Effect of different plant spacings and varieties on growth yield and quality attribute characters of sprouting broccoli (*Brassica oleracea* var. *italica* Plenck)

Abstract

To investigate the effect of different plant spacing (S_1 (45x45 cm), S_2 (60x45 cm), and S_3 (50x45 cm) and varieties (V_2 Pusa KTS-1, V_3 Ganesh, and V_1 Broccoli Green) on different quality attributes in sprouting broccoli (*Brassica oleracea* var. *italica* Plenck) with nine treatments. The field experiment was conducted at the Horticulture Research farm of the Department of Horticulture, Babasaheb Bhimrao Ambedkar University (A Central University), Vidya-Vihar, Rae-Barely Road, Lucknow-226025 (U P), India during the Kharif season of 2019-2020 in a Randomized Block Design. On November 16th, 2019, week 2nd, seedlings of three different cultivars (V_2 Pusa KTS-1, V_3 Ganesh, and V_1 Broccoli Green) were transplanted in the field at three different plant spacing. S_1 (45 x 45 cm), S_2 (60 x 45 cm), and S_3 (50 x 45 cm) were transplanted. They investigated different parameters such as growth parameters, plant height, number of leaves, length of leaves (cm), days to 50% curd initiation and 50% curd maturity, and in the case of yield parameters such as number of auxiliary branches in broccoli, weight of curd, as well as in quality parameters such as curd colour, shape of curd, curd compactness, etc. I have found that significant performance of varieties with spacing and varieties at a given parameter (S_2 60 x 45 cm) is performed better with Pusa KTS-1 as compared to (S_3 50 x 45 cm) with variety Ganesh, and at a lower recorded at (S_1 45 x 45 cm) with variety Green Broccoli.

Keys words:- Broccoli, Spacing, Varieties.

Introduction:-

Broccoli (*Brassica oleracea* var. *italica* Plenck) is a member of the Cole group of crops. It is a native place in the Mediterranean region. The word "cole" is abbreviated from "caulis", which means stem. Broccoli belongs to the family Brassicaceae. All the Cole group of crops originated from a common ancestor, wild cabbage/colewort's (*Brassica oleracea*var. *Sylvestris*). Broccoli is an Italian word derived from the Latin word brachium, meaning an arm or branch **(Thamburaj and Singh 2013).** Morphologically, broccoli resembles cauliflower, but the major difference between cauliflower and broccoli is cauliflower's lack of an auxiliary branching habit. The edible parts of the broccoli crop are the modified inflorescence and the flower stalk terminal head. Broccoli grown in India is commonly known as green sprouting broccoli or Calabrese. In the case of broccoli, after the completion of the growth of the primary inflorescence (terminal head), a small secondary inflorescence (sprout) appears in the axils of the lower leaves. They are used for salads with half-boiled vegetables. It is also used in soups with other vegetable juices or as a single vegetable mixed with potatoes. It has been found that delicious taste and good flavour, as well as nutritive

values, are very high and are easily preferred by cardiac patients. Broccoli is an important, fancy, and highly nutritive exotic vegetable. Broccoli is a rich source of sulphoraphane, which is associated with reducing the risk of cancer **(Guo et *al.*, *2001),*** also found carcinogenic and antioxidant. The primary inflorescence was characterised by higher levels of dry matter, total nitrogen, vitamin-C, chlorophylls, beta-carotene, and carotenoids and by lower levels of nitrates. The growth, yield, and quality of crop plants are mainly influenced by two principal factors, viz., genetically and cultural or management factors. The first factor deals with the various breeding techniques for the improvement of crop varieties. The second factor deals with horticultural practices, *viz.*, plant population, date of planting, fertiliser dose, irrigation, weed control, etc. Among them, the plant population per unit area is very important. They are high-demand Chinese cabbage, red cabbage, Brussels sprout, and broccoli crops.In its edible portion, broccoli has the highest nutritive value of vitamin A (9000 IU/100g), thiamine (33mg/100g), vitamin C (137mg/100g), calcium (103mg/100g), phosphorus (78mg/100g), and potassium (382mg/100g). Sprouting broccoli has 130 times more vitamin A than cauliflower and 22 times more than cabbage. Heading broccoli is highly nutritive and it contains 3.3%protein.

Materials and methods:-

The present experiment was conducted during rabi season October to February on Horticulture Research farm Department of horticulture , Babasaheb Bhimrao Ambedkar University (A Central University) Vidya Vihar Rae Bareli Road Lucknow- 226025(U P), India during of 2019-2020. Geographically luck now in situated at $26^{O}50'$ North latitude, and $80^{O}52'$ East longitude and altitude of 123 meter above mean sea level (MSL). Lucknow has sub-tropical climate with an average annual rainfall of about 1000 mm. The winters are severing and summer is dry and hot. The maximum temperature generally goes to 43℃ in summer and minimum up to 3℃ in winter. Monsoon generally sets in during third week of June and recedes by the end of September with heavy rainfall during monsoon season. Meteorological observation taken by IISR Lucknow and soil type of field was sandy clay loam with slightly alkaline while pH is near about 6.5 to 8.5. The experiment is done in RBD design with two factors (factor.1-variety and factor 2- spacing in 9 treatments with 3replication and 27 numbers of plot and net plot size 2.40m x 1.80m (3meter length and 1 meter width) and Grass cultivated area 24.1meter X 7.9 meter. The seedling become ready for transplanting 28 days after sowing (4 to 5 leaf stage). The treatments comprised of three varieties (Pusa KTS-1, broccoli green, Ganesh) and three planting spacing (60 x 45cm, 50x45cm ,45 x 45 cm) Observations recorded were growth parameters, plant height, number of leaves, length of leaves(cm), days to 50% curd initiation and days to 50% curd maturity, and in case of yield parameter such as number of auxiliary branch in broccoli, as well as in quality parameter curd colour, shape of curd, curd compactness, etc**.** Statistical analysis of data obtained in different set of experiments was calculated following the standard procedure. Application of fertilizer in field at the recommended dose of our crop in the field, 100kg of

N_2 and 80 kg of P_2O_5 and as well as 60 kg of K_2O kg/ha. The fertiliser is applied with a half dose of **N, a** full dose of **P,** and a full dose of **K** at the time of transplanting as per recommended. The half doses of N are given twice in the experiment field, one of them at 30 days and another at 45 days after transplanting.

Results and Discussion

Effect of varieties:-

The data was collected on a daily basis for the first few days after transplantation. The data presented in the table reveals a significant effect of variety. Among the varieties, with respect to plant height, number of leaves, and length of leaves (cm), we recorded that V_2 (Pusa KTS-1) showed maximum plant height superior to that of V_3 (Genesh), while V_1 (Broccoli Green) recorded a lesser plant height,number of leaves, and number of leaves than that recorded by **Singh *et al.* (2014).** While in the case of days after 50% curd initiation, it was recorded that varieties V_2 (Pusa KTS 1) take more days for 50% curd initiation than V_3 (Ganesh), while the fewer days taken for 50% curd initiation were found in variety V_1 (Broccoli Green) reported by **Thapa *et al.* (2013) and Thapa and Rai (2012).** As well as days after 50% curd maturity Varieties expressed significant effects on days of 50% curd maturity as per data recorded. According to **Singh et al. (2014) and Thapa and Rai (2012),** variety V2 (Pusa KTS-1) takes the most days to reach 50% curd maturity, followed by variety V3 (Ganesh) and variety V1 (Broccoli Green). In the case of yield parameters such as number of auxiliary branches in broccoli and curd weight, they found among the varieties, number of auxiliary showed a significant effect. V2 (Pusa KTS-1) provides the maximum number of auxiliary inflorescence as compared to V3 (Genesh). **Ngullie and Biswas (2014)** report that V1 (Broccoli Green) has fewer auxiliary genes. In the case of quality parameters such as curd colour, shape of curd, and curd compactness, they have found In the case of Pusa KTS-1, the green colour is flat and slightly loose; in the case of Ganesh, the dark green colour is domic and compact; and in the case of Broccoli Green, the green colour curd and head shape curd and slightly loose similar result found **Bhangre *et al.* (2011).**

Effect of spacing:-

The data was collected on a regular basis for several days after the broccoli crop was planted. The data presented in the table reveals a significant effect of spacing. With respect to the spacing, with respect to plant height, number of leaves, and length of leaves (cm), we have recorded that S2 (60x45cm) is the maximum as compared to S3 (50x45cm), where minimum plant height is recorded at spacing S1 (45x45cm) observed by **Singh *et al.* (2006), Bhangre *et al.* (2011), and Yadav *et al.* (2016).** Among the plant spacing, the maximum number of leaves is observed at spacing S2 (60x45cm) at a maximum as compared to S3 (50x45cm), where the minimum number of leaves is recorded at spacing S1 (45x45cm). The same result is found by **Singh et al. (2006), Gariya *et al.* (2016), and Yadav *et al.* (2016).** While in the case of the length of leaves (cm) and width of leaves (cm), there is a significant effect of plant spacing on leaf length. Maximum leaf length spacing S2 (60x45cm) is recorded as maximum as compared to S3 (50x45cm), while minimum leaf length is also recorded. S1 spacing (45 x 45 cm). Plant spacing exerted a significant effect on the number of days to 50% curd

initiation. Plant spacing S2 (60x45cm) takes more days as compared to S3 (50x45cm), where minimum days are recorded at spacing S1 (45x45cm). Similar results have been reported by **Thapa and Rai (2012) and Rhapa *et al*. (2013) in broccoli**. as well as days after 50% curd maturity Plant spacing S2 (60x45cm) takes more days to reach 50% curd maturity as compared to S3 (50x45cm), where minimum days are recorded at spacing S1 (45x45cm). Plant spacing showed a significant effect on the number of days to 50% curd maturity on the broccoli crop. Similar results have been reported by **Singh *et al.* (2014).** In the case of yield parameters such as number of auxiliary branches in broccoli and curd weight, they have found that at plant spacing, maximum weight of curd and number of auxiliary branches are observed at spacing S2 (60x45cm) as compared to S3 (50x45cm), where minimum weight of curd is recorded at spacing S1 (45x45cm). They have found a significant effect of the weight of curd on spacing. These results are in agreement with **Prasad *et al.* (2010) and Bhangre *et al.* (2011).** In terms of quality parameters, curd color, curd shape, and curd compactness, they found that Pusa KTS-1 in all spacing, where they revealed green colour curd, flat shape, and slightly loose curd; Ganesh in all spacing, where they found that dark green colour curd, domic shape, and compact of the curd; and Broccoli Green varieties in all spacing, where they found that green colour curd, head shape, and slightly loose compact of curd. Similar results are found by **Bhangre *et al*. (2011).**

Interaction effect of varieties and spacing:-

Among varieties and spacing interaction effects, significant for growth parameters such as plant height, number of leaves, length of leaves (cm) and quality parameters such as weight of curd and number of auxiliary branches, while in the case of quality parameters, curd colour, curd shape, and curd compactness are influenced by varieties but not influenced by spacing.

Conclusion:-

Finally, after our experiment, we found that the combined effect of varieties and spacing on the growth parameters such as plant height, number of leaves, length of leaves (cm), days to 50% curd initiation and days to 50% curd maturity was significant, and yield parameters such as curd weight and number of auxiliary branches were also significant. The variety V_2 (Pusa KTS-1) with a wider spacing S_2 (60 x 45 cm) is shown to be most effective in growing the vegetative growth attributes over V_3 (Ganesh) with a wide spacing S3 (50 x 45 cm) and the minimum vegetative growth obtained at V_1(Broccoli Green) with a wide spacing S1 (45 x 45 cm). While in the case of days to 50% curd initiation and days to 50% curd maturity, they found that varieties V_2 (Pusa KTS 1) with a wide spacing S_2 (60 x 45 cm) take more days for curd initiation and curd maturity as compared to V_3 (Ganesh) with a wide spacing S3 (50x45cm), while minimum days are taken by V_1 (Broccoli Green) with a wide spacing S1 (45x45cm). While in the case of quality parameters such as weight of curd and number of auxiliary branches, while in the case of quality parameters, curd colour, curd shape, and curd compactness are influenced by varieties but not influenced by spacing. So this significant result is recommended for commercial cultivation under Lucknow conditions.

Table no-1 Effect of different spacing and varieties on growth, yield parameter.

Treatment	Plant height (cm)			Number of leaves			Length of leaves (cm)			Days after 50% curd initiation	Days after 50% curd maturity	Weight of cured	Number of auxiliary branch
	30DAT	45DAT	60DAT	30DAT	45DAT	60DAT	30DAT	45DAT	60DAT				
V1		22.9	35.6	6.2	8.9	11.4	7.2	14.3	19.2	57.7	62.6	137.8	6.7
V2	16.6	25.3	36.9	8.0	11.0	13.1	8.2	16.2	20.8	68.4	73.2	193.8	10.6
V3	15.9	24.13	36.7	7.4	10.4	12.9	7.7	15.5	20.5	62.8	68.9	149.8	10.2
SEm ±	0.24	0.25	0.27	0.22	0.27	0.31	0.16	0.22	0.26	0.54	0.51	8.80	0.18
CD(P=0.05)	0.72	0.76	0.82	0.67	0.81	0.95	0.49	0.65	0.80	1.64	1.55	25.60	0.54
Spacing													
S1	15.1	23.3	35.4	6.7	9.4	11.7	7.3	14.3	18.9	59.6	64.3	141.1	7.7
S2	16.3	24.7	37.4	7.6	10.6	13.1	8.0	16.2	21.3	65.3	71.2	183.2	10.22
S3	15.9	24.4	36.4	7.4	10.3	12.7	7.7	15.5	20.3	63.4	69.1	156.1	9.5
SEm ±	0.24	0.25	0.27	0.22	0.27	0.31	0.16	0.22	0.26	0.54	0.51	8.80	0.18
CD(P=0.05)	0.72	0.76	0.82	0.67	0.81	0.95	0.49	0.65	0.80	1.64	1.55	25.60	0.54

Table no-2 Interaction effect different plant spacing and varieties on growth yield and quality of broccoli crop.

Interaction	Plant height (cm)	Number of leaves	Length of leaves (cm)	Days after 50%	Days after 50%	Weight of cured	Number of auxilia

										curd initiation	curd maturity		ry branch
	30DAT	45DAT	60DAT	30DAT	45DAT	60DAT	30DAT	45DAT	60DAT				
V1S1	14.7	22.2	35.2	5.3	7.7	10.7	6.9	12.8	17.5	55.3	60.7	134.5	5.7
V1S2	15.5	23.5	36.0	6.7	9.7	11.3	7.1	15.5	21.0	57.3	62.7	141.4	6.7
V1S3	14.7	23.1	35.7	6.7	9.3	12.3	7.5	14.6	19.2	58.7	64.3	137.7	7.7
V2S1	15.3	24.2	35.3	7.3	10.3	12.7	7.7	15.6	19.7	64.7	67.7	169.9	9.7
V2S2	17.9	26.9	39.1	9.3	12.3	15.3	9.2	17.6	22.5	75.3	81.3	259.5	13.3
V2S3	16.4	24.9	36.2	7.3	10.3	11.3	7.6	15.4	20.5	65.3	70.7	151.9	8.7
V3S1	15.5	23.5	35.7	7.3	10.3	11.7	7.3	14.4	19.7	59.6	64.7	122.1	7.7
V3S2	15.4	23.6	36.9	6.7	9.7	12.7	7.7	15.7	20.6	65.3	69.7	148.8	10.2
V3S3	16.8	25.2	37.3	8.3	11.3	14.3	8.1	16.4	21.2	63.4	72.3	178.5	9.5
SEm ±	0.41	0.44	0.47	0.39	0.45	0.54	0.28	0.37	0.46	0.94	0.89	15.23	0.31
CD(P=0.05)	1.25	1.32	1.41	1.16	1.41	1.64	0.83	1.12	1.38	2.84	2.68	46.1	0.94

Table no-3 Effect of different spacing and varieties on quality parameter of broccoli crop.

Treatment		**Colour**	**Shape**	**Compactness**
Varieties	**Spacing**			
Ganesh broccoli	**S_1(45x45cm)**	Dark green	Domic	Compact

	S_2(60x45cm)	Dark green	Domic	Compact
	S_3(50x45cm)	Dark green	Domic	Compact
Pusa KTS 1	**S_1(45x45cm)**	Green	Flat	Slightly loose
	S_2(60x45cm)	Green	Flat	Slightly loose
	S_3(50x45cm)	Green	Flat	Slightly loose
Broccoli Green	**S_1(45x45cm)**	Green	Head	Slightly loose
	S_2(60x45cm)	Green	Head	Slightly loose
	S_3(50x45cm)	Green	Head	Slightly loose

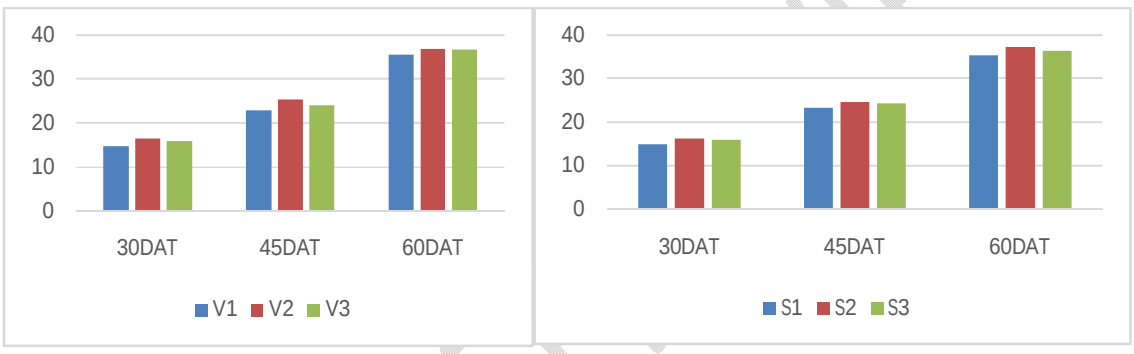

Fig.1 Effect of variety and spacing on plant height 30,45, 60 DAT(days after transplanting)

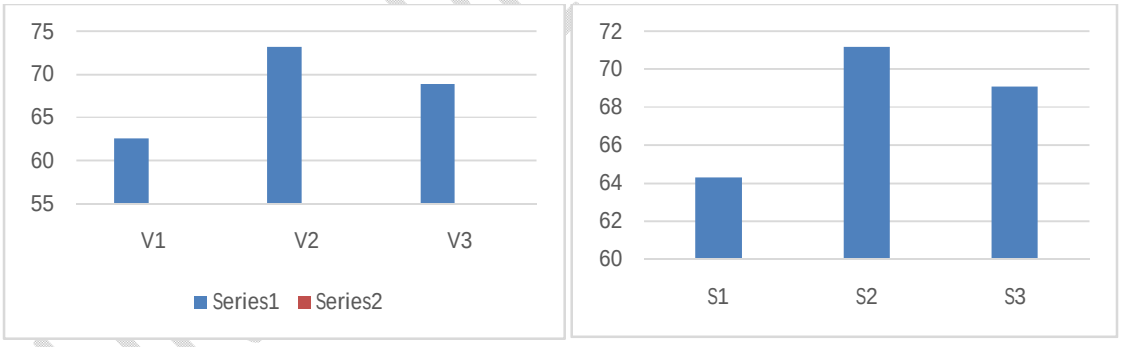

Fig.2 Effect of variety and spacing on 50% curd maturity

Fig.3 Effect of variety and spacing on weight of curd

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