm)	351.93	701.54	939.41	664.29
S_4 (90×120 cm)	493.21	784.36	1087.9	788.37
S_5 (120×120 cm)	509.37	810.35	1194.09	837.94
Mean	394.53	746.36	1020.45	720.45
Factors	**S**	**D**	**S×D**	
SE (d)	6.72	5.21	11.65	
CD (0.05)	13.57**	10.51**	23.51**	

120×120 cm spacing on 180 DAP (S_5D_3) showed significantly higher leaf breadth of 3.78 cm, followed by S_4D_3 which registered 3.60 cm and the least value of 1.61 cm was recorded in 60×60 cm at 60 DAP (S_1D_1).

Plant spread

With regard to plant spread, significant influence was observed due to different spacings and days after planting and the results are furnished in Table 3. Based on plant spacing, 120×120 cm (S_5) registered the highest plant spread with values of 837.54 cm^2 and the lowest in 60×60 cm (S_1) which had 629.70 cm^2 plant spread. Plant spread per plant was significantly higher at wider spacing of 90×120 cm (S_4) than other spacing adopted in this study. It might be attributed to the fact that under the widest spacing or more space per unit area, each plant receives enough space, sunlight and aeration required for desirable growth of the plant. The result obtained in the study regarding plant spread exhibited that wider spacing enhanced the plant spread at all stages of the growth. This is in concordance with previous finding by Gurung *et al.* (2018) in *Solanum aethiopicum.*

The plant spread was significantly higher at 180 DAP (D_3) with 1020.45 cm^2, followed by 120 DAP (D_2) which recorded 746.36 cm_2 and lower (394.53 cm^2) at 60 DAP (D_1). With an advancement in age higher plant spread was obtained at 180 DAP (D_3), than other two stages of plant growth. Islam *et al.* (2017) reported the same trend in *Brassica oleraceae*.

The interaction between plant spacing and days after planting significantly influenced the plant spread. The plant spread was found to increase under wider spacing as well as progressive increase with days after planting. Among the interactions, 120×120 cm at 180 DAP (S_5D_3) expressed the highest plant spread (1194.09 cm^2) and the lowest spread of 306.45 cm^2 was recorded in the spacing of 60×60 cm at 60 DAP (S_1D_1).

CONCLUSION

The experimental results of this study manifested that different levels of spacing and stages of growth had a significant influence on growth characters of chekkurmanis plants. Based on the above results, it can be suggested that growth characters *i.e.* plant height, number of branches, number of leaves per plant and petiole length parameters were significantly higher under closer spacing at 180 days after planting (S_1D_3). While, Maximum leaf length, leaf breadth and plant spread were recorded under wider spacing at 180 days after planting (S_5D_3)

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Conflict of interest

The authors declare that there is no conflict of interest.

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