International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(3): 117-122

Received: 07-03-2020
Accepted: 09-04-2020

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Impact of mulch, spacing and fertilizer on growth, yield and economics of broccoli (*Brassica oleracea* L. Var. Italica) under crop cafeteria in Narsinghpur district M.P

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DOI: https://doi.org/10.22271/chemi.2020.v8.i3b.9212

Abstract
A two year field experiment was conducted to examine the impact of mulch, fertilizer and spacing on growth, yield and economics of broccoli (*Brassica oleracea* L. var. italica) under crop cafeteria in Narsinghpur District M.P. Performance of broccoli was evaluated under Effect of Spacing S_1(45x30cm) S_2(45x40cm) S_3(45x50cm)**,** effect of organic manure F_0 (No manure) F_1 (FYM) F_2 (vermi-compost) and effect of mulch M_0 (no mulch) M_1 (silver black polythene) M_2 (paddy straw) was applied. Experiment was performed with three replications with completely randomized design (RBD). The use of M_2 paddy straw mulch S_3(45x50 cm) spacing and F_2 Vermi-compost showed the superior results as compared to all other treatments. The maximum marketable yield 21.32 Kg and total Yield 27.03 Kg was recorded from paddy straw mulch while the minimum marketable yield 14.18 Kg and total yield 18.66 Kgwas recorded from un mulch condition. Where the maximum marketable yield 24.06 Kg and total Yield 30.07Kg was recorded from S_3while the minimum marketable 18.30Kg and total yield 23.76Kg was recorded from S_1 plant spacing.Maximum marketable yield 26.04 Kg and total Yield 32.17 Kg was recorded from F_2 while the minimum 11.68 Kg and total yield 15.55 Kg was recorded from F_0.

Keywords: Plant spacing, organic manure, mulching, brocoli, yield

Introduction
Broccoli, botanically known as *Brassica oleracea* L. var. italica, is native to the Mediterranean. Broccoli has been considered a very valuable food by the Italians since the Roman Empire, but when first introduced in England in the mid-18th century, broccoli was referred to as "Italian asparagus. "Broccoli (*Brassica oleracea* var. italica) is an herbaceous winter vegetable and commercial cultivated in India. There are two distinct forms of broccoli: sprouting broccoli, and heading broccoli. (Dhillon *et. al.* (2005) [4] stated that broccoli is one of the most important and popular vegetable crops in many countries of the world because of its good organoleptic properties and high nutritive value. Heading broccoli is the form most commonly grown in India. The curd of broccoli is formed from a compact flower head and produces a green curd that rapidly develops into a mass of fertile flower buds stated by Biggs, T. (1993). In India, its cultivation is negligible but now it is becoming increasingly popular in metro city. It prefers cool moist climate for quality heads. Broccoli has high nutritive value and many health benefits. The American Cancer Society (ACS) indicated that it has several anti-carcinogenic effects. It is a good source of vitamin A, calcium and Vitamin B_2 and minerals especially of potassium, phosphorus, sulphur and magnesium and micro elements (Aboul-Nasr *et al.* 2000 and Sander D.C.1996) [1, 12]. It also contains flavonoids, phenolic acids and soluble dietary fiber, disaccharides, beta carotene and amino acids (including a high content of lysine) too and it has antioxidant and anticancer activity (Podsędek, A., 2007) [8]**.**Broccoli soup is a delicacy in big hotels and resorts which is more nutritious than other coles, such as cabbage, cauliflower. Proper spacing, organic manure and mulch for production of brocoli are basic requirements for obtaining maximum yield and high return of broccoli (Salaria A. S. and Salaria B. S., 2011) [11]. Unless the broccoli plant grows inappropriate weather conditions, it will not change from a vegetative to a reproductive phase, and thus it will not produce head. Higher plant population reduced head size, lower average

marketable head weight and delay maturity. Best quality of broccoli heads are produced when the day temperature is between 25 °C to 26 °C and night temperature is between 15-16 °C. The studies on the use of plastic mulch have shown the remarkable results in terms of plants growth, yield, quality for the different vegetable crops. A variety of crop can be successfully grown using mulching (Bhardwaj R L. 2013) [2].
Among various cultural practices plant spacing, organic manure and mulch are also a very important factor for plant growth and development because it has significant effect on canopy development, soil moisture loss, ability to control emerging weeds, light interception and crop growth rate. Plant population is directly related to spacing, with more spacing number of plants per unit area is decreased. So, it provides more area for plant establishment. Whereas, with decrease in spacing plant population density will be more that causes less interception of light, aeration and shady effects. Depending on how close they are grown they can also receive less air/CO2 than they require for proper growth. Plants can therefore be more vulnerable to deprivation of essential nutrients if they are not provided enough space (Singh *et al.*, 2009, Seyfi and Rashidi, 2007 Parmar *et al.* 2013 Paul *et al.*, 2013) [14, 13, 6, 7].

Materials and Methods

Site and soil description

The field experiment was carried out during two successive growth seasons of 2016 and 2017, at Krishi Vigyan Kendra Narsinghpur, JNKVV, Jabalpur M.P. The site was located at between North latitude 22º 36' and 23 º 16' and east longitude 78º 27' and 797º 40'. The climate of the study area is sub-tropical with normal annual rainfall of Narsinghpur district is 1217.6 mm. District received maximum rainfall during south west monsoon period i.e. June to September. About 91.3% of the annual rainfall received during monsoon season. Only 8.7% of the annual rainfall takes place between Octobers to May period. The average wind speed in the area is 4.2 km/h. Physical properties of soils in the experimental plots were determined for 0-30cm depth. The soils are usually clay to loamy in texture with calcareous concretions invariably present They are sticky and in summers, due to shrinkage, develop deep cracks. The soils predominantly consist of montmorillonite type of clay minerals.

Soil test value of Experimental site

PH	EC (ds/m)	OC (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)	S (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	B (ppm)
7.2	0.12	0.54	269.3	11.6	254.1	18	4.5	0.97	0.72	0.64	1.12

Experimental treatments and design

The present investigation was executed at Crop cafeteria, Krishi Vigyan Kendra Narsinghpur, JNKVV, University, Jabalpur M.P. 2016-17. The experiment was laid out in a Randomized Block Designdesign with three replications. The experiment was carried out with three different plant spacing (S1- 45 cm × 30 cm, S2- 45 cm × 40 cm and S3- 45 cm × 50 cm). B Organic manure (No, FYM, Vermi compost) and effect of Mulch M0 (No Mulch), M1(Silver black poly mulch), M2(Paddy straw). To raise the crop recommended package of practices was followed. The date of seed sowing in nursery bed was on 20th October 2016 and date of transplanting on 25th November 2016 during Rabi season. Data recorded on plant height (at 20DAT, 40DAT, at harvest), number of leaves (at 20DAT, 40DAT, at harvest), days taken for curd initiation, days taken for harvesting, number of curd per plant, curd diameter, weight of primary curd, weight of secondary curd, marketable yield, unmarketable yield and total yield.

Factor A	Factor B	Factor C
Effect of Spacing	Effect of Organic Manure	Effect of Mulch
S_1(45x30)	F_0(No manure)	M_0(No Mulch)
S_2(45x40)	F_1(FYM)	M_1(Silverblack Polythene)
S_3(45x50)	F_2(Vermicompost)	M_2(Paddy Straw)

Results and Discussion

Effect of Mulch

Application of mulching had showed significant influence on the height of broccoli plants at 20, 40DAT and maturity (Figure 1). At 20 DAT, the highest plant height (21.21 cm) was measured from M_2 that was statistically similar to that of M1 while the lowest height (20.32 cm) was recorded from M_0. At 40 DAT, the highest plant height (34.76 cm) was measured from M_2 that was statistically similar to that of M_1 while the lowest height (31.23 cm) was recorded from M_0. At maturity, the highest plant height (51.56 cm) was measured from M_2 and the lowest height (49.20 cm) was recorded from M_0 treatment. It was revealed that the plot covered by paddy straw mulching gave better plant height then control. This might be due to mulching increased crop growth rate (CGR), net assimilation rate (NAR), leaf area index (LAI) and relative growth rate (RGR). Similar result was found by Rahman *et al.* 1989 [9] on growth of cabbage. Application of mulching was significantly influenced on the number of leaves of broccoli plants at 20, 40DAT and maturity (Figure 1). At 20 DAT, the maximum numbers of leaves (11.67) were found in M_2 that was statistically similar to that of M_1 while the minimum (10.23) were found in M_0. At 40 DAT the maximum numbers of leaves (15.89) were observed from M_2 that was statistically similar to that of M_1 while the minimum (13.45) were found in M_0. At maturity, the maximum numbers of leaves (20.34) were observed from M2 which was statistically similar to M_1 while the minimum (18.67) were found in M_0.

Effect of plant spacing

The more plant spacing showed most effective in comparison to less plant spacing. At 20 DAT highest height of the plant was achieved as (21.33 cm) in S_3(45 X 50 cm) spacing followed by S_2(20.90 cm) and lowest (20.32 cm) plant height was noticed in plant spacing S_1(45 X 30 cm). At 40 DAT, highest height of the plant was achieved as (38.45 cm) in 45 X 50 cm spacing followed by 45 X 40 (35.23 cm) and lowest 34.22 cm plant height was noticed in plant spacing 45 X 30 cm. At maturity, highest height of the plant was achieved as (56.34 cm) in 45 X 50 cm spacing followed by 45 X 40 (55.12 cm) and lowest (54.23 cm) plant height was noticed in plant spacing 45 X 30 cm. In case of number of leaves at 20DAT also 45 X 50 cm plant spacing was found most effective with maximum number of leaves 15.78 and followed by 14.34 respective plant spacing 45x40 cm99mh while minimum 12.23 were found in 45x 30 cm.At 40 DAT, maximum number of leaves was achieved as (19.45) in 45 X 50 cm spacing followed by 45 X 40cm (18.56) and lowest (16.39) maximum number of leaves was noticed in plant

spacing 45 X 30 cm. At maturity, highest height of the plant was achieved as 24.78 cm in 45 X 50 cm spacing followed by 45 X 40 (23.99 cm) and 21.46 cm minimum number of leaves was noticed in plant spacing 45 X 30 cm.

Effect of Organic Manure

Application of organic manure had showed significant influence on the height of broccoli plants (Figure 1). At 20 DAT, the highest plant height (21.52 cm) F_2 followed by (20.23 cm) F_1 and lowest (19.91 cm) plant height was noticed in F_0. At 40 DAT, the highest plant height (37.66 cm) F_2 followed by (35.50 cm) F_1 and lowest (33.34 cm) plant height was noticed in F0.At maturity, highest height of the plant was achieved as 56.34 cm in F_2 followed by (55.34 cm) in F_1 and lowest plant height was achieved (54.41 cm) in F_0.

Application of manure was significantly influenced on the number of leaves of broccoli plants at 20, 40 DAT and maturity (Figure 1). At 20 DAT, the maximum numbers of leaves (13.99) were found in F2 that was statistically similar to that of F1(13.79) while the minimum (9.89) were found in F_0. At 40 DAT the maximum numbers of leaves (18.12) were observed from F_2 that was statistically similar to that of F_1(17.34) while the minimum (14.67) were found in F_0. At maturity, the maximum numbers of leaves (23.26) were observed from F_2 which was statistically similar to F_1 (22.21) while the minimum (19.99) were found in F_0.

Yield parameters

The application of mulching significantly influenced the number of days required for curd initiation (Table 2). The minimum days (65.96) required for 80% curd initiation were observed from M_2 which was statistically similar to that of M_1 and the maximum (68.12) days were required by M_0. Application of mulching significantly influenced the Days taken to first harvest of broccoli plants (Table 2). The minimum days (85.45) from M_1 which was statistically similar to that of M_2(86.67) and the maximum (89.21) days were required by M_0. This results revealed that the No. of Curd per plant increase with mulching application. The maximum no. of curd per plant observed (13.32) from M_2 which was statistically similar to that of M_1(12.11) and the minimum (10.01) days were required by M_0. This result was revealed that the curd diameter increased with mulching application. This might be caused that mulching increase soil moisture that helps in water uptake by the plants. Similar trend of the result was found by Islam *et al.* (2014) [5]**.** Maximum curd diameter was observed from15.52cm was observed from M_2 and minimum curd diameter(12.25cm) found from M_o unmulch condition. Mulching showed a significant influence on weight of primary curd of broccoli plants (Table 2). The maximum primary curd weight (379.23 g) was measured from M_2 which was statistically similar to that of M_1(322.45 g) while the minimum weight of primary curd (290.23 g) was recorded from M_0.It was observed number of secondary curd increased with mulching application. Application of mulching exhibited a significant influence on weight of secondary curd of broccoli plants (Table 2). The maximum secondary curd weight (87.21 g) was recorded from M_2 which was statistically similar to that of M_1 (75.10 g) while the minimum (60.11 g) was recorded from M_0.It was observed marketable and total yield per plot increased with mulching application. Application of mulching exhibited a significant influence on marketable and total yield of broccoli plants (Table 2). The maximum marketable yield (21.32Kg) and total Yield (27.03 Kg) was recorded from M_2 which was statistically similar to that of M_1 (18.28Kg) and total yield (23.77 Kg) while the minimum (14.18 Kg) and total yield (18.66 Kg) was recorded from M_0.

The more plant spacing showed most effective in comparison to less plant spacing influenced the number of days required for curd initiation (Table 2). The minimum days (58.87) required for curd initiation were observed from S_3(45x50) which was statistically similar (60.23) to that of S_2(45x40) and the maximum (60.78) days were required by S_1(45x30). Spacing significantly influenced the Days taken to first harvest of broccoli plants (Table 2). The minimum days (79.56) from S_3(45x50) which was statistically similar to that of S_2(45x40) (81.56) and the maximum (82.23) days were required by S_1(45x30). The maximum no. of curd per plant observed (16.23) from S_1(45x30) which was statistically similar to that of S_2(45x40)(15.56) and the minimum (15.33) days were required by S_3(45x50). This result was revealed that the curd diameter increased with plant spacing (Table 2). The maximum primary curd diameter (20.67 cm) was measured from S_3(45x50) which was statistically similar to that of S_2(45x40) (20.22 cm) while the minimum curd diameter (19.39cm) from S_1(45x30). The maximum primary curd weight (638.45g) was measured from S_1(45x30) which was statistically similar to that of S_2(45x40) (602.34g) while the minimum weight of primary curd (590.22 g) was recorded from S_3(45x50). The maximum secondary curd weight (90.23g) was measured from S_3(45x50) which was statistically similar to that of S_2(45x40) (87.34g) while the minimum weight of secondary curd (81.78 g) was recorded from S_1(45x30). The maximum marketable yield (24.06 Kg) and total Yield (30.07Kg) was recorded from S_1(45x30) which was statistically similar to that of S_2(45x40) (21.35Kg) and total yield (27.03Kg) while the minimum (18.30 Kg) and total yield (23.76 Kg)was recorded from S_3. 45cm x 30cm plant spacing produced the highest main head yield and 45cm x 50cm plant spacing produced the lowest main head yield. Similar results has reprted by (Roy *et. al.* 1990) [10].

The application of manure significantly influenced the number of days required for curd initiation (Table 2). The minimum days (59.55) required were observed from F_2 which was statistically similar to that of F_1(61.46) and the maximum (67.25) days were required by F_0. Application of manuring significantly influenced the Days taken to first harvest of broccoli plants (Table 2). The minimum days (81.22) from F_2 which was statistically similar to that of F_1(82.56) and the maximum (88.34) days were required by F_0. This results revealed that the No. of Curd per plant increase with manuring application. The maximum no. of curd per plant observed (14.89) from F_2 which was statistically similar to that of F_1(12.34) and the minimum (9.78) days were required by F_0. This result was revealed that the curd diameter increased with manure application. This might be caused that manure increase soil moisture that helps in water uptake by the plants. The maximum curd diameter observed (19.45 cm) from F_2 which was statistically similar to that of F_1(18.88 cm) and the minimum (11.89 cm) days were required by F_0. The maximum primary curd weight (645.77 g) was measured from F_2 which was statistically similar to that of F_1(567.23 g) while the minimum weight of primary curd (285.23 g) was recorded from F_0. It was observed number of secondary curd increased with manuring. Application of manure exhibited a significant influence on weight of secondary curd of broccoli plants (Table 2). The maximum secondary curd weight (84.34 g) was recorded from F_2 which was statistically similar to that of F_1 (71.45 g) while the minimum (60.89 g) was recorded from

F_0. It was observed number of marketable and total yield per plot increased with manure application. Application of mulching exhibited a significant influence on marketable and total yield of broccoli plants (Table 2). The maximum marketable yield (26.04 Kg) and total Yield (32.17 Kg) was recorded from F2 which was statistically similar to that of F_1 (14.15 Kg) and total yield (18.62Kg) while the minimum (11.68 Kg) and total yield (15.52 Kg) was recorded from F_0.

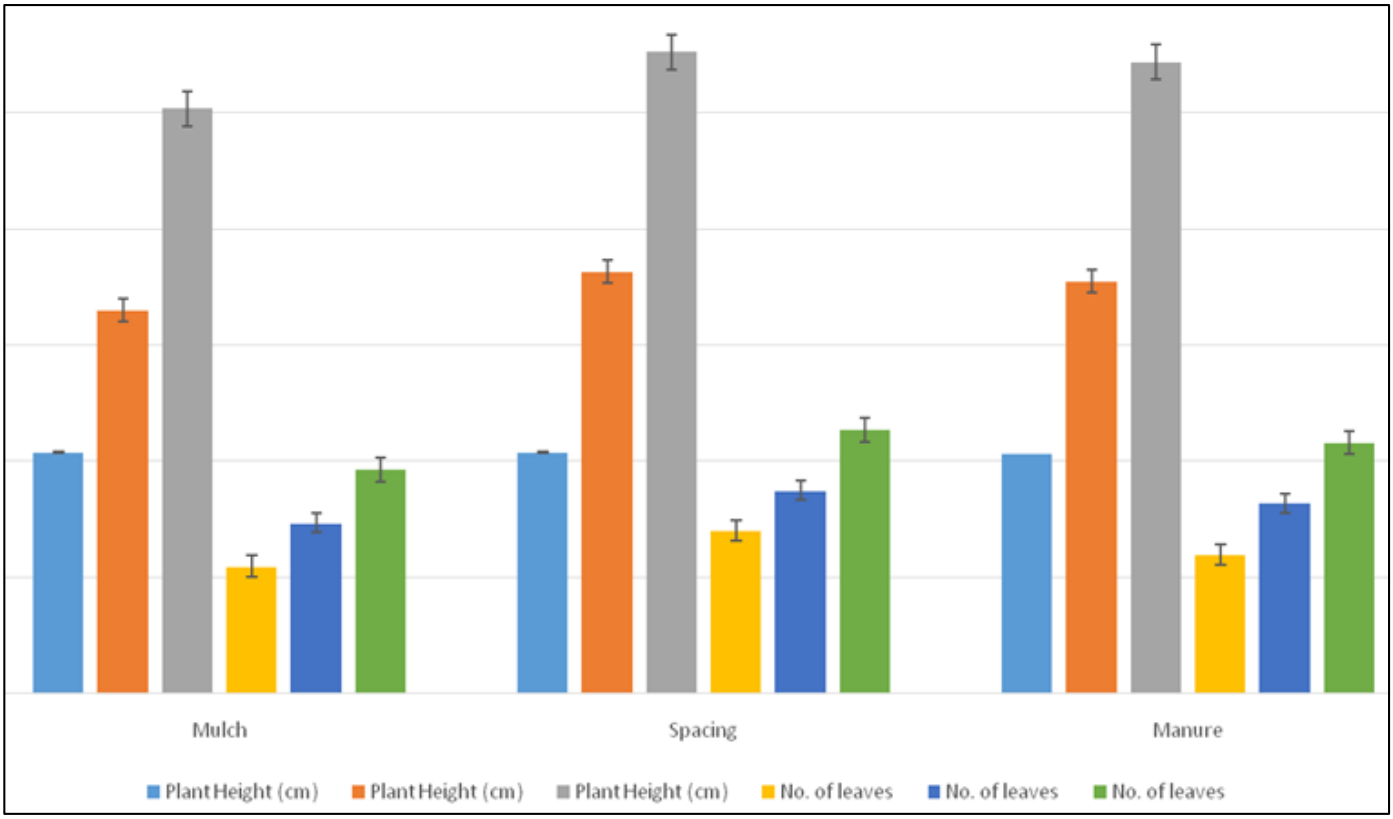

Fig 1: Effect of different treatment on Plant growth Parameters at the time of 20 DAT, 40 DAT and Harvesting

Table 1: Effect of different treatment on Plant growth parameters at the time of 20DAT, 40DAT and harvesting

Treatment	**Plant Height (cm)**			**No. of leaves**		
Mulch	**20DAT**	**40DAT**	**Harvesting**	**20DAT**	**40DAT**	**Harvesting**
M_0	20.32	31.23	49.24	10.23	13.45	18.67
M_1	20.52	32.48	50.23	10.55	15.55	19.89
M_2	21.21	34.76	51.56	11.67	15.89	20.34
Mean	20.75	32.995	50.4	10.95	14.67	19.28
SE	0.272845	1.033382	0.672119	0.436552	0.763006	0.498877
CV	2.277502	5.424669	2.309811	6.905301	9.008621	4.48174
Spacing	20DAT	40DAT	Harvesting	20DAT	40DAT	Harvesting
S_1(45x30)	20.32	34.22	54.23	12.23	16.39	21.46
S_2(45x40)	20.90	35.23	55.12	14.34	18.56	23.99
S_3(45x50)	21.33	38.45	56.34	15.78	19.45	24.78
Mean	20.8	36.335	55.285	14.005	17.475	22.725
SE	0.290593	1.275439	0.611583	1.030863	0.908741	1.001316
CV	2.419819	6.079882	1.916057	12.74906	9.007076	7.631814
Manure	20DAT	40DAT	Harvesting	20DAT	40DAT	Harvesting
No	19.91	33.34	54.44	9.89	14.67	19.99
FYM	20.23	35.50	55.34	13.79	17.34	22.21
Vermicompost	21.52	37.66	56.34	13.99	18.12	23.26
Mean	20.71	35.5	55.39	11.94	16.395	21.625
SE	0.492082	1.247077	0.548736	1.334583	1.044557	0.963898
CV	4.114461	6.084507	1.715903	19.35984	11.03523	7.720328

Table 2: Effect of different treatment with respect to days taken for Curd initiation, days taken for harvesting, Number of curd per plant, Curd diameter, weight of primary curd, weight of secondary curd, marketable yield, unmarketable yield and total yield

Treatment	Days for Curd initiation	Days taken to first harvest	No. of Curd per plant	Diameter of primary Curd	Weight of primary curd (g)	Weight of Secondary Curd (g)	Marketable yield	Un Marketable yield	Total yield
Mulch									
M_0	68.12	89.21	10.01	12.25	290.23	60.11	14.18	4.48	18.66
M_1	66.23	85.45	12.11	13.91	322.45	75.10	18.28	5.49	23.77
M_2	65.96	86.67	13.32	15.52	379.23	87.21	21.32	5.71	27.03
Mean	67.04	87.94	11.66	13.88	334.73	73.66	17.75	5.095	22.845
SE	0.679485	1.10749	0.96696	0.944004	26.01612	7.837808	2.068698	0.378697	2.435805
CV	1.755523	2.181292	14.35768	11.77576	13.46197	18.42992	20.18642	12.87383	18.46766
Spacing									
S_1(45x30 cm)	60.78	82.23	16.23	19.39	638.45	87.34	24.06	6.01	30.07
S_2(45x40cm)	60.23	81.56	15.56	20.22	602.34	81.78	21.35	5.68	27.03
S_3(45x50cm)	58.87	79.56	15.33	20.67	590.22	90.23	18.30	5.46	23.76
Mean	59.825	80.895	15.78	20.03	614.335	88.785	21.18	5.735	26.915
SE	0.567656	0.802004	0.269959	0.374893	14.48555	2.479563	1.663734	0.159826	1.821943
CV	1.643475	1.71718	2.963133	3.241802	4.084043	4.837224	13.60563	4.826979	11.72468
Manure									
No	67.25	88.34	9.78	11.89	285.23	60.89	11.68	3.90	15.55
FYM	61.46	82.56	12.34	18.88	567.23	71.45	14.15	4.47	18.62
Vermicompost	59.55	81.22	14.89	19.45	645.77	84.34	26.04	6.13	32.17
Mean	63.4	84.78	12.335	15.67	465.5	72.615	20.095	5.3	25.395
SE	2.314954	2.184521	1.475131	2.430576	109.4637	6.780561	4.432723	0.668888	5.105834
CV	6.324318	4.462965	20.71343	26.86587	40.7297	16.17335	38.20702	21.8594	34.82404

Experimental sites photographs at different stages

Conclusions

Impact of Mulch, Spacing and Fertilizer on growth, yield and economics of broccoli (*Brassica oleracea* L. var. italica) under crop cafeteria in Narsinghpur District M.P. The effect of different Mulch, Spacing and manure on the growth, yield of broccoli was evaluated. The results of the study indicated that the treatment of paddy straw mulch, maximum spacing S_3 45x50 cm and vermicompost F_2 showed the best results as compared to all other treatments. The maximum marketable yield (21.32 Kg) and total Yield (27.03 Kg) was recorded from paddy straw mulch whereas, the maximum marketable yield (24.06 Kg) and total Yield (30.07Kg) was observed under treatment S_3(45x50) and Maximum marketable yield (26.04 Kg) and total Yield (32.17 Kg) was observed under treatment F_2Application of mulch showed significant increase in yield under spacing 45x 50 cm with vermicompost. Use of mulching, manuring and proper spacing for broccoli production can be technically viable option for the farmers of Narsinghpur district, which can give them higher yields and returns under water stress periods ascompared to the present practice of keeping their fields fallow.

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