Indian Journal of Agricultural Sciences **87** (3): 318–24, March 2017/Article
https://doi.org/10.56093/ijas.v87i3.68692

Effect of intercropping, crop geometry and organic manures on growth and yield of broccoli (*Brassica oleracea* var *italica*)

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Received: 6 October 2016; Accepted: 3 November 2016

ABSTRACT

An investigation was conducted at organic research farm, Department of Vegetable Science, CCS Haryana Agricultural University, Hisar to study the effect of intercropping and crop geometry in organic production of broccoli (*Brassica oleracea* var. *italica*) during winters of 2012-14. Three organic manures (FYM, vermicompost and poultry manure) and two spacings, viz. single row (45×45cm) and paired row (30/60×45cm) were taken in main plot and five intercrops, viz. broccoli (CBH-1), beet leaf (HS-23), coriander (Hisar Bhumit), fenugreek (Hisar Suwarna) and radish (HS-1) including sole crop of broccoli as sub-plot. The trial was replicated thrice. The experimental results revealed that sole crop of broccoli with the application of vermicompost in single row spacing (M2S1C1) recorded minimum days to first and 50% harvesting (56.7), maximum number of leaves (28.4), weight of main head (200.2g), girth of head (15.4cm), number of sprouts/plant (9.8), yield of sprouts/plant (400.9g), yield of sprouts (main head + sprouts)/ plant (601.1g), total yield (296.9 q/ha), plant biomass on fresh (1 661 g) and dry weight basis (149.2 g), of broccoli. While plant height (63.45cm) and yield of intercrops (127.1 q/ha) was recorded maximum with the application of vermicompost in double row spacing (M2S2C5) treatment with radish. Among the intercropped treatments, fenugreek intercropped with broccoli recorded maximum yield (287.7 q/ha) in single row spacing.

Key words: Broccoli, Crop geometry, Intercropping, Organic manures

In India, the pure organic farming is possible partially only for the crops having high export potential in international markets. Organic broccoli cultivation offers one of the most sustainable farming systems with recurring benefits to not only long-term soil health but provides a lasting stability in production by importing better resistance against various biotic and abiotic stresses (Sridhar *et al.* 2014 and Jigme *et al.* 2015). Globally, increasing population and industrialization have resulted in cultivable land being decreased continuously. Arable lands are under pressure to produce for human consumption, especially in developing countries of Asia and Africa where growers own small holding of land. Intercropping of compatible crops can be of great value in achieving the improved productivity without requiring significant additional resources. Besides, intercropping also provide greater stability in production as well as help the farmers in maintaining the soil fertility levels. Intercropping of vegetables is a recognized system for efficient use of fertilizers and increasing the productivity per unit area. This system usually gives higher combined yield than the sole crops by making use of resources that would otherwise not be utilized by a single crop efficiently (Mandal *et al.* 1986, Poodineh *et al.* 2014, Yildirim and Turan 2013, Khan *et al.* 2016 and Kaur *et al.* 2016). Moreover, intercropping offers to the farmers an early income from the annual vegetable intercrops before the main crop is harvested (Olubode *et al.* 2015). Optimal plant spacing is important for crop production through efficient utilization of nutrients, water and light by the plants. Paired row planting (30/60 × 45 cm) may facilitate the growing of intercrops like fenugreek, coriander, beet leaf and radish in broccoli because the space available between rows of main crop is more than that available in normal row spacing (45 × 45 cm) at early growth stage (Singh 1992). Use of organic manures to meet the nutrient requirement of crops would be an inevitable practice in the years to come for sustainable agriculture. Organic manures not only improve the soil physical, chemical and biological properties but also maintain the quality of environment and plant products (Sharma *et al.* 2012 and Olubode *et al.* 2015). In order to enhance the number of crops per unit area, selection of the suitable organic manure and crop geometry become essential components for good growth and development of sharing crops. There is need for developing a promising intercropping system with suitable spacing

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and organic manures; an investigation entitled "Studies on intercropping and crop geometry in organic production of broccoli (*Brassica oleracea* var. *italica*)" was attempted.

MATERIALS AND METHODS

The study was conducted at the research farm and laboratory of Department of Vegetable Science, CCS Haryana Agricultural University, Hisar during winter season of the 2012-13 and 2013-14. Hisar is situated between 29° 10′ latitude North and of 75° 46′ longitude East and 215.2 m above mean sea level having semi-arid subtropical climate. Hot and dry winds during summer and dry severe cold in winter are common features of this region. The maximum (15-35°C) and minimum temperature (17.5- 0.20°C), bright sunshine hours (0.30-10°C), relative humidity (25-35%) and total weekly rainfall (0.00- 45mm) were recorded during the period of investigation at Meteorological Observatory at the Department of Agro-Meteorology, CCS Haryana Agricultural University. The experimental soil had pH 8.2, available-N 112.2 mg/kg, available-P 8.2 mg/kg and available –K 154.1 mg/kg. The experiment was laid out in split plot design replicated thrice with three different organic manures, viz. FYM (M_1), vermicompost (M_2) and poultry manure (M_3) and two spacings, viz. single row-S1 (45 × 45cm) and paired row-S2 (30/60 × 45cm) as main plot treatments and five intercrops, viz. broccoli-CBH-1 (C_1), beet leaf-HS-23 (C_2), coriander-Hisar Bhumit (C_3), fenugreek-Hisar Suwarna (C_4) and radish-HS-1 (C_5) including sole crop of broccoli as sub-plot treatments, thus making a total of 30 treatment combinations. The FYM, vermicompost and poultry manure were applied at the rate of 8.0, 5.0 and 5.0 tonnes/ha, respectively. The available N, P and K contents (%) in the organic manures in FYM (0.5, 0.3 and 0.3), vermicompost (1.5, 1.2 and 1.1) and poultry manure (1.1, 0.8 and 0.8), respectively. The available N content was determined by alkaline permanganate method (Subhiah and Asija 1956) and available phosphorus content was estimated by Olsen method (Olsen *et al*. 1954). The available potassium was determined by extraction of manures and with 1 N neutral ammonium acetate and estimated by flame photometer (Metson 1956). The seeds of intercrops were sown between the rows of broccoli after five days of transplanting. The intercrops viz. coriander, fenugreek and palak were harvested between 25 to 35 days after sowing and radish was harvested 40 to 45 after sowing. The harvesting of head and sprouts from 55 days after transplanting and onwards when the heads and buds are compact and unopened. Mean values of the parameters in each replication were statistically analyzed in Split Plot Design as suggested by Panse and Sukhatme (1985) and by using the software of CCS HAU, Hisar website *http://hau.ernet.in/opstat.html* for analysis of variance and test of significance.

RESULTS AND DISCUSSION

The data presented in Table 1 indicated that the individual effect of treatments like organic manures, crop geometry and intercropping of different intercrops in

Table 1 Influence of organic manures, crop geometry and intercrops on plant growth, yield and yield attributes (pooled mean of two years)

Treatment	PH	NL	DFH	WMH	GMH	NS	YS	TYPP	TYPH	PBFW	PBDW	TYI
Manures (M)												
FYM (M_1)	51.65	21.8	59.7	161.3	11.0	4.7	322.8	484.1	239.1	1387	124.6	46.3
Vermicompost (M_2)	55.32	24.6	58.8	186.6	12.8	6.5	373.5	560.1	276.6	1525	136.9	56.2
Poultry manure (M_3)	53.35	23.1	59.5	176.5	12.5	5.7	353.7	529.9	261.7	1456	130.7	50.2
CD (P = 0.05)	0.13	0.1	0.2	4.3	0.3	0.2	8.4	12.8	6.5	17	1.6	2.0
Spacing (S)												
45 cm × 45 cm (S_1)	51.26	23.7	58.6	178.6	12.6	6	357.7	536.1	264.7	1496	134.4	39.4
30/60 cm × 45 cm (S_2)	55.62	22.6	60.0	171.0	11.6	5.2	342.3	513.2	253.5	1416	127.2	62.4
CD (P = 0.05)	0.10	0.1	0.1	3.5	0.2	0.2	6.9	10.4	5.3	14	1.3	1.6
Intercrops (C)												
Broccoli (C_1)	61.80	26.3	57.1	186.0	14.3	8.4	372.5	558.0	275.6	1575	141.5	0.0
Beet leaf (C_2)	53.43	21.9	59.5	175.0	10.9	4.8	350.6	525.7	259.6	1451	130.3	59.8
Coriander (C_3)	52.44	23.7	59.4	175.9	12.4	5.8	352.3	528.3	260.9	1450	130.2	23.4
Fenugreek (C_4)	53.33	24.1	59.3	177.7	12.3	5.9	355.6	533.7	263.6	1483	133.3	56.0
Radish (C_5)	46.20	19.8	61.3	159.1	10.6	3.4	318.7	477.8	235.9	1320	118.6	115.3
Mean (M,S,C)	53.44	23.2	59.3	174.7	12.1	5.7	350.0	522.7	259.1	1454	130.8	50.9
CD (P = 0.05)	0.24	0.1	0.3	0.1	0.3	0.1	0.9	0.9	0.4	5	0.6	1.6

pH= Plant height (g), NL= number of leaves, DFH= days to first and 50% head harvesting, WMH= weight of main head (g), GMH= girth of main head (cm), NS= number of sprouts per plant, YS= Yield of sprouts per plant (g), TYPP= Total yield per plant (g) (main head+sprouts), TYPH= Total yield per hectare (q), PBFW= Plant biomass on fresh weight basis (g), PBDW= Plant biomass on dry weight basis (g) and TYI= Total yield of intercrops (q).

between the rows of broccoli showed significant effects on growth and yield of broccoli. The maximum plant height (55.32 cm), number of leaves (24.6), minimum days taken to first and 50 per cent head harvesting (58.8), weight of main head (186.6 g), girth of main head (12.8 cm), number of sprouts/plant (6.5), yield of sprouts/plant (373.5 g), total yield (main head+sprouts)/plant (560.1 g), total yield/hectare (276.6 q/ha), plant biomass of broccoli on fresh weight basis (1 525 g) and dry weight basis (136.9 g) of broccoli and total yield of intercrops (56.2 q/ha) was found with the application of vermicompost. The application of vermicompost was found more effective due to better aeration, water holding capacity and might have increased the nutrient use efficiency, supply of micronutrients and availability of major nutrients due to favourable soil condition followed by poultry manure and FYM in respect of all the above characters. The results indicated that the treatments receiving high doses of nutrients resulted in hastening of different reproductive growth phases of broccoli, whereas the commencement of different reproductive phases were drastically delayed in case of plants receiving low rate of nutrients or no nutrients (Chaudhary *et al.* 2012 and Kumar *et al.* 2013). Similar results were presented by Kale (2006) in different vegetables.

The crop geometry on broccoli crop had shown a significant effect on growth and yield attributes. The maximum number of leaves (23.7), weight of main head (178.6 g), girth of main head (12.6 cm), number of sprouts/plant (6.0), yield of sprouts/plant (357.7 g), total yield (main head+sprouts)/plant (536.1 g), total yield/hectare (264.7 q/ha), plant biomass of broccoli on fresh weight basis (1 496 g) and dry weight basis (134.4 g) of broccoli were observed in normal spacing due to less competition for growing space and light (Table 1). The minimum days taken to first and 50% head harvesting (58.6) were also recorded in normal spacing. However, maximum plant height (55.62 cm) and total yield of intercrops (62.4 q/ha) were recorded in paired row planting (30/60 × 45 cm) due to closer spacing that supported erect growth as compared to normal spacing.

Table 2 Interaction effect of organic manures, crop geometry and intercrops on plant height, number of leaves and days taken to first and 50% harvesting of heads (pooled mean of two years)

Intercrops grown in broccoli	Plant height (cm)											
	M_1			M_2			M_3			Mean for plant spacing		Mean for organic manures
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	
C_1	57.40	62.44	59.92	60.89	66.01	63.45	59.61	64.43	62.02	59.30	64.29	61.80
C_2	49.56	53.56	51.56	52.61	58.17	55.39	51.57	55.09	53.33	51.25	55.61	53.43
C_3	48.53	52.80	50.67	51.93	56.27	54.10	50.63	54.49	52.56	50.36	54.52	52.44
C_4	49.37	53.34	51.36	51.38	60.04	55.71	49.93	55.91	52.92	50.23	56.43	53.33
C_5	43.56	45.90	44.73	46.93	48.97	47.95	44.91	46.94	45.93	45.13	47.27	46.20
Mean	49.68	53.61	51.65	52.75	57.89	55.32	51.33	55.37	53.35	51.25	55.62	53.44
CD (P = 0.05) for interaction : Manures × Spacing = 0.10, Manures × Intercrops = 0.15, Spacing × Intercrops = 0.12, Manures × Spacing × Intercrops = 0.21												
Intercrops	*Number of leaves*											
C_1	24.4	23.6	24.0	30.1	26.7	28.4	27.8	25.4	26.6	27.4	25.2	26.3
C_2	21.4	21.1	21.3	24.3	22.8	23.6	21.0	20.6	20.8	22.2	21.5	21.9
C_3	21.1	22.5	21.8	24.9	25.1	25.0	24.3	23.9	24.1	23.4	23.8	23.6
C_4	22.7	23.6	23.2	26.0	25.6	25.8	23.4	23.4	23.4	24.0	24.2	24.1
C_5	20.1	17.4	18.8	21.6	18.4	20.0	22.5	18.8	20.7	21.4	18.2	19.8
Mean	21.9	21.6	21.8	25.4	23.7	24.6	23.8	22.4	23.1	23.7	22.6	23.2
CD (P = 0.05) for interaction : Manures × Spacing = 0.1, Manures × Intercrops = 0.1, Spacing × Intercrops = 0.1, Manures × Spacing × Intercrops = 0.1												
Intercrops	*Days taken to first anf 50% harvesting*											
C_1	57.0	57.9	57.5	55.4	58.0	56.7	55.9	58.2	57.1	56.1	58.0	57.1
C_2	59.4	60.7	60.1	58.0	59.8	58.9	58.3	60.7	59.5	58.6	60.4	59.5
C3	59.2	59.9	59.6	57.7	60.0	58.9	58.9	60.4	59.7	58.6	60.1	59.4
C_4	58.5	60.5	59.5	58.2	59.4	58.8	59.0	60.2	59.6	58.6	60.0	59.3
C_5	61.3	62.3	61.8	59.9	61.0	60.5	62.2	61.0	61.6	61.1	61.4	61.3
Mean	59.1	60.3	59.7	57.8	59.6	58.7	58.9	60.1	59.5	58.6	60.0	59.3
CD (P = 0.05) for interaction: Manures × Spacing = 0.3, Manures × Intercrops = NS, Spacing × Intercrops = 0.5, Manures × Spacing × Intercrops = 0.9												

Table 3 Interaction effect of organic manures, crop geometry and intercrops on plant height, girth of head and number of sprouts of broccoli at final harvest of heads (pooled mean of two years)

Intercrops grown in broccoli	Weight of main head (g)											
	M_1			M_2			M_3			Mean for plant spacing		Mean for organic manures
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	
C_1	175.4	170.4	172.9	205.0	195.4	200.2	188.6	181.6	185.1	189.7	182.5	186.1
C_2	162.1	156.0	159.1	189.7	186.5	188.1	184.8	171.7	178.3	178.9	171.4	175.1
C_3	163.4	157.7	160.6	190.7	185.8	188.3	183.6	174.6	179.1	179.2	172.7	176.0
C_4	165.7	160.1	162.9	194.0	186.7	190.4	185.9	174.2	180.1	181.9	173.7	177.8
C_5	155.4	147.4	151.4	170.7	161.0	165.9	164.1	156.3	160.2	163.4	154.9	159.2
Mean	164.4	158.3	161.4	190.0	183.1	186.6	181.4	171.7	176.5	178.6	171.0	174.8
CD (P = 0.05) for interaction : Manures × Spacing = NS, Manures × Intercrops = 0.2, Spacing × Intercrops = 0.2, Manures × Spacing × Intercrops = 0.3												
Intercrops	*Girth of head (cm)*											
C_1	13.6	12.8	13.2	15.9	14.9	15.4	14.9	14.2	14.6	14.8	14.0	14.4
C_2	10.8	9.3	10.1	12.0	10.9	11.5	11.4	11.2	11.3	11.4	10.5	10.9
C_3	11.9	9.9	10.9	13.4	12.5	13.0	13.8	12.7	13.3	13.0	11.7	12.4
C_4	12.0	10.0	11.0	13.8	12.8	13.3	12.5	12.9	12.7	12.8	11.9	12.3
C_5	10.7	9.2	10.0	10.8	10.9	10.9	11.5	10.5	11.0	11.0	10.2	10.6
Mean	11.8	10.2	11.0	13.2	12.4	12.8	12.8	12.3	12.6	12.6	11.6	12.1
CD (P = 0.05) for interaction : Manures × Spacing = 0.4, Manures × Intercrops = 0.4, Spacing × Intercrops = NS, Manures × Spacing × Intercrops = 0.6												
Intercrops	*Number of sprouts/plant*											
C_1	6.6	6.1	6.4	10.4	9.2	9.8	9.5	8.5	9.0	8.8	7.9	8.4
C_2	4.5	4.2	4.4	5.7	5.0	5.4	4.8	4.3	4.6	5.0	4.5	4.8
C_3	5.6	5.0	5.3	7.1	6.1	6.6	6.6	4.7	5.7	6.4	5.3	5.9
C_4	5.7	5.0	5.4	6.9	6.4	6.7	6.4	5.0	5.7	6.3	5.5	5.9
C_5	2.3	1.8	2.0	4.6	3.9	4.2	4.1	3.4	3.7	3.7	3.0	3.3
Mean	4.9	4.4	4.7	6.9	6.1	6.5	6.3	5.2	5.7	6.1	5.2	5.6
CD (P = 0.05) for interaction : Manures × Spacing = 0.3, Manures × Intercrops = 0.2, Spacing × Intercrops = 0.1, Manures × Spacing × Intercrops = 0.2												

Singh *et al.* (2004) suggested that closer spacing of broccoli tended to produce taller plant than widely spaced plant. This might be due to competition of solar energy couple with shallow root system and higher plant height at closer spacing. Rakesh *et al.* (2006) recorded significant results in respect to different growth parameters of broccoli on different spacings.

The growing of intercrops in broccoli had significant effects on the plant growth and yield of main crop. The growing of sole crop of broccoli recorded maximum plant height (61.80 cm), number of leaves, days taken to first and 50% head harvesting, weight of main head, girth of main head, number of sprouts per plant, yield of sprouts per plant, total yield per plant, total yield/ha, plant biomass of broccoli on fresh weight basis and dry weight basis of broccoli. However, amongst the intercropping patterns, the maximum plant height and girth of main head of broccoli plants were recorded with growing of beet leaf that was due to fast and vigorous growth of beet leaf that resulted in erect growth of broccoli plants, whereas all other growth and yield parameters were recorded with growing of fenugreek that was due to fixing of atmospheric nitrogen and small canopy growth of fenugreek, which was statistically at par in the treatment C_3 and C_2. However, the intercropping of radish had an adverse effect on growth and yield of broccoli due to intense competition for light, space, nutrients and moisture. Intercrops are most productive when their component crops differ greatly in growth duration so that their maximum requirements for growth resources occur at different times (Poodineh *et al.* 2014, Malhotra *et al.* 2011 and Olubode *et al.* 2015).

The interaction between organic manure, crop geometry and intercrops remarkably influenced the growth and yield parameters of broccoli and yield of intercrops (Table 2-5). The treatment $M_2S_1C_1$ was found superior in respect to all growth and yield parameters of broccoli except minimum

Table 4 Interaction effect of organic manures, crop geometry and intercrops on yield of sprout, total yield/plant and total yield/ha of broccoli at final harvest (pooled mean of two years)

Intercrops grown in broccoli	Yield of sprouts per plant (g)											
	M_1			M_2			M_3			Mean for plant spacing		Mean for organic manures
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	
C_1	350.0	339.0	344.5	410.5	391.2	400.9	380.8	363.5	372.2	380.4	364.6	372.5
C_2	324.5	312.3	318.4	379.8	373.4	376.6	369.9	343.7	356.8	358.1	343.1	350.6
C_3	327.1	315.8	321.5	381.8	372.0	376.9	367.5	349.5	358.5	358.8	345.8	352.3
C_4	331.8	320.4	326.1	388.5	373.8	381.2	372.2	348.7	360.5	364.2	347.6	355.9
C_5	311.1	295.1	303.1	341.8	322.4	332.1	328.5	312.9	320.7	327.1	310.1	318.6
Mean	328.9	316.5	322.7	380.5	366.6	373.5	363.8	343.7	353.7	357.7	342.2	350.0
CD (P = 0.05) for interaction : Manures × Spacing = NS, Manures × Intercrops = 1.5, Spacing × Intercrops = 1.3, Manures × Spacing × Intercrops = 2.2												
Intercrops	*Total yield/plant (g)*											
C_1	525.3	509.3	517.3	615.5	586.6	601.1	566.1	545.1	555.6	569.0	547.0	558.0
C_2	486.6	468.3	477.5	569.5	559.9	564.7	554.7	515.4	535.1	536.9	514.5	525.7
C_3	490.6	473.5	482.1	572.5	557.8	565.2	551.1	524.1	537.6	538.1	518.5	528.3
C_4	497.5	480.7	489.1	582.6	560.5	571.6	558.1	522.9	540.5	546.1	521.4	533.7
C_5	466.5	442.5	454.5	512.6	483.4	498.0	492.6	469.2	480.9	490.6	465.0	477.8
Mean	493.3	474.9	484.1	570.5	549.6	560.1	544.5	515.3	529.9	536.1	513.3	524.7
CD (P = 0.05) for interaction : Manures × Spacing = NS, Manures × Intercrops = 1.6, Spacing × Intercrops = 1.3, Manures × Spacing × Intercrops = 2.2												
Intercrops	*Total yield (q/ha)*											
C_1	259.4	251.5	255.5	304.0	289.7	296.9	279.6	269.2	274.4	281.0	270.1	275.6
C_2	240.3	231.3	235.8	281.3	276.5	278.9	273.9	254.5	264.2	265.2	254.1	259.6
C_3	242.2	233.8	238.0	282.7	275.5	279.1	272.2	258.8	265.5	265.7	256.0	260.9
C_4	245.7	237.4	241.6	287.7	276.8	282.3	275.6	258.2	266.9	269.7	257.5	263.6
C_5	230.4	218.5	224.5	253.1	238.7	245.9	243.3	231.7	237.5	242.3	229.6	236.0
Mean	243.6	234.5	239.1	281.8	271.4	276.6	268.9	254.5	261.7	264.8	253.5	259.1
CD (P = 0.05) for interaction : Manures × Spacing = NS, Manures × Intercrops = 0.5, Spacing × Intercrops = 0.4, Manures × Spacing × Intercrops = 8.0												

days taken to harvest and yield of intercrops, which were found best in the treatment $M_3S_1C_1$ and $M_2S_2C_1$, respectively. Application of vermicompost coupled with paired row spacing of 30/60 × 45 cm having sole broccoli crop recorded higher plant height (66.01 cm) followed by $M_3S_2C_1$. However, application of vermicompost with a spacing of 45 × 45 cm with sole crop of broccoli recorded maximum number of leaves (30.1), earliest days required to first and 50% harvesting (55.4) and weight of main head (205.0 g), maximum girth of head (15.9 cm), number of sprouts/plant (10.4), yield of sprouts/plant (410.5 g), total yield (main head + sprouts)/plant (615.5 g), total yield/ha (304.0 q) and biomass on fresh (1710 g) and dry weight (153.6 g). The above results demonstrated that combination of vermicompost + 45 × 45 cm + sole broccoli was superior over other combinations. Amongst the intercropping patterns, best results were observed in the treatment $M_3S_1C_4$ and worst in the treatment $M_1S_2C_5$ except plant height which was superior in the treatment $M_3S_2C_4$. Amongst the intercrop treatments, broccoli + fenugreek along with vermicompost application following the spacing of 45 × 45 cm ($M_2S_1C_4$) recorded highest yield and yield attributing characters followed by the treatment broccoli + fenugreek + 30/60 × 45 cm ($M_2S_2C_4$) except number of sprouts/plant which were found in the treatment ($M_2S_1C_3$). The treatment $M_2S_1C_3$ was found statistically at par with the treatment $M_2S_1C_4$ likewise treatment $M_2S_2C_3$ and $M_2S_2C_4$ for number of sprouts/plant, $M_2S_1C_2$ and $M_2S_1C_3$, $M_2S_2C_4$, $M_2S_2C_3$, and $M_2S_2C_2$ for yield of sprouts/plant, $M_2S_2C_4$, $M_2S_2C_2$, and $M_2S_2C_3$ for total yield/plant (main head + sprouts) and total yield/ha were statistically at par to each other. Application of organic based nutrients mainly biogas slurry + FYM, vermicompost + FYM and vermicompost alone recorded the maximum fruit size and more number of fruits/plant in tomato (Renuka and Ravishankar 1998). These findings clearly indicated that vermicompost played a significant role on enhancing the growth of broccoli. Improvement in plant growth attributes

Table 5 Interaction effect of organic manures, crop geometry and intercrops on plant biomass on fresh weight and dry weight basis and total yield of intercrop (pooled mean of two years)

Intercrops grown in broccoli	Plant biomass on fresh weight basis (g)											
	M_1			M_2			M_3			Mean for plant spacing		Mean for organic manures
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	
C_1	1521	1440	1481	1710	1612	1661	1609	1560	1585	1613	1,537	1,575
C_2	1395	1369	1382	1553	1491	1522	1476	1424	1450	1475	1,428	1,451
C_3	1419	1379	1399	1578	1438	1508	1500	1382	1441	1499	1,400	1,449
C_4	1409	1434	1422	1597	1512	1555	1530	1417	1474	1512	1,454	1,483
C_5	1312	1198	1255	1444	1312	1378	1386	1268	1327	1381	1,259	1,320
Mean	1411	1364	1388	1576	1473	1525	1500	1410	1455	1496	1,416	1,456
CD (P = 0.05) for interaction : Manures × Spacing = 23, Manures × Intercrops = 9, Spacing × Intercrops = 8, Manures × Spacing × Intercrops = 13												
Intercrops	*Plant biomass on dry weight basis (g)*											
C_1	136.6	129.4	133.0	153.6	144.8	149.2	144.6	140.1	142.4	144.9	138.1	141.5
C_2	125.2	122.9	124.1	139.5	133.9	136.7	132.6	127.9	130.3	132.4	128.2	130.3
C_3	127.4	123.8	125.6	141.7	129.2	135.5	134.8	124.2	129.5	134.6	125.7	130.2
C_4	126.5	128.8	127.7	143.5	135.8	139.7	137.5	127.3	132.4	135.8	130.6	133.2
C_5	117.8	107.6	112.7	129.6	117.9	123.8	124.5	113.8	119.2	124.0	113.1	118.5
Mean	126.7	122.5	124.6	141.6	132.3	137.0	134.8	126.7	130.7	134.4	127.2	130.8
CD (P = 0.05) for interaction : Manures × Spacing = 2.2, Manures × Intercrops = 1.1, Spacing × Intercrops = 0.9, Manures × Spacing × Intercrops = 1.5												
Intercrops	*Total yield of intercrops (q/ha)*											
C_1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C_2	35.9	76.7	56.3	47.0	86.6	66.8	37.1	75.4	56.3	40.0	79.6	59.8
C_3	15.6	28.4	22.0	16.2	35.6	25.9	14.0	30.9	22.5	15.3	31.6	23.5
C_4	40.1	60.1	50.1	40.1	81.7	60.9	38.0	75.7	56.9	39.4	72.5	56.0
C_5	91.9	114.7	103.3	113.5	140.7	127.1	101.7	128.9	115.3	102.4	128.1	115.2
Mean	36.7	56.0	46.3	43.4	68.9	56.1	38.2	62.2	50.2	39.4	62.4	50.9
CD (P = 0.05) for interaction : Manures × Spacing = 2.8, Manures × Intercrops = 2.7, Spacing × Intercrops = 2.2, Manures × Spacing × Intercrops = 3.9												

with the application of vermicompost might be due to better photosynthesis, energy storage, cell division and cell enlargement, moisture holding capacity, supply of micronutrients and availability of major nutrients due to favourable soil condition (Reddy *et al.* 1998, Uddin *et al.* 2009. Sinha *et al.* 2013, Jigme *et al.* 2015). Poultry manure also enhanced the vegetative growth of broccoli. It might be due to the fact that poultry manure contains uric acid having 60 per cent nitrogen. The uric acid rapidly changes to ammonia form causing its immediate and efficient utilization for better plant growth and development. These results were supported by Chaterjee *et al.* (2005) and Maurya *et al.* (2008). These results are in partial conformity with the findings of Kale (2006), Rakesh *et al.* (2006), Maurya *et al.* (2008), Choudhary *et al.* (2012), Devi and Singh (2012), Kumar *et al.* (2013), Mohapatra, *et al.* (2013), Poodineh *et al.* (2014) and Olubode *et al.* (2015). Based on the experimental results, it may be concluded that the application of vermicompost coupled with paired row spacing of 30/60 × 45 cm + fenugreek intercropped with broccoli improved the growth and yield of broccoli and yield of intercrops.

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