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## Effect of Intercropping on yield of red cabbage with leafy vegetables and root crops

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### Abstract

Intercropping under fragile environmental conditions makes sure the constancy in return and minimizes risk of crop damage due to weather difficulties. In the present, due to the raising population the need of increase in food production is one of the major problem, while in physical area under cultivation cannot be increased the productivity per unit area /unit time. This can be achieved by raising more crops in a year through multiple, relay and intercropping. Red cabbage (*Brassica oleracea* L. var. *capitata* f. *rubra*) is an important vegetable just like others. It has high anti-oxidant property that immunizes the system of human. For marketing purpose head size and yield of Red Cabbage matters the most. The N application influences these factors in Red Cabbage. The purple colour of Red Cabbage is due to anthocyanin content.

Hence, a field experiment entitled “Effect of Intercropping on Yield of Red Cabbage with Leafy vegetables and Root crops” was conducted during the October 2020 to March 2021, at the Horticulture Research Farm, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj. The experiment consisted of thirteen different combinations of treatments which was laid out in Randomized Block Design with three replications. Results revealed that the treatment T<sub>9</sub> (Red Cabbage + Radish) was found significantly superior over all other treatments with respect to yield characteristics. The yield parameters like head weight (0.83 kg), head girth (0.80 cm), head length (13.14 cm), TSS (4.30) and yield per plot (14.33 kg) and in intercrops, weight of radish (3.313 kg), weight of Carrot (1.36 kg), weight of Coriander leaves (0.78 kg) and weight of Spinach leaves (2.065 kg) respectively. However, spinach was harvested three times.

**Keywords:** Red cabbage, intercropping, radish, carrot, coriander and spinach

### Introduction

Intercropping is perceived as beneficial in terms of economy of space, saving on tillage, use efficiency of nutrient and moisture in inactive space. Intercropping is relevant to cultivating of two or more different crops may belong to different family, at the same instant on the same part of land. Tillable lands are under pressure to grow food for human intake, especially in developing countries in Asia and Africa where cultivators have own small plots of land (Awal *et al.*, 2007) [2]. There will be an intercrop competition bit by bit in all stages of growth. Intercropping under delicate environmental conditions assures constancy in yield and derogate the risk of crop loss due to weather deviancy (Sharma *et al.*, 2006) [16]. The peasant farmers generally prefer the intercropping system because it produces higher total crop yield per unit area, provides insurance against total crop failure, and also decreases situations of pests and diseases (Lyocks *et al.*, 2013) [8]. Many studies have revealed that intercropping with different vegetables is more in terms of yield and profits than sole cropping, because of the contrastive effects of intercrops (Guvenc and Yildirim, 2006) [4]. The profits of intercropping are risk minimization, efficient use of available inputs, effective use of labour, increased crop productivity, degradation control and food security (Addo-quaye *et al.*, 2011) [1].

Red cabbage (*Brassica oleracea* var. *capitata* f. *rubra*) is an important exotic and highly nutritive vegetable. It is a biennial but cultivated as annual for its character of purple or red edible heads. It is a rich source of carotene, proteins (0.35%), fats (0.25%), minerals like calcium (3.57%), phosphorus (19.91%), potassium, sulphur etc. and vitamins like A, B1, B2 and C. Red cabbage is known for its highly medicinal properties. Red cabbage contain anthocyanin at all the developmental stages of its vegetative growth (Yuan, 2009) [21]. Red cabbage recognized by the presence of exceptional health improving properties like anticancer properties due to the presence of Indole-3-Carbinol and many beneficial sensory traits, which has become more and more important in recent years (Wojciechowska *et al.*, 2007) [20].

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In India, cabbage including red cabbage is cultivated in an area of about 4.03 lakh hectares producing 91.92 lakh metric tonnes (NHB, 2019) [12].

Radish (*Raphanus sativus* L.) belongs to genus *Raphanus*, family Brassicaceae or Cruciferae originated from the Central and Western China and India. The edible part of radish is tap root. The eatable part of radish root develops from both primary root and hypocotyls.

Carrot (*Daucus carota* L.) belongs to the family umbelliferae. It is a very popular winter vegetable and one of the important root crops cultivated throughout the world for its fleshy delicious, fancy edible roots. It's grown in spring, summer and autumn seasons, in temperate countries and during winter in tropical and subtropical regions. In recent years, the intake of carrot and its products have increased steadily due to their recognition as an important source of natural antioxidants besides, anticancer activity of beta-carotene being a precursor of vitamin A.

Amongst the leafy vegetable, Spinach (*Spinacea oleracea*) is one of the most important leafy vegetable consumed all over the country. It is commonly known as 'Palak' and is very popular due to its high nutritive value. Spinach leaves are known for their medicinal properties. The leaves are advised to take in inflammation, paralysis, headache, earache, and is cure for disease of spleen and liver. Fresh leaves are applied in burn. It also acts as a mild laxative besides other medicinal values, it balances the acidity produced during the digestion of fatty substance and help to prevent constipation.

Coriander (*Coriandrum sativum*) is a plant belonging to family Umbelliferae (Apiaceae) which is a large family. Leaves are alternate, compound and petiole has a pair of stipules sheathing the stem base. The lower leaves are broad, pinnate and have long leafstalk with scalloped lobed margins. The coriander seeds are used as spice in the preparation of spice, pickles, sauces and seasoning.

## Materials and Methods

The experiment was conducted during winter season of the year 2020-21 at Research field, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agricultural Technology and Sciences, Prayagraj. The university is situated on the right bank of Yamuna on Rewa road at a distance of about 5 km from Prayagraj city. It is situated at 25°57'N latitude and 81°85' E longitudes on elevation of 98 meters from the sea level, with the annual rainfall ranges of 1013.4mm.

The area of Prayagraj district comes under subtropical belt in the South east of Uttar Pradesh, which experiences extremely hot summer and comparatively chilled winter. The maximum temperature of the location reaches up to 46°C – 48°C and often falls as low as 4°C – 5°C. The relative humidity ranges between 25 to 94 per cent and the average rainfalls in this area occurs around 1013.4 mm annually.

After analyzing the soil chemical properties, it revealed that soil was sandy loam in texture, acidic in reaction (pH 6.9) medium in organic carbon (0.358%) and potassium (225.1 kg ha<sup>-1</sup>), low in available phosphorus (14.59 kg ha<sup>-1</sup>). The electrical conductivity of the soil was 0.15 ds m<sup>-1</sup>.

The experiment was laid out in Randomized Block Design (RBD), with 13 treatments replicated thrice. Treatment was randomly arranged in each replication, with plot size of 3.24 m<sup>2</sup>(1.8m x 1.8m) each. Thirteen treatments combinations, comprising (i) T<sub>0</sub> (Sole) (ii) T<sub>1</sub> [Red Cabbage + Radish] (iii) T<sub>2</sub> [Red Cabbage + Carrot] (iv) T<sub>3</sub> [Red Cabbage +

Coriander] (v) T<sub>4</sub> [Red Cabbage + Spinach] (vi) T<sub>5</sub> [Red Cabbage + Radish] (vii) T<sub>6</sub> [Red Cabbage + Carrot] (viii) T<sub>7</sub> [Red Cabbage + Coriander] (ix) T<sub>8</sub> [Red Cabbage + Spinach] (x) T<sub>9</sub> [Red Cabbage + Radish] (xi) [Red Cabbage + Carrot] (xii) T<sub>9</sub> [Red Cabbage + Coriander] (xiii) T<sub>9</sub> [Red Cabbage + Spinach]

Red Cabbage with variety Sakata planted in nursery on 15, October, 2020 as per the spacing for that particular crop. Germination took place after three days of sowing and on 29, November, 2020 it was transplanted in the main field. The intercrops were applied for sowing as per the combination written above. The parameter reading were taken after harvesting of the main crop and intercrops respectively.

The observations on head weight, head girth, head length, TSS, yield per plot and weight of each intercrops as well after harvesting.

## Results and Discussion

### Effect of intercropping on yield parameters of main crop

#### Head Weight

The data on Head weight (kg) of Red cabbage is influenced by intercropping with Radish, Carrot, Coriander and Spinach in different treatments was recorded. Based on the data it is found that the treatments T<sub>9</sub> (Red cabbage + Radish) recorded maximum (0.83 kg) Head weight after harvesting, followed by T<sub>12</sub> (Red cabbage + Spinach) with (0.78 kg) where as minimum head weight (0.56 kg) was recorded in treatment T<sub>0</sub> (Sole crop). The maximum head weight showed by T<sub>9</sub> (Red cabbage + Radish) and minimum in T<sub>0</sub> (Sole Crop) might be due the nutrient absorption by crops. The red cabbage intercropped with radish has maximum head weight among all the intercropped red cabbage. It might be due to absorption of N in red cabbage shown good results in weight of head. It appears that the root crop might have helped the main crop to a certain extent. Results of head weight were in line with findings Vipul *et al.*, 2017 [19]; Kanase *et al.*, 2018 [6] in broccoli.

#### Head Girth

The data on Head girth (cm) of Red cabbage is influenced by intercropping with Radish, Carrot, Coriander and Spinach in different treatments was recorded Based on the data it is found that the treatments T<sub>9</sub> (Red cabbage + Radish) recorded maximum (0.80 cm) Head girth after harvesting, followed by T<sub>12</sub> (Red cabbage + Spinach) with (0.76 cm) where as minimum head girth (0.57 cm) was recorded in treatment T<sub>0</sub> (Sole crop). The maximum head girth showed by T<sub>9</sub> (Red cabbage + Radish) and minimum in T<sub>0</sub> (Sole Crop) also might be due to fertilizer application of urea and DAP. The average head girth of red cabbage was also affected significantly by use of intercrops. The red cabbage intercropped with radish has maximum head girth among all the intercropped red cabbage. The N- Level although enhanced the average girth but insignificantly. The similar results were found in cabbage (Lavanya *et al.*, 2014) [7] and broccoli (Shapla *et al.*, 2014) [15] for head circumference.

#### Head Length

The data on Head length (cm) of Red cabbage is influenced by intercropping with Radish, Carrot, Coriander and Spinach in different treatments was recorded Based on the data it is found that the treatments T<sub>9</sub> (Red cabbage + Radish) recorded maximum (13.14 cm) Head length after harvesting respectively, followed by T<sub>12</sub> (Red cabbage + Spinach) with

(11.67cm) where as minimum head length (9.63 cm) was recorded in treatment T<sub>0</sub> (Sole crop).The maximum head length showed by T<sub>9</sub> (Red cabbage + Radish) and minimum in T<sub>0</sub> (Sole Crop) might be due to fertilizer application of urea and DAP. The red cabbage intercropped with radish has maximum head length among all the intercropped red cabbage. It might be due to absorption of fertilizers in red cabbage shown good results in weight of head. Red cabbage because of application of fertilizers in other hand sole crop did not show good result in head weight might be due to less absorption of nutrients. The results were in collaboration with findings obtained in cabbage (Singh *et al.*, 2010)<sup>[17]</sup>, Broccoli (Abd, 2008; Vinod *et al.*, 2017<sup>[18]</sup>) for head length.

### TSS

The data on TSS of Red cabbage is influenced by intercropping with Radish, Carrot, Coriander and Spinach in different treatments was recorded. Based on the data it is found that the treatments T<sub>9</sub> (Red cabbage + Radish) recorded maximum (4.30) TSS after harvesting respectively, followed by T<sub>12</sub> (Red cabbage + Spinach) with (4.07) where as minimum TSS (3.13) was recorded in treatment T<sub>0</sub> (Sole crop). The TSS quality parameter is maximum in T<sub>9</sub> (Red cabbage + Radish) and minimum in T<sub>0</sub> (Sole Crop) might be due to fertilizer application of urea and DAP. The red cabbage intercropped with radish has maximum TSS among all the intercropped red cabbage. The effect of intercrop can be attributed to the competition for nutrients and space. And it might be due to absorption of fertilizers in red cabbage shown good results in TSS. These results are in correspondence with

red cabbage (Manasa *et al.*, 2017 and Patel *et al.*, 2017)<sup>[9, 13]</sup> and broccoli (Vinod *et al.*, 2017<sup>[18]</sup>; Vipul *et al.*, 2017<sup>[19]</sup> and Kanase *et al.*, 2018<sup>[6]</sup>).

### Yield per plot

The data on Yield per plot of Red cabbage is influenced by intercropping with Radish, Carrot, Coriander and Spinach in different treatments was recorded Based on the data it is found that the treatments T<sub>9</sub> (Red cabbage + Radish) recorded maximum (14.33 kg) yield per plot after harvesting respectively, followed by T<sub>12</sub> (Red cabbage + Spinach) with (13.5 kg) where as minimum (10.66 kg) was recorded in treatment T<sub>0</sub> (Sole crop). The better results were due to the favourable conditions that prevailed during crop growth period and due to optimum level of nitrogen supplied to the crop. Similar findings have been reported in red cabbage (Maria and Krzysztof, 2012)<sup>[10]</sup>, cabbage (Singh *et al.*, 2010<sup>[17]</sup>; Abed *et al.*, 2015), broccoli (Shapla *et al.*, 2014<sup>[15]</sup>; Kanase *et al.*, 2018<sup>[6]</sup>). The Yield per plot parameter is maximum in T<sub>9</sub> (Red cabbage + Radish) and minimum in T<sub>0</sub> (Sole Crop) might be due to fertilizer application of urea and DAP. Treatment T<sub>9</sub> consumed more of nutrients of red cabbage as well as 2/3<sup>rd</sup> fertilizer of recommended dose of radish also. The red cabbage intercropped with radish has maximum yield among all the intercropped red cabbage. With respect to head yield per plot, Similar results are found in red cabbage (Maria and Krzysztof, 2012)<sup>[10]</sup> and broccoli (Shapla *et al.*, 2014<sup>[15]</sup>; Vipul *et al.*, 2017<sup>[19]</sup>; Vinod *et al.*, 2017<sup>[18]</sup>; Kanase *et al.*, 2018<sup>[6]</sup>).

**Table 1:** Effect of intercropping on yield parameters of main crop

Treatment Symbol	Treatment Combination	Head weight(kg)	Head girth(cm)	Head length(cm)	Yield per plot(kg)	TSS
T <sub>0</sub>	Sole Crop	0.56	0.57	9.63	10.66	3.13
T <sub>1</sub>	Red Cabbage + Radish	0.65	0.70	10.11	11.56	3.30
T <sub>2</sub>	Red Cabbage + Carrot	0.68	0.68	9.65	11.66	3.57
T <sub>3</sub>	Red Cabbage + Coriander	0.74	0.69	10.83	11.66	3.47
T <sub>4</sub>	Red Cabbage + Spinach	0.67	0.70	10.24	11.33	3.40
T <sub>5</sub>	Red Cabbage + Radish	0.63	0.73	11.03	13.26	3.70
T <sub>6</sub>	Red Cabbage + Carrot	0.63	0.68	10.67	11.46	3.33
T <sub>7</sub>	Red Cabbage + Coriander	0.68	0.70	11.11	12.5	3.33
T <sub>8</sub>	Red Cabbage + Spinach	0.74	0.68	11.00	12.5	3.80
T <sub>9</sub>	Red Cabbage + Radish	0.83	0.80	13.14	14.33	4.30
T <sub>10</sub>	Red Cabbage + Carrot	0.71	0.75	10.69	11.66	3.90
T <sub>11</sub>	Red Cabbage + Coriander	0.66	0.65	11.28	12.66	3.23
T <sub>12</sub>	Red Cabbage + Spinach	0.78	0.76	11.67	13.5	4.07

### Effect of intercropping on yield of intercrops

**Weight of Radish:** The data on Weight of root without leaves of Radish is influenced by intercropping with Red Cabbage in different treatments was recorded. Based on the data it is found that the treatments T<sub>9</sub> (Red cabbage + Radish) recorded maximum (3.313 kg) Weight of root without leaves followed by T<sub>5</sub>(Red cabbage + Radish) with (2.552 kg) and minimum was T<sub>1</sub> (Red cabbage + Radish) with (2.102 kg) after harvesting respectively. Weight of root without leaves is maximum in T<sub>9</sub>. It might be due to quick and luxuriant growth of radish which produced more competition in plots with higher plant stand. It gained the nitrogen from the application of fertilizers like urea and DAP. This enhanced the nitrogen uptake by the roots of the plants. Nayek (2001)<sup>[11]</sup> found the same result trend in cabbage based intercropping system.

### Weight of Carrot

The data on Root weight without leaves Carrot is influenced

by intercropping with Red Cabbage in different treatments was Based on the data it is found that the treatments T<sub>10</sub> (Red cabbage + Carrot) recorded maximum (1.36 kg) Root weight without leaves followed by T<sub>2</sub>(Red cabbage + Carrot) with (0.90 kg) and minimum was T<sub>6</sub>(Red cabbage + Carrot) with (0.88 kg) after harvesting respectively. The root weight without leaves in T<sub>10</sub> is best might be due to proper absorption of nutrients such as N, P, K for their growth. However it takes upto four months for harvesting. It did not show good results as compare to other intercrops with red cabbage. May be it was due to high competition of red cabbage for nutrients. Similar type of observations was also recorded by Hussain (2003)<sup>[5]</sup>.

### Weight of Coriander Leaves

The data on Weight in Coriander is influenced by intercropping with Red Cabbage in different treatments was recorded Based on the data it is found that the treatments T<sub>11</sub>

(Red cabbage + Coriander) recorded maximum (0.78 kg) Weight followed by T<sub>3</sub>(Red cabbage + Coriander) with (0.53 kg) and minimum was T<sub>7</sub>(Red cabbage + Coriander) with (0.44 kg) after harvesting respectively. Weight of coriander leaves was good. The fertilizer application lead this crop to yield better overall. The crop was provided by N, P, K and application at the intervals. It enhances the yield of crop and helped to result better. However coriander harvested only once. Similar findings were observed by Patil, 1988 [14].

### Weight of Spinach Leaves

The data on Weight in Spinach is influenced by intercropping with Red Cabbage in different treatments was Based on the data it is found that the First, Second and Third harvesting of Spinach recorded maximum weight in treatment T<sub>12</sub> (Red

cabbage + spinach) with (2.06, 1.605 and 1.928 kg), followed by T<sub>4</sub> (Red cabbage + spinach) with (1.614, 1.142 and 1.517 kg) and minimum in T<sub>8</sub> (Red cabbage + spinach) with (1.498, 1.025 and 1.350 kg) respectively. Spinach resulted better as compare to coriander, intercropped with red cabbage it gave quite good yield as it was harvested thrice, and each time the yield was quite good. It might be due to availability of N, P, K was better in that plot. It shows the red cabbage did not affected this crop for nutrient competition. Proper availability of space, water and sunlight helped it to grow more. Singh and Srivastava (1987) reported that although the cauliflower yield was highest in sole cropping, but profitability per hectare was greatest when it was intercropped with spinach especially when the N level was high.

**Table 2:** Effect of intercropping on yield per plot of intercrop

Treatment Symbol	Treatment Combination	Weight of intercrops only(kg)
T <sub>0</sub>	Sole Crop	
T <sub>1</sub>	Red Cabbage + Radish	2.102
T <sub>2</sub>	Red Cabbage + Carrot	0.90
T <sub>3</sub>	Red Cabbage + Coriander	0.53
T <sub>4</sub>	Red Cabbage + Spinach	1.614
T <sub>5</sub>	Red Cabbage + Radish	2.552
T <sub>6</sub>	Red Cabbage + Carrot	0.88
T <sub>7</sub>	Red Cabbage + Coriander	0.44
T <sub>8</sub>	Red Cabbage + Spinach	1.498
T <sub>9</sub>	Red Cabbage + Radish	3.313
T <sub>10</sub>	Red Cabbage + Carrot	1.36
T <sub>11</sub>	Red Cabbage + Coriander	0.78
T <sub>12</sub>	Red Cabbage + Spinach	2.065

### Conclusion

On the basis of results obtained, it is concluded that the treatment T<sub>9</sub> having Red Cabbage + Radish was found best in terms of yield parameters viz., head weight, head girth, head length, yield per plot and TSS. And in terms of intercrops, weight of each crop was recorded and Radish was found best among all intercropped crops followed by Spinach. Radish was found beneficial for intercropping with Red Cabbage as in both the crops the yield obtained was good. Radish is early growing crop and is harvested earlier than Red Cabbage so it can be suggested to farmers for their land utilizations and better income. However Spinach can also be suggested as it can be harvested for atleast two times. However, these findings are based on one season trial. Therefore, further evaluation trials are needed to substantiate the findings.

### Future Scope

Based on the present investigations it may be concluded that, there is a good interactive effect of different combinations of Red cabbage with root crops and leafy vegetables on yield attributes like head weight, head girth, head length, yield per plot, TSS and weight of each intercrops. These intercropping systems would help in improving utilisation of vacant land and to get income profit. This help in rotation of crops as well as to enhance the quality of the soil. In small piece of land also it can be applied to get extra profit. As red cabbage takes upto three months for harvesting till then crops like radish, spinach and coriander get ready for harvesting however carrot takes upto four months. It can be helpful for those poor farmers who doesn't have bigger land or area for farming.

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### Conflict of Interest

As a Corresponding Author, I Priya Kumari, confirm that none of the others have any conflicts of interest associated with this publication.

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