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Intercropping in broccoli (*Brassica oleracea* L. var. *italica*)

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ABSTRACT

A field trial was carried out at Horticultural Research Station, Mondouri,Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal in rabi season of 2018-2019 to investigate the intercropping effect on vegetative and reproductive parameters of broccoli. The trial was laid out in randomized block design (RBD) with nine (9) treatment combinations replicated thrice. Data on various growth characters like plant height (60.89 cm), stem girth (14.44 cm), root weight (77.51 gm) and root volume (74.44 ml) were recorded maximum in broccoli+French bean (T1) intercropping system. The same trend was also observed for reproductive characters. Data on yield parameters like head diameter (12.33 cm), head weight (346.11 gm) and yield per plot (10.38 kg) were recorded maximum in broccoli +French bean intercropping system. The result may be due to better utilization of available resources due to less competition effects and contribution of nutrient from the legume crop French bean.

Keywords: Broccoli, French bean, growth, yield and intercropping

Broccoli (*Brassica oleracea* L. *var. italica*), belonging to cruciferae family sometimes said as green cauliflower forms green curd with several flower heads are gaining its popularity in today's agriculture. It is a highly nutritious crop packed with several vitamins like A,B, C, E and K, fibre, protein, and minerals like iron, potassium, calcium, selenium and magnesium. It contains comparatively more amount of protein and vitamin A than other popular cole crops like cabbage and cauliflower. Broccoli has high content of glucosinolates which combat cancer (Avila *et al.,* 2013). The edible part of broccoli is called head consisting green buds. Recently area under broccoli in India is increasing day by day. Average yield of broccoli in India is remarkably low i.e., 5-8 tonnes per hectare. Due to rapid growth rate of population per capita land resources in India is decreasing at an alarming rate. On the other hand, due to degradation of soil fertility, sudden outbreak of natural hazards, pest and disease incidences, market price fluctuation etc. the farming families are facing the insecurity of income generation for their livelihood. Hence, intensive cultivation and effective utilization of land resources through intercropping is demanded badly to overcome the prevalent situation. Intercropping is a technique of crop intensification in both space and time where in the competition between crops may occur during a part or whole of crop growth period (Dodiya *et al.,*2018). Addo-quaye *et al.* (2011) reported the benefits of intercropping like risk minimization, better utilization of available resources, farm labour, higher crop productivity, prevents erosion and provides food security. Guvence and Yildrim (2006) observed the added advantage of vegetable based intercropping system which was more productive and profitable than sole cropping due to their complementary effects. The crop under study faces frequent market fluctuation with its poor productivity. The soil and climatic conditions of gangetic plains of West Bengal is highly favorable for cultivation of this low yielding non-traditional and high value crop like broccoli. Under these circumstances the present investigation was undertaken to study the effect of intercropping in broccoli.

The present study on broccoli based intercropping system was carried out at Horticultural Research Station, Mondouri of Bidhan Chandra Krishi Viswavidyalaya Nadia,West Bengal in *rabi* season of 2018-2019. The farm was located at 23.5° North latitude and 80° East longitude with an altitude of 9.75m above the MSL. The experiment was laid out in randomized block design (RBD), replicated thrice with nine (9) treatments.The plot size of the said work was 3 m x 1.8 m. The trial comprised of nine treatment combinations viz.T_1 - Broccoli + Radish; T_2 - Broccoli + French bean; T_3 - Broccoli + Palak; T_4 - Broccoli + Coriander; T_5 - Sole Broccoli; T_6 - Sole Radish; T_7 - Sole French bean, T_8 - Sole Palak and T_9 - Sole Coriander. Seeds of intercrops were sown in between the rows of the main crop i.e., broccoli in 1:1 proportion. Healthy broccoli seedlings one month age were transplanted in the main plot in the lines with a spacing of 60 x 30 cm. Seeds of radish, French bean, palak and coriander as a sole crop were sown at spacing of 20 x 10cm, 50 x 20cm, 20 x 10cm and 20 x 10cm respectively. In this experiment, varieties taken for broccoli, radish, French bean, palak and coriander were Centauro, Khashikata Red Bombay, Green Komal, All Green and Local variety, respectively. Data on vegetative and reproductive parameters were recorded. Based on recommended dose of fertilizers for

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the concerned crops, $N_2P_2O_5$ and K_2O were supplied through Urea, SSP and MOP for 5.4 m^2 plot area. As source of manure FYM was applied for the crops under study. Crops were raised according to standard crop husbandry methods. Statistical analysis of the experimental data was done according to the procedure of Panse and Sukhatme (1978). The significance was tested by referring to the vales of F table (Fisher and Yates, 1963). The biological functions for analyzing the efficiency of the intercropping system were done after computation of aggressivity (A), LER and relative crowding coefficient (K).

Competitive functions

i ***Aggressivity (A)***

The value was calculated by the formula of Mc Gilchrist (1965).

Aab= Yab/Yaa x Zab- Yba/Ybb x Zba

Where,

Aab means Aggressivity of the component crop "a".

ii. ***Relative crowding coefficient (K)***

This was worked out with the equation coined by Hall (1974):

Kab = Yab/Yaa–Yab × Zba/Zab

Where,

Kab= Relative crowding coefficient of component crop "a".

iii. ***Land equivalent ratio***

LER can be defined as the relative area under sole crop that would be required to produce the equivalent yield under an intercropping system, at the same level of management.

LER =Yab/Yaa + Yba/Ybb

Yab = Yield of Crop *a* in intercropping

Yba = Yield of Crop *b* in intercropping

Yaa = Yield of Crop *a* in pure stand

Ybb = Yield of Crop *b* in pure stand

Plant height (cm)

Data pertinent to plant height of broccoli, represented in Table 1 revealed that broccoli intercropped with French bean (T_2) recorded maximum plant height (60.89 cm) which was superior to all other treatments except broccoli + coriander intercropping system (T_4) where it was found statistically at par (58 cm). The minimum value (56.66 cm) for the same was noticed in broccoli + radish (T_1) intercropping system which was might be due to minimum value of LER(1.99) and maximum value of aggressivity (0.93) whereas higher values for plant height was observed with broccoli+ French bean system which might be due maximum value of LER (2.49), minimum value of aggressivity (0.38) obtained in this system depicting maximum use of all the vertical and horizontal resources and minimum competition within the intercrops for solar radiation, compared to other intercropping treatments (Table 4). Kandeyang (2004) also found maximum plant height with okra+cowpea and okra+ French bean intercropping system. Kumari *et al.* (2018) also studied the influence of intercropping of chilli with some short duration vegetables and found increased plant growth for chilli+fenugreek system.

Plant spread (cm)

Data pertaining to plant spread of broccoli, presented in the Table 1, clearly revealed that sole cropping of broccoli (T_5) recorded maximum plant spread (73.22 cm), rather than intercropping with other crops where the plant spread of broccoli was affected to some extent. This might be due to competition effect of intercropping which reduced the plant spread of broccoli. The competition was found to be highest when broccoli was intercropped with radish (T_1) as the plant spread was found minimum (65.89 cm) in this. This might be due to lowest value LER(1.99) and maximum value of aggressivity (0.93) in broccoli + radish intercropping system (Table 4) . Among the intercropping treatments the maximum value of plant spread (72 cm) was found in broccoli + coriander intercropping system (T_4) which indicated least competition of coriander with broccoli.

Number of leaves plants^{-1}

After perusal of data, presented in Table 1, on number of leaves per plant it was found that broccoli+coriander (T_4) intercropping system produced the maximum number of leaves per plant (13.22) which was statistically at par with T_2 (broccoli+ French bean) treatment with a value of 13.11 for the same parameter, but significantly superior to all other treatments. This indicates these two intercrops of broccoli utilized all the available resources properly because of higher LER and relative crowding coefficient values and minimum aggressivity to promote uniform growth of leaves. But other than these two treatments other systems recorded lower values which might be due to more competition for nutrition and other resources. Paul *et al*. (2015) observed greater number of leaves per plant in brinjal + coriander intercropping system.

Stem girth (cm)

Data pertaining to stem girth of broccoli has been presented in Table 2. Broccoli intercropped with French bean (T_2) depicted the maximum value (14.44 cm) for stem girth followed by treatment T_4(13.67 cm) in broccoli + coriander intercropping system. But it had been found that treatment T_2 was statistically at par with rest of the treatments under trial like T_1, T_3, T_4 and T_5. Among the intercrops lowest value of stem girth was found in treatment T_1 when broccoli was intercropped with radish (12.89 cm). This was due to the maximum competitive effects among all the intercrops to broccoli.

Root weight (g)

The results (Table 2) revealed that root weight of broccoli was maximum (77.51 g) when intercropped with French bean (T_2). This was undoubtedly because of higher values of biological function when broccoli was intercropped with French bean. Due to synergic effect the root growth of broccoli enhanced. So, according to the data we can say that treatment T_2 was statistically at par with treatment T_5 i.e., sole broccoli, and was significantly superior to other intercrop combinations. Lowest value of root weight was found in broccoli when intercropped with palak in treatment T_3 (66.55g).

Root volume (ml)

Data pertaining to root volume of broccoli is represented in Table 2. Like root weight, root volume of broccoli was maximum (74.45 ml) when intercropped with French bean (T_2) gave the highest root weight and least when intercropped with radish (T_1) i.e., 58.33 ml. This was also because of higher values of biological function when broccoli was intercropped with French bean which helped to produce longer and heavier roots in this combination. Due to synergic effect, the root volume of broccoli had been increased. So, after perusal of the data it could be said that treatment T_2 was statistically at par with treatment T_3 (broccoli+palak) 65ml, T_4 (broccoli+coriander) 67.22ml and T_5 (sole broccoli). Higher values for root volume was also recorded in brinjal + French bean intercropping system (Maurya, 2019).

Head diameter (cm)

Head is the economic product of broccoli as the diameter of head is directly related to yield. Data on head diameter, presented in Table 3 clearly showed that maximum head diameter (12.33 cm) was obtained from treatment T_2 i.e., broccoli+ French bean which was statistically at par with T_4 (broccoli + coriander), T_5 (sole broccoli) and T_3 (broccoli + Palak) which recorded head diameter of 12.22 cm,11.56 cm and 11.33 cm respectively. Significantly minimum head diameter (9.55 cm) of broccoli was recorded in T_1 treatment i.e.,when radish was intercropped with broccoli. This was due to maximum competition for resources between radish and broccoli as because both the crops are having similar pattern of crop geometry, also having same type of rooting system. Similar type of trend was observed by Choudhuri (2011) in cabbage based intercropping system where maximum head diameter (13.61 cm) was obtained in cabbage + pea combination and it was minimum (11.41 cm) in cabbage + beet intercropping system.

Head weight (g)

After perusal of data pertaining to head weight of broccoli , presented in Table 3, revealed that maximum head weight (346.11g) of broccoli was obtained from treatment T_2 i.e. when broccoli was intercropped with French bean, followed by treatment T_4 (broccoli+coriander) with a head weight value of 306.67 g. Lowest value (242.28 g) for the same was obtained from treatment T_1 i.e., when broccoli was intercropped with radish. This was might be due to maximum competition for resources, like water, nutrition or other, between radish and broccoli as both the crops being similar pattern, have same type of rooting systems. Yadav *et al.*(2016) found the same trend in broccoli based intercropping system.

Yield (kg ha^{-1})

Yield data of broccoli has been presented in Table 3. It was observed that the treatment T_2 (broccoli + French bean) recorded significantly maximum yield (19.23 t ha^{-1}) followed by treatment T_4 (broccoli+coriander) with a yield of 17.04 t ha^{-1}. Minimum yield of 13.46 t ha^{-1} was obtained when broccoli was intercropped with radish (T_1).

Maximum yield in broccoli + French bean intercropping system might be due to higher values of growth and yield attributes along with better utilization of all the available inputs due to lesser aggresivity and more LER and relative crowding coefficient values. Due to higher values of all the biological functions broccoli and radish intercropping combination recorded minimum yield per hectare than all other treatments. This result was in consonance of the findings of Choudhuri (2011) in cabbage based intercropping system.

Economics of production

Data related to economics of production (Table 5) revealed that when broccoli was taken as intercrop with French bean it was most remunerative and recorded highest net return and B:C ratio (Rs. 2,77,255.67and 2.58 respectively) followed by broccoli + coriander (Rs. 2,41,179.74 and 2.42 respectively) system of intercropping. Field data also revealed that broccoli when taken as intercrop with radish was least economical as this system showed lowest net return and B:C ratio (Rs. 1,58,914.70 and 1.44 respectively). Among different treatments, broccoli +French bean system was most economical probably due to higher yield of broccoli and lower cost of cultivation over all other treatments.On the other hand, broccoli + radish combination was least remunerative than all other treatments due to highest cost of cultivation and

comparatively lowest yield of broccoli. Similar trend was also recorded by Maurya (2019) who found maximum monetary advantage in brinjal + French bean intercropping system.

After threadbare discussion of the experimental findings, it is clear that intercropping of different short duration crops had influenced the vegetative and reproductive parameters of broccoli. Due to symbiotic effect of legumes and higher values of biological functions like LER, relative crowding coefficient incorporation of French bean with broccoli had out yielded other combinations. Broccoli and French bean combination had also been found economically most viable intercropping system. On the other hand, growing radish with broccoli recorded most of the values for growth and yield characters due to more competition for all the vertical and horizontal resources. So, it may be concluded that broccoli + French bean intercropping system can be an alternate and sustainable option to increase the overall farm productivity and to minimize the market risk.

Table 1: Effect of intercropping on plant height, plant spread and number of leaves of broccoli

Treatments	Plant height (cm)	Plant spread (cm)	No. of leaves plant^{-1}
T_1	56.66	65.89	12.11
T_2	60.89	69.89	13.11
T_3	57.11	66.78	12.55
T_4	58.00	72.00	13.22
T_5	57.33	73.22	11.33
SEm (±)	**0.99**	**0.79**	**0.26**
LSD(0.05)	**2.96**	**2.45**	**0.77**

Table 2: Effect of intercropping on stem girth, root weight and root volume of broccoli

Treatments	Stem girth (cm)	Root weight (g)	Root volume (ml)
T_1	12.89	66.89	58.33
T_2	14.44	77.51	74.44
T_3	13.00	66.55	65.00
T_4	13.67	67.11	67.22
T_5	13.44	73.10	65.55
SEm (±)	**0.53**	**1.94**	**3.18**
LSD (0.05)	**1.56**	**6.05**	**9.91**

Table 3: Effect of intercropping on head diameter, head weight and yield of broccoli

Treatments	Head diameter (cm)	Head weight (g)	Yield (t ha^{-1})
T_1	9.55	242.28	13.46
T_2	12.33	346.11	19.23
T_3	11.33	279.67	15.54
T_4	12.22	306.67	17.04
T_5	11.56	269.44	14.97
SEm (±)	**0.40**	**5.95**	**0.097**
LSD (0.05)	**1.24**	**18.55**	**1.89**

Table 4: Effect of intercropping on biological functions of broccoli

Treatments	Land equivalent ratio	Aggressivity	Relative crowding coefficient
T_1	1.99	0.93	1.31
T_2	2.49	0.38	1.86
T_3	2.17	0.73	1.35
T_4	2.48	0.35	1.48
T_5	1.00		

Table 5: Economics of broccoli based intercropping system

Treatments	Gross income (Rs.)	Total cost (Rs.)	Net return (Rs.)	B:C ratio
T_1	269203.70	1,10,289.00	158914.70	1.44
T_2	384566.67	1,07,311.00	277255.67	2.58
T_3	310744.44	1,00,700.00	210044.44	2.09
T_4	340740.74	99,561.00	241179.74	2.42
T5	299381.48	98,326.00	201055.48	2.04

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