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The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(9): 1583-1586

www.thepharmajournal.com
Received: 01-07-2023
Accepted: 02-08-2023

Effect of plant densities on growth and yield of Chinese potato (*Coleus rotundifolius* L.)

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Abstract
The experiment titled "Standardization of plant densities and fertilizers in Chinese potato (*Coleus rotundifolius* L.)" was carried out during the *Rabi* season of the year 2022-2023 at the College of Horticulture, Venkataramannagudem, Dr. Y. S. R. Horticultural University. The study involved twelve treatment combinations of four plant densities: 45 cm × 10 cm (S_1), 45 cm × 20 cm (S_2), 45 cm × 30 cm (S_3), and 45 cm × 40 cm (S_4). The experimental design used was a Randomized Block Design and was replicated three times. The results indicated that Chinese potato planted at a plant density of 45 cm × 30 cm (S_3) demonstrated superior performance in various vegetative *viz*., vine length, number of leaves, plant spread and number of nodes and yield parameters *viz*., days to tuber harvest, number of tubers, tuber yield per plant

Keywords: Chinese potato, plant densities, vegetative, yield

Introduction
Under utilized tuber crops offer an important agronomic advantage as staple food because of their favourable adaptation to diverse soil and environmental conditions and as part of the diversification of farming systems with minimum agricultural inputs. (Sethuraman *et al*. 2019). Tuber crops are grown in an area of 67 million hectares with a production of 887 Mt ha^{-1} in 2017 out of which other root and tuber crops area is 1.8 Mt ha^{-1} with production of 10.64 Mt and productivity of 5.93 t ha^{-1}. (FAOSTAT 2019) [4].

Chinese potato belongs to the family Lamiaceae (Labiatae) of order Lamiales with a chromosome number of 2n= 64,84 (Murugesan *et al*. 2019) [8] Chinese potato is a small herbaceous bushy annual crop grows up to 30 cm - 60 cm. The plant has quadrangular, prostrate or ascending succulent stems with nodes. Leaves are aromatic in smell, juicy, dark thick green in colour with oval, serrate, irregular shapes which are present on opposite sides of the stem. Tubers are the edible parts of Chinese potato borne at the nodes of vines which are underground. Tubers and vine cuttings are the propagating material in Chinese potato. Chinese potato leaves and tubers are used medicinally to treat many ailments of humans. In Africa traditionally leaves of Chinese potato are especially used in treating conditions like dysentery, eye disorders, diarrhea, hematuria, vomiting, mouth and throat infections, abdominal pain, insect bites, burns and wounds.

There are several production problems like photosensitivity, low yields and poor tuberization in cultivation of Chinese potato limiting its area expansion throughout the country. Agro-techniques like plant densities play an important role in commercial production. Lack of knowledge about package of practices particularly on plant density is one of the reasons for not obtaining higher yields. A basic concern during crop production is determining the optimum plant population for maximum yield. The use of spacing in crop production is very important because it reduces competition for sunlight, water and fertilizers between weeds and plants by manipulation of inter and intra row spacing. Therefore, plant population can affect the yield directly or indirectly.

Plant density plays a crucial role in the cultivation of Chinese potato. The right plant density is vital to ensure optimal growth and tuber yield. Inadequate plant density can lead to poor growth, low tuber yield. On the other hand, excessive plant density can result in vigorous growth but may lead to reduced tuber quality and overall output due to increased competition among plants. Proper spacing is essential as it reduces competition between plants and weeds, allowing Chinese potato plants to thrive.

Optimum spacing promotes favourable growth conditions and higher yield. Achieving the right plant density is important because it directly influences plant development and ultimately impacts the overall yield of Chinese potato. Therefore, careful consideration and implementation of right plant density are vital for successful Chinese potato cultivation, ensuring better crop productivity.

Materials and Methods

The experiment was carried out during Rabi season of 2022-2023 at College of Horticulture, Venkataramannagudem. The study included four plant densities 45 cm × 10 cm (S_1), 45 cm × 20 cm (S_2), 45 cm × 30 cm (S_3), and 45 cm × 40 cm (S_4) followed Randomized block design with three replications each. The soil of experimental site is red sandy loam with good drainage and moderate water holding capacity. Well decomposed Farm Yard Manure @ 10 kg per plot was incorporated by mixing with the soil uniformly as basal application and filled up to 3- 5 cm above the ground level. The field is thoroughly ploughed twice to fine tilth and requires area is marked and made into raised beds and divided into plots of 2.0 m x 2.0 m size. Chinese potato variety Sree Dhara was selected for conducting the experiment. This variety was developed by CTCRI, Trivandrum in the year 1993. The healthy and vigorous vine cuttings of 10 to 18 cm length were taken for planting in the main field. The vine cuttings were planted vertically covering atleast 2-3 nodes with the soil on the ridges at different spacings of. Irrigation was given immediately after planting. Gap filling was carried out after 7 days after planting. The experimental plots of Chinese potato crop were kept free from weeds by periodical manual hand weeding. Irrigation was given at an interval of 5-6 days depending on the soil moisture condition.

Results and Discussion

The effect of different plant densities on vegetative and yield parameters are tabulated in Tables 1, 2, 3 and 4.

Vegetative parameters

Vine length (cm)

The data pertaining to the vine length of Chinese potato were recorded at 60 and 120 DAT and are presented in (Table 1). From the data it was observed that plant densities, had significantly influenced on the vine length.

The vine length at 60 DAT showed significant influence with plant densities. The maximum vine length (32.86 cm) was recorded in S_4 is on par with S_3 with vine length of (32.22 cm), followed by S_2 (28.86 cm) whereas, the minimum vine length (26.11 cm) was recorded in S_1. The vine length at 120 DAT had also shown significant difference with plant densities. The maximum vine length (53.08 cm) was recorded in S_4 followed by S_3 with vine length of (49.06 cm) and S_2 with vine length of (48.51 cm) whereas, the minimum vine length (39.44 cm) was recorded in S_1 (45 cm x 10 cm).

S_1 (45 cm x 10 cm) showed minimum vine length due to dense plant population leading to competition for nutrients and water. The increase in vine length in S_4 (45 cm x 40 cm) might be due to proper uptake of nutrient, water, availability of more space and less competition among the plants in wider spacing than the closer spaced plants. Kumar *et al*. (2016) [6] in colacasia.

Table 1: Effect of plant density on vine length (cm) and number of leaves of Chinese potato (*Coleus rotundifolius* L.)

	Vine length(cm)				Number of leaves			
	60 DAT Mean		120 DAT Mean		60 DAT Mean		120 DAT Mean	
S_1 (45 x 10 cm)	26.11		39.44		272.45 (16.54)		325.08 (18.03)	
S_2 (45 x 20 cm)	28.86		48.51		246.17 (15.69)		300.32 (17.33)	
S_3 (45 x 30 cm)	32.22		49.06		315.06 (17.75)		368.64 (19.29)	
S_4 (45 x 40 cm)	32.86		53.08		282.92 (16.85)		353.44 (18.80)	
	SE(m) ±	CD @ 5%	SE(m) ±	CD @ 5%	SE(m) ±	CD @ 5%	SE(m) ±	CD @ 5%
S	0.462	1.363	0.411	1.214	0.056	0.165	0.132	0.390

Figures in parenthesis are square root transformed values

Number of leaves

The data related to the number of leaves of Chinese potato was recorded at 60 and 120 DAT are presented in (Table 2). From the data it was observed that plant densities, had significantly influenced the number of leaves. The number of leaves at 60 DAT was significantly influenced by plant densities. The maximum number of leaves (315.06) was recorded in S_3 followed by number of leaves of (282.92) in S_4, followed by S_1(45 cm x 10 cm) (272.45), whereas, the minimum number of leaves (246.17) was recorded in S_2. The number of leaves at 120 DAT was also significantly influenced by plant densities. The maximum number of leaves (368.64) was recorded in S_3 is on par with S_4 (353.44), followed by S_1 (325.08), whereas, the minimum number of leaves (300.32) was recorded in S_2.

S_3 and S_4 are on par for number of leaves at 120 DAT. This might be due to wider spacing that might provide favorable environment for plant growth and less competition for nutrients. Pant *et al*. (2010) [11] in taro, Odedine *et al*. (2011) [9] in cassava, Ogbomna and Nweze (2012) [10] in cocoyam, Umah *et al*. (2013) [15] in cassava.

Plant spread (cm)

The plant spread of Chinese potato was recorded at 60 and 120 DAT are presented in (Table 2). From the data it was observed that plant densities had significantly influenced the plant spread.

Plant spread at 60 DAT was significantly influenced by plant densities. The maximum plant spread (E-W) (53.58 cm) was recorded in S_4 which is on par with (E-W) of S_3 with (53.00 cm), followed by S_2 with (44.42 cm). Whereas, the minimum (E-W) plant spread (42.57 cm) was recorded in S_1. In (N-S) the maximum plant spread (52.60 cm) was recorded in S_4 followed by (N-S) S_3 with (49.42 cm) plant spread, S_2 with (43.96 cm) plant spread and minimum plant spread (N-S) recorded in S_1 with (43.02 cm). Plant spread at 120 DAT was also significantly influenced by plant densities. The maximum plant spread (E-W) (61.91 cm) was recorded in S_3 followed by (E-W) S_4 (54.54 cm) and (E-W) S_2 with (53.83 cm). Whereas, the minimum (E-W) plant spread (50.54 cm) was recorded in S_1 and (N-S) (60.91 cm) plant spread was recorded in S_3 which is on par with S_4 with (60.40 cm), followed by (N-S) S_2 with plant spread of (52.28 cm) and minimum (N-S)-plant spread (53.13 cm) was recorded in S_1. Similar findings were found in medicinal coleus by Mastiholi *et al.* (2014) [7].

Table 2: Effect of plant density on plant spread and number of nodes of Chinese potato (*Coleus rotundifolius* L.)

	Plant spread				Number of nodes			
	60 DAT Mean		120 DAT Mean		60 DAT		120 DAT	
	EW-NS		EW-NS		Mean		Mean	
S_1 (45 x 10 cm)	42.57-43.02		50.84-53.13		79.21 (8.90)		95.84 (9.79)	
S_2 (45 x 20 cm)	44.42-43.96		53.83-56.28		82.99 (9.11)		117.50 (10.84)	
S_3 (45 x 30 cm)	53.00-49.42		61.91-60.91		105.47 (10.27)		142.08 (11.92)	
S_4 (45 x 40 cm)	53.58-52.60		54.54-60.40		104.85 (10.24)		144.72 (12.03)	
	SE(m) ±	CD @ 5%	SE(m) ±	CD @ 5%	SE(m) ±	CD @ 5%	SE(m) ±	CD @ 5%
S	1.06-0.81	3.14-2.4	0.63-0.58	1.86-1.72	0.498	NS	0.352	1.039

Figures in parenthesis are square root transformed values

Number of nodes

The number of nodes of Chinese potato was recorded at 60 and 120 DAT intervals are presented in table (Table 2). From the data it was observed that plant densities, fertilizers and their interaction had no significant influence on the number of nodes.

The number of nodes at 60 DAT had no significant influence on the number of nodes but at 120 DAT the number of nodes had significant influence by plant densities. Maximum number of nodes (144.72) was recorded in S_4 which is on par with (142.08) number of nodes in S_3 followed by S_2 (117.50) Whereas, minimum number of nodes (95.84) was recorded in S_1. This may be because nitrogen has a growth-promoting effect by boosting the production and storage of proteins, amino acids, and enzymes that are necessary for cell division and elongation. Amoah (1997) [2] in Sweet potato and Gamit *et al*. (2021) [5] in sweet potato.

Yield parameters of Chinese potato

Days to tuber harvest

The data recorded on DAT to tuber harvest of Chinese potato are presented in (Table 3). From the data it was observed that Plant densities had no significant effect.

Days to tuber harvest had no significant influence but had significant difference by plant densities. The maximum number of days taken to tuber harvest was recorded in S_1 (124.88), followed by S_2 (125.55), S_4 (120.11) and minimum number of days taken to tuber harvest was recorded in S_3 (119.50) (45 cm x 30 cm).

Number of tubers per plant

The data recorded on the number of tubers per plant of Chinese potato are presented in (Table 3). From the data it was observed that plant densities significantly influenced the number of tubers per plant.

Number of tubers per plant was significantly influenced by plant densities. The maximum number of tubers per plant (56.25) was recorded in S_4 was on par with (55.20) number of tuber in S_3 followed by S_2 (49.28) whereas, the minimum number of tubers per plant (44.08) was recorded in S_1(45 cm x 10 cm). Salem *et al*. (2016) [12] in Elephant foot yam.

Tuber yield per plant (kg)

The data on tuber yield per plant of Chinese potato was presented in (Table 4). From the data it was observed that Plant densities had significantly influenced the tubers per plant.

Tuber yield per plant was significantly influenced by plant densities. The maximum tuber yield per plant (0.639 kg) was recorded in S_3 (45 cm x 30 cm) is on par with S_2 (0.608 g), followed by S_4 (0.54 g) whereas, the minimum tuber yield per plant (0.38 g) was recorded in S_1. Adubasin *et al*. (2017) [1] in Sweet potato, Boampong *et al*. (2020) [3] in Taro.

Table 3: Effect of plant density on days to tuber harvest, number of tubers per plant and tuber yield per plant of Chinese potato (*Coleus rotundifolius* L.)

	Days to tube harvest		Number of tuber per plant		Tuber yield per plant	
S_1 (45 x 10 cm)	124.88		44.08 (6.64)		0.38	
S_2 (45 x 20 cm)	125.55		49.28 (7.02)		0.60	
S_3 (45 x 30 cm)	119.33		55.20 (7.43)		0.63	
S_4 (45 x 40 cm)	120.11		56.25 (7.50)		0.54	
	SE(m) ±	CD @ 5%	SE(m) ±	CD @ 5%	SE(m) ±	CD @ 5 %
S	2.608	NS	0.207	0.611	0.029	0.085

Figures in parenthesis are square root transformed values

Fig 1: Experimental field view of Chinese potato

Fig 2: Chinese potato tubers

Conclusion

Based on the findings of the present investigation, it can be concluded that plant densities of S_3 (45 cm × 30 cm) and S_4 (45 cm × 40 cm) showed maximum values which are on par in vine length at 60 DAT and 120 DAT, number of leaves at 120 DAT, plant spread EW at 60 DAT, number of nodes at 120 DAT. Number of leaves at 60 DAT recorded maximum value in S_3, plant spread at 60 DAT NS S_4 recorded higher value, plant spread at 120 days EW and NS S_3 recorded higher values.

The days taken to tuber harvest was recorded minimum in S_3, Number of tubers recorded maximum value at S_4 which is on par with S_3, tuber yield per plant recorded maximum values in S_3 which is on par with S_4.

However, it is noteworthy that the highest number of tubers and tuber yield per plant were obtained from plants grown at plant density of S_3 (45 cm × 30 cm) and S_4 (45 cm × 40 cm) In light of these results, for achieving maximum tuber yield with more number of plant accommodation it is recommended to plant Chinese potato at plant density of S3 (45 cm × 30 cm) which had better tuber yield performance.

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