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EFFECT OF PLANTING DENSITY ON THE GROWTH AND YIELD OF CHINESE CABBAGE (*Brassica campestris* var. *pekinensis* L.)

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ABSTRACT

An experiment was conducted in the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from October 2006 to February 2007 to study the effect of different planting density on the growth and yield of Chinese cabbage. Different types of planting density viz. S_1 (50 cm × 20 cm), S_2 (50 cm × 30 cm) and S_3 (50 cm × 40 cm) were used in this experiment. The experiment was laid out in the Randomized Complete Block Design (RCBD) with six replications. Data on different yield contributing characters and yield were recorded. Yield and yield contributing characters varied statistically due to the different planting density of Chinese cabbage. At harvest, S_1 (50 cm × 20 cm) gave the tallest plant (24.91 cm) which was statistically similar (24.51 cm) with S_2 treatment, while the treatment S_3 (50 cm × 40 cm) gave the shortest (23.28 cm) plant. During harvest, treatment S_3 gave the maximum spread of plant (43.91 cm), number of unfolded leaves per plant (11.78), days from transplanting to initiation of head (21.56), days from transplanting to head formation(54.56), thickness of head (18.70 cm), diameter of head (15.93 cm), fresh weight of head per plant (2.11 kg) and number of roots per plant (17.25) in S_3 treatment which was statistically identical with S_2(50 cm × 30 cm), while on the contrary, S_1 gave the minimum spread of plant (40.19 cm), number of unfolded leaves per plant (10.89), days from transplanting to initiation of head (17.33), days from transplanting to head formation (50.89), thickness of head (17.21 cm), diameter of head (14.06 cm), fresh weight of head per plant(1.02 kg) and number of roots per plant (16.74), respectively. At harvest, treatment S_2 gave the maximum (26.22) number of folded leaves per plant which was statistically similar (24.89) to S_3 treatment, whereas S_1 gave the minimum (24.11), respectively. Treatment S_2 gave the longest (6.86 cm) length of stem, while S_1 gave the shortest (4.84 cm). Planting density, S_2 gave the highest gross yield per hectare (78.53 ton/ha) and S_1 gave the lowest (60.60 ton/ha). The present results concluded that the treatment S_2 (50 cm × 30 cm) gave the maximum yield exposed to other treatments.

Key Words: Planting density, growth and yield, Chinese cabbage

INTRODUCTION

Chinese cabbage (*Brassica campestris* var. *pekinensis* L.) belongs to the family Brassicaceae. It is an important leafy, herbaceous vegetable crop (Rashid, 1999). It is originated in China and then it was extended towards Japan, Korea, Taiwan and Indonesia (Matsumura, 1981). It is also a well known and widely distributed crop within Asia and has been introduced successfully into parts of Central America, West Africa, America, Canada and Europe (Talekar and Selleck, 1982). It is a short duration crop and grown for its compact head and yield is directly associated with circumstances of its vegetative growth (Anon., 1992).

In Bangladesh, Chinese cabbage is not well known and is being grown on a very limited scale due to the lake of awareness regarding its consumption practices and appropriate method of production technology. But, in recent years a good deal of interest has generated among the farmers for raising this crop extensively. At that time consumption utility and interest increasing day by day to the common people in our country. The production package of Chinese cabbage is not much known to Bangladeshi farmers. To attaining considerable production and quality yield for any crop it is necessary to know proper management practices including ensuring the availability of essential nutrient components (Tindall, 1983). Chinese cabbage thrives well in a fertile, clay loam soil because it requires considerable amount of nutrients to sustain rapid growth in short time. Plant density for Chinese

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cabbage cultivation is an important criterion for attaining the maximum yield. Densely planted crop obstruct the proper growth and development with hampering the basic requirements of plant growth. On the other hand wider planting density ensure the basic requirements but decrease the total number of plant as well as total yield. Yield may be increased upto 25% by using optimum planting density (Bansal, *et al.*, 1995). As there is a great differences between the tropical and temperate regions in terms of temperature, light and humidity, there may be some differences in cultural practices including planting density and mulching. In China, the optimum planting density of Chinese cabbage is 50 cm × 40 cm. The optimum density adapted for early maturing varieties was about 40 cm × 40 cm (Opena, *et al.*, 1988). The major aim of the investigation was to evaluate growth and yield performance of Chinese cabbage under different planting density.

MATERIALS AND METHODS

The experiment was conducted in the Horticultural farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from October 2006 to December 2006 to study the effect of different planting density on growth and yield of Chinese cabbage. The area had sub tropical climate characterized by high temperature (28^0-32^0C) accompanied by moderately high rainfall during Kharif (April-September) season and low temperature (15^0-20^0C) in the Rabi (October-March) season under AEZ-28 (FAO, 1988). Soil pH 5.6 and have organic carbon 0.82 %. The hybrid variety 'White Sun' was selected for investigation. Seeds of 'White Sun' were collected from Dhaka seed store, Siddique Bazar, Dhaka. The experiment was laid out in the Randomized Complete Block Design (RCBD) with six replications. Different types of planting density viz. S_1 (50 cm × 20 cm), S_2 (50 cm × 30 cm) and S_3 (50 cm × 40 cm) were used in this experiment. The seeds were sown on October 10, 2006 in the seedbed and completed germination within seven days. Healthy and 30 days old seedlings were transplanted into the experimental field on November 10, 2007. Each plot size was 2.40 m × 1.0 m and different planting density was considered for the study. Irrigation and weeding was done at ten days interval. Randomly selected ten plants were harvested from each plot for data collection.

RESULTS AND DISCUSSION

Plant height (cm)

Plant height varied statistically due to the different planting density at 15, 30, 45 DAT and at harvest (Fig.1). Planting density S_1 (50 cm × 20 cm) gave the tallest (12.00 cm) plant at 15 DAT which was statistically similar (11.82 cm) to at S_2 (50 cm × 30) Planting density, while S_3 (50 cm × 40 cm) Planting density gave the shortest (11.38 cm) plant. The tallest (18.48 cm) plant was observed from treatment S_1 which was closely followed (17.44 cm) with S_2 treatment and the shortest (16.79 cm) plant was from the S_3 treatment at 30 DAT. At 45 DAT, the tallest (22.92 cm) plant was recorded from the treatment S_1 which was statistically identical (22.36 cm) with S_2 treatment and the shortest (21.71 cm) plant was from the S_3 treatment. During harvest, treatment S_1 gave the tallest (24.91 cm) plant which was statistically similar (24.51 cm) with S_2 treatment, while the treatment S_3 gave the shortest (23.28 cm). The results indicated that closer planting density helps to increases plant height than wider planting density. This may be due to the competition for light among the plants of Chinese cabbage. Bali *et al.* (2000) found that closer planting density increase plant height in comparison with wider Planting Density Chinese cabbage. Leonard (1962) reported that planting density influence the vegetative growth of cabbage.

Spread of plant (cm)

A statistically significant variation was recorded in terms of spread of plant due to the different planting density at 15, 30, 45 DAT and at harvest (Fig.2). At 15 DAT, treatment S_3 (50 cm × 40 cm) gave the maximum (19.36 cm) spread of plant followed by (18.79 cm) with S_2 (50 cm × 30cm while S_1 (50 cm × 20 cm) gave the minimum (17.48 cm). The maximum (29.97 cm) spread of plant was observed from treatment S_3 which was statistically identical (29.41 cm) with S_2 treatment and the minimum (28.06 cm) was found from the S_1 treatment at 30 DAT. At 45 DAT, the maximum (38.02 cm) spread of plant

was recorded from treatment S_3 which was statistically similar (37.50 cm) with S_2 treatment and the minimum (36.19 cm) was obtained from S_1 treatment. During harvest, S_3 gave the maximum (43.91 cm) spread of plant which was statistically identical (43.34 cm) with S_2 treatment, while the treatment S_1 gave the minimum (40.19 cm). The results indicated that wider planting density helps to increases spread of plant with ensuring maximum space and light. Similar findings also reported by Batesi *et al.* (1979) and Shamim and Kamruzzaman (2004) from an experiment.

Number of unfolded leaves per plant

Statistically significant difference was recorded in number of unfolded leaves per plant due to the different planting density at 15, 30, 45 DAT and at harvest (Fig.3). Treatment S_3 gave the maximum (6.33) number of unfolded leaves per plant at 15 DAT which was statistically similar (6.11) with S_2, while the treatment S_1 gave the minimum (5.56). The maximum (7.56) number of unfolded leaves per plant was observed from treatment S_3 which was statistically identical (7.11) with S_2 treatment and the minimum (6.44) was found from the S_1 treatment at 30 DAT. At 45 DAT, the maximum (9.56) number of unfolded leaves per plant was recorded from the treatment S_3 followed by (9.00) with S_2 treatment and the minimum (8.11) was from the S_1 treatment. During harvest treatment S_3 gave the maximum (11.78) number of unfolded leaves per plant which was statistically identical (11.33) with S_2 treatment, while the treatment S_1 gave the minimum (10.89). The results indicated that wider planting density helps to increases number of unfolded leaves per plant.

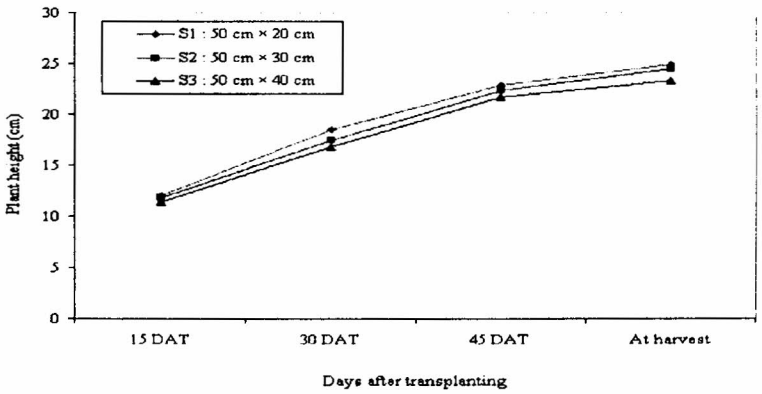

Fig. 1. Effect of planting density on plant height at different days after transplanting of Chinese cabbage

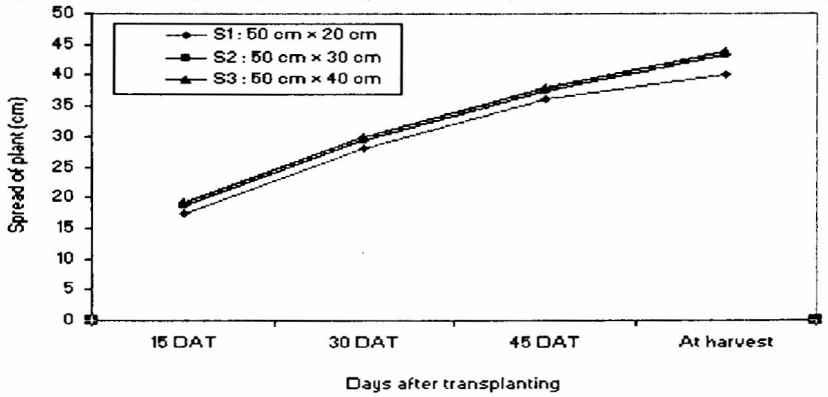

Fig. 2. Effect of planting density on spread of plant at different days after transplanting of Chinese cabbage

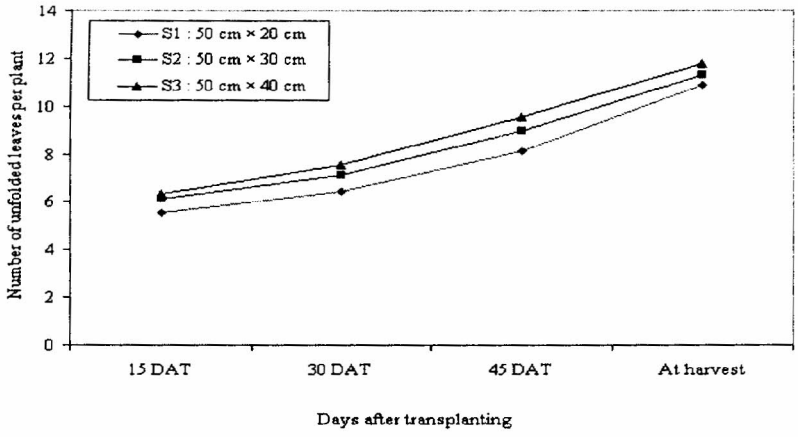

Fig. 3. Effect of planting density on number of unfolded leaves per plant at different days after transplanting of Chinese cabbage

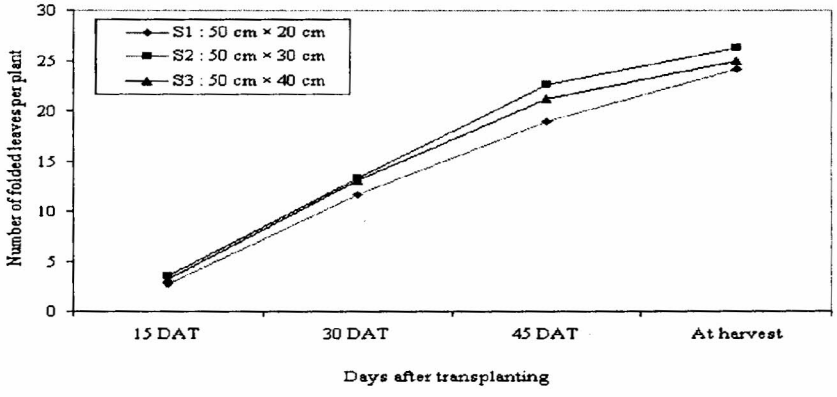

Fig. 4. Effect of planting density on number of folded leaves per plant at different days after transplanting of Chinese cabbage

Number of folded leaves per plant

Folded leaves per plant showed a statistically significant difference due to the different planting density at 15, 30, 45 DAT and at harvest (Fig 4). At 15 DAT, planting density (50 cm × 30 cm) S_2 gave the maximum (3.56) number of folded leaves per plant which was statistically similar (3.22) with the planting density (50 cm × 40 cm), while (50 cm × 20 cm) planting density as treatment S_1 gave the minimum (2.67). The maximum (13.33) number of folded leaves per plant was observed from S_2 treatment which was statistically identical (13.11) with S_3 and the minimum (11.67) was recorded from the S_1 treatment at 30 DAT. At 45 DAT, the maximum (22.56) number of folded leaves per plant was recorded from S_2 treatment which was statistically identical (21.22) with S_3 treatment and the minimum (18.89) was obtained from the S_1 treatment. During harvest treatment S_2 gave the maximum (26.22) number of folded leaves per plant which was statistically similar (24.89) to S_3 treatment, while S_1 gave the minimum (24.11). The results indicated that both closer and wider Planting Density helps to decrease the number of folded leaves per plant.

Days from transplanting to initiation of head

A statistically significant variation was recorded in terms of days from transplanting to initiation of head due to the different planting density (Fig 5). The maximum (21.56) days from transplanting to initiation of head was recorded from S_3 which was closely followed by (19.78) with S_2 treatment (50

cm × 30 cm), while planting density at (50 cm × 20 cm) S_1 showed the minimum (17.33) days. Kato (1981) and Shoemaker (1974) reported the similar results when find out the physiological mechanism of heading in Chinese cabbage.

Days from transplanting to head maturity

A statistically significant variation was recorded in terms of days from transplanting to head maturity due to the different planting density (Table 1). Treatment S_3 took the maximum (54.56) days from transplanting to head maturity which was followed (53.11) by S_2 treatment and (50 cm × 20 cm) planting density (S_1) required the minimum (50.89) days from transplanting to maturity.

Number of roots per plant

A statistically non significant variation was recorded in case of number of roots per plant due to the different planting density (Table 1). Treatment S_3 gave the highest (17.25) number of roots per plant which was statistically similar (16.90) with S_2 treatment, while the treatment S_1 showed the lowest (16.74) and it was also statistically similar with S_3.

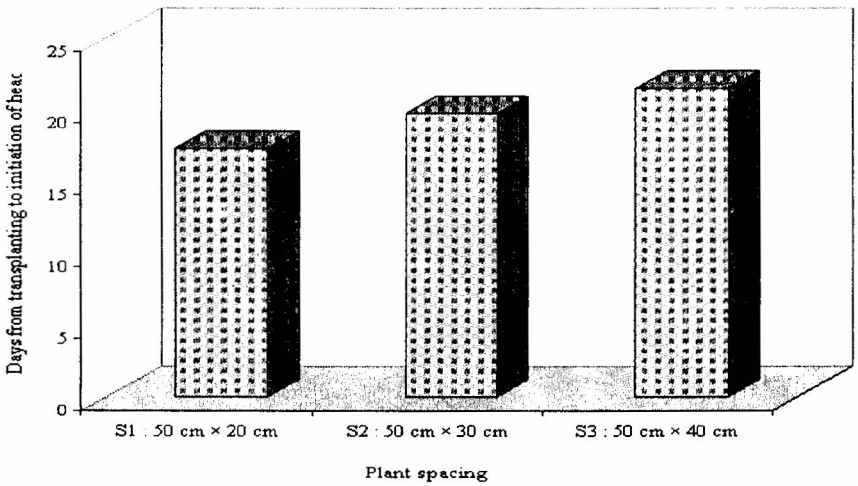

Fig. 5. Effect of planting density on days from transplanting to initiation of head of Chinese cabbage

Length of root (cm)

There was no statistically significant difference in terms of length of root due to the different planting density (Table 1). The longest (22.12 cm) length of root was obtained from the planting density (50 cm × 40 cm) S_3 which was statistically similar (21.81 cm) to S_2 and the shortest (21.77 cm) length of root was found from S_1 treatment.

Length of stem (cm)

A statistically significant variation was recorded in case of length of stem due to the different plant Planting Density at harvest (Table 1). Treatment S_2 gave the longest (6.86 cm) length of stem which was statistically similar (6.07 cm) with S_3 treatment (50 cm × 40 cm), while S_1 treatment gave the shortest (4.84 cm).

Diameter of stem (cm)

A statistically significant variation was recorded in terms of diameter of stem due to the different planting density at harvest (Table 1). Treatment S_2 gave the maximum (2.10 cm) diameter of stem which was statistically similar (2.02 cm) with S_3 treatment, while the minimum (1.38 cm) diameter of stem was obtained from S_1 treatment. The results indicated wider planting density increases the growth and development of plant which ensure the maximum diameter of stem.

Thickness of head (cm)

A statistically significant variation was recorded in case of thickness of head due to the different planting density at harvest (Table 1). The maximum (18.70 cm) thickness of head was recorded from S_3 which was statistically similar (18.35 cm) with S_2, while S_1 showed the minimum (17.21 cm) thickness of head.

Diameter of head (cm)

The effect of different plant Planting Density showed significant variation on diameter of head (Table 1). Planting Density (50 cm × 40 cm) S_3 gave the maximum (15.93 cm) diameter of head which was statistically identical (15.62 cm) with S_2 (50 cm × 30 cm), while (50 cm × 20cm) S_1 gave the minimum (14.06 cm). The results indicated wider Planting Density increases the growth and development of plant which ensure the maximum stem diameter of head.

Table 1. Effect of different planting density on yield contributing characters of Chinese cabbage

Treatment	Days from transplanting to head maturity	Number of roots per plant	Length of roots (cm)	Length of stem (cm)	Diameter of stem (cm)	Thickness of head (cm)	Diameter of head (cm)
S_1(50 cm × 20 cm)	50.89 c	16.74	21.77	4.84 c	1.38 b	17.21 b	14.06 b
S_2(50 cm × 30 cm)	53.11 b	16.90	21.81	6.86 a	2.10 a	18.35 a	15.62 a
S_3(50 cm × 40 cm)	54.56 a	17.25	22.12	6.07 b	2.02 a	18.70 a	15.93 a
$LSD_{(0.05)}$	0.962	--	--	0.154	0.184	0.913	0.951
Significance level	**	NS	NS	**	**	**	**

Fresh weight of unfolded leaves per plant (g)

A significant variation was recorded in terms of fresh weight of unfolded leaves per plant due to the different planting density at harvest (Table 2). Treatment S_3 gave the maximum (357.03 g) fresh weight of unfolded leaves per plant which was statistically similar (349.89 g) with S_2 treatment (50 cm × 30 cm) planting density and the minimum (191.59 g) was found from S_1.

Fresh weight of head (kg)

A statistically significant variation was recorded on fresh weight of head per plant due to the different planting density at harvest (Table 2). Planting density 50 cm × 40 cm (S_3) exhibited the maximum (2.11 kg) fresh weight of head per plant which was statistically similar (2.01 kg) with S_2 (50 cm × 30 cm) planting density, while 50 cm × 20 cm Planting density (S_1) gave the minimum (1.02 kg). Lawande *et al.* (1986) reported that Planting density influence the fresh weight of head of cabbage.

Fresh weight of plant (kg)

A significant variation was recorded in terms of fresh weight of total plant due to the different planting density at harvest (Table 2). Treatment S_3 showed the maximum (2.47 kg) fresh weight of total plant which was statistically similar (2.36 kg) with S_2 treatment (50 cm × 30 cm) planting density, while 50 cm × 20 cm planting density (S_1) gave the minimum (1.21 kg).

Dry matter content of head (%)

A statistically non significant variation was recorded in terms of dry matter content of head due to the different planting density at harvest (Table 2). Planting density 50 cm × 40 cm (S_3) exhibited the maximum (13.58%) dry matter content of head (Table 2), while 40 cm × 20 cm Planting density as treatment S_1 showed the minimum (13.18%). Hembry *et al.* (1994) recorded the similar trend of results.

Gross yield (kg/plot)

A statistically significant variation was recorded in terms of gross yield per plot due to the different planting density (Table 2). Treatment S_2 showed the maximum (18.85 kg) gross yield per plot S_1 performed the minimum (14.54 kg) value which was statistically similar (14.83 kg) with S_3 treatment.

Marketable yields (kg/plot)

A significant variation was observed in terms of marketable yield per plot due to the different planting density (Table 2). Planting density 50 cm × 30 cm (S_2) gave the maximum (16.05 kg) marketable yield per plot, while 50 cm × 20 Planting density (S_1) showed the minimum (12.25 kg) which was

statistically similar (12.68 kg) with S_3. Damrong and Krung (1994) and Thompson and Kelly (1957) reported the similar results from their experiment.

Gross yield (t/ha)

A statistically significant variation was recorded in terms of gross yield per hectare due to the different planting density. Treatment S_2 gave the maximum (78.53 t/ha) gross yield per hectare, while 50 cm × 20 cm Planting density (S_1) showed the minimum (60.60 t/ha) which was followed (61.78 t/ha) by S_3 treatment at 50 cm × 40 cm Planting density under the present trial (Table 2). Vleck and Polack (1977); White and Forbes (1978) reported the similar results from their experiment.

Table 2. Effect of different planting density on yield contributing characters and yield of Chinese cabbage

Treatment	Fresh weight of unfolded leaves per plant (g)	Fresh weight of head per plant (kg)	Fresh weight of plant (kg)	Dry matter content of head (%)	Gross yield (kg/plot)	Marketable yield (kg/plot)	Gross yield (t/ha)
S_1(50 cm × 20cm)	191.59 b	1.02 c	1.21 c	13.18	14.54 b	12.25 b	60.60 b
S_2(50 cm × 30cm)	349.89 a	2.01 b	2.36 b	13.31	18.85 a	16.05 a	78.53 a
S_3(50 cm × 40cm)	357.03 a	2.11 a	2.47 a	13.58	14.83 b	12.68 b	61.78 b
$LSD_{(0.05)}$	18.64	0.105	0.110	--	0.919	0.879	3.830
Significance level	**	**	**	NS	**	**	**

Marketable yield (t/ha)

Statistically significant differences were recorded in terms of marketable yield per hectare due to the different planting density (Fig. 6). Treatment S_2 gave the maximum (66.87 t/ha) marketable yield per hectare, while treatment S_1 performed the minimum (51.02 t/ha) which was statistically similar (52.85 t/ha) with S_3 treatment at 50 cm × 40 cm Planting density (Figure 6).

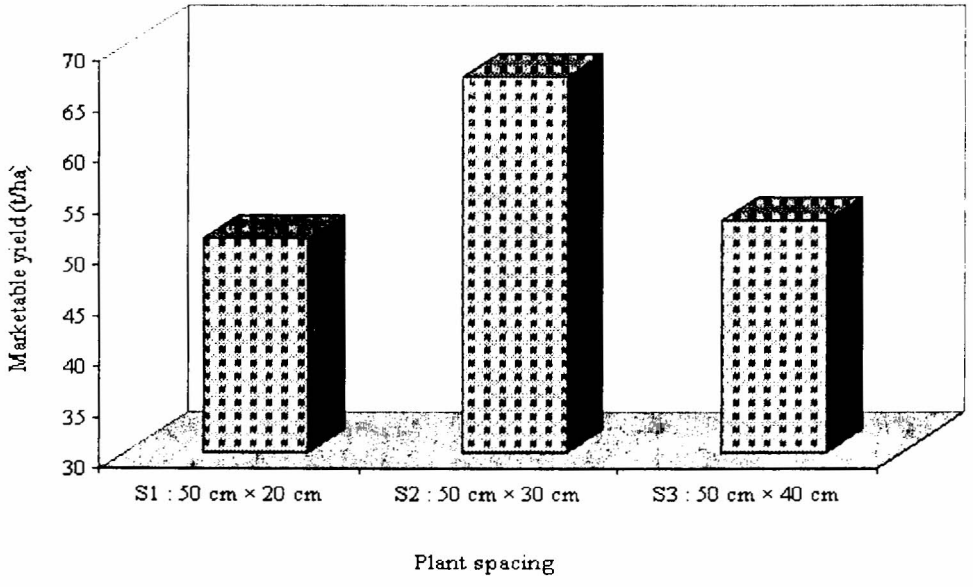

Fig. 6. Effect of planting density on marketable yield of Chinese cabbage

CONCLUSION

The present results concluded that the treatment S_2 (50 cm × 30 cm) gave more yield compared to other treatments.

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