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

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A B S T R A C T

The present an investigation 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 yield, yield attributing characters and quality parameters and mean performance studies revealed significant difference in all parameters. The interaction effect of planting dates and nitrogen levels was found significant. The yield contributing characters like head volume (980cc), head length (19.46cm), head compactness (1.40), 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 recorded with the treatment combination of 15th October planting date and application of 200 kg N/ha (D2N4). It also maintained best quality with maximum anthocyanin content (122mg/100g), ascorbic acid (38.65mg/100g) and TSS (9.06°Brix) recorded. 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 200 kg N/ha (D2N4) proved to be best for getting higher growth, yield, quality 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.*, 2014) 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 (A.P.).

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 yield attributing

and quality parameters 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 yield and yield attributing characters viz., head circumference (cm), head length (cm), head volume (cc), head compactness, 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

Yield attributes parameters

Head circumference (cm)

The interaction effect between planting dates and nitrogen levels on head circumference was found to be non-significant. However, the maximum head circumference (53.66cm) was recorded with combination of 15th October planting date and 200kg N/ha (D2N4) and the minimum head circumference (30.10cm) was recorded with combination of 30th September planting date and 80kg N/ha (D1N1). Similar findings have been reported in cabbage (Lavanya *et al.*, 2014). The data presented in Table 1 & Figure 1.

Head length (cm)

The interaction effect of planting dates and nitrogen levels on head length of red cabbage at time of harvest was significant. The maximum head length (19.46cm) was recorded with combination of 15th October planting date and 200kg N/ha (D2N4). Whereas combination of 30th September planting date and 80kg N/ha (D1N1) gave minimum head length (10.25cm) compared to all other treatment combinations. This 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 which has increased head length. Similar findings have been reported in red cabbage (Patel *et al.*, 2014). The data regarding the head length presented in Table 1 and Figure 2.

Head volume (cc)

The interaction effect of planting dates and nitrogen levels on head volume was found to be significant. The maximum head volume (980.00cc) was recorded with combination of 15th October planting date and 200kg N/ha (D2N4). Whereas 30th September planting date and 80kg N/ha (D1N1) gave minimum head volume (675.00cc) compared to all other treatment combinations.

This 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 which has increased the head volume. Similar findings have been reported in cabbage (Lavanya *et al.*, 2014). The data regarding on head volume are presented in Table 1 and Figure 3.

Head compactness

The interaction effect between planting dates and nitrogen levels on head compactness was found to be significant. The maximum head compactness (0.47) was observed with 30th October planting date and 200kg N/ha (D3N3) and the minimum head compactness (1.03) was recorded with combination of 30th September planting date and 80kg N/ha (D1N1). The highest head compactness were obtained with combination of 15th October planting date and 200kg N/ha (D2N4) it is due to adequate supply of nutrients and favorable climatic conditions prevailing during the crop growth period. The data presented in Table 1.

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.,* (2014) in cabbage. The data on head weight are presented in Table 2 and Figure 4.

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.,* 2014). The data are presented in Table 2 and Figure 5.

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 yield parameters like volume of head, head circumference, 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. 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 and Singh, 2004), Coriander (Gujar *et al.,* 2005). The data are presented in Table 2 and Figure 6.

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 interactions effect of planting dates, nitrogen levels and data presented in Table 2 and Figure 7.

Table.1 Interaction effect of planting dates and nitrogen levels on head circumference (cm), head length (cm), head volume (cc) and head compactness of red cabbage.

Treatment combinations	Head circumference (cm)	Head length (cm)	Head volume (cc)	Head compactness
D1N1: 30th September + 80kg N/ha	30.10	10.25	675.00	1.03
D1N2: 30th September + 120kg N/ha	33.02	10.48	760.00	0.95
D1N3: 30th September + 160kg N/ha	35.54	11.57	876.66	0.80
D1N4: 30th September + 200kg N/ha	42.41	12.41	930.00	0.55
D2N1: 15th October + 80kg N/ha	40.39	12.86	775.00	0.59
D2N2: 15th October + 120kg N/ha	44.07	16.61	806.66	0.51
D2N3: 15th October + 160kg N/ha	48.75	17.99	876.67	0.51
D2N4: 15th October + 200kg N/ha	53.66	19.46	980.00	0.47
D3N1: 30th October + 80kg N/ha	34.21	11.85	733.33	0.69
D3N2: 30th October + 120kg N/ha	40.82	13.55	800.00	0.58
D3N3: 30th October + 160kg N/ha	43.83	15.31	866.66	0.53
D3N4: 30th October + 200kg N/ha	45.30	18.45	941.66	0.51
SEm±	2.840	0.667	13.337	0.069
CD @ 5%	NS	1.969	39.369	0.203

Table.2 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.3 Interaction effect of planting dates and nitrogen levels on anthocyanin content (mg/100g), ascorbic acid content (mg/100g), TSS (°Brix) and Benefit: Cost ration of red cabbage.

Treatment combinations	Anthocyanin content (mg/100g)	Ascorbic acid (mg/100g)	TSS (°Brix)	Benefit: Cost ration (₹)
D1N1: 30th September + 80kg N/ha	106.66	33.48	7.36	1.75:1
D1N2: 30th September + 120kg N/ha	107.00	34.85	7.50	2.19:1
D1N3: 30th September + 160kg N/ha	110.33	35.80	7.56	2.74:1
D1N4: 30th September + 200kg N/ha	111.66	37.98	7.66	2.99:1
D2N1: 15th October + 80kg N/ha	115.33	36.66	8.16	2.09:1
D2N2: 15th October + 120kg N/ha	116.66	36.93	8.30	2.81:1
D2N3: 15th October + 160kg N/ha	121.33	38.48	8.63	3.08:1
D2N4: 15th October + 200kg N/ha	122.00	38.65	9.06	3.82:1
D3N1: 30th October + 80kg N/ha	109.33	34.33	7.66	1.98:1
D3N2: 30th October + 120kg N/ha	113.00	35.96	7.90	2.62:1
D3N3: 30th October + 160kg N/ha	115.00	37.41	8.21	2.96:1
D3N4: 30th October + 200kg N/ha	117.33	38.33	8.31	3.17:1
SEm±	0.487	1.002	0.095	-
CD @ 5%	1.439	NS	0.281	-

Fig.1 Interaction effect of planting dates and nitrogen levels on head circumference of red cabbage.

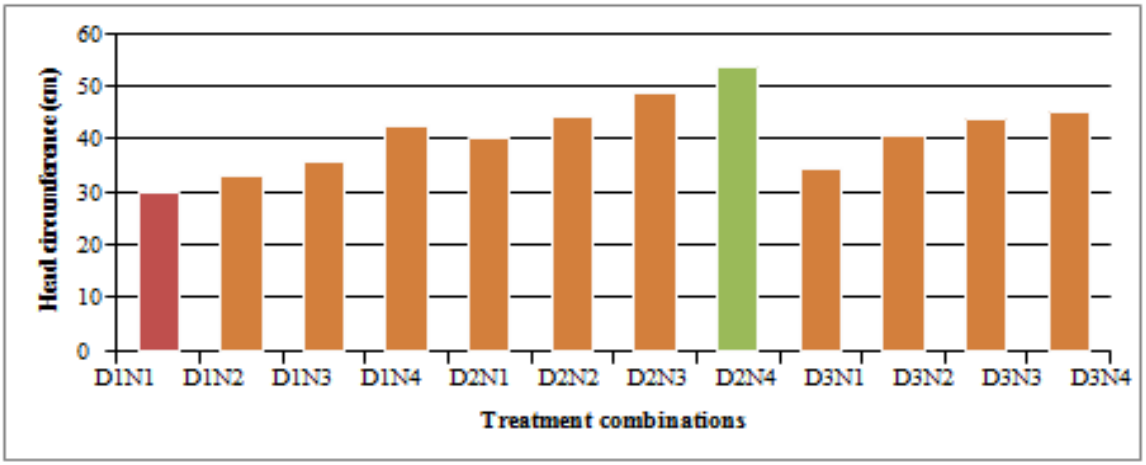


Fig.2 Interaction effect of planting dates and nitrogen levels on head length (cm) of red cabbage.

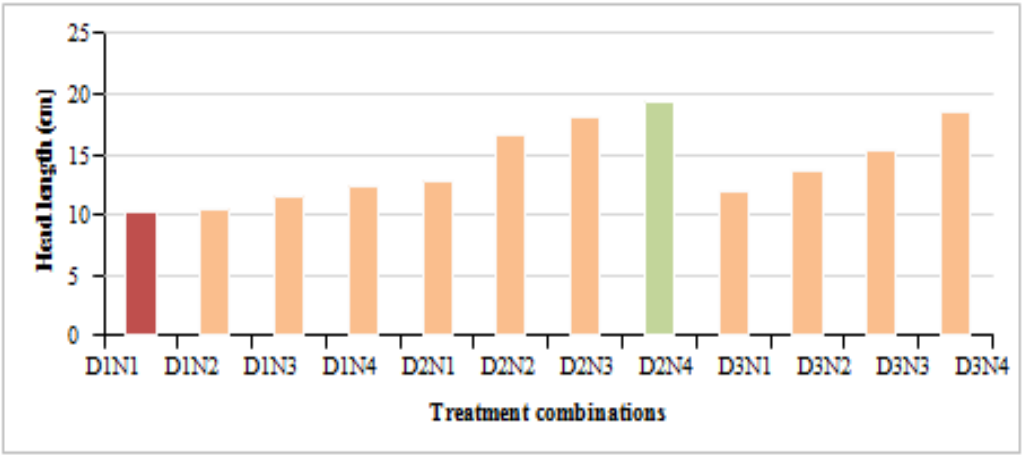


Fig.3 Interaction effect of planting dates and nitrogen levels on head volume (cc) of red cabbage.

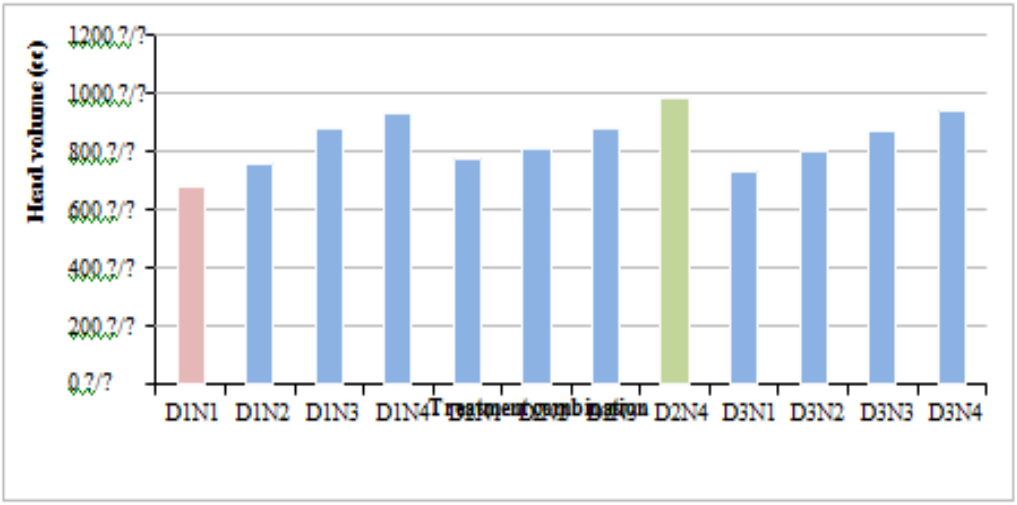


Fig.4 Interaction effect of planting dates and nitrogen levels on head weight (kg) of red cabbage.

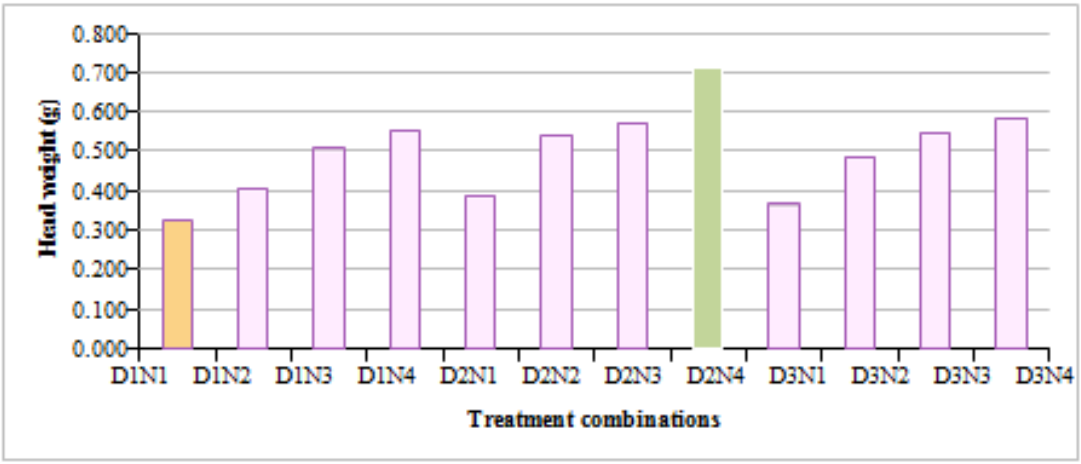


Fig.5 Interaction effect of planting dates and nitrogen levels on head yield per plot (kg) of red cabbage.

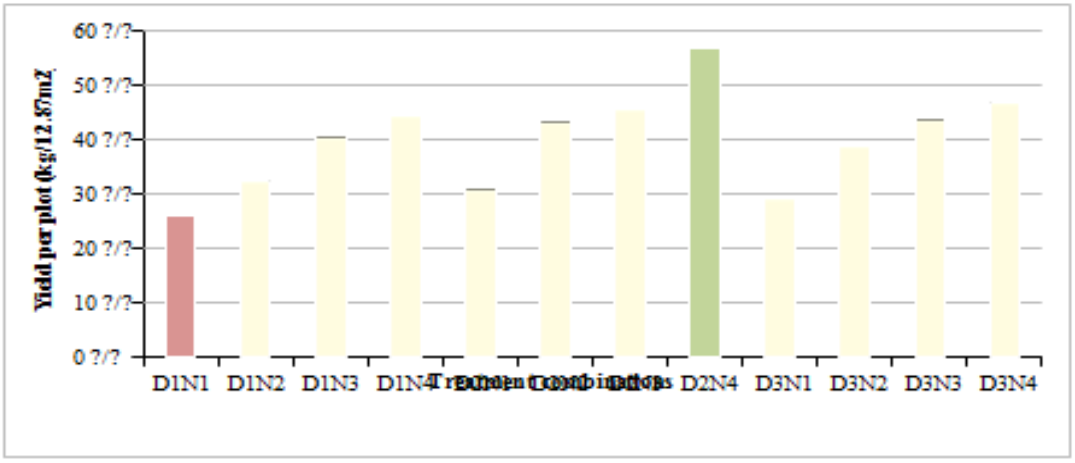


Fig.6 Interaction effect of planting dates and nitrogen levels on estimated yield per hectare (q/ ha) of red cabbage.

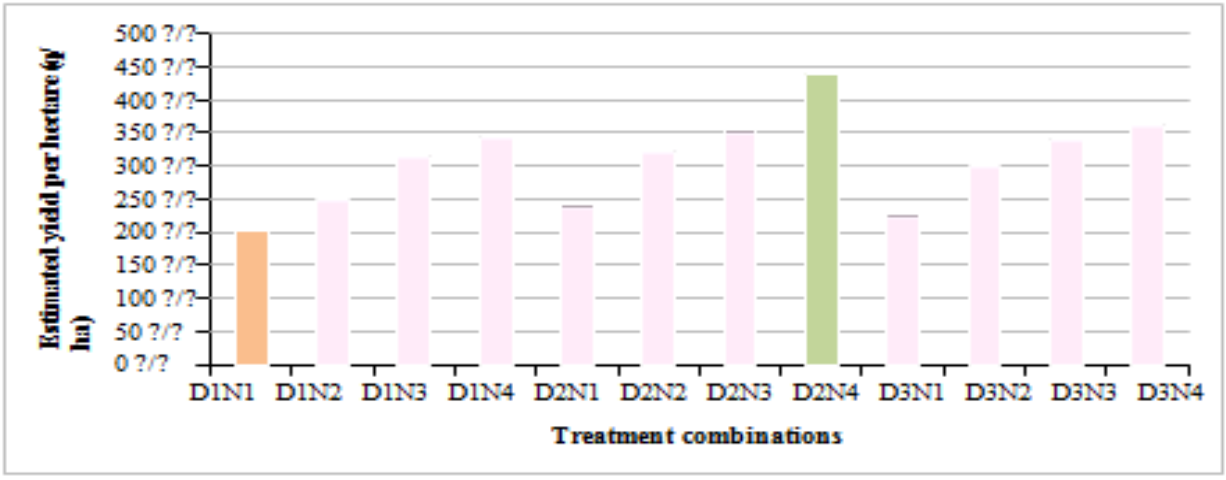


Fig.7 Interaction effect of planting dates and nitrogen levels on dry matter production (%) of red cabbage.

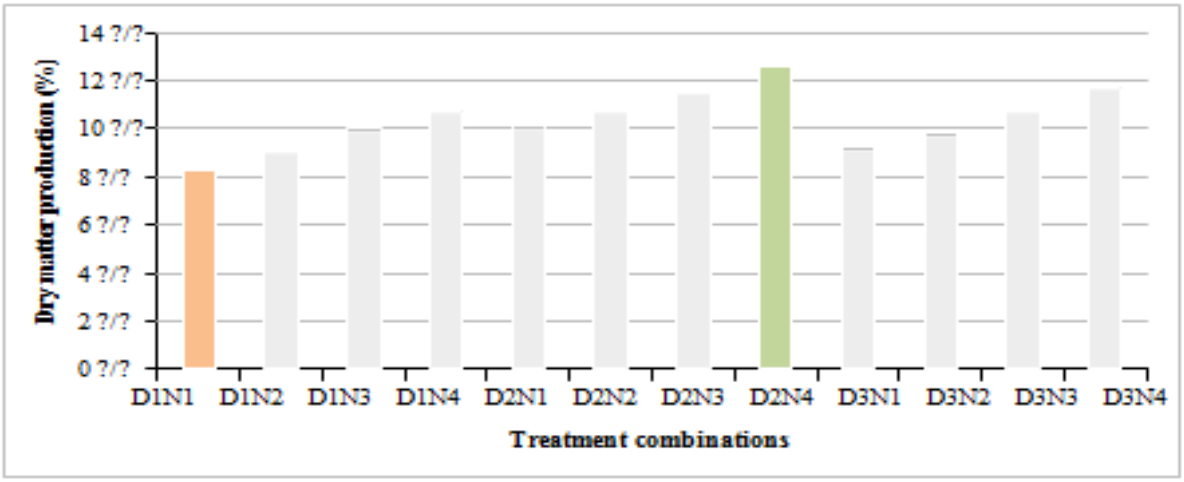


Fig.8 Interaction effect of planting dates and nitrogen levels on anthocyanin content (mg/100g) of red cabbage.

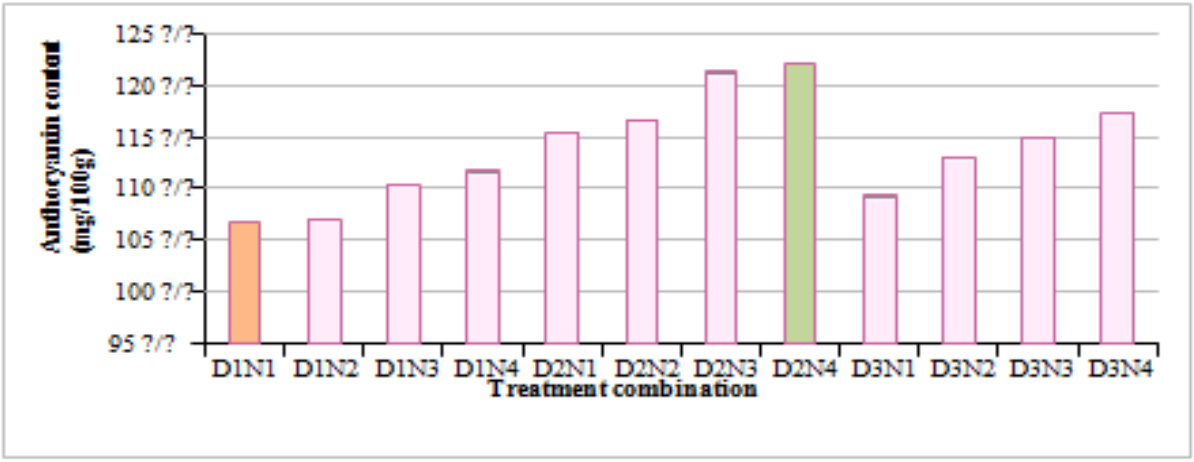


Fig.9 Interaction effect of planting dates and nitrogen levels on ascorbic acid content (mg/100g) of red cabbage.

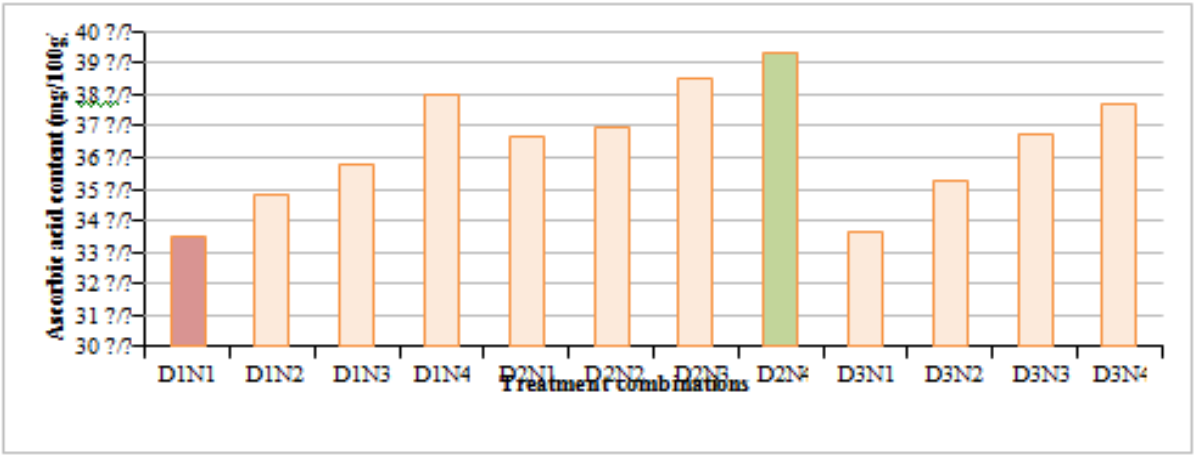


Fig.10 Interaction effect of planting dates and nitrogen levels on TSS (°Brix) of red cabbage.

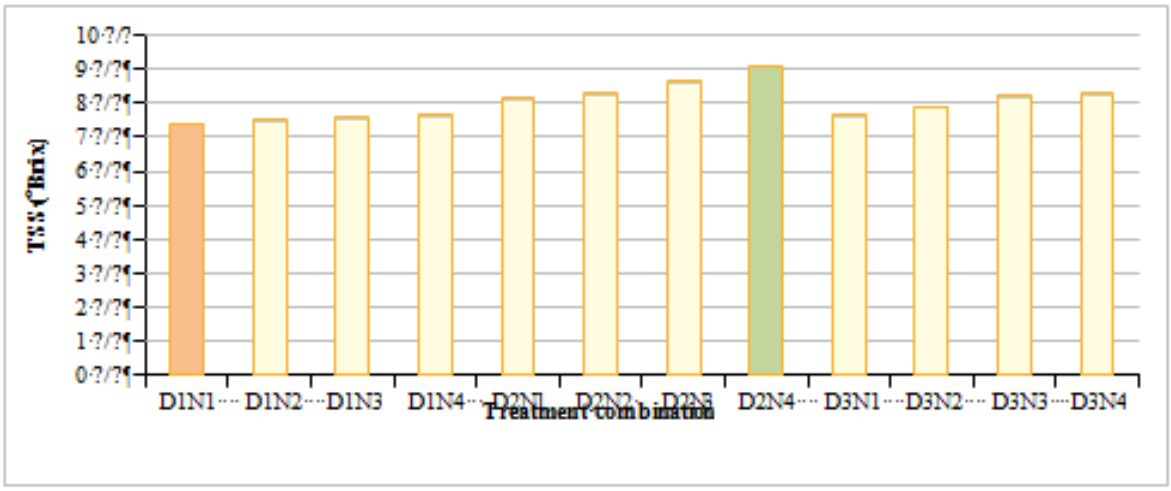
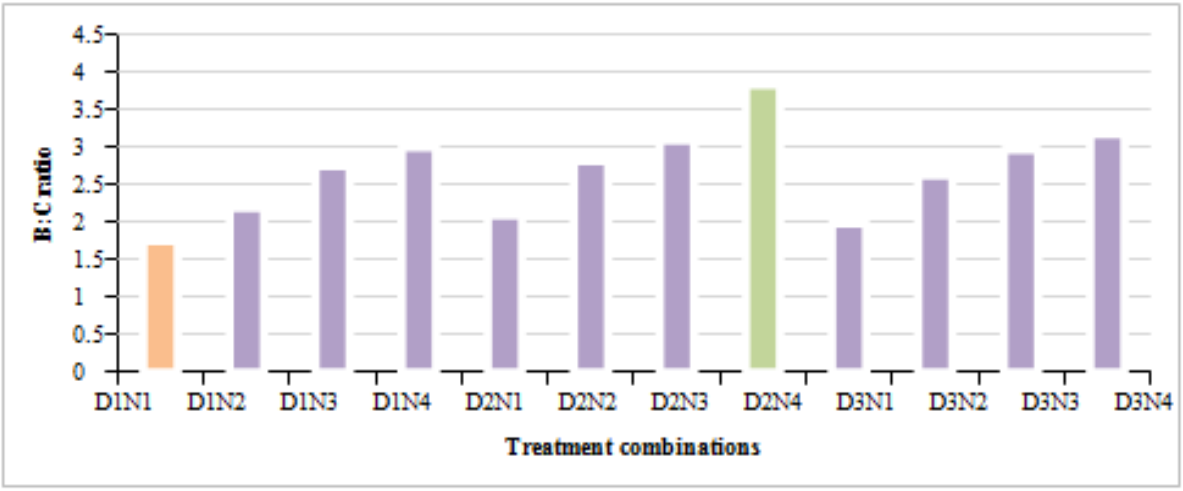


Fig.11 Interaction effect of planting dates and nitrogen levels on Benefit : Cost ratio of red cabbage.



Quality Parameters

Anthocyanin content (mg/100g)

Significant interaction effects were recorded with planting dates and nitrogen levels for anthocyanin content. However, highest anthocyanin content (122mg/100g) was observed with 15th October planting date and 200kg N/ha (D2N4) and least (106.66mg/100g) were recorded with 30th September planting date and 80kg N/ha (D1N1). These results were contradicting with Roselle (Raja and Arivazhagan, 2014) and red cabbage (Biesiada *et al.,* 2010). The data presented in Table 3 and Figure 8.

Ascorbic acid content (mg/100g)

The interaction effect of planting dates and nitrogen levels on the ascorbic acid content in Red cabbage was non-significant. The highest ascorbic acid (38.65mg/100g) was recorded in combination of 15th October planting date and 200kg N/ha (D2N4) and lowest (33.48mg/100g) was noticed in 30th September planting date and 80kg N/ha (D1N1). These results are in accordance with Lavanya *et al.,* (2014) in cabbage. The data presented in Table 3 and Figure 9.

TSS (° Brix)

The maximum TSS (9.06°B) was recorded with of 15th October planting date and 200 kg N/ha (D2N4) and minimum TSS (7.36°B) recorded with 30th September planting date and 80kg N/ha (D1N1). This increase in TSS content due to the favorable climatic conditions prevailing during head formation stage along with certain level of nitrogen. The increased TSS content in head might be due to the fact that nitrogen is the major constituent of plant protein, amino acid and carbohydrate; as a result of increased uptake of nitrogen might have increased TSS content. These results are in line with the findings of Maheshkumar and Rawat (2002) in cabbage. The data are presented in Table 3 and Figure 10.

Benefit cost ratio

The data regarding the effect of planting dates and nitrogen levels on benefit cost ratio are presented in Table 3 and Figure 10. 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.*, 2014), radish (Kanaujia and Sharma, 1998), potato (Yenagi *et al.*, 2003) and fenugreek (Nandre and Sahane, 2011). The data are presented in Table 3 and Figure 11.

The interaction effect of planting dates and nitrogen levels was found significant. The yield contributing characters like head volume (980.00cc), head length (19.46cm), head compactness (1.40), 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 the treatment combination of 15th October planting date and application of 200kg N/ha (D2N4). It also maintained best quality with maximum anthocyanin content (122mg/100g), ascorbic acid (38.65mg/100g) and TSS (9.06°Brix) recorded. 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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