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Influence of Different Plant Spacings on Vegetative Growth and Yield of Red Cabbage (*Brassica oleracea* var. *capitata* f. *rubra*)

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A B S T R A C T

A field study was conducted at AICRP on Citrus, Citrus Research Station, Tirupati, Andhra Pradesh during the year 2017 under Dr. Y.S.R. Horticultural University, to find out the Influence of different plant densities on vegetative growth and yield of red cabbage (*Brassica oleracea* var. *capitata* f. *rubra*) cv. Red Jewel. Three different spacings were taken *viz.*, 45x45 cm, 60x45 cm and 60x60 cm. The experimental variables measured were vegetative characters (plant height, plant spread and number of leaves at 30, 60 DAT and at harvest along with number of days for head initiation and harvest) and yield (yield per plot and marketable yield). Plant spread, number of leaves, days for head initiation and days to harvest generally increased as the plant spacing increased, whereas, plant height, yield per plot and marketable yield were increased with a decrease in plant spacing.

Introduction

Red cabbage (*Brassica oleracea* var. *capitata* f. *rubra*) is an important fancy and highly nutritive exotic vegetable. It belongs to the family Brassicaceae, having chromosome number 2x=2n=18. It comes under the subgroup *rubra* of cabbage (*Brassica oleracea* var. *capitata* L.). It is a biennial but grown as annual for its characteristic purple or red edible heads. It is used as salad, boiled vegetable, cooked in curries, used in pickling as well as dehydrated vegetable. Red cabbage is known to possess medicinal properties. It has an anticancer property due to the presence of indole-3-carbinol. It is a rich source of carotene, proteins (0.35%), fats (0.25%), minerals like calcium (3.56%), phosphorus (19.90%), potassium, sulphur etc. and vitamins *viz.*, A, B_1, B_2 and C. In India, its cultivation is negligible but now gaining popularity with Indian growers for the last few years due to its high nutritive value and increased tourist influx.

In India, cabbage including red cabbage is cultivated in an area of 388 thousand ha producing 8755 thousand MT (Anonymous, 2015-16). In Andhra Pradesh, the crops are cultivated in 5.43 thousand ha with a production of 81.45 thousand tonnes. Apart from India, red cabbage can be found

throughout Northern Europe, America, and parts of China. Since this crop has been introduced recently in Andhra Pradesh, there is a need to standardize the package of practices to suit the local conditions. Among various factors that contribute towards the attainment of potential yield in red cabbage, spacing is of prime consideration. Maintenance of optimum plant population per unit area plays an important role on yield. Too high or too low plant densities per unit area reduce the crop yields. In recent years, there has been a growing interest in the use of narrow rows as well as narrow plant spacing for the production of cabbage. By changing inter and intra row spacings, several workers reported higher yield in crops like broccoli (Agarkar *et al.,* 2010), tomato (Singh, 2004) and cabbage (Mahesh Kumar and Rawat, 2002).

In spite of its greater importance in terms of returns, no systematic research work has been carried out to standardize the suitable agro-techniques for successful cultivation of red cabbage in Andhra Pradesh.

Therefore, it is essential to find out the optimum plant densities for vegetative growth and yield maximization of red cabbage (*Brassica oleracea* var. *capitata* f. *rubra*) in Andhra Pradesh.

Materials and Methods

The present investigation entitled "Influence of different plant spacings on vegetative growth and yield of red cabbage (*Brassica oleracea* var. *capitata* f. *rubra*)" was executed at AICRP on Citrus, Citrus Research Station, Tirupati, Andhra Pradesh during *rabi*, 2017 under Dr. YSR Horticultural University. The experiment was laid out in a factorial randomized block design with three replications. The experiment was carried out with the variety Red Jewel. The experimental area was divided into plots of 3.5 m x 3.5 m size. Red cabbage seedlings were transplanted at a spacing of 45 x 45cm, 60 x 45 cm and 60 × 60 cm as per the treatments. To raise the crop recommended package of practices were followed. The various parameters were recorded from five randomly selected tagged plants *viz*., plant height, plant spread, number of leaves, days taken for head initiation, days to harvest, yield per plot and marketable yield. The data was subjected to statistical analysis as per method suggested by Panse and Sukhatme (1967).

Results and Discussion

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads:

Plant height

The result of the experiment revealed significant difference among treatments with regard to plant height at 30, 60 DAT and at harvest. At 30, 60 DAT and at final harvest, the tallest plants (19.62, 24.52 and 30.69 cm, respectively) were recorded at closer spacing (45 x 45cm) followed by medium spacing (18.00,22.71 and 30.05 cm, respectively) while the shortest plants (17.80, 20.05 and 28.75 cm, respectively) were found from wider spacing (60 × 60 cm) (Table 1).

It was observed that maximum plant height was recorded with the closer plant spacing of 45 x 45cm at different sampling occasions. Increased plant density coupled with shallow root system limits the availability of space for lateral growth.

This leads to the competition between the plants for light and nutrients, resulting in increased plant height. These findings were in agreement with Rastogi *et al.,* (1987) in

radish, Khurana *et al.,* (1990) in cauliflower and Hill (2000) in Chinese cabbage.

Leaf number per plant

Data in Table 1 revealed that the wider the plant spacing the higher was the leaf number. Maximum number of leaves per plant at 30, 60 DAT and at final harvest (19.56, 26.51 and 33.10, respectively) was obtained at the widest spacing of 60 cm × 60 cm and minimum number of leaves per plant (16.43, 23.94 and 30.09, respectively) was found at the lowest spacing of 45 × 45 cm. This might be due to lesser competition for nutrients and light amongst the plants with lower plant density. Hence in wider spacing due to the availability of more space and light, the crop might have produced more number of leaves per plant. These results were in conformity with the results of Hill (2000) in Chinese cabbage, Singh (2005) in cauliflower and Agarkar *et al.,* (2010) in broccoli.

Plant spread

Effect of plant spacing on spread of plant was found to be significant at different DAT (at 30, 60 DAT and at harvest). Maximum spread of plant at 30, 60 DAT and at harvest (22.70, 51.85 and 66.46 cm, respectively) was obtained from 60 cm × 60 cm followed by 60 × 45 cm and the lowest (18.62, 44.18 and 51.95 cm, respectively) from 45 × 45 cm. These results can be attributed to fact that, in wider spacing the individual plant gets plenty of light and more nutrients in comparison to closer spacing. The results of present findings were in agreement with the findings of Sharma and Chaudhary (1996) in cauliflower and Purushottam (2001) in cabbage.

Number of days for head initiation

Number of days from transplanting to head initiation was not significantly varied among different plant densities. However, wider spaced plants required maximum days for head initiation (50.44) whereas minimum number of days (47.73) for closer spaced plants. Higher photosynthesis and dry matter assimilation due to higher number of leaves coupled with higher availability of nutrients leads to vegetative growth for longer period and as such the reproductive phase was delayed. Similar results were reported by Sharma *et al.,* (1995) in broccoli, Sharma and Koul (2004) in leek and Chatterjee (2006) in cauliflower.

Table.1 Effect of different plant spacings on plant height, number of leaves and plant spread in red cabbage

Treatments	Plant height (cm)			Number of leaves			Plant spread		
	30 DAT	60 DAT	At harvest	30 DAT	60 DAT	At harvest	30 DAT	60 DAT	At harvest
45 × 45 cm	19.62	24.52	30.69	16.43	23.94	30.09	18.62	44.18	51.95
60 × 45 cm	18.00	22.71	30.05	18.59	24.93	32.12	20.71	47.92	59.70
60 × 60 cm	17.80	20.05	28.75	19.56	26.51	33.10	22.70	51.85	66.46
S.Em ±	0.154	0.119	0.350	0.155	0.113	0.100	0.125	0.170	0.154
C.D(P=0.05)	0.462	0.356	1.051	0.466	0.340	0.301	0.375	0.512	0.464

Table.2 Effect of plant spacings on days for head initiation, days to harvest, yield per plot and marketable yield in red cabbage

Treatments	Days for head initiation	Days to harvest	Yield per plot	Marketable yield
45 × 45 cm	47.73	82.55	23.80	183.69
60 × 45 cm	48.55	83.33	19.87	153.29
60 × 60 cm	50.44	85.55	16.23	125.21
S.Em ±	0.732	0.409	0.077	0.783
C.D(P=0.05)	N.S.*	1.227	0.232	2.350

Days to harvest

Number of days to harvest was significantly influenced by different plant densities (Table 2). The treatment 45 × 45 cm took lowest number of days to harvest (82.55), which was statistically identical with 60 × 45 cm (83.33), while at 60 × 60 cm (85.55) maximum number of days were required for harvesting. Closely spaced plants experience heavy competition among themselves for available nutrients which induces poor synthesis and utilization of accumulates reduced photosynthetic efficiency. This results in limited vegetative growth and short vegetative phase that leads to an early commencement of reproductive phase. Similar results were reported by Sharma *et al.,* (1995) in broccoli, Sharma and Koul (2004) in leek and Chatterjee (2006) in cauliflower.

Yield per plot

Perusal of the data in Table 2 indicates highly significant results for yield per plot. Planting density of 45 x 45 cm gave the highest yield (23.80 kg/plot) which was statistically similar to medium plant density (19.87kg/plot). The lowest yield (16.23 kg/plot) was recorded with lower plant density. The maximum yield per plot was found superior at higher plant density which was possibly due to more number of plants per unit area; higher ground covers of leaf area resulted in higher light interception and hence, higher assimilate production. Similar results have been reported by Sharma and Chaudhary (1996) in cauliflower and Agarwal *et al.,* (2007) in broccoli.

Marketable yield

Marketable yield of red cabbage was significantly influenced by the plant spacing. The maximum marketable yield (183.69 q/ha) was obtained from the spacing of 45 × 45 cm followed by the medium plant density (153.29 q/ha) while, minimum yield (125.21 q/ha) was recorded with lower plant density.

This is due to the reality that as plant spacing decreases, total plant population increases and this in turn contributes to increase in total head yield. The current result is in agreement with works of different authors. Hossain *et al.,* (2011) recorded that closer spacing (60 x 40 cm) produced the maximum yield (18.8 t/ha), which was statistically similar when spaced at 60 x 50 cm (17. 6 t/ha) and lowest yield (16 t/ha) was from wider (60 x 60 cm) spacing in broccoli. “Captain” broccoli hybrid recorded the highest yield (10.8 t/ha) at highest plant density (60 x 50 cm) due to more number of plants/m^2, whereas at 70 x 50 cm spacing higher values of curd weight and morphometric traits were recorded (Fabek*et al.,* 2011). According to Bhangre *et al.,* (2011) planting of broccoli at a spacing of 45 x 30 cm and 60 x 60 cm recorded higher (77.08 q/ha) and lower head yield (50.38

q/ha), respectively. Similar results have been reported by Agarwal *et al.*, (2007) in broccoli.

The study was conducted to investigate the best plant spacing for highest yield. The spacing used in the study showed significant variation among the different treatment. From the investigation it can be concluded that, at 30, 60 DAT and at final harvest, the tallest plants (19.62, 24.52 and 30.69 cm, respectively) were recorded at closer spacing (45 x 45cm) and the shortest plants (17.80, 20.05 and 28.75 cm) were found from low density planting (60 × 60 cm). Highest number of leaves (19.56, 26.51 and 33.10, at 30, 60 DAT and at final harvest, respectively) and plant spread (22.70, 51.85 and 66.46 cm, at 30, 60 DAT and at final harvest, respectively) were noticed at 60 × 60 cm and the lowest were recorded at 45 × 45 cm. High density plants took less number of days for both head initiation and days to harvest. But, highest yield per plot (23.80 kg) and marketable yield (183.69 q/ha) were recorded at high plating density (45 x 45 cm).

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