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Studies on the Interaction Effect of Planting Dates and Nitrogen Levels on Growth, Yield and Economics of Red Cabbage (*Brassica oleracea* var. *capitata* f. *rubra*)

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A B S T R A C T

The present an experiment entitled "Studies on the effect of planting dates and nitrogen levels on growth, yield and quality of red cabbage (*Brassica oleracea* var. *capitata* f. *rubra*)" was carried out in *Rabi/Winter* season 2018- 2019 at Mango Research Station, Nuzvid, Krishna district, Andhra Pradesh (India) with the objective of studying the interaction effect of planting dates and nitrogen levels on growth, yield and quality of red cabbage besides studying economic returns. Present study included 12 treatments combinations with three levels of planting dates (30th September, 15th and 30th October) and four nitrogen levels (80, 120,160 and 200kg/ha) each replicated thrice in Factorial Randomized Block Design (FRBD). Observations were recorded on 6 growth, 4 yield and yield attributing parameters and mean performance studies revealed significant difference in all parameters. The interaction effect of planting dates and nitrogen levels was found significant. Highest number of heading leaves (24.87), plant height (38.43 cm) and plant spread (59.78cm) were recorded with the treatment combination of 15th October planting date and application of 200 kg N/ha (D2N4). The yield contributing characters like head weight (709g), head yield per plot (56.67kg), estimated head yield per hectare (438.55q) and dry matter production (12.55%) recorded higher values with same treatment. Highest BC ratio (3.82:1) was obtained from the combination of 15th October planting date with 200kg Nitrogen/hector (D2N4). Based on the results obtained in the present investigation, it can be concluded that 15th October planting date combined with application of 200kg N/ha (D2N4) proved to be best for getting higher growth, yield and economic returns in Red cabbage for coastal Andhra Pradesh.

Introduction

Red cabbage (*Brassica oleracea* var. *capitata* f. *rubra*) is also known as purple cabbage or red kraut. It is an important fancy and highly nutritive exotic vegetable. It belongs to the family brassicaceae and comes under the subgroup rubra of cabbage (*Brassica oleracea* var. *capitata* L.). It is having chromosome number 2n=2X=18. Red cabbage is a native crop in the Mediterranean region of Europe and now grows all over the world as a fresh market vegetable (Yuan, 2009). It is biennial crop but cultivated as an annual for its characteristic purple or red edible heads, its characters and requirements

are similar to that of cabbage except it is having pigments which imparts red colour to red cabbage (Bakar, 2006). Red cabbage synthesized and accumulated anthocyanins at all the developmental stages of vegetative growth (Yuan, 2009). It is cool season crop and widely grown in temperate and subtropical region of India. The transition from vegetative to reproductive growth is triggered by temperature. Therefore, it will produce head in areas of mild winters. The optimum temperature for growth is 15-18°C. It can tolerate freezing temperatures but is less tolerant to high temperatures (More, 2006).

It is used as salad, boiled vegetable, cooked in curries, used for pickling as well as dehydrated vegetable. Its juice is said to be a remedy against poisonous mushrooms. It is a rich source of carotene, anthocyanins, proteins, fats and minerals like calcium, phosphorus, potassium, sulphur etc. and vitamins viz., A, B1, B2 and C. Red cabbage distinguished by the presence of exceptional health enhancing properties and many beneficial sensory traits, which has become more and more important in recent years (Wojciechowska *et al.*, 2007). Among various types of cabbages, red cabbage is characterized by the presence of highest chemical compounds that are considered to be antioxidants. The average weight of red cabbage heads is mostly lower than white cabbage. Red cabbage is a vegetable characterized by a higher content of health enhancing components, compared to white cabbage (Tendaj *et al.*, 2013). In India, cabbage including red cabbage is cultivated in an area of 4.03 lakh hectares producing 91.92 lakh metric tonnes (NHB, 2019-20).

The study of cultivation practices with respect to suitable planting dates and nitrogen requirements are a pre-requisite for any new crop assessment to achieve more returns per unit area. Since, red cabbage crop has been introduced recently in India, there is a need to standardize the planting dates and nitrogen levels to suit the local conditions. Although, total market returns are determined primarily by crop yield, head quality is also an important factor as it determines the marketability of the crop. Among various factors that contribute towards the attainment of potential yield in red cabbage, planting dates and nitrogen levels are prime consideration. Maintenance of optimum planting dates plays an important role on yield. Too early or too late planting dates reduce the crop yields. In recent years, there has been a growing interest in the use of planting dates for the production and higher yield of red cabbage. By changing planting dates and nitrogen levels, several workers reported increased yield in Cole crops like red cabbage (Maria and Krzysztof, 2012; Manasa *et al.,* 2017; Patel *et al.,* 2017; Abhilash *et al.,* 2019; Abhilash *et al.,* 2020), cabbage (Lavanya *et al.,* 2015) and broccoli (Kanase *et al.,* 2018).

Materials and Methods

The research work entitled "Studies on the effect of planting dates and nitrogen levels on growth, yield and quality of red cabbage (*Brassica oleracea* var. *capitata* f. *rubra*)" was carried out during *rabi/winter* season, 2018-2019 at Mango Research Station, Nuzvid, Krishna district, Andhra Pradesh, India.

The location falls under Agro-climatic zone-10, east coastal plain and hills (Krishna-Godavari zone) with an average rainfall of 900 mm, located at an altitude of 34 m (112 feet) above mean sea level. The location is geographically situated at 16°.83' N latitude and 81°5' E longitude. It experiences hot humid summer and mild winter climate. Present study included 12 treatments combinations (D1N1, D1N2, D1N3, D1N4, D2N1, D2N2, D2N3, D2N4, D3N1, D3N2, D3N3 and D3N4) with three levels of planting dates (D1:30th September, D2:15th October and D3:30th October) and four nitrogen levels (N1:80 kg/ha, N2:120 kg/ha, N3:160 kg/ha and N4:200 kg/ha) each replicated thrice in Factorial Randomized Block Design (FRBD). Observations were recorded on growth, yield and economics and mean performance studies revealed significant difference in all parameters with varying interaction effect of planting dates and nitrogen levels.

The data obtained in respect to all the characters viz., plant height (cm), plant spread (cm), number of heading leaves per plant, number of loose leaves per plant, number of days to head initiation (days), number of days to head harvest (days), head weight (g), head yield per plot (kg), head yield per hectare (q), dry matter production (%) was subjected to the following statistical analysis. The data were analyzed by the methods outlined by Panse and Sukhatme (1985) using the mean values of five random plants in each replication from all treatment combinations to find out the significance of interaction effect of planting dates and nitrogen levels.

Results and Discussion

Growth parameters

Plant height (cm)

The interaction effect between planting dates and nitrogen levels on plant height was found to be non-significant at 30DAT, 60DAT and at final harvest. However, at 30DAT, 60DAT and at final harvest, maximum plant height of 22.83cm, 29.86cm and 38.43cm respectively was recorded with combination of 15th October planting date and 200kg N/ha (D2N4) resulted in synthesis of more plant metabolites which has increased plant height, whereas the minimum plant height of 13.18cm, 17.56cm and 22.35cm respectively was recorded with combination of 30th September planting date and 80kg N/ha (D1N1). Similar findings have been reported in cabbage (Lavanya *et al.,* 2015), cauliflower (Rahman *et al.,* 2016), lettuce (Rehman *et al.,* 2005) and okra (Muhammad *et al.,* 2001). The data is presented in Table 1 and Figure 1.

Plant spread (cm)

The Interaction effect of planting dates and nitrogen levels on plant spread were found to be non-significant at 30DAT, 60DAT and at final harvest. However the maximum plant spread of 20.09cm, 44.19cm and 59.78cm was recorded with combination of 15th October planting date and 200kg N/ha (D2N4) at 30DAT, 60DAT and at final harvest respectively resulted in synthesis of more plant metabolites which has increased plant spread, whereas the minimum plant spread of 10.08cm, 18.04cm and 30.00cm were recorded with combination of 30th September planting date and 80kg N/ha (D1N1) at 30DAT, 60DAT and at final harvest respectively. Similar findings have been reported in cabbage (Lavanya *et al.,* 2015). The data are presented in Table 1 and Figure 2.

Number of heading leaves per plant (No's)

The interaction effect of planting dates and nitrogen levels on number of heading leaves per plant was found to be significant. The maximum heading leaves per plant (24.87) were recorded with 15th October planting date and 200kg N/ha (D2N4) and the minimum number of heading leaves per plant (13.52) was recorded with 30th September planting date and 80kg N/ha (D1N1). This might be due to the favorable climate condition with sufficient quantity of nutrient favorable for increases heading leaves. Similar result found in red cabbage (Manasa *et al.,* 2017). The data is presented in Table 2 and Figure 3.

Number of loose leaves per plant (No's)

The interaction effect between planting dates and nitrogen levels on number of loose leaves per plant was found to be significant. However, the maximum loose leaves per plant (16.12) were recorded with 30th September planting date and 200kg N/ha (D1N4) followed by 30th October and 200kg/ha (D3N1) and the minimum number of loose leaves per plant (8.65) was recorded with 15th October and 80kg N/ha (D2N1). There was a significant interaction between planting dates and nitrogen levels and the highest values were obtained during 30th September planting date and 200kg N/ha. Similar results were obtained in cauliflower (Rahman *et al.,* 2016), radish (Akoumianakis *et al.,* 2011) and potato (Yenagi *et al.,* 2003). The data is presented in Table 2 and Figure 3.

Number of days to head initiation (days)

The interaction effect of planting dates and nitrogen levels on days to head initiation was found to be non-significant. However the combination of 15th October planting date and 200kg N/ha (D2N4) recorded minimum number of days to head initiation (40.46days) and the maximum number of days to head initiation (64.91days) was recorded with combination of 30th September planting date and 80kg N/ha (D1N1). Similar findings have been reported in cabbage (Lavanya *et al.*, 2015) and spinach (Darani *et al.*, 2013). The data are presented in Table 2 and Figure 4.

Number of days to head harvest (days)

The interaction effect between planting dates and nitrogen levels on number of days to head harvest was found to be non-significant. However the combination of 15th October planting date and 200kg N/ha (D2N4) recorded minimum number of days to harvest (75.23days) and the maximum number of days to head harvest (110.25days) was recorded with combination of 30th September planting date and 80kg N/ha (D1N1). Similar findings have been reported in cabbage (Lavanya *et al.*, 2015) and spinach (Darani *et al.*, 2013). The data are presented in Table 2 and Figure 4.

Yield parameters

Head weight (g)

The interaction effect of planting dates and nitrogen levels on head weight of red cabbage was found to be significant. The combination of 15th October and 200kg N/ha (D2N4) produced significantly maximum head weight (709g), whereas the treatment combination of 30th September planting date and 80kg N/ha (D1N1) recorded minimum head weight (322g). The increased head weight might be due to the favorable climatic conditions prevailing during head formation stage of 15th October planting date coupled with optimum nitrogen application of 200kg N/ha resulted in synthesis of more plant metabolites. Similar results are found with Lavanya *et al.*, (2015) in cabbage. The data on head weight are presented in Table 3 and Figure 5.

Head yield per plot (kg)

The interaction effect between planting dates and nitrogen levels on yield per plot in Red cabbage was found to be significant. The combination of 15th October planting date and 200kg N/ha (D2N4) produced significantly highest yield per plot (56.67kg), whereas the combination of 30th September planting date and 80kg N/ha (D1N1) recorded lowest yield per plot (25.76kg). Similar results found in cabbage (Lavanya *et al.*, 2015). The data are presented in Table 3 and Figure 6.

Estimated yield per hectare (q)

The interaction effect of planting dates and nitrogen levels on estimated yield per hectare in red cabbage was found to be significant. The combination of 15th October planting date with 200kg N/ha (D2N4) produced significantly highest yield per hectare (438.55q/ha), whereas the combination of 30th September planting date and 80kg N/ha (D1N1) recorded the lowest yield per hectare (200.33q/ha). The data obtained during the investigation clearly showed that, planting on 15th October with application of nitrogen at 200kg/ha had positive effect on growth and yield of red cabbage. Significantly higher values were recorded with vegetative parameters like plant height, plant spread and number of leaves leads to maximum photosynthetic activity and thereby facilitates better translocation of food material to economic parts. This might have resulted in obtaining higher values in growth and yield parameters like head weight and yield per plot with the above treatment combination (D2N4). Planting on 30th September planting date (D1) recorded the lowest values for vegetative and yield parameters. The crop transplanted on 30th September planting date (D1) received very high temperature and high humidity.

Table. 1 Interaction effect of planting dates and nitrogen levels on plant height (cm) and plant spread (cm) at different growth stages of red cabbage.

Treatment combinations	Plant height (cm)			Plant spread (cm)		
	At 30 DAT	At 60 DAT	At Final harvest	At 30 DAT	At 60 DAT	At Final harvest
D1N1: 30th September + 80kg N/ha	13.18	17.56	22.35	10.08	18.04	30.00
D1N2: 30th September + 120kg N/ha	15.21	19.61	25.65	11.78	21.05	34.86
D1N3: 30th September + 160kg N/ha	16.93	21.75	28.35	13.42	27.32	40.20
D1N4: 30th September + 200kg N/ha	18.41	23.71	31.46	14.96	32.87	48.44
D2N1: 15th October + 80kg N/ha	16.68	21.66	28.16	12.30	24.93	40.32
D2N2: 15th October + 120kg N/ha	18.62	23.68	31.46	15.35	32.20	48.23
D2N3: 15th October + 160kg N/ha	20.42	27.13	35.21	17.95	38.56	53.52
D2N4: 15th October + 200kg N/ha	22.83	29.86	38.43	20.09	44.19	59.78
D3N1: 30th October + 80kg N/ha	14.48	18.53	25.50	10.96	21.88	34.83
D3N2: 30th October + 120kg N/ha	16.43	22.63	28.63	13.26	27.25	41.08
D3N3: 30th October + 160kg N/ha	18.65	24.68	31.70	15.20	32.16	49.06
D3N4: 30th October + 200kg N/ha	20.76	27.58	34.91	17.73	36.95	53.20
SEm±	1.075	1.369	1.796	1.128	2.915	3.583
CD @ 5%	NS	NS	NS	NS	NS	NS

Table.2 Interaction effect of planting dates and nitrogen levels number of heading leaves, loose leaves, number of days to head initiation and head harvest in red cabbage.

Treatment combinations	Number of heading leaves per plant	Number of loose leaves per plant	Number of days to head initiation	Number of days to harvest (days)
D1N1: 30th September + 80kg N/ha	13.52	10.70	64.91	110.25
D1N2: 30th September + 120kg N/ha	15.67	12.83	62.16	104.66
D1N3: 30th September + 160kg N/ha	18.10	13.80	59.00	96.00
D1N4: 30th September + 200kg N/ha	21.77	16.12	53.00	94.00
D2N1: 15th October + 80kg N/ha	19.24	8.65	52.08	87.83
D2N2: 15th October + 120kg N/ha	19.97	9.08	48.83	83.16
D2N3: 15th October + 160kg N/ha	21.89	10.20	46.67	79.00
D2N4: 15th October + 200kg N/ha	24.87	11.35	40.46	75.23
D3N1: 30th October + 80kg N/ha	15.03	9.13	58.33	98.93
D3N2: 30th October + 120kg N/ha	17.54	10.75	55.49	92.60
D3N3: 30th October + 160kg N/ha	20.88	12.60	52.06	86.43
D3N4: 30th October + 200kg N/ha	22.91	14.16	46.86	85.86
SEm±	0.479	0.427	1.424	5.900
CD @ 5%	1.415	1.262	NS	NS

Table.3 Interaction effect of planting dates and nitrogen levels on head weight (g), head yield per plot (kg), estimated yield per hectare (q/ ha) and dry matter production (%) in red cabbage.

Treatment combinations	Head weight (g),	Head yield per plot (kg)	Estimated yield per hectare(q)	Dry matter production (%)
D1N1: 30th September + 80kg N/ha	322	25.76	200.33	8.23
D1N2: 30th September + 120kg N/ha	404	32.33	251.21	9.11
D1N3: 30th September + 160kg N/ha	507	40.57	315.20	10.00
D1N4: 30th September + 200kg N/ha	554	44.28	344.05	10.73
D2N1: 15th October + 80kg N/ha	387	30.92	240.23	10.14
D2N2: 15th October + 120kg N/ha	541	43.28	322.66	10.73
D2N3: 15th October + 160kg N/ha	569	45.55	353.88	11.55
D2N4: 15th October + 200kg N/ha	709	56.67	438.55	12.55
D3N1: 30th October + 80kg N/ha	365	29.21	226.93	9.23
D3N2: 30th October + 120kg N/ha	483	38.66	300.41	9.84
D3N3: 30th October + 160kg N/ha	547	43.78	340.16	10.73
D3N4: 30th October + 200kg N/ha	585	46.83	363.86	11.73
SEm±	18.142	1.450	10.715	0.050
CD @ 5%	53.209	4.281	31.629	0.147

Table.4 Interaction effect of planting dates and nitrogen levels on Benefit: Cost ration of red cabbage.

Treatment combinations	Head yield (q/ha)	Gross returns (₹/ha)	Cost of cultivation (₹/ha)	Net returns (₹/ha)	Benefit: Cost Ration (₹)
D1N1: 30th September + 80kg N/ha	200.33	200330.00	114443.00	85887.00	1.75:1
D1N2: 30th September + 120kg N/ha	251.21	251210.00	114554.20	136655.80	2.19:1
D1N3: 30th September + 160kg N/ha	315.20	315200.00	114664.60	200535.40	2.74:1
D1N4: 30th September + 200kg N/ha	344.05	344050.00	114775.00	229275.00	2.99:1
D2N1: 15th October + 80kg N/ha	240.23	240230.00	114443.00	125787.00	2.09:1
D2N2: 15th October + 120kg N/ha	322.66	322660.00	114554.20	208106.00	2.81:1
D2N3: 15th October + 160kg N/ha	353.88	353880.00	114664.60	239215.40	3.08:1
D2N4: 15th October + 200kg N/ha	438.55	438550.00	114775.00	323775.00	3.82:1
D3N1: 30th October + 80kg N/ha	226.93	226930.00	114443.00	112487.00	1.98:1
D3N2: 30th October + 120kg N/ha	300.41	300410.00	114554.20	185855.80	2.62:1
D3N3: 30th October + 160kg N/ha	340.16	340160.00	114664.60	225495.40	2.96:1
D3N4: 30th October + 200kg N/ha	363.86	363860.00	114775.00	249085.00	3.17:1

Fig.1 Interaction effect of planting dates and nitrogen levels on plant height (cm) at different growth stages of red cabbage.

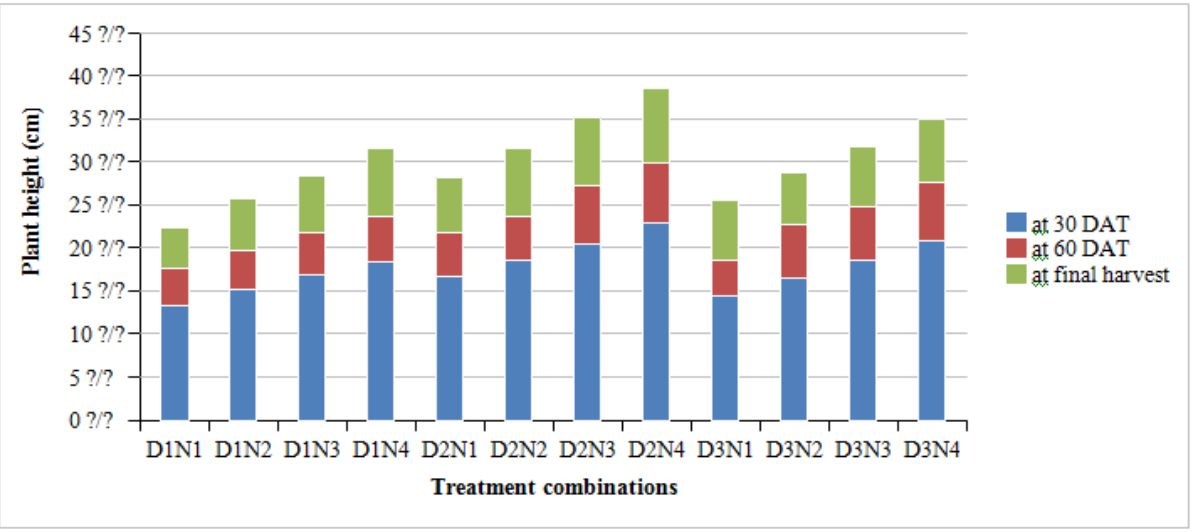


Fig.2 Interaction effect of planting dates and nitrogen levels on plant spread (cm) at different growth stages of red cabbage.

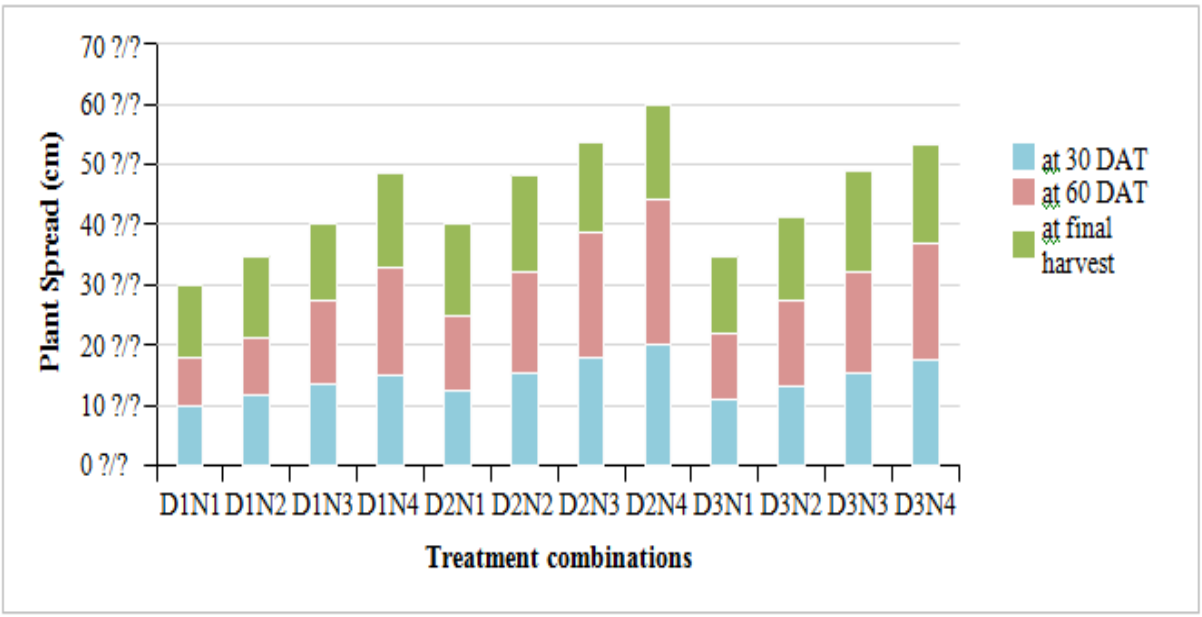


Fig.3 Interaction effect of planting dates and nitrogen levels on number of heading and loose leaves per plant of red cabbage.

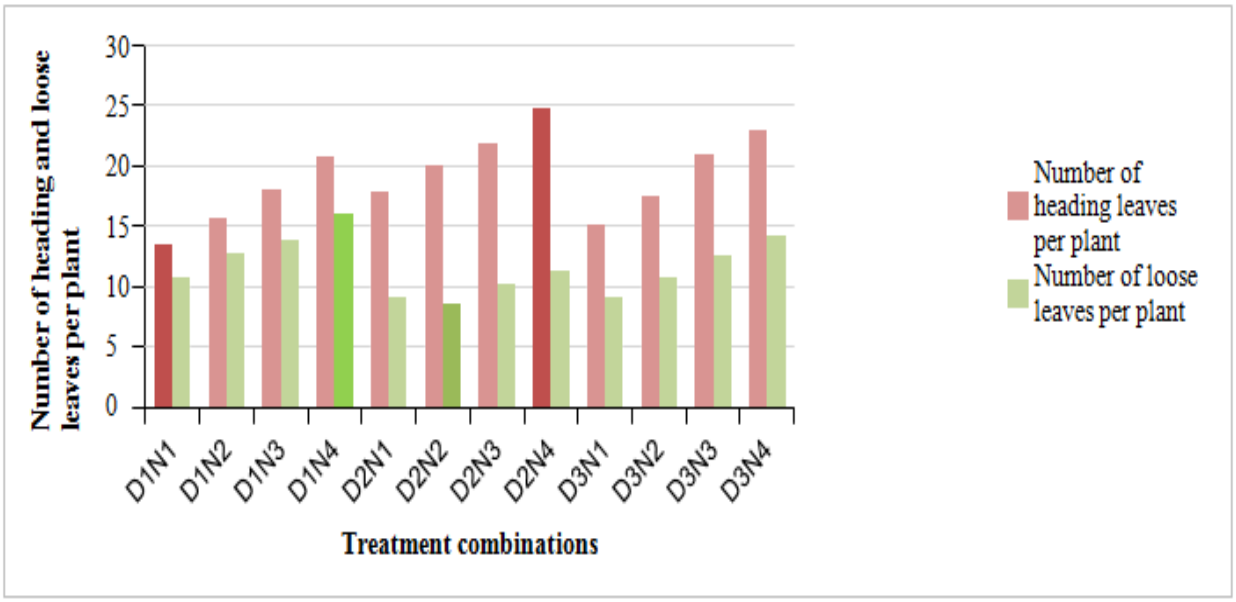


Fig.4 Interaction effect of planting dates and nitrogen levels on number of days to head initiation & harvest of red cabbage.

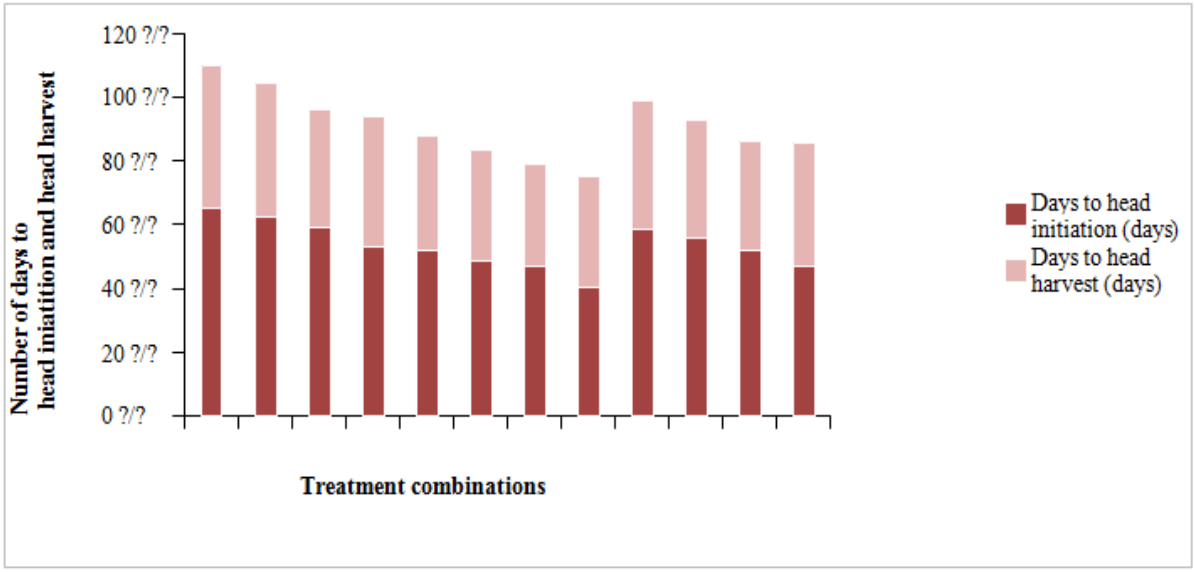


Fig.5 Interaction effect of planting dates and nitrogen levels on head weight (kg) of red cabbage.

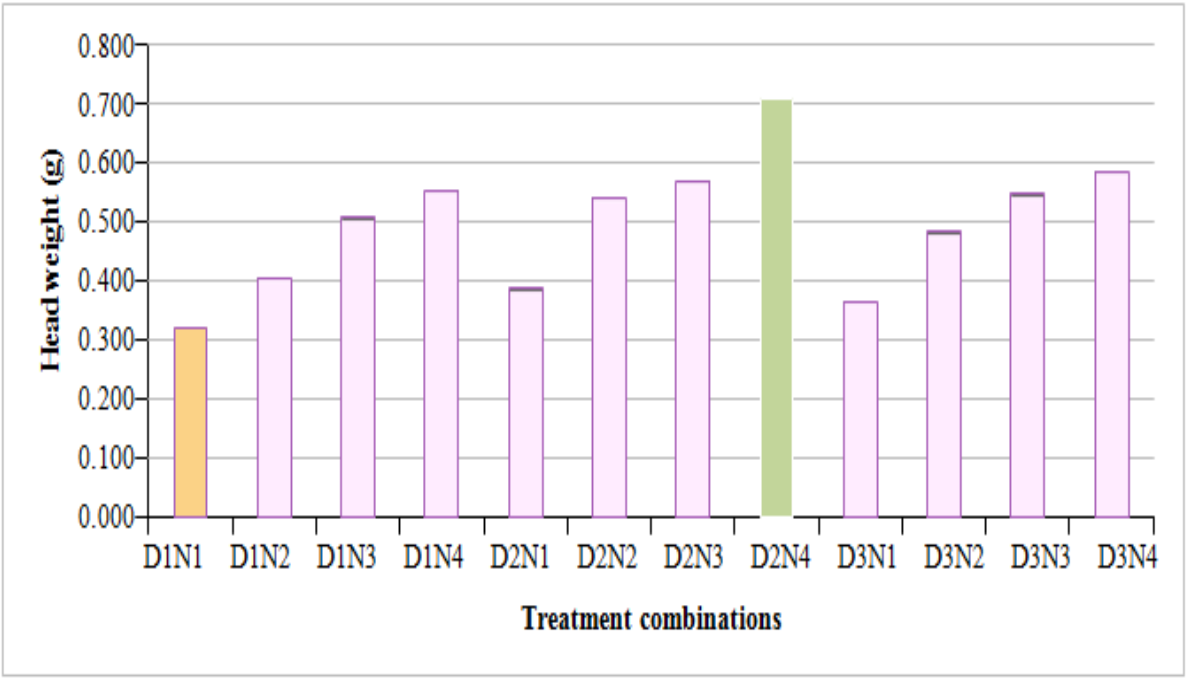


Fig.6 Interaction effect of planting dates and nitrogen levels on head yield per plot (kg) of red cabbage.

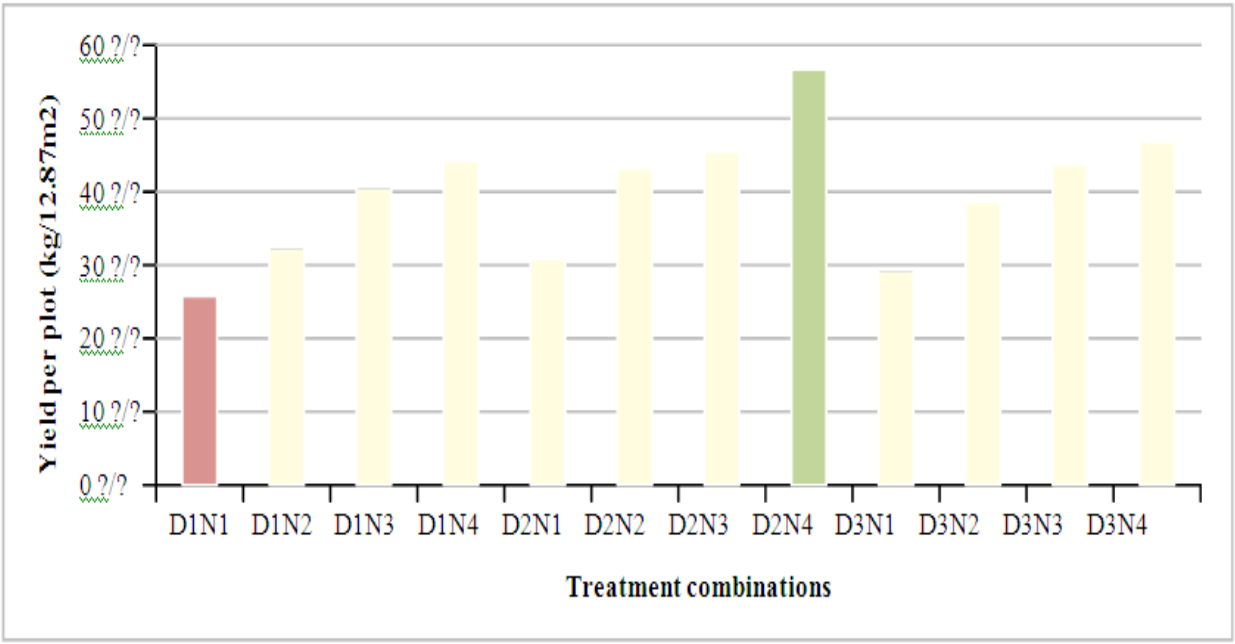


Fig.7 Interaction effect of planting dates and nitrogen levels on estimated yield per hectare (q/ ha) of red cabbage.

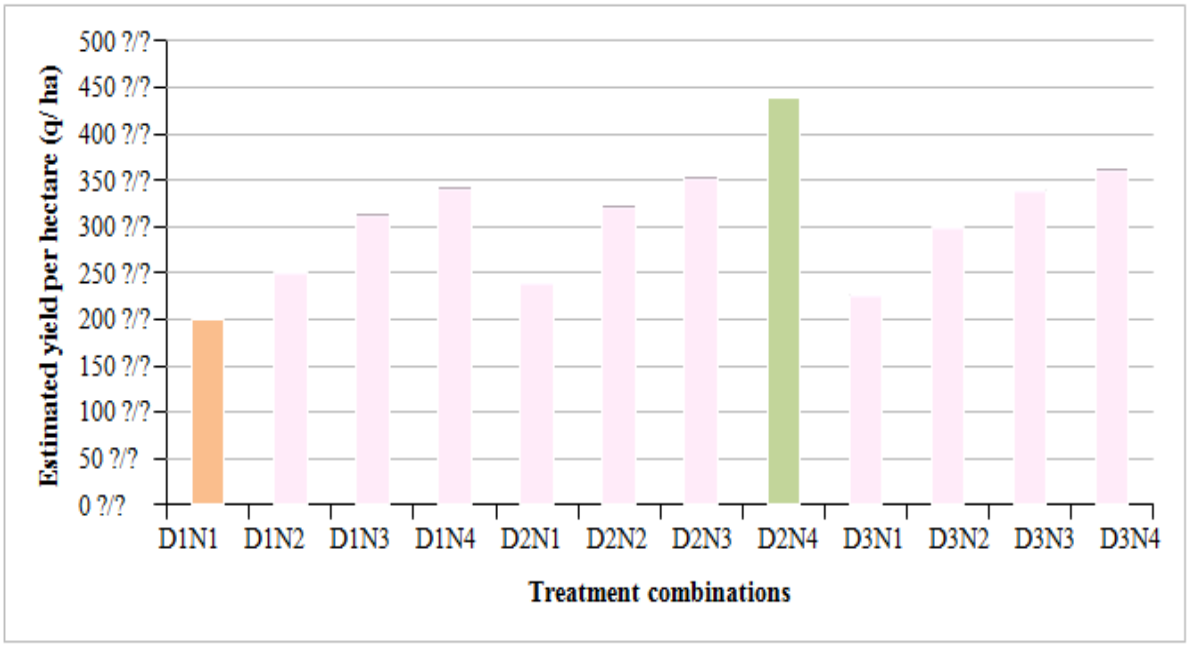


Fig.8 Interaction effect of planting dates and nitrogen levels on dry matter production (%) of red cabbage.

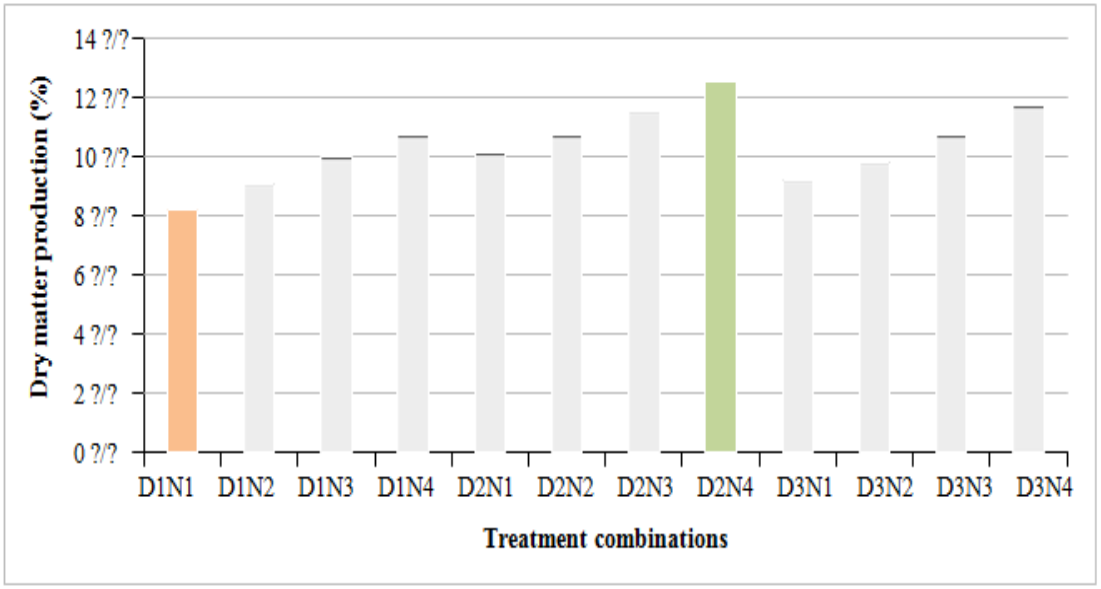
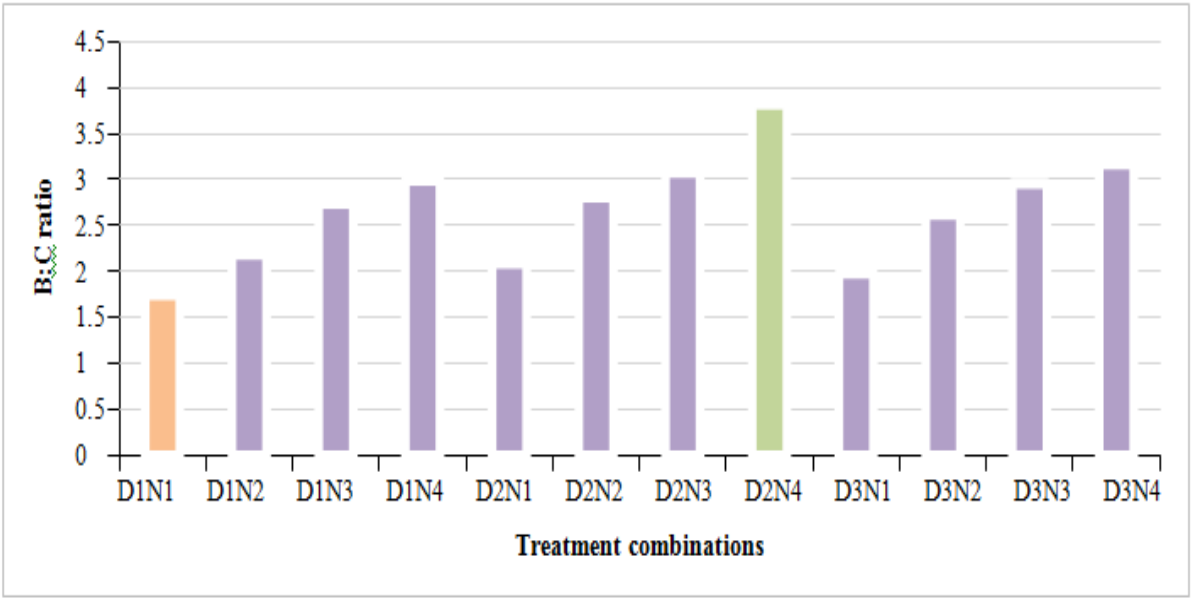


Fig.9 Interaction effect of planting dates and nitrogen levels on Benefit : Cost ratio of red cabbage.



The temperature and humidity during the period were 38.67° C and 82.22-93.47% respectively which are not conducive for red cabbage. The adverse climatic conditions like higher temperature and relative humidity during the crop period restricted the photosynthetic activity and translocation of food materials that might have resulted in poor vegetative growth leading to lesser yields with the above treatment (D1N1). Similar result obtained in cauliflower (Baghel and Singh, 1995; Csizinsky, 1996; Amoli *et al.*, 2007; Rahman *et al.*, 2016), Brussel sprout (Kolota and Biesieda, 1990; Babik, 1999), radish (Kanaujia and Sharma, 1998), sugar beet (Kandil *et al.*, 2002), garlic (Talukder *et al.*, 2000; Singh *et al.*, 2004), Coriander (Gujar *et al.*, 2005). The data are presented in Table 3 and Figure 7.

Dry Matter Production (%)

Significantly higher dry matter production (12.55%) was found with 15th October planting date and 200kg N/ha (D2N4) and minimum dry matter production (8.23%) was recorded with combination of 30th September planting date and 80kg N/ha (D1N1). Red cabbage dry matter production (%) showed statistically significant variation to different planting dates, nitrogen levels and their interactions and data presented in Table 3 and Figure 8.

Economics Benefit: Cost ratio

The data regarding the effect of planting dates and nitrogen levels on benefit cost ratio are presented in Table 4 and Figure 9. The data on economics proved that the treatment combination of 15th October planting date and 200kg N/ha (D2N4) recorded maximum net return of ₹3, 23,775 per hector. The increase in gross return due to treatment combination of D2N4 was reported as ₹ 4, 38,550 per hector over the other treatment combinations. This could be due to higher yields obtained under the respective treatments. The highest cost benefit ratio was recorded with the combination of 15th October planting date and 200kg N/ha (D2N4) resulted in highest benefit cost ratio (3.82:1), whereas the lowest benefit cost ratio of (1.75:1) was obtained from 30th September planting date with an application of 80kg N/ha (D1N1). Application of nitrogenous fertilizers with suitable climate conditions can improve the crop yield and thereby increase the net return and benefit cost ratio. Similar

results were also reported in red cabbage (Sharma *et al.*, 2004), cabbage (Lavanya *et al.*, 2015), radish (Kanaujia and Sharma, 1998), potato (Yenagi *et al.*, 2003) and fenugreek (Nandre and Sahane, 2011).

The interaction effect of planting dates and nitrogen levels was found significant. Highest number of heading leaves (24.87), plant height (38.43 cm) and plant spread (59.78 cm) were recorded with the treatment combination of 15th October planting date and application of 200kg N/ha (D2N4). The yield contributing characters like head weight (709g), head yield per plot (56.67kg), estimated head yield per hectare (438.55q) and dry matter production (12.55%) recorded higher values with same treatment combinations. Highest BC ratio (3.82:1) was obtained from the combination of 15th October planting date with 200kg N/ha (D2N4). Based on the results obtained in the present investigation, it can be concluded that 15th October planting date combined with application of 200kg N/ha (D2N4) proved to be best for getting higher growth, yield, quality and economic returns in Red cabbage for coastal Andhra Pradesh.

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