Studies on the influence of varieties and spacing on growth, yield and quality traits of sprouting broccoli (*Brassica oleracea* L. var. *italica* Plenck)

THESIS

Submitted To
Babasaheb Bhimrao Ambedkar University
(A Central University)
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In

HORTICULTURE

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2021

Dedicated To

My

Loving Parents

Pradeep Kumar

DECLARATION

I, **Pradeep Kumar**, Enrollment No. **1327/16**, hereby declare that, I am a candidate for the degree of **Doctor of Philosophy in Horticulture**, Department of Applied Plant Science (Horticulture), School for Bio-sciences and Biotechnology, Babasaheb Bhimrao Ambedkar University (A Central University), Vidya Vihar, Raebareli Road, Lucknow-226025 (U.P.), India and have carried out my research work entitled **"Studies on the influence of varieties and spacing on growth, yield and quality traits of sprouting broccoli (*Brassica oleracea* L. var. *italica* Plenck)".** This thesis has been submitted for the award of the degree of Doctor of Philosophy in Horticulture is my original research work.

I do also hereby undertake that the thesis is essentially free from any kinds of plagiarism.

Date: 29/06/2021

Place: BBAU, Lucknow

Pradeep Kumar

(Pradeep Kumar)

CERTIFICATE

This is to certify that the thesis titled **"Studies on the influence of varieties and spacing on growth, yield and quality traits of sprouting broccoli (*Brassica oleracea* L. var. *italica* Plenck)".** Submitted by **Mr. Pradeep Kumar**, Enrollment No. **1327/16** is an original research work and has not been previously submitted in part or full for the award of any other degree or diploma to this or any other university.

The thesis submitted to Babasaheb Bhimrao Ambedker University, Lucknow satisfies all the requirements as stipulated in the Doctor of Philosophy (Ph.D.) regulations- 1999 as amended in 2008/2010/2013 and it is fit for submission and evaluation for the award of the degree of Doctor of Philosophy of the University.

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Contents

List of Tables

List of Graphs

List of Plates

List of Abbreviations

Symbol	Abbreviation	Stands for
%	-	Percentage
&	-	And
/	-	Per
@	-	At the rate of
-	^0C	Degree Celsius
-	ANOVA	Analysis of variance
-	CD	Critical difference
-	Cm	Centimeter
	cm^2	Centimeter square
	M	Meter
-	cv.	Cultivar
-	Df	Degree of freedom
-	*et al.*	and others/ associates
-	etc.	Etcetera
-	Fig.	Figure
-	FRBD	Factorial Randomized Block Design
-	G	Gram
-	Ha	Hectare
	q/ha	Quintal per hectare
-	i.e.	That is
-	Kg	Kilogram
-	M.P.	Madhya Pradesh

-	M.S.S.	Mean sum of square
-	Max.	Maximum
-	Min.	Minimum
-	Mg	Milligram
-	G	Gram
-	Kg	Kilogram
-	No.	Number
-	NS	Non significant
-	ml	Milliliter
-	mm	Millimeter
-	R.H.	Relative humidity
-	S.Em±	Standard error of mean
-	e.g.	For example
-	Viz.	Namely
-	N	Normal solution
-	ug	Microgram
-	nm	Nanometer
-	rpm	Rotation per minute
-	Conc.	Concentrated
-	hr.	Hour
-	IU	International unit
-	0_B	Degree brix
-	fig	Figure
-	Vit-c	Ascorbic acid
-	Vis.,	Namely
-	Vs.	Against
-	i.e.	That is
-	Per se	As such with mean
-	VRS	Vegetable Research Station

Chapter-1

Introduction

CHAPTER -1

INTRODUCTION

Vegetable consist an important component of the balance diet for human beings. They supply significant nutrients and minerals that the human body requirement for the healthy and active life. India is currently, the second biggest producer of vegetables on the world with an all out production of 191.77 (MT) from 10.35 million hectare area and grown in 2.8% of all out developed land which share 13.64% of world production with a productivity of 19.01(MT/ha) (NHB, 2019). Cruciferous vegetable are huge and increasingly important vegetables. Broccoli (*Brassica oleracea* L. var. *italica*) is a member of the cruciferous or Brassicaceae group of vegetables is a rich wellspring of sulforaphane, which has proved for its anti-carcinogenic properties. It is a native of eastern Mediterranean area, derived from *Brassica oleracea*. Italy is a center of diversification (Singh and Nath, 2012). Broccoli is an Italian word started from Latin 'Brachium' which means an arm or branch (Thamburaj and Singh, 2018). There are several forms within italic groups like 'Purple sprouting broccoli' 'Purple cape broccoli' 'White sprouting broccoli" 'Purple Sicilian broccoli cavolfiore violetto di sicilia' couve broccoli Roxo de cabeca' and calabrese and Black broccoli (broccoli neri) yet calabreseis generally developed for the frozen food industries. Purple and white sprouting types and to a lesser degree purple cape broccoli is popular gardencrop in Europe. It is cultivated ancient roman times and about first grown in 1720 in England, on the other hand in USA. It was first appear in 1806 but commercially cultivated of broccoli was begun 1923 (Decoteau, 2000). Broccoli industriees in USA is biggest producer in world is thought be begun establishing in 1923 when D'Aqrigo Brother started growing broccoli in California. During the nineteen changing the horticultural necessity, heading crossing botrytis and italica groups evolved broccoli. The head is 'green 'yellowish green' purple, chocolate colour. As indicated by (Ngullie and Biswas, 2014) the word broccoli is derived from the Italian plural of *broccolo* which refers to 'the flowering top of a cabbage'. Morphologically, sprouting broccoli resemble cauliflower. The plant structure a kind of head, contain of green buds and thick fleshy flower stalks. The flower stalks are longer than cauliflower and the terminal head is loose and green in color. Broccoli can be easily differentiated from cauliflower by obtaining a head

composed of separated flower bud rather than curd. Its edible portion be composed of immature, fully-distincted flower buds and tender portion of the upper stem. After the culmination of the growth of primary inflorescence (terminal head), small secondary inflorescences (sprouts) develop in the axils of lower leaves. The sprouts in the axils of leaves grow strongly, particularly after the removal of terminal head. Both terminal head and the sprouts with bud clusters are consumed as human nourishment. It is utilized as salad, half boiled vegetables, mixed in soup with juice of different vegetables and cooked as single or mixed vegetables in with potato (Bose *et al.,* 1986). The seedling is generally described by raddish coloured hypocotyls, two notched cotyledons and taproot with lateral roots. There are numerous unusual root emerging after tap root damaged on transplanting. The vast majority of the root are 0.5mm with few accomplishing 1cm thickness. Most of root occurs in about 20-30cm soil depth.

Broccoli fruit is glabrous silique around 10-30 seed for each silique comprise 325 seed for per gram. Broccoli is member of crucifer group henceforth its floral biology similar to outher crucifer kike 4 sepal, 4 petal 6 stamen and 2 carpel. There are the special type among cole group is tetradynamous like 4 long and 2 short stamen, superior ovary with false septum and two row of the compylotropous ovules. The flower is racemes on the main stem and its branches. The broccoli require vernalization following 10-12 weeks after juvenile stage at the temperature 4 to 8^0C for 6-8 weeks. The kinds of inflorescences are cymose. Petal are yellow colour which open quickly under the pressure, anthesis begins 7.30 am and up to 11.30am, however top anthesis around 8-9am, dehiscence is longitudinal, mainly insect (honey bees) pollinated because of two nactaries arranged between the base of the short stamens and ovaries. Self-incompatibility system is sporophytic in nature governed various alleles around 50-70 alleles. Broccoli is most elevated cross-pollinating in the nature among cole group 96 percentages. The glycoprotein like (SLG), (SRK), (SCR), is major which initiated incompatibility response among pollen and pistil. The stigma gets responsive around five days before anthesis due to protogyny and remains so 2-3 days after anthesis (Hazara, P. furthermore, Som, M. G. 2015). Cytoplasmic male sterility framework is for the most part used in mixture seed production,the ogura male sterile framework used in developing male sterility in broccoli.

The broccoli in India is commonlly grown green sprouting broccoli but now a day with the intensive research has been made by IARI to created purple colour like (Palam vichitra) and yellow colour like (Palam kanchan) has been progressively grown among Indian cultivator because of the interest colour rich vegetable and expanding mindfulness about neutral-rich vegetable. Broccoli most nutritious among cole crops having 50 times more vitamin A than cabbage and cauliflower, preventive of certain types of cancer like prostate, colon, breast cancer, heart diseases, osteoporosis, and high blood pressure. Broccoli has high anti-oxidant activity for the most part in light of the nearness of impressive measure of flavonoids like kempherol, B-carotene, and ascorbic acid. However over half of world population fail to benefit from this because they lack specific receptor gene (GSTMI) that help hold the compound in the bodies (Kirsh *et al*., 2007). Broccoli contains around, 103 mg calcium, 78 mg phosphorus, 382 mg potassium and per 100 g edible portion. Broccoli is high in vitamin A (3500 IU/100 g fresh) and vitamin C (137 mg/100 g fresh), as well as protein (3.3 g/100 g fresh), carotenoids, fibres, calcium, and folic acid (Michaud *et al*., 2002). Broccoli substance glucosinolates (thioglucosidess). Glucosinolates for the most part are the amino acid occur in the plant mostely as the potassium salt, the separate of these (myrosinase enzymes) impart the tangible properties like smell and flavor (Zhao *et al*., 2008)**.** The decayed enzymes of glucosinolates possess B-D-glucose, sulphate, and organic agluconmoiety, contingent on ph metal aglucon go intermolecular rearrangement and fracture can yield compound like thiocynates, isothiocynates nitrites, cyanides, and ozazolidine-2 thiones (Tookey, 1980 & Van Etten and Daxenbichler, 1977). The glucosinolates content of purple – headed broccoli was found as in the extended of 72-212mg\100g (Lewis *et al*., (1991). Brassica vegetables increased utilization, as a measure to diminish the occurrence of human malignant growth (Anon, 1982). The decreased occurrence of malignant growth is because of the compound, for example, isothiocynates and indoles (Birt, 1988). (Wattenberg, 1983) recommended that tumorigenesis is hindered via carcinogen-metabolizing system initiated by compound in Brassicas plant.

Various contemplates have shown that the hydrolytic products of some of glucosinolates have anti-carcinogenic activity (Stoewsand, 1995). Sulforaphane (I-isothiocyanato-4 methyl-sulfinyl) isolated from broccoli was found to restrain the

stage 1 cytochrome p-450 isoenzymes 2 E 1, which is responsible for activation of several carcinogenic including diakylnitrosamines. Indoles-3 carbinol, a metabolite of the glucinolates glucobrassin, (Stoewsand,1995). (Goodman *et al.,* 1992) examined the impact of different vegetables in diet on the endurance of human cancer, particularly among ladies seem to improve to endurance against the lung cancer by consumption of broccoli. Broccoli may help diminishing serum cholesterol. Broccoli may content about 3.5g/kg D-glucaric acid. The amount of the calcium prerequisite for every day can be effectively made be consumption of broccoli, among than different vegetables eating the broccoli may a week decreased the risk of prostate cancer by up to 45 percentage.

It is cultivated as comparable like late cauliflower, seed sown in September-October and seedling transplanted mid October-mid November in north India around 25-30 days old seedling, however under ensured structure it might easily to grow. At early August or early September. The head become prepared around 45-65 days after transplanting depending upon the variety (Kirsh *et al.,* 2007). It requires 15-20° C temperature for head production. Temperature above 25° C isn't helpful for its growth and can cause loosening and bolting of heads. The head is harvested along with a couple of leaves and stem (Singh *et al.*, 2014).

Sprouting broccoli is sensitive to high temperature which cause the heads to be distorted, making it a high-risk crop. Yield and head size of sprouting broccoli dependupon temperature conditions all through the entire ultivation period. The growing season mean (GSM) temperatures decide several important market quality attributes, for example, head shape, colour and thickness (Dufault, 1996).

Access to selected high yielding varieties and optimum plant spacing may aid farmers in achieving higher returns per unit area, as well as more efficient fertilizers consumption and solar energy uptake (Bhangre *et al.,* 2011).

A diverse range of tropical, sub-tropical, and temperate vegetable crops can be found in India. However, there are a few vegetables that are less well-known or unfamiliar to producers and consumers. Our farmers may make a lot of money farming these unusual or irregular high-value vegetables near big cities and towns.

Mostly broccoli cultivation is spread over to U.K., Japan, USA and Europe. A large part of produce in the USA goes to freezing industry (Singh and Nath, 2012). In India, its cultivation is irrelevant however now it is getting progressively well known in hotels in Delhi, Bombay, Calcutta, Chennai, and Bangalore. Recently, it is picking up prevalence in plains because of increasing consciousness of nutritional security especially in close by zone of big cities. It is mainly cultivated in Himachal Pradesh, Uttrakhand, Uttar Pradesh, Jammu & Kashmir, the Nilgiri Hills (Tamil Nadu), and the northern plains of India (Chadha, 2003).

The greatest genetic diversity of cole crops including broccoli is the mediterrean gene center including Greece, Syria, Cyprus, Italy, Spainand Pourtugal. The annual types broccoli occur in Italy and surrounding areas (Hazara, P. 2015). It has been descended through mutation and selection from a common precursor Brassica oleracea var sylvestris, the leafy kale like vegetable. Most likely kale was first cole crop to be selected and embraced by man, cultivated species chose by man had biennial habit with yellow flowered racemose inflorescences dissimilar to the ancestral kale or broccoli of the Mediterranean region which had cymose inflorescences with white bloom (Hazara, P and Som M G *et al.,* 2015)

The exact timing of seed sowing in the nursery and transplanting into the field is critical for obtaining a high yield and quality of vegetables (Ksizinszky, 1996). Both the yield and the size of the broccoli head are affected by plant spacing. According to recent research, more extensive splitting leads to larger and heavier heads, while closer spacing increases output per hectare. Consequently, it is important to optimize proper plant spacing for acquiring higher yield with better quality. Various cultivars have different growth, yield and quality parameters differing with growing conditions (Thapa *et al.,* 2013). Growth, yield and quality of crop plant are mainly effected by two major factors viz. varieties and spacing. The existing varieties have emerged mostly through selection from wide variability available. The improvement in the crop is mainly achieved through selection and evaluation. For successful cultivation of any crop in any area, the identification of suitable varieties is of most importance. Optimum plant spacing is one of the important factors in increasing the growth, yield and quality of crops. Therefore, present studies were focused at promote high-value

broccoli by determining and specifying the best plant spacing for better growth, yield, and quality under Lucknow region.

OBJECTIVES OF THE STUDY

Therefore, present study was conducted to evaluate the effect of different varieties and spacing on the performance of broccoli in this region with following objective.

1. To find out the effect of different varieties on growth, yield and quality of sprouting broccoli.

2. To investigate the effect of plant spacing on growth, yield and quality of sprouting broccoli.

3. To determine the interactive effect of varieties and plant spacing on growth, yield and quality of sprouting broccoli.

4. To work out the economic of the crop.

Chapter-2

Review of Literature

CHAPTER -2

REVIEW OF LITERATURE

The effect of varieties and spacing on growth, yield and quality of broccoli particularly varieties viz. V_1- Pusa Broccoli KTS-1, V_2-Palam Kanchan, V_3-Palam Vichitra and V_4-Palam Samridhi with the plant spacing viz.- S_1- 60x45 cm, S_2- 60x30 cm, S_3- 45x45 cm and S_4- 45x30 cm and their interaction effect yet has not been adequately, but several researches has been in this direction to evaluate the growth, yield and quality traits on broccoli. The research entitled **"Studies on the influence of varieties and spacing on growth, yield and quality traits of sprouting broccoli (*Brassica oleracea* L. var. *Italica* Plenck)"** is being given under the following heads:

1. **Effect of varieties**
2. **Effect of spacing**
3. **Interactive effect of varieties and spacing**

1. Effect of varieties

Dufault (1996) revealed that fifty-six field plantings of 'Baccus', 'Reference', 'Packman', and 'Southern Comet' broccoli were made in Charleston, S.C., at 2-week interims. They found that Head leafiness and thickness of 'Baccus' were inhumane toward GSM min (7.0 to 23.5 °C) and GSM max (17.5 to 32.5 °C) temperatures experienced during these years. 'Baccus' head colour was unsuitable at <20.3 °C GSM max and head shape was inadmissible at <19.8 and >26.8 °C GSM max. 'Reference' head colour and leafiness were unsuitable at >20.5 and >20.2 °C GSM max, individually. Head thickness of 'Reference' was unsuitable at <19.2 and >28.9 °C GSM max and head shape was unsatisfactory at <18.4 and >25.7 °C GSM max. Nature of 'Packman' was unsuitable for head shading at <21.0 and >27.3 °C GSM max, head leafiness at >32.0 °C GSM max, head thickness at <8.4 and >18.0 °C GSM min, and head shape at >22.0 °C GSM max. 'Southern Comet' head quality was unsuitable for head shading at <9.2 and >16.5 °C GSM min, head leafiness at >32.0 °C GSM max, head thickness at <8.9 and >16.2 °C GSM min, and head shape at

<21.0 and >25.3 °C GSM max. GSM min or max temperatures didn't influence globule size of any cultivar during any planting time studied.

Chatterjee *et al.* (2006) directed an analysis into the optimum transplanting and different dates for cauliflower cv. Pusa Early Synthetic in West Bengal, and reported that the highest length (15.86 cm) and width ((22.38 cm) were recorded in fifteenth September planting.

Mihov and Antonova (2009) examined the exhibition of five broccoli cultivars and lines under two 80/60 cm and 80/40 cm planting scheme. It was built up that both the focal and parallel flower head weight and horizontal head number expanded in developing with littler planting thickness (80/60 cm). This outcome in getting of better return of central and lateral flower heads more than1.500 t/da and 0.450 t/da, individually. It reflects in acknowledgment of higher all out yield. More prominent plant thickness applies a diminishing impact on the efficiency indications as the estimations of every contemplated character are lower than those read in developing with littler thickness. The genetic factor has the most grounded, prevailing impact over 53% on all out scatter all things considered. Contrasts in plant thickness impact on variety of profitability characters from 25% to 33%.

Dogra and Awasthi (2009) assessed the fresh edible portion of heads of four cultivars of broccoli for different biochemical constituents at preharvest, collect and post-harvest stages. Wide variation in quality parameters viz., dampness, protein, complete lipids, sugars, all out chlorophyll, absolute carotenoids, ascorbic corrosive, all out phenols, glucosinolates, calcium, iron, sodium, potassium and phosphorus content was seen to extend from 89.09 to 89.49%, 2.08 to 2.71%, 183.3 to 196.9 mg/100g, 4.2 to 4.6%, 0.06 to 0.23 mg/g, 0.10 to 0.60 mg/g, 50.69 to 69.40 mg/100g, 0.58 to 0.89%, 125.5 to 249.2 mg/100g, 46.93 to 76.90 mg/100g, 0.70 to 1.10 mg/100g, 17.00 to 21.00 mg/100g, 117.31 to 318.00 mg/100g and 47.00 to 74.00 mg/100g at pre-gather stage and 89.56 to 91.24%, 3.16 to 3.86%, 243.3 to 288.3 mg/100g, 5.4 to 5.6%, 0.13 to 0.42 mg/g, 0.36 to 1.40 mg/g, 58.80 to 81.31 mg/100g, 0.87 to 1.18%, 264.1 to 344.2 mg/100g, 54.00 to 79.88 mg/100g, 0.90 to 1.61 mg/100g, 23.00 to 26.00 mg/100g, 123.82 to 324.66 mg/100g and 52.00 to 79.00 mg/100g at collect organize, as needs be. At post-harvest stage, variation in the above expressed quality parameters was seen from 88.44 to 87.78%, 3.02 to 3.75%, 228.6 to

276.6 mg/100g, 4.8 to 5.1%, 0.04 to 0.30 mg/g, 0.29 to 1.33 mg/g, 47.24 to 71.04 mg/100g, 1.32 to 1.49%, 250.1 to 329.8 mg/100g, 53.31 to 78.83 mg/100g, 0.90 to 1.60 mg/100g, 22.16 to 25.60 mg/100g, 122.00 to 324.50 mg/100g and 52.00 to 79.00 mg/100g, separately. In view of genotypic rating at various gather organizes, the heads of cultivar(s) Palam Vichitra developed to be the best followed by Palam Haritika, Palam Samridhi and Palam Kanchan and collect stage 129 DAS rose out to be the best harvest stage.

Koh *et al.* (2009) examind 80 commercial broccoli tests to decide regular variety in the degrees of ascorbic corrosive (AA), nutrient C (the entirety of AA and dehydro ascorbic corrosive [DHAA]), the transcendent flavonoids quercetin and kaempferol, and absolute phenolics at the consumer level. Levels of AA and vitamin C fluctuated between 13.37–110.30 and 57.35–131.35 mg/100 g fresh weight (FW), individually. The degrees of quercetin and kaempferol extended from 0.03 to 10.85 and 0.24 to 13.20 mg/100 g FW, individually. Complete phenolic action extended from 48.15 to 157.77 mg/100 g FW. Huge occasional variety and year-to-year inconstancy were seen in the substance of all phyto-chemicals inspected. Complete phenolic levels corresponded emphatically with levels of vitamin C, quercetin, and kaempferol. In light of the USDA/ERS 2007 database for utilization dependent on deals, and the information detailed in this, the every day accessibility of vitamin C from broccoli was evaluated at 8.99 mg; representing 15% of Reference Daily Intake (RDI). The normal day by day accessibility of quercetin, kaempferol and complete phenolics from broccoli was evaluated as 0.23, 0.32 and 5.50 mg, respectively.

Prasad *et al.* (2010) observed the reaction of varieties, spacing and aphid the board on development and yield of sprouting broccoli. They detailed that varieties Early You was seen as a lot of reasonable varieties among the four assortments which created most elevated curd yield of 87.04q/ha. The closer dividing of 45×45 cm likewise delivered most extreme yield contrasted with other two spacing of 60×60 cm and 75×75 cm.

Bhangre *et al.* (2011) directed an investigation to examine the impact of different varieties (Ganesh broccoli and Pusa KTS-1). The results showed that cv. Ganesh Broccoli compression to cv. Pusa KTS-1 in terms of days to harvest (53.4 days), days to last harvest (68.4 days), curd diameter (10.81 cm), average weight of

curd (154.80 g), and yield per hectare (70.75 q), while cv. Pusa KTS-1 had the highest growth parameters.

Ramos *et al.* (2011) assessed 38 broccoli promotions for their ability to aggregate Se and for their reactions to selenate treatment regarding wholesome characteristics and sulfur quality articulation. We found that the all out Se content changed with more than 2-overlay distinction among the leaf tissues of broccoli increases when the plants were treated with 20 μM Na2SeO4. Around half of all out Se aggregated in leaves was Se-methylselenocysteine and elenomethionine. Transcriptional guideline of adenosine 5′-phosphosulfate sulfurylase and selenocysteine Se-methyltransferase quality articulation may add to the various degrees of Se collection in broccoli. Absolute glucosinolate substance were not influenced by the grouping of selenate application for most of broccoli increases. Fundamental micronutrients (i.e., Fe, Zn, Cu, and Mn) stayed unaltered among half of the germplasm. In addition, the all out cancer prevention agent limit was incredibly animated by selenate in over portion of the promotions. The assorted genotypic variety in Se, glucosinolate, and cancer prevention agent substance among promotions gives the chance to breed broccoli cultivars that all the while aggregate Se and other health benefit compounds.

Farnham and Bjorkman (2011) reported that the experimental hybrids showed progressively predictable quality crosswise over various development times in the New York tests. Results of this exploration show that broccoli reaction to summer states of the eastern United States is subject to the cultivar developed. Numerous cultivars are not adjusted to extraordinary summer states of the South east since they won't be viably vernalized and will along these lines not head. Others, for example, 'Wanderer' and 'Packman' will head, yet non-uniform bud improvement brings about an unpleasant showing up curd where flower buds are at different phases of advancement. The test half and halves that are single crosses of inbreds chose for adjustment to south eastern summer conditions speak to a special class of broccoli crossovers that consolidate early development and the capacity to deliver heads under summer states of South Carolina. Extra trial of these last cross breeds in New York demonstrate that they might be by and large adjusted to summer situations of the eastern United States.

Thapa and Rai (2012) examine twelve varieties of Broccoli [Viz. Holiday, Princess, Sultan, Nokguk, Early You, KE-180, Priya, Puspa, Grandsino, Rapido, Prema and Packman]. Among all of the Broccoli varieties, Nokguk was showed better results, yielding a higher yield [145.47q/ha] in combination with the finest head growth. KE-180 variation was revealed to have favourable condition in chlorophyll b, decreasing sugar, full sugar, and carotene content among the genotypes taken under observation.

Renaud *et al.* (2013) compared performance of 23 broccoli cultivars (G) under two the executives (M) system (natural and ordinary) in two districts of the United States (Oregon and Maine), including spring and fall trials. Results uncovered that area and season had the biggest impact on broccoli head weight, with Oregon outflanking Maine, and fall preliminaries beating spring plantings. M principle impacts and G × M connections were frequently little, yet G × M × E (area and season) were large. Cultivars with both more noteworthy head weight and strength under customary conditions commonly had high head weight and dependability under natural developing conditions, in spite of the fact that there were exemptions in cultivar rank between the executives frameworks. Bigger genotypic fluctuations and to some degree expanded blunder changes saw in natural contrasted with regular the board frameworks drove with repeatability for head weight and other plant attributes that were comparative or considerably higher in organic compared with conventional conditions.

Giri *et al.* (2013) With three replications in each treatment combination, researchers looked at two types of broccoli (Cabbage and Green Sprouting) and five N rates (0, 50, 100, 150, and 200 kg ha1). The effects of variety and N rate on overall curd yield were considerable, whereas the impact of collaboration was minor. Cabbage yielded 11% more total curd after green sprouting.

Abou El-Magd (2013) assessed the exhibition of five broccoli cultivars (Centauro, Snowball, Heraklion H., Calabrese and Sakura). Discoveries showed that Herklion H. cultivar plants were the tallest, denser leaves, higher new weight and dry weight level of heads and leaves just as the most noteworthy head yield, yield increment and its rate with the least quality (head stature and distance across). In actuality, the most reduced estimations of development and head yield were recorded

by cv. Sakura yet with high head quality. Different cultivars extended in the middle. Regarding connections, cv. Centauro in the medium planting date was superior in total yield, yield increment and its rate pursued by Heraklion H. in the medium planting date. Lower estimations of complete head yield were acquired by other interactions. The most reduced complete head yield was gotten by Snowball cv. at the point when planted in the late planting date.

Nooprom *et al.* (2013) reported that Top Green, Green Queen and Yok Kheo had seedling endurance paces of 76.53-100.00% aside from the Special. The Yok Kheo had the most examine highest yield of 12.31 and10.65 t ha-1 when the planting in January and March, separately. The Yok Kheo is an intriguing new hybrid and hybrid variety which creating the yield higher than the Top Green which is prominent variety developed in southern Thailand. The yield of the Green Queen was not essentially not the same as the Top Green. It tends to be collected at 11.67 and 9.38 days sooner than the Top Green and Yok Kheo, respectively.

Thapa *et al.* (2013) studied execution of four hybrid varieties of sprouting broccoli (viz., Early You, Princess, Fiesta and Nokguk). They saw that among these varieties the plant stature, number of leaves, plant spread, days to gathering and curd yield fluctuated from 67.78 to 38.88 cm, 17 to 29, 3462.5 to 5853.2 cm2, 55 to 76 days and 76.93 to 119.0 q/ha, respectively.

Uniyal *et al.* (2013) tested the performance of three cross breeds viz., Fiesta, Premier and ATX-218a and an open pollinated variety viz., KTS-1(IARI, Katrain, Himachal Pradesh) at four dates of transplanting viz., 27thJune seventh July, and 27th July under rainfed mid-slope states of Ranichauri. Discoveries of present examination uncovered that Fiesta mixture on 27th July was generally appropriate for getting best return and greatest net benefit. Moreover, another beneficial treatment mix which could likewise be prescribed to vegetable cultivators of Uttarakhand is transplanting of Premier Hybrid on 27th of July.

Nooprom and Santipracha (2013) assessed the performance of six planting dates: July, August, September, October, November and December and four broccoli varieties: 'Top Green', 'Green Queen', 'Yok Kheo' and 'Uncommon' during stormy season. This investigation indicated that four broccoli varieties had exceptionally seedling endurance paces of 70.31-99.22% when planting in July-December with the

exception of 'Unique' of 54.68% when planting in August. 'Yok Kheo' had plant measurement of 67.54-75.24 cm when planting in July and December, not altogether not the same as 'Top Green' planting in July, August and November of 69.15-71.24 cm and 'Green Queen' in July and September of 68.69-68.88 cm. The most elevated all out yield was gotten by 'Yok Kheo' when planting in July and December of 7.73-7.87 tha−1.

Ngullie and Biswas (2014) compared the performance of various varieties of broccoli viz., Inspiration, Aiswarya, Packman, Puspa and KTS-1 under rainfed mid-slope states of Mokokchung district of Nagaland. Among all the varieties, Packman was discovered most prevalent which gave best return (115.29 q/ha) in mix with best head formation.

Singh *et al.* (2014) conducted investigate four different broccoli varieties having diverse shading heads for example Palam Samridhi (green head), Palam Kanchan (yellowish green head), Palam Vichitra (purple head) and Palam Haritika (green head) for their exhibition and furthermore their inclination in the business sectors. The broccoli varieties Palam Vichitra yielded the most elevated (210.7 q/ha) trailed by Palam Kanchan (206.9 q/ha). An average weight of terminal head of Palam Kanchan was the most elevated for example 357.5g, though Palam Samridhi created the earliest head under low hill condition of Himachal Pradesh. To the extent inclination of head shading is concerned, just green head varieties were favored in the neighborhood advertise, while, green and purple coloured varieties were favored in bigger mandis of urban areas like New Delhi, Shimla, Chandigarh and so forth. There is least inclination for yellow coloured broccoli varieties in the market.

Torricelli *et al.* (2014) analyzed the performance of two synthetic varieties of (*Brassica oleracea* var. *italica* Plenck) with a F_1 hybrid variety. Indistinguishable tests were done over a time of 2 years in three areas in Italy having diverse the executives and pedo-climatic conditions. At first, an investigation of change, did utilizing a direct blended model (LMM), with "Genotype" ("G") and "Location" ("L") as fixed components and "Year" ("Y") as an arbitrary factor, indicated that the "Genotype" impact was noteworthy for a considerable length of time to heading (DH), head number (HN), plant measurement (PD), plant force (PV) and plant stature (PH).

The "L" impact was significant for PD and PV. "G × L" interaction was significant for DH, PV and for yield.

Shiwani *et al.* (2016) observed significant difference among genotypes of sprouting broccoli recommending adequate hereditary changeability for yield and other yield related characters. The most noteworthy appraisals of phenotypic coefficient of variety and genotypic coefficient of variety were watched for number of lances per plant (42.85 % and 83.93 %) followed by weight of spearss per plant (40.46 % and 35.31 %) and terminal head weight per plant (33.60 % and 31.96 %). High heritability combined with high genetic advance was watched for characters viz., terminal head weight per plant (90.46 % and 62. 61 %), marketable yield per plant (89.44 % and 56.51 %), number of spears per plant (82.56% and 72.86 %), harvest index (77.03 % and 35.35 %) and weight of spears per plant (76.17 % and 63.50 %). These high gauges propose considerable fluctuation for the characters.

Thakur *et al.* (2016) considered the exhibition of six varieties (Palam Haritika, Palam Kanchan, Palam Samridhi, Palam Vichitra, MSB-12 and Ganesh) of broccoli with two environmental conditions (open field and normally ventilated polyhouse). Among the varieties maximum dry weight of plant at curd stage (161.92g) and harvesting stage (279.33g), SPAD esteem (67.10) and curd yield (375.41q/ha) were found in Palam Kanchan though plant spread (10852.40cm2) in Palam Vichitra. Most elevated stem diameter was recorded if there should be an occurrence of Palam Haritika at curd commencement (3.33cm) and harvesting stage (3.79cm).

2. Effect of spacing

Aldrich *et al.* (1961) reported that closer the separating, the littler the heads created. Total yield expanded to a greatest when spacing was diminished to 8 or 11 inches (contingent upon season and varity). Further decline in the space between plants bring about a sudden decrease in yield.

Chung (1982) conducted a field study with two cultivars. Plant densities from 2.1 to 98.0 plants m−2 were utilized and successive reaping during the maturity period was embraced. Super yield and maturity status changed persistently during the collecting time frame contingent upon the overall extent of lances getting attractive

and over-develop. For cv Futura planted in mid-January, gathering for all densities can be bound to a three-day time frame from Day 87 to Day 90. A comparative collecting period would in all probability be reasonable for cv Gem. The marketable yield at this stage is about 10% not exactly the most extreme marketable yield. For productive handling in the manufacturing plant, this decrease in yield is more than made up for by limiting the amount of waste material gathered from over-develop plants. The type of the yield-density relationship shows that spear yield moves toward the asymptote at a moderately low plant thickness in every one of the three cultivars (20 plants m−2). Thusly the most appropriate plant density to be utilized could be dictated by the size traits required by the processing companies.

Salter *et al.* (1984) reported that three systematic fan structures were utilized at every one of three sowings of another type of terminal-headed broccoli, made in late March, early May and early July; two gave densities in the range 2-100 plants m-2 of every 20 logarithmic interims with fixed rectangularities of 1:1 and 6:1 individually, and the third given rectangularities somewhere in the range of 1:1 and 6:1 at a constant density of 20 plants m-2. Singular heads were collected when full grown and the mean gather dates for the three sowings were 25 June, 22 July and 29 September. Maximum fresh weight yields of trimmed heads were 2.16, 2.01 and 1.75 kg m-2 from sowings 1 to 3, and most extreme yields were constantly acquired from the plots with a square (1:1) planting course of action. The connection among yield and density was commonly asymptotic, yield being generally inhumane toward thickness over 20 plants m-2 however mean head size diminishing with expanding thickness. With all sowings the extent of purple: green heads additionally diminished with expanding density. Yield, development and quality were influenced by condition. The late-planted yield, for instance, gave a lower yield with a lower reap file, littler and shallower heads with less fortunate shading and a more prominent plant-to-plant variability contrasted and crops from the earlier sowing.

Sharma and Arora (1984), Islam *et al.* (2002), Oad *et al.*(2002) and Masood *et al.* (2003) who suggested 45 cm plant spacing as the best spacingng for getting higher yield because they laid out research impact of various spacing on yield performance in cauliflower and he found that the , Maximum yield (30.77 t ha-1) was obtained from, (45 cm) intently pursued by (50 cm), which created the yield of 29.30 t ha-1, both were factually the equivalent. The most minimal yield was recorded as

19.87 tons per hectare in (30 cm), (35 cm) and (40 cm) were at standard with one another by creating a yield of 22.07 and 23.47 tons per hectare, individually. Low yield in the case of close spacing may be because of the higher death rate, lower plant stature and leaves per plant, shorter measurement of curd and furthermore the aggressive development of the plants.

Fresh *et al.* (1986) led a field investigation to survey the impacts of spacing on characters. Five sub-populaces of green-sprouting broccoli chose from the F2, F3 and F4 were developed at five spacings (15 × 15 to 75 × 75 cm). Most characters influencing quality were unaffected by spacing. Characters influencing yield demonstrated direct and quadratic reactions to dividing, stressing the significance of equivalent spacing between plants in determination plots. Some yield characters indicated straight contrasts between the reactions of sub-populaces to separating, demonstrating that cultivars may be reared which were adjusted to specific spacings.

Ghormade *et al.* (1989), Kanwar (1993) and Gill and Gill (1995) reported regarding dispersing, altogether most extreme plant stature was observed in 45 × 10 cm and minimum in spacing 45 × 30 cm in radish (Pusa Chetki). Increased plant density constrains the accessibility of room for sidelong development, bringing about expanded plant height **(Khurana *et al.*, 1990)** and **Pandita *et al.*, 2005)**. While, the interaction was not influenced essentially on plant height.

M. Griffin and D.E. Carling *et al.* (1990) he carried out research two variety Green valiant and Emperor at two spacing 90cm and 45cm and revealed that the mean head diameter demonstrated to be more sensitive to environmental factors than mean multiplied the plant density, with an average head weight, all throughthere was no critical impact on head weight, broccoli head were harvested at Fairbank midpoints (33%) was more extensive than the Palmer and he reported that the head harvested from single plant were (30%) was more extensive than the double plant and finally he discover that the head harvested from 90cm row was 17% more prominent than the 45cm. H e could likewise announced that the head of Green valiant was 18% more prominent than the Emperor.

Mullins and Straw (1990) evaluated parameters for fresh-market broccoli production in eastern USA. Cultivars Packman, Premium Crop and Emperor were planted at spacings of 6 and 12 inchess inside rows that were 36 inches separated.

Packman created the best number of heads/acre in 1988, however there were no noteworthy cultivar differences in the quantity of heads/acre of land in 1989. Yields in lb/acre of land didn't differ between cultivars in either year. More heads/section of land and lower normal head loads were delivered at 6-inch dispersing in the two years. In 1988, 6-inch dividing brought about a better return, in lb/acre of land, than 12-inch spacing. Head width was biggest in Packman. In 1989, head and stem breadths were bigger with 12-inch spacing than with 6-inch spacing. Stem immovability was more noteworthy at 12-inch spacing in the both years. Head colour didn't differ with spacing in either year, yet varied among cultivars in every year. It is suggested that a spacing of 6 inches is attractive for fresh market creation, where a small head size is required.

Jett *et al.* (1995) inspected two spatial courses of action (single v. twin row) and five plant densities (10.8, 7.2, 5.4, 4.3 and 3.6 plants/m2) for single head broccoli production. Spatial game plan had no huge impact on any deliberate property, despite the fact that the twin-push course of action brings about less plant harm with each gather. For select creation quality single head broccoli with exceptional returns of attractive florets, 3.6 plants/m^2 (46 cm inside line separating) ought to be utilized.

A wide scope of plant densities for the impact on overhang (Andrade, 1995; Villalobos *et al.* 1994). From the minute when plants begin to contend, plant density is higher than the ideal, causing a decrease in the plant size that is primarily reflected in the leaf region per plant. Overhang structure is additionally influenced by the variety of the density. At higher densities, the coefficient is lower than at lower densities related with erectophile and planophile plants; **(Monsi *et al.*, 2005).**

Sharma and Chaudhary (1996) in cauliflower and **Agarwal *et al.* (2007)** in broccoli he revealed that Significantly best return per plot (23.80 kg/12.96 sq.m.) was recorded with the higher plant density (45× 45 cm) which was measurably like medium plant density (60 × 45 cm) (19.87kg/12.96 sq.m.). Most minimal yield (16.23 kg/12.96 sq.m.) was recorded with lower plant density (60 × 60 cm), the greatest yield per plot was discovered prevalent at higher plant density which was conceivably because of increasingly number of plants per unit area.

Pornsuriya *et al.* (1997) spread out research on impact of spacing on yield and execution of broccoli and he found that, The best return per plant (571.1 g) was

recorded from T_5 (60×60) and it was factually like T_{10} (544.4 g), T_4 (539.3 g) and T_{15} (515.9 g). The most minimal yield per plant (258.4 g) was obtained from the treatment mix T_{11} (60×30).

Kunicki *et al.* (1999) researched the impact of various plant densities (3.2, 4.0, 5.3, 8.0 plants per square m) of three broccoli cultivars on the yield and its quality. Plant density significantly efffected the attractive yield that ran from 11.0 t/ha (3.2 plants/m^2) to 16.6 t/ha (8.0 plants/m^2). An extraordinary reduction in plant thickness brought about a 46 percent expansion in the mean load of broccoli head and the best yield consistency. No noteworthy impact of the tried cultivars on marketable yield was found. At the best plant density the nitrate content was 39 percent higher than at the most reduced.

Kumar and Rawat *et al.* (2002) direct research impact of spacing on broccoli and he got the greatest T.S.S (8.7%) at the spacing 60x60cm and he found the (8.6%) T.S.S content at the spacing 30x60cm and **Raj kumar (1997),** reported that cultivars with low total soluble solids met with high stockpiling misfortunes. The sugar fixation is related with torpidity and capacity life of onion, happening as reduction in glucose, fructose and fructan **(Cho *et al.*, 2010).**

Dasgan and Abak (2003) who announced that Fruit dry matter expanded as plant density expanded o revealed that there was no impact of plant density on fruit dry matter. Plant density didn't influence levels of vitamin C (130.4 mg/100 g fresh matter), total phenolic compounds (58.5 mg/100 g fresh matter), P (14.9 mg/100 g fresh matter), Mg (5.2 mg/100 g fresh matter) or K (183.8 mg/100 g fresh matter) and **Wszelaki (2003),** detailed that the level of soluble solids was higher in the low plant spacing, followed by the medium spacing and the high plant dividing in cabbage.

Badi *et al.* (2004) lead inquire about on lettuce, revealed that the closer dispersing delivered a noteworthy increment in leaf territory and leaf number m-2 which thus created altogether higher new and dry mass m-2. In spite of the fact that the more extensive spacing (20x25 cm) gave more leaves, bigger leaf zone, higher leaf fresh and dry mass per plant when contrasted with nearer separating, despite everything it brought about lower esteems per unit region. Distinctive verdant lettuce cultivars reacted diversely on yield parameters and yield of lettuce. Progressively overwhelming cultivars were 'NIZ 44-675' and 'Tango' because of fundamentally

higher leaf number and expanded leaf regions which added to higher leaf crisp and dry mass. The outcomes show that the best plant separating for the verdant lettuce cultivars assessed is 10x20 cm (50 plants m-2) contrasted with other dividing utilized in this preliminary. The higher number of plants per m-2 expanded all yield parameters. The more vivacious development of cultivars 'NIZ 44-675' and 'Tango' can be attributed to contrasts in hereditary cosmetics. It was seen that firmly divided plants become quick when contrasted with more extensive separated plants. This is primarily the after effect of rivalry for photosynthetic radiation which expanded yield.

Singh *et al.* (2006) examined the three spacing for example 45 × 30 cm, 45 × 45 cm and 45 × 60 cm on broccoli. The seedlings of 25 days old were transplanted in the long stretch of October during both the years of experimentations. The observations with respect to the growth and yield characters were recorded at occasional interims to survey the reaction of treatment on growtht and yield of broccoli. Discoveries demonstrated that development and yield parameters were influenced essentially with various spacing. Increment in spacing fundamentally expanded the plant tallness at 30, 45 DAT and at development, number of leaves per plant, decreased the days taken to curd inception and curd development by transplanting of seedlings at 45×60cm spacing. Increment in spacing fundamentally expanded the length and width of curd, stalk length and diameter as well as curd yield.

Francescangeli *et al.* (2006) led an analysis to decide the impact of plant density on captured photosynthetically active radiation (PAR), plant design and plant development and generation. "Inheritance" broccoli plants were developed in pots in a nursery in the periods of 2002 and 2003 at 2, 4, 6 or 8 plants m−2 (temperatures: somewhere in the range of 10.0 and 16.1 °C, normal episode PAR: 12 mol m−2 day−1). Plant density influenced the caught and amassed PAR. There were not impacts on the length of the vegetative and regenerative periods, the aggregate and last number of leaves, and the lance distance across and new weight. The extent and development of leaf territory (LA) was free of plant thickness as long as 70 days after transplant (dat). From that point forward on, LA expanded directly with plant density. The most elevated captured PAR was 70–72% with 6–8 plants m−2. With the expansion in plant density: the erectness of the upper leaves and stem length expanded, the termination coefficient diminished and business skewer (inflorescence in addition to a bit of stem 10 cm long) weight diminished (however it was because of

the stem part of the lance and not to the consumable segment). On a territory premise, the abatement in business skewer weight with plant thickness was more than repaid by the higher number of plants. The radiation use proficiency (RUE) expanded relatively with the leaf zone file (LAI) up to a LAI of around 3, and afterward balanced out. The main impact of plant thickness on dry weight parceling was to diminish the dry weight dispensed to the stem bit of the lance. As plant thickness expanded, and subsequently the level of concealing expanded, the net absorption rate (NAR) diminished and the leaf zone proportion (LAR) expanded. This compensatory change among NAR and LAR, kept the relative development rate (RGR) for singular plants practically consistent.

Kumar *et al.* (2007) decided the reasonable transplanting date and planting geometry of broccoli (*Brassica oleracea* L. cv *Italica*) for mid-hills of Himalaya. Transplanting dates and planting geometry had huge effect on broccoli yields, while development and yield crediting characters were affected essentially just because of transplanting dates. Transplanting of broccoli on 30 September was seen as the best in this manner giving most noteworthy curd yield. Tending to advertise needs it very well may be stretched out up to 15 and 30 October acquiring at standard yield. Postponed transplanting on 15 November essentially diminished generation of broccoli in both the years. The mean yield decreased by 15.6, 20.4 and 46.5 % when the transplanting was done on 15 October, 30 October and 15 November, separately contrasted with 30 September. The closer spacing of (45 cm × 30 cm) recorded most noteworthy curd yield which was at standard with (45 cm×45 cm) spacing and essentially higher than more wider spacing of 45 cm × 60 cm in both the years. The mean curd yield diminished by 11.2 and 30.1% under more wider spacing of 45 cm × 45 cm and 45 cm × 60 cm individually when contrasted with the closer spacing of 45 cm × 30 cm. Along these lines transplanting of broccoli can be stretched out from 30 September to 30 October and at closer spacinging of 45 cm × 30 cm for higher creation in northwest Himalaya.

Sharif and Azim (2008) led an analysis to decide the impact of spacing and potassium on the growth and yield of broccoli. The preliminary comprises of 12 treatment mixes of 3 spacing and 4 degrees of manure application. In the widest dividing yet the most significant stem length, the most extreme plant stature, number of leaves per plant, greatest new weight of leaves per plant, leaf dry weight per plant,

essential curd weight, essential curd distance across, number of auxiliary curd per plant, weight of optional curd per plant, curd dry weight per plant, and yield per plant (372.80g) were recorded from the closest spacing.

Sharma *et al.* (2005) saw that planting on 6th June created maximum sprout length (2.77 cm) and diameter (2.08 cm) in brussels sprout and **Khadireta J. (1989)** detailed that,the head distance across and head weight was most extreme because of less challenge among them and thus accessible head weight was greatest in wider spacing .The more extensive spacing give increasingly adequate space and the less challenge between accessible supplement. So there was increment in the head breadth and head weight.

Muzeeb Ur Rahman and Mohhamadiqbal *et al.* (2007) direct research on different spacing (30cm, 35cm, 40cm, 45cm and 50cm) on cauliflower and he found, a profoundly huge information in regards to the curd measurement demonstrated the matchless quality of (45 cm) among the various plant spacing, as it delivered the greatest curd diameter (19.13 cm), which was intently trailed by (50 cm) with a diameter of 18.70 cm. Be that as it may, least curd diameter (15.63 cm) was recorded in (30 cm) trailed by (35 cm) with 16.33 cm curd diameter. The closer plant spacing showed poor outcomes because of close challenge for procuring the supplements, daylight and space for better curd growth and development.

Muhammad Din and Muhammad Qasim (2007) did investigate on impact of planting on the yield execution on cauliflower and he found that the ,second planting date (16th June) created a head yield (37.83t ha-1) higher than that acquired from the last planting date (1st August) of a head yield (3.25t ha-1) and **Lewis *et al.*, (1995)** recorded altogether most extreme head yield (22.7 t/ha) at a spacing of 15 cm inside the row and most noteworthy head size was acquired from 46 cm spacing in linear arrangement of broccoli plants.

Sharif and Azim (2008) led a test to decide the impact of dividing and he detailed that the essential curd weight, primary curd diameter, number of auxiliary curd per plant, weight of optional curd per plant, curd dry weight per plant and yield per plant (372.80g) were recorded in most stretched out separating yet the most noteworthy stem length, and yield/ha were recorded from the nearest dispersing and **Md.Shyduzzaman Roni, Mohammad Zakaria (2017)** did inquire about in broccoli

He found that the maximum primary curd weight (480.8 g/plant) was obtained from T_5 (S60x60 N) and that it was quantitatively indistinguishable from T_{10} (458.7 g), T4 (457.3 g), and T_{15} (457.3 g) on the impact of N composts and plant spacing on individual curd weight (431.8 g). T_{11} (S60x30N) had the highest reduction in principle curd load (206.8 g/plant).

Sharif and Azim (2008) directed a test to decide the impact weight per plant and yield per plant (372.80g) were recorded in wider spacing yet the most elevated stem length, and yield/ha were recorded from the closest spacing and **Sharma *et al.,* (2001)** tried with twenty-four treatment blends of six transplanting dates in lettuce cv. Alamo-1 viz., first Aug., sixteenth Aug., first Sept., sixteenth Sept., first Oct. what's more, sixteenth October and four spacing levels viz., 30×30 cm, 45×30 cm, 45×45 cm and 60×45 cm and he discovered greatest yield of 241.3 q/ha was gotten when the transplanting was done on first September pursued by 226.5 q/ha on l6th September and on the premise he found that, the wider spacing of 60×45 cm gave the greatest new weight and dry weight per plant (yield/plant) yet least per hectare. The closest spacing of 30×30 cm recorded least yield/plant, which didn't remunerate ideal yield per hectare. A plant spacing of 45×30 cm was discovered best for getting ideal yield per plant just according to per hectare in Himanchal Pradesh.

Grabowska *et al.* (2009) surveyed the impact of the technique for development and separating available and nutritive nature of 'Lord F_1' broccoli heads. The broccoli development approach (direct planting or transplanting with spacing of 20, 30, 40, and 50 cm 67.5 cm) showed no noticeable effect on the dry issue content in the heads. In broccoli heads, the maximum dry issue content was 9.5 percent, with reducing sugar accounting for 1.12 percent of new issue. When compared to straight planting, transplanting resulted with an increase in solvent sugar concentration. The component content in broccoli was reliant fundamentally on the vegetation season, however much of the time legitimately planted plants had more phosphorus, potassium, calcium, and magnesium. With the expansion of dividing in lines the substance of certain components (P, K, Ca &Mg) in broccoli heads rose in the main year of the analysis. The mean substance of components found in broccoli heads was as per the following (in mg kg^{-1} of dry issue): phosphorus 6001, potassium 23447, calcium 3696, magnesium 1583, and iron 66.7.

Mihov and Antonova (2009) examined the presentation of five broccoli cultivars and lines under two 80/60 cm and 80/40 cm planting plan. It was set up that both the focal and parallel bloom head weight and horizontal head number expanded in developing with littler planting diameter (80/60 cm). This outcome in acquiring of better return of focal and sidelong blossom heads more than1.500 t/da and 0.450 t/da, individually. It reflects in acknowledgment of higher complete yield. More prominent plant thickness applies a lessening impact on the efficiency signs as the estimations of every examined character are lower than those read in developing with littler thickness. Contrasts in plant thickness impact on variety of profitability characters from 25% to 33%.

Singh al *et al.* (2009) examined the impact of three spacing viz., 45cm × 30cm, 45cm × 45cm and 45cm × 60cm on broccoli. The test was spread out in factorial randomized block design with three replications. They announced that separating demonstrated non-noteworthy impact on plant stature in both the years. Separating had noteworthy impact on stalk measurement in both the years and there was an expansion in stalk width with increment in dispersing. The quantity of leaves didn't contrasted altogether with separating. The dispersing had its checked impact on days taken to initially gather in the second year when the nearest dividing indicated noteworthy headway in head development contrasted with the most extensive separating. Per plant weight was extraordinarily impacted by dispersing and it was the most elevated at broadest separating. The most elevated net head weight was acquired at the broadest dividing in the two years and the distinction from other dispersing was huge during second year. Gather list had non huge impact of dividing. The yield displayed noteworthy impact of dividing. Among various dispersing, the yield was outstandingly most extreme at the nearest dividing which had the most noteworthy plant populace. There was non significant effect of spacing on ascorbic acid substance and shelf life of heads.

Fillmore (2010) he accomplished the most noteworthy attractive yield in broccoli at 5.56 plants per m^2 in a solitary line with 90 cm between the line and 20 cm inside the column and **Singh and Naik (1988)** saw that closest spacing of 45 x 30 cm created fundamentally higher number of attractive heads bringing about higher attractive yield/ha in cabbage, notwithstanding, greatest head weight/plant was found in the wider spacing of 60 x 45 cm.

Saikia *et al.* (2010) led probe broccoli variety Pusa Broccoli KTS-1 to assess six planting distances viz., 30 cm × 30 cm, 45 cm × 30 cm, 45 cm ×45 cm, 45 cm × 60 cm, 60cm × 60cm and 75cm × 60 cm. Among planting densities 45 cm × 45 cm planting recorded the most noteworthy head yield of 40.78 q/ha pursued by 60 cm ×45 cm (39.49 q/ha). Concentrate on financial aspects of development uncovered that planting on fifteenth October and planting at a separating of 45 cm × 45 cm was the most proficient treatment with a money saving advantage proportion of 1:2.35. Accordingly, it tends to be inferred that for productive development of broccoli var. 'Pusa Broccoli KTS-1' planting on center piece of October by keeping up a planting distance of 45cm × 45cm between and within rows is most favourable under the climate conditions of Jorhat (Assam).

Saikia *et al*. (2010) he ought to be examined for that the quantity of leaves per plant was highest in plants transplanted on 15th September pursued by 30th September (11.59) in broccoli and **Hossain *et al.,* (2011)** in cabbage he showed that the quantity of free leaves in red cabbage was non-noteworthy as for the impact of plant densities. In any case, most extreme number of free leaves (11.66) at lower plant density (60 × 60 cm) trailed by medium plant density (60 × 40 cm) (11.11) and least number of free leaves per plant (10.55) was found with the higher plant density (45 × 45 cm).

Prasad *et al.* (2010) examined the reaction of varieties, spacing and aphid the board on development and yield of sprouting broccoli. They repprted that assortment the closer spacing of 45×45 cm producedd most extreme yield contrasted with other two spacing of 60×60 cm and 75×75 cm.

Hossain *et al.* (2011) assessed three planting time viz. (I) 1 October, (ii) 15 October and (iii) 30 October and three plant spacing viz., (I) 60×40 cm, (ii) 60×50 cm and (iii) 60×60 cm to discover the ideal time of planting and plant dividing for broccoli production. Yield and yield contributing characters were essentially affected by the medications. Closer spacing (60 × 40 cm) resulted the best return (18.8 t/ha) which was observed in 60×50 cm (17.6 t/ha) and minimum yield (16 t/ha) was obtained from 60 × 60 cm spacing. first October planting and 60×40 cm plant spacing mix showed the best return (22.5 t/ha) which was measurably like first October planting and 60×50cm plant spacing (21.9 t/ha) and the least yield (12.8 t/ha) was created from 30 October planting and 60 × 60 cm plant spacing combination.

Moniirzzaman (2011) detailed that the most extreme number of heading leaves (19.56) at lower plant density (60 × 60 cm) trailed by medium plant density (60 × 45 cm) (18.59) and least number of heading leaves per plant (16.43) was found with the higher plant density (45 × 45 cm). Higher plant density brought about greatest number of heading leaves per plant in red cabbage. The plants become under more extensive dispersing got more supplements, light and dampness around contrasted with plants of closer spacing, which was presumably the reason for better execution in yield characteristics like number of heading leaves per plant.

Moniruzzaman (2011) directed a field investigate cabbage (*Brassica oleracea* var. *capitata*) including two plant spacing i.e. 60 × 40 cm and 60 × 45 cm and his outcomes demonstrated that most elevated attractive head yield (73.32 t/ha) was created in K-K Cross cultivar at a spacing of 60 x 40 cm and **Singh and Naik (1988)** observed that nearest dividing of 45 x 30 cm delivered fundamentally higher number of attractive heads bringing about higher attractive yield/ha in cabbage, nonetheless, greatest head weight/plant was found in the broadest spacing of 60x45 cm.

Solunke *et al.* (2011) contemplated the impact of three spacing viz., 60 × 30 cm, 60 × 45 cm and 60 × 60 cm on development and yield of broccoli. The broccoli transplanted on the spacing 60×60 cm demonstrated essentially most extreme development for tallness, number of leaves, stem distance across and leaf zone. Curd yield/hectare was gotten greatest (131.86 q ha^{-1}) with planting at S_1-60 × 30 cm spacing.

Bhangre *et al.* (2011) analysed the impact of five spacings (60x60 cm, 60x45 cm, 45x45 cm, 60x30 cm, 45x30 cm) on various varieties (Ganesh Broccoli and Pusa KTS-1). The data revealed that of the five spacings tested, S5 (45x30 cm) yielded the highest overall estimates of several metrics such as days to half collect (64.5 days) and yield per hectare (77.08q). In any case, S_1 (60 × 60 cm) gave fundamentally most extreme estimations of different parameters viz., plant height, curd diameter, average weight of curd (181.54 g).

Jj and Jj (2011) assessed the impact of four plant spacing, viz., S_1 (60 cm×50 cm), S_2 (60 cm × 40 cm), S_3 (50 cm × 50 cm) and S_4 (50 cm × 40 cm on growtht and yield of broccoli. The growth and physio-morphological characters, yield properties and yield were fundamentally impacted by plant spacing. In spite of the fact that the

best return per plant (357.75 g) was acquired from the widest spacing (60 cm × 50 cm) however the highest marketable yield (12.87 t/ha) was gotten from the nearest spacing (50 cm × 40 cm).

Dev (2012) studied the impact of three spacing viz S_1: 60 × 30 cm, S_2: 60 × 45 cm and S_3: 60 x 60 cm during two back to back Rabi periods of 2005-06 and 2006-07 on growth and yield of broccoli cultivation Green Head in a Randomized Block Design with three replications. With the exception of plant tallness and days to head commencement, development, and collect span over both years, the variation in plant spacing had a significant impact on yield and its qualities. With increasing plant spacing, the yield per plant, essential head weight, extra head weight, and auxiliary heads per plant all showed an increasing pattern, and the most significant attributes were observed at the wider spacing of 60×60 cm. Such reaction more likely than not been because of the accessibility of more space giving more supplements, air and daylight per plant which prompted vigorous growth of plants. Anyway plant stature, days to head commencement, development and collect term didn't demonstrate noteworthy reaction to dividing levels. However, the highest gross yields of 154.8 and 142.7q/ha were produced at the nearest spacing of (60x30 cm) in 2005-06 and 2006-07, respectively, which could be due to the increased plant thickness at this spacing. It reveals that the highest yield per plant under (60x60 cm) spacing did not compensate for the drop in per hectare output caused by lower plant density at this wider spacing.

Meena and Paliwal and Rawat (2014) carried out research on impact of spacing (60x45cm and 45x45cm) ,and he found that the greatest number of head weight (0.80kg) recorded at 60x45cm as correlation with 45x45cm and **Kumar *et al.*, (2007)** determined the appropriate transplanting date and planting geometry of broccoli (*Brassica oleracea* L. cv *Italica*) for mid-slopes of Himalaya he found that the transplanting of broccoli on 30 September was seen as the best along these lines giving most noteworthy curd yield. Postponed transplanting on 15 November altogether decreased generation of broccoli. The mean yield diminished by 15.6, 20.4 and 46.5 % when the transplanting was done on 15 October, 30 October and 15 November, respectively compared to 30 September.

Roni *et al.* (2014) determining the optimal nitrogen level and sorting broccoli to improve its nutritive nature The study included 15 treatments, involving five levels of

nitrogen (0, 80, 120, 160, and 200 kg/ha) and three plant spacings (60cm x 60cm, 60cm x 45cm, and 60cm x 30cm). The outcomes uncovered that the water substance of curd was likewise essentially affected by the diverse plant dividing. The greatest water content (91.58%) was recorded from the wider spacing S_1 (60 cm×60 cm) which was factually indistinguishable from S_2 (91.46%) and least water content (91.29%) was recorded from S_3 (60 cm×30 cm). The dry issue substance of curd was altogether affected by the different spacing. The most extreme dry issue content (8.71%) was recorded from the closest spacing S_3 (60 cm×30 cm), which was trailed by S_2 (8.54%) treatment and the base dry issue content (8.42%) was recorded in S_1 (60cm×60cm). The ascorbic corrosive substance of curd didn't change altogether by the diverse dividing. Numerically it ran from 39.19 mg/100g to 40.11mg/100g. The β-carotene substance of curd was essentially impacted by the wider spacing. The most extreme β-carotene content (40.00 IU/100g) was recorded from the wider spacing S_1 (60 cm×60 cm), which was trailed by S_2 (37.40 IU/100g) treatment and least β-carotene content (36.27 IU/100g) was recorded from S_3 (60 cm×30 cm). If there should arise an occurrence of plant spacing a critical outcome was found in iron substance. The most extreme iron substance (131.410 ppm) was recorded from the medium spacing S_2 (60cm × 45cm), which was trailed by S_3 (120.304 ppm) and least iron substance (106.210 ppm) was recorded from largest spacing S_1 (60 cm × 60 cm plant spacing had applied huge impact on phosphorus and potassium content. The most extreme phosphorus content (0.189%) and potassium content (0.883%) was recorded from the widest spacing S_1 (60cm×60cm).

Firoj Asadul Haqu and N. Islam (2015) revealed the most noteworthy dry matter substance of the head found in the wider spacing, while the least was in with the closest spacing. Noteworthy an analysis was directed with cabbage during October 2012 to February 2013 at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh with the , three plant spacing: 50 x 30, 50 x 40 and 50 x 50 cm were applied in a Randomized Block Design with three replications variation was additionally found in their blend as far as the dry matter substance of the head, so he watched the most extreme dry matter content at plan spacing 50x50cm instead of the two.

Yadav *et al.* (2016) led a field test to assess the sufficiency of intercropping and crop geometry in natural generation of broccoli (*Brassica oleracea* var. *italica*) during

winter period of the year 2013-14. The analysis was spread out in split plot configuration repeated thrice with three different organic manures and two spacing viz., S1-45cm× 45cm, S2 – 30/60cm×45cm, as main plot medications and five intercrops. The crop geometry on broccoli crop had demonstrated a huge impact on growth and yield properties. The maximum number of leaves (22.3), weight of main head (176.9 g), girth of main head (11.9 cm), number of sprouts per plant (5.5), yield of sprouts per plant (354.7 g), total yield (main head + sprouts) per plant (531.6 g), total yield per hectare (262.5 q), vitamin A per 100 g (12.50 mg) and vitamin C per 100 g (81.78 mg) of broccoli was seen in normal spacing because of less challenge for developing space and light. Nonetheless, the greatest plant height (53.34 cm) and complete yield of intercrops per ha (60.5 q) was recorded in paired row planting (30/60 × 45 cm) because of closer spacing that bolstered erect development when contrasted with normal spacing. There was no huge impact of yield geometry on carotene substance.

Gariya *et al.* (2016) The effect of spacing and drip irrigation system levels on sprouting broccoli grown in a combined push framework from October to February in 2013-14 and 2014-15 was researched. The medicines comprised of three spacing (60 × 30 cm, 60 × 40 cm and 60 × 50 cm), and four drip irrigation system levels (120, 100, 80 and 60% of crop water requirement) alongside surface irrigation. The outcomes demonstrated huge impact of spacing and irrigation system levels on broccoli performance. Two years' pooled information plainly demonstrated that different development parameters were fundamentally affected by planting geometry and water system water level. Yield spacing at (60 × 50) cm had recorded the most extreme plant stature (66.03 cm), plant spread (106.09 cm), number of leaves per plant (19.87), leaf area per plant (400.59 cm2), stalk distance across (3.67 cm) and plant crisp weight (1.96 kg) and it was intently trailed by spacing (60 × 40 cm). The time taken to head commencement from the date of transplanting was fundamentally affected by plant geometry and water level through trickle framework. Least days to head inception (57.22) were recorded in plant spacing of (60×50 cm) and factually it differed altogether with other dispersing. The most extreme load of heads (344.68 g) was additionally recorded in a similar planting geometry I. e. (60×50 cm). Difference to this, the best return of heads (168.40 q/ha) was acquired in least plant spacing of (60×30 cm). This yield was 46.08 and 15.67% increasingly over plant spacing of

(60×50 cm and 60×40 cm), individually. Effect of planting geometry and irrigation water levels were unmistakably noticeable in present examination. When all is said in done, water use productivity was decreased as the plant spacing and irrigation levels were expanded. Most extreme water use effectiveness for plant spacing and irrigation levels were turned out in plant spacing of (60 × 40 cm) spacing (4.78 q/ha/cm). Monetary investigation worked out for broccoli development under various dribble water system levels and harvest geometry uncovered that the expense of growth, net returns, net returns and B : C proportion in the present study were discovered most noteworthy in the closer most spacing of (60×30 cm). It showed diminishing pattern as dividing expanded up to the degree of (60 x 50 cm). The development cost, net returns, net benefit and B : C proportion in three dispersing extended from Rs. 72,939.95 to 74,233.65; 1,72,338.00 to 2,51,766.00, Rs. 99,398.04 to 1,77,512.30 and 2.36 to 3.38, respectively.

Yadav *et al.* (2016) conducted a field investigation to assess the viability of intercropping and crop spacing in growth of broccoli (*Brassica oleracea* var. *italica*) during winter period of the year (2013-14) he examine two spacing at (45x45 and 60x45 cm) and detailed that the results of main head (11.9 cm) at (60x45cm than the 45x30cm).

Md. ShyduzzamanRoni, Mohammad Zakaria (2017) did saw that the mix of N composts and plant spacing and he found ,he most stretched out canopy spread (70.6 cm) was found in T_5 which (S60×60N) was measurably indistinguishable from T_{10} (70.5 cm), T_4 (69.8 cm), T_3 (66.5 cm), T_9 (65.4 cm), T_8 (64.5 cm), T_{13} (61.9 cm) and T_{15} (61.6 cm) while it was the lowest (50.4 cm) in T_{11} (S60×30N0).

S. Manasa, L.and Mukunda Lakshmim (2017) laid research and revealed that the, Maximum dry matter production (%) in red cabbage was recorded (10.57 %) at the lowest plant density (60 × 60 cm) examined by medium plant spacing (60 × 45 cm) (10.11 %). Then found, dry matter production (9.10 %) was found from (45 × 45cm) and **A. Khasmakhi-Sabet (2009)** announced that the, Fruit dry matter increased as plant density expanded. This can't help contradicting **Dasgan and Abak (2003)** who detailed that there was no impact of plant density on fruit dry matter. Plant density didn't influence levels of plant density on fresh matter. Plant thickness

didn't influence levels of nutrient new issue), P (14.9 mg/100 g new issue), Mg (5.2 mg/100 g new issue), or K (183.8 mg/100 g new issue.

S. Manasa and L.Mukunda Laxmi *et al.* (2017) direct research effect of nitrogen and different plant spacing like (45x45cm, 60x45cm, 60x60cm) and he find that the various doses of nitrogen application and different plant spacing affected higher yield of red cabbage. Best return (183.69 q/ha) was recorded with the higher plant density (45 × 45 cm) trailed by the medium plant density (60 × 45 cm) (153.29 q/ha) while, least yield (125.21 q/h) found at lower plant density (60x60cm).

2.3 Interactive effect of varieties and spacing

Griffith and Carling (1991) assessed the potential to produce broccoli (*Brassica oleracea* L. spp. *Italica* Plenck 'Green Valiant' and 'Ruler') at high scopes by estimating yield, head size and incidence of hollow stem in plantings at two sites and eight spacings. The most extreme yield of individual heads for fresh market was obtained at a spacing of 45 × 30 cm used single plant transplants. At this spacing, yields for Green Valiant and Emperor were 18.3 and 15.0 MT ha-1, individually. Broccoli heads little enough to be utilized for manage were gotten at a spacing of 45 × 40 cm utilizing two plants for each transplant plug with yields of 21.4 MTha-1 for Green Valiant. The incidence of hollow stem was low in Alaska and happened in Green Valiant planted at wide spacing. Only plants that produced heads with the biggest mean weight and mean widths showed hollow stem. The utilization of numerous plants per transplant plug diminishes mean head weight and diameter and lessens the occurrence of hollow stem.

Mihov and Antonova (2009) examined the performance of five broccoli cultivars and lines under two 80/60 cm and 80/40 cm planting plan and he detailed focal and lateral flower head weight expanded in developing with littler planting density (80/60 cm and Singh et al. (2006) contemplated the three spacing for example (45 × 30 cm, 45 × 45 cm &45 × 60 cm) on broccoli and he discover that the greatest Increase in spacing altogether expanded the length and width of curd, stalk length and diameter as well as curd yield at 45x60cm instead of the two.

Prasad *et al.* (2010) contemplated the reaction of varieties, (V_1 - Early you, V_2 - Nokguk, V_3 - Fiesta, V_4 – Princes) and plant spacing, (S_1-45×45 cm, S_2-60×60 cm, S_3-75×60 cm) and aphid management on growth and yield of broccoli. They detailed that altogether greatest plant height (57.95 cm), leaf area (1174.19) cm), plant spread (7196.85 cm), stem diameter (3.92 cm) and sprout weight (39.71 g) was recorded under the communication among S_1V_4 and most extreme stalk length (32.4 cm) under S_3V_2 collaboration and greatest curd diameter (25.9 cm), curd weight (466.0 g) and number of sprout (6.48) under S_2V_1 and greatest curd yield/plot (4.68 hg) and curd yield/ha (93.5q) under S_1V_1 and maximum sprout yield/plot (399.09 g) under S_1V_4.

Bhangre *et al.* (2011) examine the impact of various varieties (Ganesh Broccoli and Pusa KTS-1) with five spacing (60×60 cm, 60×45 cm, 45×45 cm, 60×30 cm & 45×30 cm). Interaction impact of various varieties and spacing was found most important role. Interaction V_1S_1 was the best among the all treatment combination except yield per hectare.

Chapter-3

Materials and Methods

CHAPTER -3

MATERIALS AND METHODS

The methods to be employed during the course of investigation and materials utilized have great significance in the research program. The details of the material and methods would be used during the present investigation entitled **"Studies on the influence of varieties and spacing on growth, yield and quality traits of sprouting broccoli (*Brassica oleracia* L. var. *italica* Plenck)"** has been discussed under the some of the fallowing head:

3.1: Experimental site:

The field experiment was conducted at the Horticulture Research Farm of the Department of Applied Plant Science (Horticulture), School for Bio-sciences and Biotechnology, Babasaheb Bhimrao Ambedkar University, (A Central University), Vidya Vihar, Raebareli Road, Lucknow-226025 (U.P.), India, during rabi season of (2017-18 & 2018-19) from the mid October to mid March. The geographically Lucknow is situated at 26^0 50, N latitude, 80^0 52, E longitude and the altitude of 111 meter above mean sea level (MSL). The topography field is plain.

3.2: Climatic conditions:

The climatic condition, Lucknow has fall under the humid subtropical climate with the average rainfall of about 110cm and relative humidity ranged during these condition approximately ranging 60-90% depending upon the weather and the climatic factor. During the winter condition (December-January) the temperature may be fall up to the 2^0Cand the during summer (May-June), the temperature may go beyond the 43^0C. The Lucknow condition received major form of the rainfall only by south-west monsoon, which received during the generally third week of June and recedes by the end of September with heavy rainfall during the monsoon season. The weather parameter which prevailed during the course of the investigation was recorded at Meterological Observatory of the Indian Institute of Sugarcane Research (IISR), Lucknow, which has presented as following tables:

Table 3.1: Weekly meteorological observations recorded during the experimental period of the crop (2017-18).

Period		Mean Temp.(^{0}C)		Relative Humidity (%)		Wind Velocity (km/hr)	Total Rainf-all (mm)
Month	**Date**	**Maximum**	**Minimum**	**Maximum**	**Minimum**		
Jul.-Aug.-2017	26-04	31.3	14.0	97.0	35.0	0.7	0
	05-11	28.9	12.8	96.0	47.0	1.2	0
	12-18	29.0	11.7	97.0	37.0	0.9	0
	19-25	28.0	11.2	94.0	38.0	1.4	0
Sep.-Oct.-2017	26-02	26.9	10.6	95.0	58.0	1.0	0
	03-09	20.5	10.6	98.0	76.0	1.0	0
	10-16	22.2	8.8	99.0	58.0	0.9	0
	17-23	23.6	8.1	96.0	46.0	1.3	0
	24-31	22.2	9.1	97.0	66.0	0.9	0
Nov.-Dec.-2017	01-07	19.6	9.4	97.0	75.0	1.1	0
	08-14	20.2	5.5	92.0	42.0	1.8	0
	15-21	22.4	5.7	95.0	41.0	1.7	0
	22-28	25.9	9.8	95.0	43.0	2.0	0
Jan.-Feb. 2018	29-04	23.1	8.6	96.0	54.0	1.7	0
	05-11	25.6	9.9	93.0	39.0	3.4	0
	12-18	26.1	10.0	96.0	42.0	1.6	0
	19-25	28.9	12.5	82.0	30.0	4.2	0
Feb.-Mar. 2018	26-04	30.0	12.7	82.0	24.0	4.0	0
	05-11	28.9	13.4	79.0	33.0	4.1	0.6
	12-18	28.4	11.1	82.0	23.0	4.7	0.7
	19-25	33.4	17.0	74.0	24.0	4.1	0
Mar.-Apr. 2018	26-01	38.2	19.3	67.0	20.0	5.3	0
	02-08	38.7	21.8	65.0	24.0	4.1	0
	09-15	37.3	18.6	54.0	17.0	5.3	0
	16-22	38.7	24.4	72.0	37.0	2.2	0
	23-30	38.7	23.9	52.0	23.0	4.9	0

Source: Indian Institute of Sugarcane Research (IISR), Lucknow

Table 3.2: Weekly meteorological observations recorded during the experimental period of the crop (2018-19).

Period		Mean Temp. (ºC)		Relative Humidity (%)		Wind Velocity (Km/hr)	Total Rainfall (mm)
Month	Date	Maximum	Minimum	Maximum	Minmum		
Oct. 2018	01-07	35.30	20.80	90	41	2.3	0.0
	08-14	34.10	19.70	90	46	1.4	0.0
	15-21	34.40	16.70	93	29	1.7	0.0
	22-28	32.40	14.80	93	32	1.3	0.0
Oct. to Nov.2018	29-04	32	14.3	94	40	0.9	0.0
	05-11	31.9	15.9	94	37	1.5	0.0
	12-18	29.1	12.7	90	36	1.9	0.0
	19-25	28.1	10.3	92	37	1.6	0.0
Nov. to Dec.2018	26-02	26.9	9.8	97	44	1.0	0.0
	03-09	25.1	6.7	97	42	1.1	0.0
	10-16	23.9	7.0	95	44	1.6	0.0
	17-23	23.5	3.4	95	34	1.2	0.0
	24-31	21.8	2.5	93	31	2.1	0.0
Jan. 2019	01-07	22.7	4.9	97	45	1.5	0.0
	08-14	22.6	5.8	93	37	1.8	0.0
	15-21	22.9	4.5	96	40	2.3	0.0
	22-28	21.8	10.3	90	65	2.0	0.0
Jan. to Feb. 2019	29-04	22.3	7.0	94	45	2.7	0.0
	05-11	22.5	9.5	97	58	2.5	0.0
	12-18	23.6	10.4	94	53	2.3	0.0
	19-25	26.4	11.3	93	42	3.6	0.0
Feb to Mar.2019	26-04	23.6	9.5	91	51	2.9	0.0
	05-11	27.5	10.9	88	38	4.4	00
	12-18	30.5	13.1	78	30	4.1	0.0
	19-25	32.1	15.0	71	27	5.5	0.0
	26-01	35.8	17.0	68	23	4.2	0.0
Apr. 2019	02-08	35.7	19.8	70	33	2.5	00
	09-15	35.2	19.6	71	26	3.3	0.0
	16-22	39.5	21.8	47	17	4.8	0.0
	23-29	37.7	18.2	54	25	3.8	0.0

Source: Indian Institute of Sugarcane Research (IISR), Lucknow

3.3: Soil status of the experimental areas:

In our Horticulture Research for, the field soil is sandy loam and slightly alkaline in nature with soil pH8.2, with uniform topography. The physical and chemical properties of soil has been presented in fallowing tables:

Table 3.3: Physical and chemical properties of soil

A.	**Physical Property of soil**		
S. No.	**Soil Particle**	**Percentage**	**Method of Determination**
1	Sand	34.50	Hydrometer meter method (Block, 1965)
2	Silt	50.20	
3	Clay	15.30	
4	Texture class	Sandy loam	Triangular method (Sigmoid, 1928)
B	**Chemical property of soil**		
	Component	**Amount**	**Method of determination**
1	Available N_2 (Kg/ha)	110.50	Kjeldahl's method (A.O.A.C., 1980)
2	Available P_2O_5 (Kg/ha)	40.50	Olsen's method (Jackson, 1983)
3	Available K_2O (Kg/ha)	190.40	Flame photometer (Jackson, 1983)
4	Organic carbon (%)	0.12	Rapid titration method (Jackson, 1983)
5	Ph	8.2	Glass electrode, pH meter (Jackson, 1983)
6	E.C (1:1)	0.26	Conductivity meter (Jackson, 1983)
7	E.S.P.	14.80	Conductivity meter (Jackson, 1983)

Table 3.4: Experimental materials

S. No.	**Name of variety**	**Source**
1.	KTS-1	IARI Reginal Station, Katrain (H. P.)
2.	Palam Kanchan	C.S.K. H.P.K.V., Palampur (H. P)
3.	Palam Vichitra	C.S.K. H.P.K.V., Palampur (H. P)
4.	Palam Samridhi	C.S.K. H.P.K.V., Palampur (H. P)

Table 3.5: Layout of experiment field

Treatment	Replication	Replication	Replication
T_1	R_1 V_1 S_1	R_2 V_2 S_1	R_3 V_3 S_1
T_2	R_1 V_1 S_2	R_2 V_2 S_2	R_3 V_3 S_2
T_3	R_1 V_1 S_3	R_2 V_2 S_3	R_3 V_3 S_3
T_4	R_1 V_1 S_4	R_2 V_2 S_4	R_3 V_3 S_4
T_5	R_1 V_2 S_1	R_2 V_3 S_1	R_3 V_4 S_1
T_6	R_1 V_2 S_2	R_2 V_3 S_2	R_3 V_4 S_2
T_7	R_1 V_2 S_3	R_2 V_3 S_3	R_3 V_4 S_3
T_8	R_1 V_2 S_4	R_2 V_3 S_4	R_3 V_4 S_4
T_9	R_1 V_3 S_1	R_2 V_4 S_1	R_2 V_1 S_1
T_{10}	R_1 V_3 S_2	R_2 V_4 S_2	R_3 V_1 S_2
T_{11}	R_1 V_3 S_3	R_2 V_4 S_3	R_3 V_1 S_3
T_{12}	R_1 V_3 S_4	R_2 V_4 S_4	R_3 V_1 S_4
T_{13}	R_1 V_4 S_1	R_2 V_1 S_1	R_3 V_2 S_1
T_{14}	R_1 V_4 S_2	R_2 V_1 S_2	R_3 V_2 S_2
T_{15}	R_1 V_4 S_3	R_2 V_1 S_3	R_3 V_2 S_3
T_{16}	R_1 V_4 S_4	R_2 V_1 S_4	R_3 V_2 S_4

R = Replication
V = Variety, V_1- Pusa Broccoli KTS-1, **V_2-**Palam Kanchan **, V_3-**Palam Vichitra **, V_4-** Palam Samridhi.
S = Spacing, S_1- 60 ×45 cm, **S_2** - 60×30 cm, **S_3** - 45×45 cm, **S_4** - 45×30 cm

Table 3.6: Details of experiment Layout

Location		:	Department of Applied Plant Science (Horticulture) School for Bio-sciences and Biotechnology Babasaheb Bhimrao Ambedkar University (A Central University) Vidya Vihar, Raebareli Road, Lucknow
Name of crop		:	Sprouting Broccoli (*Brassica oleracea* L. var. *italica* Plenck)
Season		:	Rabi Season 2017-18 & 2018-19
Number of varieties		:	4
Number of treatments		:	16
Replication		:	3
Total plots		:	48
Number of spacing		:	4
Spacing first (row to row x plant to plant)		:	60 cm x 45cm
	Net plot size	:	1.8m x 1.8m
	Gross plot size	:	2.32m X 2.32m
	Number of plants per plot	:	12
Spacing second (row to row x plant to plant)		:	60 cm x 30cm
	Net plot size	:	1.8m x 1.8m
	Gross plot size	:	2.25m X 2.25m
	Number of plants per plot	:	18
Spacing third (row to row x plant to plant)		:	45cm x 45cm
	Net plot size	:	1.8m x 1.8m
	Gross plot size	:	2.35m X 2.35m
	Number of plants per plot	:	16
Spacing third (row to row x plant to plant)		:	45cm x 30cm
	Net plot size	:	1.8m x 1.8m
	Gross plot size	:	2.18m x 2.18m
	Number of plants per plot	:	24
Total plants are required for entire field		:	864
Design		:	Factorial Randomized Block Design

3.4: Cultural operation:

3.4.1: Nursery Raising:

Fine well drained, 15-20cm raised, 1m wide and of convenient length about 2m, should be prepared. Fully decomposed FYM @ 3-4 kg should be well mixed to the bed, the bed should be covered with transparent polyethylene sheet about (100 micron) should covered at 8-10 days for soil solarisation, and after them it should be removed 3-5 days before sowing and kept open. The seed should be soaked @ 6-8 hour in water for facilitated germination and the N seed should be removed from water and kept wet cloths until sowing. The seed should be treated with Thiram and Bavistin @ 2:1 ratio/kg seed.

The seed are sown at 3rd November 2017, seed sowing done at shallow depth 0.5cm apart,1-1.5cm depth and 5cm spaced, and covered with fine sand or soil and lightly irrigated just after sowing and covered with organic mulch like straws about 2-3cm thickness ,care should taken does not more because it's effect on germination. The seed start germination at 3-5 days after, them mulch should removed. The proper care taken in respect like irrigation, weeding, protection from rain, wild animals and plant protection like drenching with Bavistin and Redomil were under taken till seedling were ready for transplanting.

3.4.2: Soil preparation and fertilizer application:

The field should be prepared by one deep plugging at summer months at May-June, and then left, afterward should be 2-3 deep plugging carried by the tractor followed by leveling. The field should be prepared three replication and each having nine treatments. The generally 3-4 kg FYM should be mixed each plot, about 15-20 days before transplanting and mixed thoroughly. Then fertilizer should be applied @ 150 Kg N, 60 Kg P_2O_5 & 60 Kg K_2O per hectare through Urea, Single Super Phosphate and Muriate of Potash. All these fertilizers were applied uniformly and were mixed with the help of spade in each bed. Remaining 50 percent of Nitrogen in the form of urea was applied as top dressing after 30 days of transplanting as band placement.

Fig no.-1: A general view of broccoli nurseery

Fig no.-2: A general view of priparation lay-out plan of experimental site

3.4.3: Transplanting:

The transplanting should be done at 30 days old seedling. The transplanting was carried out by me at 4th December, 2017 and 4th December, 2018 at evening time at four spacing (60x45cm, 60x30cm, 45x45cm & 45x30cm), according our research investigation. Seedling of uniform size was selected from nursery for this purpose. The care should be taken seedling should hardening by withhold irrigation 4-6 days before transplanting for better establishment and easily recover transplanting shock. Gap filling carried out by me about 2-3 days after transplanting

3.4.4: Irrigation:

The broccoli require sufficient moister in the soil for uniform and continuous growth .The light irrigation should be given just after transplanting and them frequently irrigated at each morning and evening at continuous 3-4 day for better establishment. The soil moister should be sufficient for better yield and quality hence irrigation at weekly interval at (November-mid December) and 10-12 days interval at (mid December-mid march) given. About 10-13irrigation needed during whole growing season. Water logging should be avoided. The furrow irrigation carried out by me. The earthing up carried out by me at 25 days after transplanting(30cm plant height) and second earthing should be done at 40days by covering 5-6 cm height of plant stem.

Fig no.-3: A general view of transplanting the plant in experimental site

Fig no.-4: A general view of broccoli crop after 25 DAT

3.4.5: Weeding:

The first hand weeding carried out by at 25 days after transplanting, and second weeding carried out at the 35days and third at 45 days respectively.The care should be taken deep hoeing or weeding avoided below depth (5-6cm) because broccoli is shallow rooted crop and most of the feeding root are concentrated at upper surface.

3.4.6: Earthing up:

Earthing up is an important practice in broccoli crop. This process is done after the weeding.

3.4.7: Harvesting:

The harvesting of broccoli 1st year started earlier of Pusa Broccoli KTS-1,(Mid maturing 85-90days) from 20 February (2018) to Palam Samridhi, Palam Vichitra & Palam Kanchan (Late maturing 115-125 days) to until 20 March 2018. Harvesting of broccoli 2nd year started earlier of Pusa Broccoli KTS-1, (Mid maturing 90-95days) from 26 February (2019) to Palam Samridhi, Palam Vichitra & Palam Kanchan (Late maturing 115-125 days) to until 28 March 2019. The harvesting done before flower bud sprouting and compact curd when attainment about 10-15cm diameter, without any loosing curd.

Fig no.-5: A general view of broccoli crop after 35 DAT

Fig no.-6: A general view of irrigation time in broccoli crop

Fig no.-7: A general view of broccoli crop at growth stage

3.5: Observations were recorded during our investigation:

3.5.1: Influence of varieties and spacing on vegetative growth character.

3.5.1.a: Plant height (cm)

3.5.1.b: Stem diameter (cm)

3.5.1.c: Plant canopy spreading east-west direction (cm)

3.5.1.d: Plant canopy spreading north-south direction (cm)

3.5.1.e: Numbers of leaves per plant

3.5.1.f: Length of leaves (cm)

3.5.1.g: Width of leaves (cm)

3.5.1.h: Dry weight of plant (g)

3.5.2: Influence of varieties and spacing on yield and yield attributes characters:

3.5.2.a: Curd initiation days

3.5.2.b: Day taken to curd harvest after curd initiation

3.5.2.c: Curd diameter (mm)

3.5.2.d: Weight of curd with guard leaf (g)

3.5.2.e: Weight of curd without guard leaf (g)

3.5.2.f: Yield (kg/plot)

3.5.2.g: Yield (Q/ha)

3.5.3 Influence of varieties and spacing on quality character:

3.5.3.a: Ascorbic Acid (vit-C) (mg/100g)

3.5.3.b: T.S.S (Total soluble solids)(^{0}Brix)

3.5.3.c: Total sugar (%)

3.5.3.d: Reducing sugar (%)

3.5.3.e: Non-reducing sugar (%)

3.5.4: Economic Analysis:

3.5.4.a: Cost of cultivation

3.5.4.b: Price/ quintal

3.5.4.c: Gross return

3.5.4.d: Net return

3.5.4.e: Benefit cost ratio

3.6: Procedure for taking observation:

The observations were taken from three randomly selected plants from each plot.

3.6.1: Influence of varieties and spacing on vegetative growth character.

3.6.1.a: Plant height (cm):

The observations were taken at 30 DAT, 45 DAT, 60 DAT and at harvesting stage from the three randomly selected plants from the transplanting to until final observations at harvesting stage. The height of the plant was recorded from surface of soil to the tip of the longest leaf of the plant with the help of meter scale. The mean height of the plant was obtained by summing up the length of four tagged plants and dividing it by four.

3.6.1.b: Stem diameter (cm):

The observations were taken at 30 DAT, 45 DAT and 60 DAT from the four randomly selected plants from the transplanting to until final observations at 60 DAT. The stem diameter of the plant was recorded (peduncle length10-15 cm length which should be attached with curd after final harvesting) of curd after the harvesting of three

randomly selected plants was measured at thickest portion of the stem using Verniercaliper and expressed in centimeters.

3.6.1.c: Plant canopy spreading east-west direction (cm):

The average of distance between two outer most leaves in both direction (east-west). The plant spread of three randomly selected plants was recorded as product (east-west). The average distance between outer most leaves east to outer most leaves west direction were recorded by measuring scale.

3.6.1.d: Plant canopy spreading north-south direction (cm):

The average of distance between two outer most leaves in both direction (north-south). The plant spread of three randomly selected plants was recorded as product (north- south).The average distance between outer most leaves north to outer most leaves south direction were recorded by measuring scale.

3.6.1.e: Number of leaves per plant:

The taking of these observation done at 30 days, 45 days and, 60 days and after transplanting fully open leaves of three tagged plants were counted from each plot, while small leaves attached inside the whorl were left out in three randomly selected and tagged plants and the average of three plants was computed to get mean number of leaves per plant.

3.6.1.f: Length of leaves (cm):

During the taking these observation care should be taken only fully grown mature leaves should be selected, length of three fully leaves per plant was measured with scale in all the three observational selected plants. The average of three, leaves gave per leaf length.

3.6.1.g: Width of leaves: (cm):

The width of leaves were measured with the help of scale. The cumulative total of the width of three leaves from each of the three tagged plants were averaged to get per leaf.

3.6.1.h: Dry weight of plant (g):

Dry weight of plant was observed in harvesting stage in three randomly selected and tagged plants and the average of three plants was computed to get mean of dry weight of plant (g).

3.6.2: Influence of varieties and spacing on yield and yield attributes characters:

3.6.2.a: Curd initiation days:

Curd initiation days are observed after fully curd initiation in three randomly selected and tagged plants and the average of three plants was computed to get mean of curd initiation days.

3.6.2.b: Day taken to curd harvest after curd initiation:

Day taken to curd harvest after curd initiation in three randomly selected and tagged plants and the average of three plants was computed to get mean of day taken to curd harvest after curd initiation.

3.6.2.c: Curd diameter (cm):

The curd diameter of three selected plant should be recorded at Lab after the removing of all jacket leaves with the help of the veniercalipers. The curd size index should be calculated on the basis of curd length (vertical) × curd breadth (Horizontal). The curd length was recorded as average of three randomly marketable curds from base to tip of curd and curd breadth from widest part of curd.

3.6.2.d: Weight of curd with guard leaf (g):

The Weight of three curds at edible maturity stage was recorded during final harvesting in Lab using electronic weighing balance. The weight of the curd should be

taken after remove the leaves and stalk were recorded and the weight of curd with gurad leaf (g) was worked out. The average weight of curd with gurad leaf (g) was expressed in grams.

3.6.2.e: Weight of curd without guard leaf (g):

The weight of curd without guard three curds at edible maturity stage was recorded during final harvesting in Lab using electronic weighing balance. The weight of curd without guard leaf should be taken after removing the leaves and stalk were recorded and the weight per curd was worked out. The average weight of curd without guard leaf was expressed in grams.

3.6.2.f: Yield (kg/plot):

The yield was recorded as net weight of marketable curd from each bed was later converted into kg/plot.

3.6.2.g: Yield (q/ha):

The yield was recorded as net weight of marketable curd from each bed was later converted into q/ha by multiplying with common factor.

3.6.3: Influence of varieties and spacing on quality character:

3.6.3.a: Ascorbic acid (Vitamin-C) contents (mg/100g):

It was estimated with using of 2, 6-dichlorophenol indo phenol dye suggested by A.O.A.C. (1975). It was expressed in mg/100 g edible part.

3.6.3.b: Total soluble solids (T.S.S)(^{0}Brix):

To determine the TSS of broccoli curd were selected (10g), (Broccoli curd were composed several pre-floral knob), hence knob should selected from curd, were crushed to form a homogenized sample and then the juice was extracted through muslin cloth. The extract was used for determination of T.S.S. in ^{0}Brix by Digital Refractometer. Few drops of juice were placed on the surface of Refractometer. The reading was noted by revolving the eyepiece at room temperature.

3.6.3.c: Total sugar(%):

The total sugar percentage was determined by the method suggested by **Dubois *et al*., (1956)** using Fehling solution A & B**.** and calculate with the help of standard curve and results were expressed in % on the basis of 100 g fruit sample.

3.6.3.d: Reducing sugar (%):

Reducing sugar in fruit was determined by the method suggested by **Miller (1959).** It was calculate with the help of standard curve and results were expressed in % on the basis of 100 g fruit sample.

3.6.3.e: Non- reducing sugar(%):

Non reducing sugar was obtained by subtraction of reducing sugar from total sugar.

Non- reducing = (Total sugar – reducing sugar) x 0.95.

3.6.4: Economic Analysis:

In order to evaluate the most profitable treatment, economic analysis of treatments was worked out in terms of net returns and cost benefit (C: B) ratio. The net returns and C: B ratio was calculated as follows: Net returns were calculated by deducting the cost of cultivation from the gross income. C: B ratio = Gross return 100 Cost of cultivation

3.6.4.a: Cost of cultivation:

Cost of cultivation **=** Total variable Cost + Total fixed cost

3.5.4.b: Price/ quintal:

Price per quintal was estimate according to market average price. Average market price 1500 Rs./quintal.

3.5.4.c: Gross return:

Gross return = Yield (q/ha) × Market price of the crop (Rs. /q).

3.5.4.d: Net return:

Net return = Total income - Total cost of cultivation

3.5.4.e: Benefit cost ratio:

Benefit cost ratio = Cost of total benefit / Cost of production

Table 3.7: Average cost of cultivation of broccoli (Rs/ ha):

S. No.	Operation	No. / Quantity	Cost
A	**Production cost**		
1.	Nursery bed preparation for one hectare land	3 beds	750
2.	Seed	350 g	1750
3.	Field preparation (Tractorisation)	2 times	9000
4.	Hired labour		
a.	Layout	40	10000
b.	Fertilizer application & ridge making	40	10000
c.	Transplanting	15	3750
d.	Irrigation	4	1000
e.	Hoeing & Weeding	40	10000
f.	Earthing up	20	5000
g.	Harvesting	10	250
h.	Spray of insecticides/ pesticides	02	500
5.	Fertilizer (N, P & K)	120:60:60	6550
6.	FYM		16000
7.	Insecticide / pesticides		2500
8.	Miscellaneous expenditure		7000
	Total production cost		68050
B.	Marketing cost		
1.	Transporting cost		4500
2.	Carry bag		2000
	Total marketing cost		6500
	Total cost (A+B)		90550

3.7: Statistical analysis:

In our investigation, data should be collected from various growth, yield,

and the quality parameter has been statistically analysis was carried out by using, Randomized Block Design. Data collected from various parameter can analysed statistically and the significance of the treatment effect can be judge with the help of "F" (Variance ratio) test fallowing Randomized Block Design

(A) .Sum of square:

1. Correction factor(C.F)= (G.T.) 2/N

2. Total S.S (T.S.S) =(X 12+X22+.....X 33) –C.F.

3. S.S. is due block = ($B1^2$+ .....$B3^2$)2 – C.F.

4. S.S. due to treatment =(1^2 +$Z2^2$+.....$Z11^2$)2 –C.F.

5. S.S. due to error = (Total S.S- Block S.S – Treatment S.S)

(B) Analysis of Variance:

Suppose if no of treatment is "n" and no of replication them degree of freedom (D.F.) can be calculated into three parts:

1. Between block

2. Between treatment

3. Random variation which provides basis for the estimation of error

Table 3.8: The structure of analysis as fallow:

Source of variation	D.F.	S.S.	M.S.S	FValue Calculated (F cal.)	Table value of F at 5%	Table value of F at 5%
Block	r-1=2	SSR	MSR	MSR/MSS		
Variety	(v-1)=2	SSV	MSV	MSV/MSS		
Spacing	(s-1)=2	SSS	MSS	MSS/MSS		
VXS	(v-1(s-1)=4	SSVS	MSVS	VMSVS/MSS		
Error	22	SSS	MSS			
Total	(rvs-1)=35	SST				

The significant differences between different treatments were judged by using critical difference (CD), which was calculated with the formula given by Panse and Sukhatme (1985).

1. Standard error of mean (S.Em ±)

$$S.Em \pm (S) = \frac{EMS}{\text{No. of replications} \times \text{No of Variety}}$$

2. Critical Difference (CD) = S.Em ± (S) ×□2 × t value for error df at 5%

3. $$S.Em \pm (V) = \frac{EMS}{\text{No of replication} \times \text{No of spacing levels}}$$

4. Critical Difference (CD) = S.Em ± (V) ×□2 × t value for error df at 5%

5. $$S.Em \pm (V \times S) = \frac{EMS}{\text{No of replication}}$$

6. Critical Difference (CD) = S.Em ± (V×S) ×□2 × t value for error df at 5%

Hence, the total number of observation in nr, the total degree of freedom will be nr-1,as the block and treatment are represented by "r" and "n" respectively their corresponding degree of freedom will be (r-1) and (n-1) standard error (S.E.) due to treatment = + √VE/r

Standard Error (S.E.) and Critical difference (C.D.):

The standard error of the mean based on "r" replication was estimated by relation-

(S.E.) Mean = √VE/r

Critical difference (C.D) at 5% level of significance =(SE) difference X at 5% for error degree of freedom.

Chapter-4

Experimental Findings

CHAPTER -4

EXPERIMENTAL FINDINGS

The present investigation entitled **"Studies on the influnce of varieties and spacing on growth, yield and quality traits of sprouting broccoli (*Brassica oleracea* L. var. *italica* Plenck)"** was carried out at Horticulture Research Farm, Department of Applied Plant Science (Horticulture), School for Bio-sciences and Biotechnology, Babasaheb Bhimrao Ambedkar University (A Central University), Vidya Vihar, Raebareli Road, Lucknow 226025 (U.P.), India, during the rabi season of (2017-18 & 2018-19). The response of vegetative growth, yield and quality character of sprouting broccoli have been described in this chapter with the help of tables and figures wherever considered necessary. In our investigation the following data related on growth characters, yield attributes and quality have been recorded by me, which as follows.

4.1: Studies on the influence of varieties, spacing and their interaction on vegetative growth characters:

4.1.1: Plant height (cm)

4.1.2: Stem diameter (cm)

4.1.3: Plant canopy spread east-west direction (cm)

4.1.4: Plant canopy spread north-south direction (cm)

4.1.5: Numbers of leaves per plant

4.1.6: Length of leaves (cm)

4.1.7: Width of leaves (cm)

4.1.8: Dry weight of plant (g)

4.2: Studies on the influence of varieties, spacing and their interaction on yield attributes characters:

4.2.1: Curd initiation days

4.2.2: Day taken to curd harvest after curd initiation

4.2.3: Curd diameter (cm)

4.2.4: Weight of curd with gourd leaf (g)

4.2.5: Weight of curd without gourd leaf (g)

4.2.6: Yield (kg/plot)

4.2.7: Yield (q/ha)

4.3: Studies on the influence of varieties, spacing and their interaction on quality characters:

4.3.1: Vitamins-C (mg/100g)

4.3.2: T.S.S. (Total soluble solids) (^{0}Brix)

4.3.3: Total sugar (%)

4.3.4: Reducing sugar (%)

4.3.5: Non reducing sugar (%)

4.4: Economic Analysis:

4.4.a: Cost of cultivation

4.4.b: Price/ quintal

4.4.c: Gross return

4.4.d: Net return

4.4.e: Benefit cost ratio

4.1.1: Plant height:

Among the two years (2017-18 & 2018-19) and pooled data plant height (cm) was recorded at 30, 45 and 60 days after transplanting and at harvesting stage. The data

presented in (Table & Fig.-4.1.1) revealed significant influence of varieties and spacing on plant height at all the stages.

Varieties V_1 Pusa Broccoli KTS-1 showed (24.24 cm) the highest plant height in 1st year i.e. in (2017-18) and (24.23 cm) in 2nd year i.e. in (2018-19), respectively at 30 DAT followed by V_2 Palam Kanchan showed (23.88 and 23.88 cm, consequently) 1st year and 2nd year. Pooled value showed the highest plant height (24.24 cm) was measured in varieties V_1 Pusa Broccoli KTS-1 as compared to V_2 Palam Kanchan value (23.88 cm) and lowest in V_3 Palam Vichitra in 1st year (23.52 cm), 2nd year (23.58 cm) and pooled (23.55 cm) followed by V_4 Palam Samridhi in 1st year (23.67cm), 2nd year (23.59 cm) and pooled (23.52 cm), respectively. The difference between V_1, V_2, V_3 and V_4 was significant at 30 DAT.

Plant spacing S_1 (60x45 cm) as found (24.11 cm) had recorded maximum plant height 1st year i.e. in (2017-18), (24.14 cm) in 2nd year i.e. in (2018-19), respectively at 30 DAT followed by S_2 (60x30 cm) showed (23.97 and 23.99 cm, consequently) 1st year and 2nd year. Pooled value showed the highest plant height (24.13 cm) was measured in varieties S_1 (60x45 cm) as compared to S_2 (60x30 cm) showed in (23.98 cm) and lowest in S_4 (45x30 cm) in 1st year (23.58 cm), 2nd year (23.59 cm) and pooled data (23.12 cm) respectively followed by S_3 (45x45 cm) in 1st year (23.65 cm), 2nd year (23.62 cm) and pooled data (23.64 cm). The difference between S_1, S_2, S_3 and S_4 were significant at 30 DAT.

The combined influence of varieties and spacing on (interaction) recorded at 30 DAT was found maximum for plant height V_1S_1 (24.36 cm) 1st year i.e. in (2017-18) and (24.42 cm) in 2nd year i.e. in (2018-19), respectively at 30 DAT followed by V_1S_2 showed (24.33 and 24.22 cm, consequently) 1st year and 2nd year. Pooled value showed the highest plant height (24.39 cm) was measured in interaction V_1S_1 as compared to V_1S_2 (24.28 cm) and lowest value in V_3S_4 in 1st year (23.06 cm), 2nd year (23.16 cm) and pooled data (23.12 cm) respectively followed by V_4S_4 in 1st year (23.24 cm), 2nd year (23.18 cm) and pooled data (23.20 cm) It showed significant effect on plant height at all stages of growth at 30 DAT.

At 45 DAT Varieties V_1 Pusa Broccoli KTS-1 showed (44.22 cm) the highest plant height in 1st year i.e. in (2017-18), (44.16 cm) in 2nd year i.e. in (2018-19) and polled

data (44.19 cm), respectively followed by V_2 Palam Kanchan showed (43.81, 43.98 and 43.90 cm, consequently) 1st year, 2nd year and pooled value. The lowest value in V_3 Palam Vichitra in 1st year (42.95 cm), 2nd year (42.97 cm) and pooled data (42.96 cm) respectively followed by V_4 Palam Samridhi in 1st year (43.78 cm), 2nd year (43.73 cm) and pooled data (43.76 cm). The difference between V_1, V_2, V_3 and V_4 was significant at 45 DAT.

Plant spacing S_1 (60x45 cm) as found (44.13 cm) had recorded maximum plant height 1st year i.e. in (2017-18), (44.27 cm) in 2nd year i.e. in (2018-19), respectively at 45 DAT followed by S_2 (60x30 cm) showed (44.11 and 43.89 cm, consequently) 1st year and 2nd year. Pooled value showed the highest plant height (44.20 cm) was measured in spacing S_1 (60x45 cm) as compared to S_2 (60x30 cm) showed (44.00 cm) and lowest value in S_4 (45x30 cm) in 1st year (43.02 cm), 2nd year (42.93 cm) and pooled data (42.98 cm) respectively followed by S_3 (45x45 cm) in 1st year (43.48 cm), 2nd year (43.65 cm) and pooled data (43.57 cm). The difference between S_1, S_2, S_3 and S_4 were significant at 45 DAT.

The combined influence of varieties and spacing on (interaction) recorded at 45 DAT was found maximum for plant height V_1S_1 (44.99 cm) 1st year i.e. in (2017-18), (44.88 cm) in 2nd year i.e. in (2018-19) and polled data (44.93 cm), respectively at 45 DAT followed by V_2S_2 showed (44.98 and 44.46 cm, consequently) and (44.43 cm) 1st year, 2nd year and both year. The minimum value in V_3S_4 in 1st year (42.03 cm), 2nd year (42.16 cm) and pooled data (42.10 cm) consequently pursued by V_4S_4 in 1st year (42.79 cm), 2nd year (42.88 cm) and pooled data (42.84 cm). It showed significant effect on plant height at all stages of growth at 45 DAT.

At 60 DAT varieties V_1 Pusa Broccoli KTS-1 showed (60.74 cm) the highest plant height in 1st year i.e. in (2017-18), (60.63 cm) in 2nd year i.e. in (2018-19) and (60.69 cm) cumulative data consequently pursued by V_2 Palam Kanchan showed (60.38 cm), (60.34 and 60.36 cm, respectively), 1st year, 2nd year and polled data. The lowest plant height was measured in V_3 Palam Vichitra 1st year (59.59 cm), 2st year (59.86 cm) and combined data (59.73 cm) respectively followed by V_4 Palam Samridhi 1st year (59.70 cm), 2nd year (59.88 cm) and combined data (59.79 cm). The difference between V_1, V_2, V_3 and V_4 was significant at 60 DAT.

Plant spacing S_1 (60x45 cm) as found (60.96 cm) had recorded maximum plant height 1st year i.e. in (2017-18), (61.14 cm) in 2nd year i.e. in (2018-19), (61.05 cm) combined data respectively at 60 DAT followed by S_2 (60x30 cm) showed (60.68 cm), (61.14 cm) and (61.05) 1st year, 2nd year and pooled data. Minimum plant height was measured in S_4 (45x30 cm) in 1st year (59.10 cm), 2nd year (59.10 cm) and pooled data (59.10 cm) consequently pursued by S_3 (45x45 cm) in 1st year (59.14cm), 2nd year (59.74 cm) and pooled data (59.43 cm). The difference between S_1 S_2, S_3 and S_4 were significant at 60 DAT.

The combined influence of varieties and spacing on (interaction) recorded at 60 DAT was found maximum for plant height V_1S_1 (61.23cm) 1st year i.e. in (2017-18), (61.93 cm) in 2nd year i.e. in (2018-19) and combined data (61.58 cm) respectively at 60 DAT followed by V_1S_2 showed (61.13, 61.90 and 61.51 cm, respectively) 1st year, 2nd year, and cumulative data. Minimum plant height was measured in V_3S_4 in 1st year (58.03 cm), 2nd year (58.02 cm) and pooled data (58.03 cm) consequently pursued by V_4S_4 (58.05 cm) 1st year i.e. in (2017-18), (58.34 cm) in 2nd year i.e. in (2018-19) and combined data (58.20 cm). It showed significant effect on plant height at all stage of growth at 60 DAT.

At harvesting stage varieties V_1 Pusa Broccoli KTS-1 showed (66.78 cm) the highest plant height in 1st year i.e. in (2017-18), (67.21cm) in 2nd year i.e. in (2018-19) and (67.00 cm) cumulative data consequently pursued by V_2 Palam Kanchan showed (66.50, 67.12 and 66.81 cm, respectively) 1st year, 2nd year and polled data. The lowest plant height was measured at harvesting stage in V_3 Palam Vichitra 1st year (66.08 cm), 2nd year (66.01 cm) and combined data (66.05 cm) respectively followed by V_4 Palam Samridhi 1st year (66.75 cm), 2nd year (66.65 cm) and combined data (66.70 cm). The difference between V_1, V_2, V_3 and V_4 was significant at harvesting stage.

Plant spacing S_1 (60x45 cm) as found (67.37 cm) had recorded maximum plant height 1st year i.e. in (2017-18), (68.44 cm) in 2nd year i.e. in (2018-19), (67.91 cm) combined data respectively at harvesting stage consequently pursued by S_2 (60x30 cm) showed (67.32, 67.48 and 67.40 cm, respectively) 1st year, 2nd year and pooled data. Minimum plant height was measured in harvesting stage S_4 (45x30 cm) in 1st year (64.63 cm), 2nd year (65.12 cm) and pooled data (64.88 cm), consequently pursued by

S_3 (45x45 cm) in 1st year (65.80 cm), 2nd year (65.95 cm) and pooled data (65.88 cm). The difference between S_1 S_2, S_3 and S_4 were significant at harvesting stage.

The combined influence of varieties and spacing on (interaction) recorded at harvesting stage was found maximum plant height V_1S_1 (68.37 cm) 1st year i.e. in (2017-18), (68.85 cm) in 2nd year i.e. in (2018-19) and combined data (68.61 cm) respectively followed by V_1S_2 showed (67.89, 68.11and 68.50 cm, consequently) 1st year, 2nd year, and cumulative data. Minimum plant height was measured in V_3S_4 in 1st year (64.35 cm), 2nd year (64.49 cm) and pooled data (64.42 cm) consequently pursued by V_4S_4 (64.65 cm) 1st year i.e. in (2017-18), (65.15 cm) in 2nd year i.e. in (2018-19) and combined data (65.40 cm).

Table -4.1.1: Influence of varieties, spacing and their interaction on plant height (cm) of sprouting broccoli.

Treatment	Plant height (cm)											
	30 DAT			45 DAT			60 DAT			At Harvesting Stage		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Varieties (V)												
V_1 (Pusa Broccoli KTS-1)	24.24	24.23	24.24	44.22	44.16	44.19	60.74	60.63	60.69	66.78	67.21	67.00
V_2 (Palam Kanchan)	23.88	23.88	23.88	43.81	43.08	43.90	60.38	60.34	60.36	66.50	67.12	66.81
V_3 (Palam Vichitra)	23.52	23.58	23.55	42.95	42.97	42.96	59.59	59.86	59.73	66.08	66.01	66.05
V_4 (Palam Samridhi)	24.67	23.59	23.62	43.78	43.73	43.76	59.70	59.88	59.79	66.75	66.65	66.70
S. Em ±	0.10	0.09	0.11	0.23	0.25	0.24	0.30	0.34	0.32	0.38	0.41	0.39
$CD_{5\%}$	0.29	0.26	0.32	0.67	0.72	0.70	0.87	0.99	0.93	1.11	1.19	1.13
Spacing (S)												
S_1 (60x45 cm)	24.11	24.14	24.13	44.13	44.27	44.20	60.96	61.14	61.05	67.37	68.44	67.91
S_2 (60x30 cm)	23.97	23.99	23.98	44.11	43.89	44.00	60.68	60.53	60.61	67.32	67.48	67.40
S_3 (45x45 cm)	23.65	23.62	23.64	43.48	43.65	43.57	59.11	59.74	59.43	65.80	65.95	65.88
S_4 (45x30 cm)	23.58	23.59	23.59	43.02	42.93	42.98	59.10	59.10	59.10	64.63	65.12	64.88
S. Em ±	0.09	0.07	0.08	0.25	0.23	0.24	0.29	0.32	0.30	0.39	0.43	0.41
$CD_{5\%}$	0.23	0.20	0.21	0.72	0.67	0.69	0.84	0.93	0.88	1.13	1.25	1.19
Interaction (VxS)												
V_1S_1	24.36	24.42	24.39	44.99	44.88	44.93	61.23	61.93	61.58	68.37	68.85	68.61
V_1S_2	24.33	24.22	24.28	44.98	44.46	44.43	61.13	61.90	61.51	67.89	68.11	68.00
V_1S_3	24.12	24.14	24.13	44.12	44.18	44.15	60.08	59.88	59.98	66.20	66.33	66.27
V_1S_4	24.16	24.08	24.12	43.41	43.12	43.27	59.85	59.74	59.80	64.98	65.57	65.28
V_2S_1	24.02	23.98	24.00	43.83	44.24	44.04	61.09	61.44	61.27	67.41	68.79	68.10
V_2S_2	23.98	24.04	24.01	44.40	43.96	44.18	60.79	60.76	60.76	67.60	67.69	67.65
V_2S_3	23.66	23.56	23.61	43.09	43.78	43.44	60.11	59.84	59.98	65.91	65.29	66.32
V_2S_4	23.88	23.94	23.91	43.92	43.56	43.74	59.47	59.32	59.40	65.11	65.29	65.20
V_3S_1	24.01	24.06	24.04	42.80	43.84	43.32	60.06	61.02	60.54	67.58	68.25	67.92
V_3S_2	23.56	23.74	23.65	43.37	42.32	42.85	60.05	60.06	60.06	66.79	67.43	67.11
V_3S_3	23.48	23.34	23.41	43.63	43.56	43.60	59.23	59.36	59.30	65.63	65.46	65.55
V_3S_4	23.06	23.16	23.12	42.03	42.16	42.10	58.03	58.02	58.03	64.35	64.49	64.42
V_4S_1	24.06	24.12	24.09	44.93	44.12	44.33	60.86	60.98	60.92	65.54	66.89	66.22
V_4S_2	24.03	24.08	24.06	44.31	44.44	44.38	60.08	60.32	60.20	67.01	66.69	66.85
V_4S_3	23.36	23.24	23.30	43.11	43.08	43.10	59.84	59.89	59.87	65.49	65.32	65.42
V_4S_4	23.24	23.18	23.20	42.79	42.88	42.84	58.05	58.34	58.20	64.65	65.15	65.40
S. Em ±	0.33	0.85	0.59	0.60	1.00	0.80	0.49	1.09	0.79	0.78	0.72	0.75
$CD_{5\%}$	0.95	2.46	1.71	1.74	2.90	2.32	1.42	2.95	2.19	2.26	2.09	2.18

Fig. -4.1.1.a: Influence of variety on plant height (cm) of sprouting broccoli

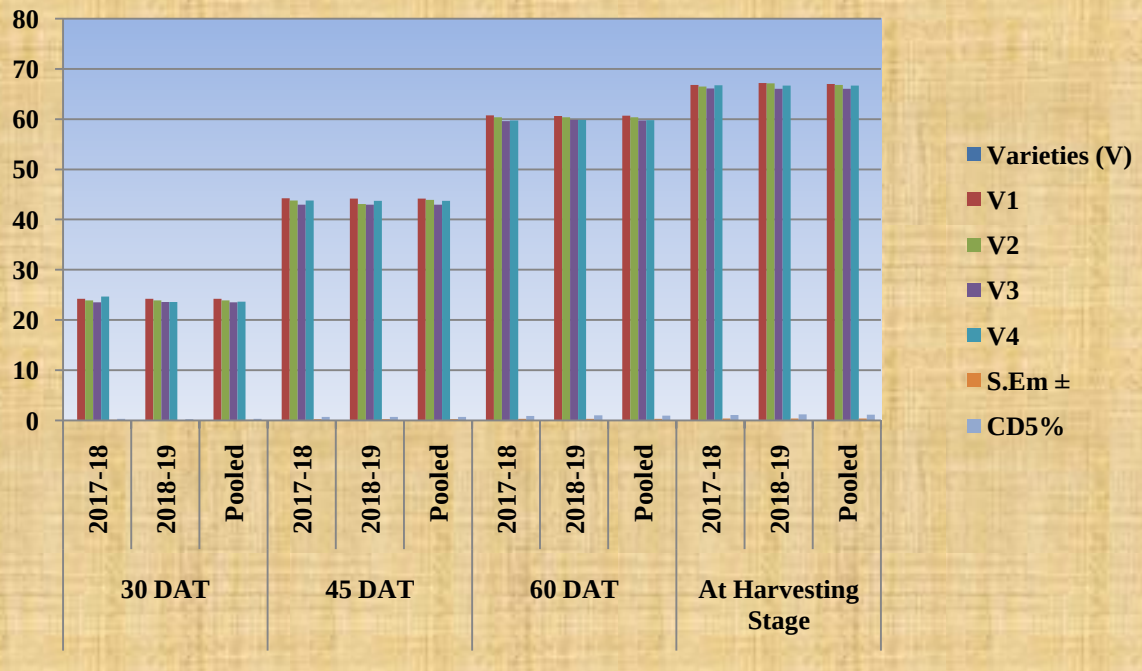


Fig. -4.1.1.b: Influence of spacing on plant height (cm) of sprouting broccoli

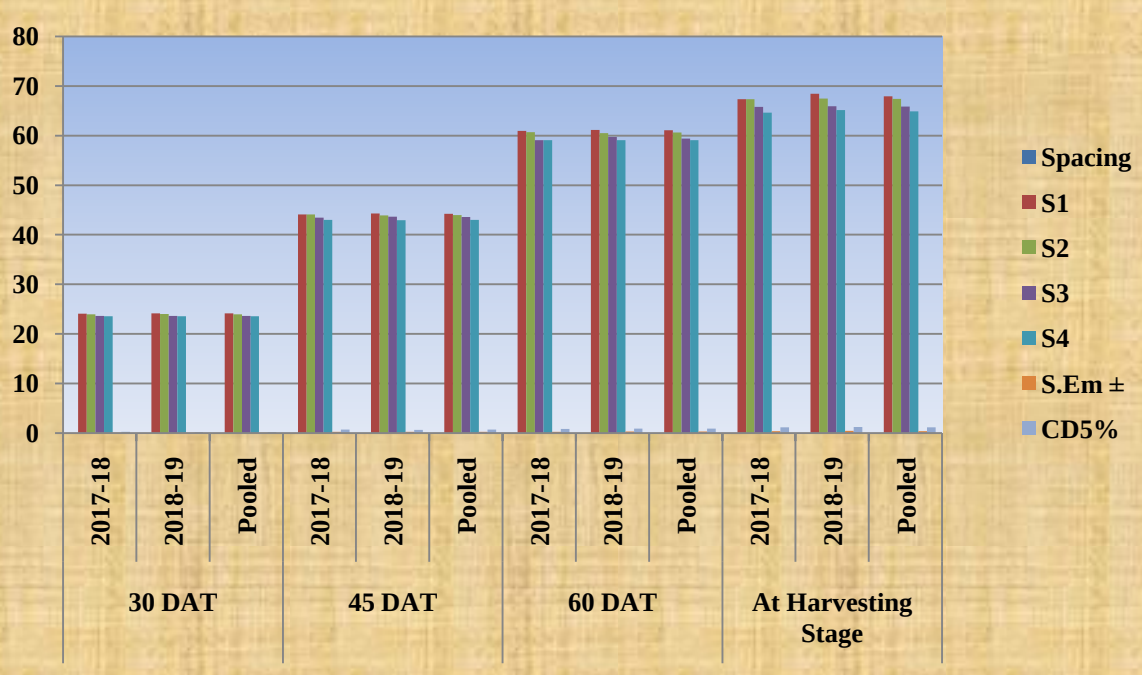
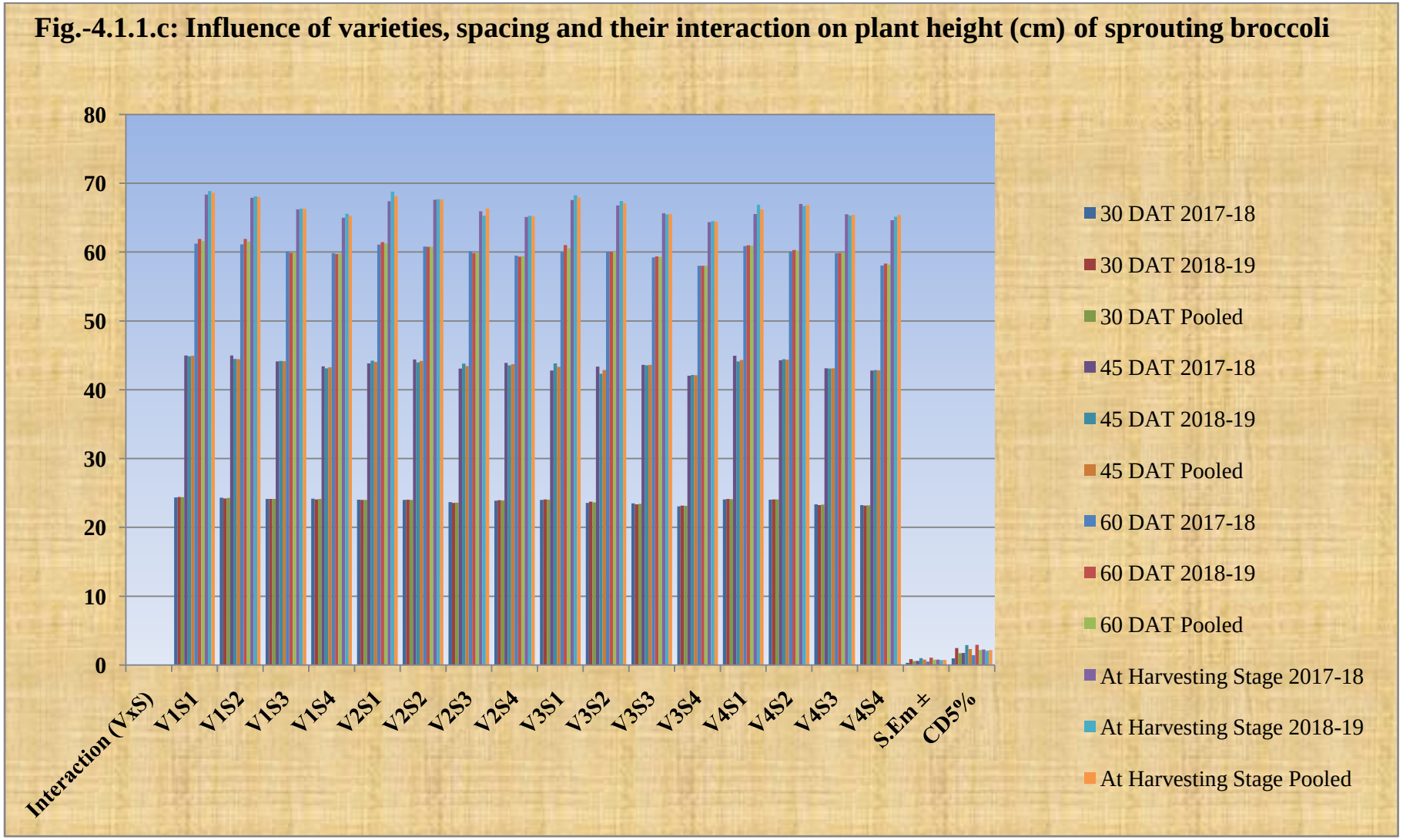


Fig.-4.1.1.c: Influence of varieties, spacing and their interaction on plant height (cm) of sprouting broccoli



4.1.2: Stem diameter:

Among the two years (2017-18 & 2018-19) and pooled data stem diameter (cm) recorded at 30, 45 and 60 days. The data presented in (Table & Fig.- 4.1.2) revealed significant influence of varieties and spacing on stem diameter at all the stages.

Varieties V_1 Pusa Broccoli KTS-1 showed (2.45 cm) the topmost stem diameter in 1st year i.e. in (2017-18) and (2.35 cm) in 2nd year i.e. in (2018-19), respectively at 30 DAT followed by V_2 Palam Kanchan showed (2.27 cm) and (2.26 cm) 1st year and 2nd year, respectively. Pooled value showed the highest stem diameter (2.40 cm) was measured in varieties V_1 Pusa Broccoli KTS-1 as compared to V_2 Palam Kanchan value (2.27 cm) and lowest in V_3 Palam Vichitra in 1st year (1.75 cm), 2nd year (1.50 cm) and pooled (1.62 cm) followed by V_4 Palam Samridhi in 1st year (1.83 cm), 2nd year (1.70 cm) and pooled (1.76 cm), respectively. The difference between V_1, V_2, V_3 and V_4 was significant at 30 DAT.

Plant spacing S_1 (60x45 cm) as found (2.42 cm) had recorded maximum stem diameter 1st year i.e. in (2017-18), (2.10 cm) in 2nd year i.e. in (2018-19), respectively at 30 DAT followed by S_2 (60x30 cm) showed (2.11 cm) and (2.04 cm) 1st year and 2nd year, respectively. Pooled value showed the topmost stem diameter (2.26cm) was measured in varieties S_1 (60x45 cm) as compared to S_2 (60x30 cm) showed in (2.08 cm) and lowest stem diameter in S_4 (45x30 cm) in 1st year (1.78 cm), 2nd year (1.80 cm) and pooled data (1.79 cm) respectively followed by S_3 (45x45 cm) in 1st year (1.99 cm), 2nd year (1.87 cm) and pooled data (1.93 cm). The difference between S_1, S_2, S_3 and S_4 were significant at 30 DAT.

The combined influence of varieties and spacing on (interaction) recorded at 30 DAT was found maximum stem diameter V_1S_1 (2.98 cm) 1st year i.e. in (2017-18) and (2.49 cm) in 2nd year i.e. in (2018-19), respectively at 30 DAT followed by V_1S_2 showed (2.38 and 2.47 cm, consequently) 1st year and 2nd year. Pooled value showed the highest stem diameter (2.73 cm) was measured in interaction V_1S_1 as compared to V_1S_2 (2.43 cm) and lowest value in V_3S_4 in 1st year (1.45 cm), 2nd year (1.45 cm) and pooled data (1.44 cm) respectively followed by V_4S_4 in 1st year (1.55 cm), 2st year (1.44 cm) and pooled data (1.50 cm) It showed significant effect on stem diameter at all stages of growth at 30 DAT.

At 45 DAT Varieties V_1 Pusa Broccoli KTS-1 showed (3.03 cm) the stem diameter in 1st year i.e. in (2017-18), (3.05 cm) in 2nd year i.e. in (2018-19) and polled data (3.04 cm), respectively followed by V_2 Palam Kanchan showed (3.00 cm), (3.01 cm) and (3.01 cm) 1st year, 2nd year and pooled value, respectively. The lowest value in V_3 Palam Vichitra in 1st year (2.58 cm), 2nd year (2.49 cm) and pooled data (2.53 cm) respectively followed by V_4 Palam Samridhi in 1st year (2.75 cm), 2nd year (2.78 cm) and pooled data (2.76 cm). The difference between V_1, V_2, V_3 and V_4 was significant at 45 DAT.

Plant spacing S_1 (60x45 cm) as found (2.92 cm) had recorded maximum stem diameter 1st year i.e. in (2017-18), (2.90 cm) in 2nd year i.e. in (2018-19), respectively at 45 DAT followed by S_2 (60x30 cm) showed (2.87 and 2.86 cm, consequently) 1st year and 2nd year. Pooled value showed the topmost stem diameter (2.91 cm) was measured in spacing S_1 (60x45 cm) as compared to S_2 (60x30 cm) showed (2.87 cm) and lowest value in S_4 (45x30 cm) in 1st year (2.76 cm), 2nd year (2.78 cm) and pooled data (2.77 cm) respectively followed by S_3 (45x45 cm) in 1st year (2.81 cm), 2nd year (2.80 cm) and pooled data (2.80 cm). The difference between S_1, S_2, S_3 and S_4 were significant at 45 DAT.

The combined influence of varieties and spacing on (interaction) recorded at 45 DAT was found maximum stem diameter V_1S_1 (3.98 cm) 1st year i.e. in (2017-18), (3.10 cm) in 2nd year i.e. in (2018-19) and polled data (3.09 cm), respectively at 45 DAT followed by V_1S_2 showed (3.07, 3.08 and 3.08 cm, consequently) 1st year, 2nd year and both year. The minimum value in V_3S_4 in 1st year (2.70 cm), 2nd year (2.40 cm) and pooled data (2.56 cm) consequently pursued by V_4S_4 in 1st year (2.71 cm), 2nd year (2.71 cm) and pooled data (2.71 cm). It showed significant effect on stem diameter at all stages of growth at 45 DAT.

At 60 DAT varieties V_1 Pusa Broccoli KTS-1 showed (3.52 cm) the stem diameter in 1st year i.e. in (2017-18), (3.55 cm) in 2nd year i.e. in (2018-19) and (3.53 cm) cumulative data consequently pursued by V_2 Palam Kanchan showed (3.38, 3.47 and 3.42 cm, respectively), 1st year, 2nd year and polled data. The lowest stem diameter was measured in V_3 Palam Vichitra 1st year (3.16 cm), 2nd year (3.17 cm) and combined data (3.16 cm) respectively followed by V_4 Palam Samridhi 1st year (3.17 cm), 2nd year (3.21 cm) and combined data (3.19 cm). The difference between

V_1, V_2, V_3 and V_4 was significant at 60 DAT.

Plant spacing S_1 (60x45 cm) as found (3.40 cm) had recorded maximum stem diameter 1st year i.e. in (2017-18), (3.46 cm) in 2nd year i.e. in (2018-19), (3.43 cm) combined data respectively at 60 DAT followed by S_2 (60x30 cm) showed (3.29, 3.34 and 3.31 cm, respectively) 1st year, 2nd year and pooled data. Minimum stem diameter was measured in S_4 (45x30 cm) in 1st year (3.25 cm), 2nd year (3.27 cm) and pooled data (3.26 cm) consequently pursued by S_3 (45x45 cm) in 1st year (3.27 cm), 2nd year (3.29 cm) and pooled data (3.28 cm). The difference between S_1 S_2, S_3 and S_4 were significant at 60 DAT.

The combined influence of varieties and spacing on (interaction) recorded at 60 DAT was found maximum stem diameter in V_1S_1 (3.57 cm) 1st year i.e. in (2017-18), (3.64 cm) in 2nd year i.e. in (2018-19) and combined data (3.61 cm) respectively at 60 DAT followed by V_1S_2 showed (3.56 cm), (3.59 and 3.58 cm, consequently) 1st year, 2nd year, and cumulative data. Minimum stem diameter was measured in V_3S_4 in 1st year (3.11 cm), 2nd year (3.11 cm) and pooled data (3.11 cm) consequently pursued by V_4S_4 (3.12cm) 1st year i.e. in (2017-18), (3.12cm) in 2nd year i.e. in (2018-19) and combined data (3.12 cm). It showed significant effect on stem diameter at all stage of growth at 60 DAT.

Table -4.1.2: Influence of varieties, spacing and their interaction on stem diameter (cm) of sprouting broccoli.

Treatment	Stem diameter (cm)								
	30 DAT			45 DAT			60 DAT		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Varieties (V)									
V_1 (Pusa Broccoli KTS-1)	2.45	2.35	2.40	3.03	3.05	3.04	3.52	3.55	3.53
V_2 (Palam Kanchan)	2.27	2.26	2.27	3.00	3.01	3.01	3.38	3.47	3.42
V_3 (Palam Vichitra)	1.75	1.50	1.62	2.58	2.49	2.53	3.16	3.17	3.16
V_4 (Palam Samridhi)	1.83	1.70	1.76	2.75	2.78	2.76	3.17	3.21	3.19
S. Em ±	0.13	0.15	0.14	0.17	0.23	0.20	0.43	0.47	0.45
$CD_{5\%}$	0.38	0.42	0.40	0.49	0.67	0.58	1.26	1.38	1.32
Spacing (S)									
S_1 (60x45 cm)	2.42	2.10	2.26	2.92	2.90	2.91	3.40	3.46	3.43
S_2 (60x30 cm)	2.11	2.04	2.08	2.87	2.86	2.87	3.29	3.34	3.31
S_3 (45x45 cm)	1.99	1.87	1.93	2.81	2.80	2.80	3.27	3.29	3.28
S_4 (45x30 cm)	1.78	1.80	1.79	2.76	2.78	2.77	3.25	3.27	3.26
S. Em ±	0.12	0.14	0.13	0.14	0.20	0.17	0.82	0.78	0.80
$CD_{5\%}$	0.35	0.41	0.38	0.41	0.58	0.49	2.40	2.28	2.34
Interaction (VxS)									
V_1S_1	2.98	2.49	2.73	3.08	3.10	3.09	3.57	3.64	3.61
V_1S_2	2.38	2.47	2.43	3.07	3.08	3.08	3.56	3.59	3.58
V_1S_3	2.34	2.31	2.32	3.02	3.04	3.03	3.49	3.51	3.50
V_1S_4	2.13	2.15	2.14	2.98	3.01	2.99	3.47	3.49	3.48
V_2S_1	2.37	2.37	2.37s	3.05	3.06	3.05	3.55	3.58	3.57
V_2S_2	2.26	2.27	2.27	3.04	3.03	3.04	3.35	3.49	3.42
V_2S_3	2.16	2.23	2.19	2.99	2.98	2.96	3.33	3.37	3.35
V_2S_4	2.01	2.20	2.10	2.92	2.49	2.95	3.29	3.35	3.32
V_3S_1	2.02	1.57	1.79	2.83	2.57	2.71	3.28	3.28	3.28
V_3S_2	1.95	1.55	1.75	2.76	2.72	2.74	3.14	3.16	3.15
V_3S_3	1.91	1.45	1.68	2.73	2.77	2.74	3.13	3.15	3.14
V_3S_4	1.45	1.43	1.44	2.70	2.42	2.56	3.11	3.11	3.11
V_4S_1	2.04	1.97	2.01	2.75	2.88	2.81	3.21	3.26	3.23
V_4S_2	1.85	1.88	1.86	2.81	2.82	2.82	3.16	3.15	3.16
V_4S_3	1.57	1.52	1.54	2.81	2.73	2.72	3.15	3.14	3.15
V_4S_4	1.55	1.44	1.50	2.71	2.71	2.71	3.12	3.12	3.12
S. Em ±	0.15	0.14	0.15	0.09	0.08	0.09	0.49	1.09	0.79
$CD_{5\%}$	0.44	0.39	0.42	0.26	0.21	0.24	1.42	2.95	2.19

Fig.-4.1.2.a: Influence of varieties on stem diameter (cm) of sprouting broccoli

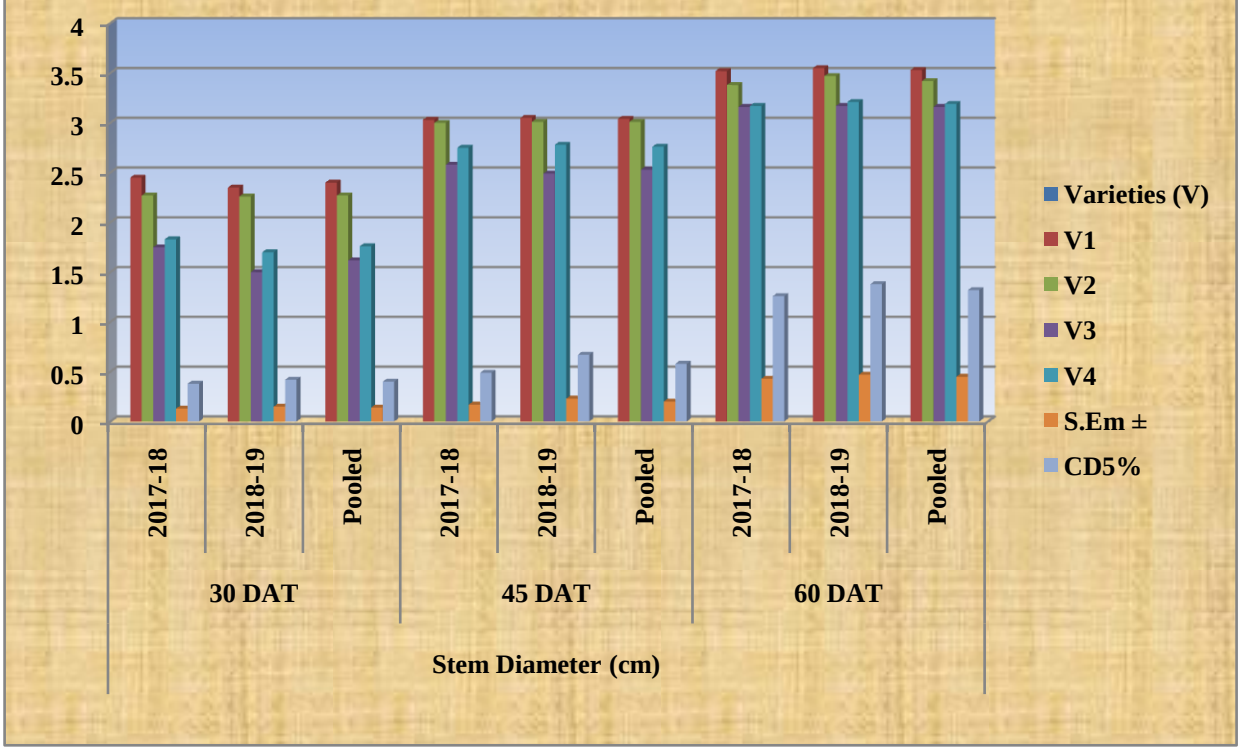


Fig.-4.1.2.b: Influence of spacing on stem diameter (cm) of sprouting broccoli

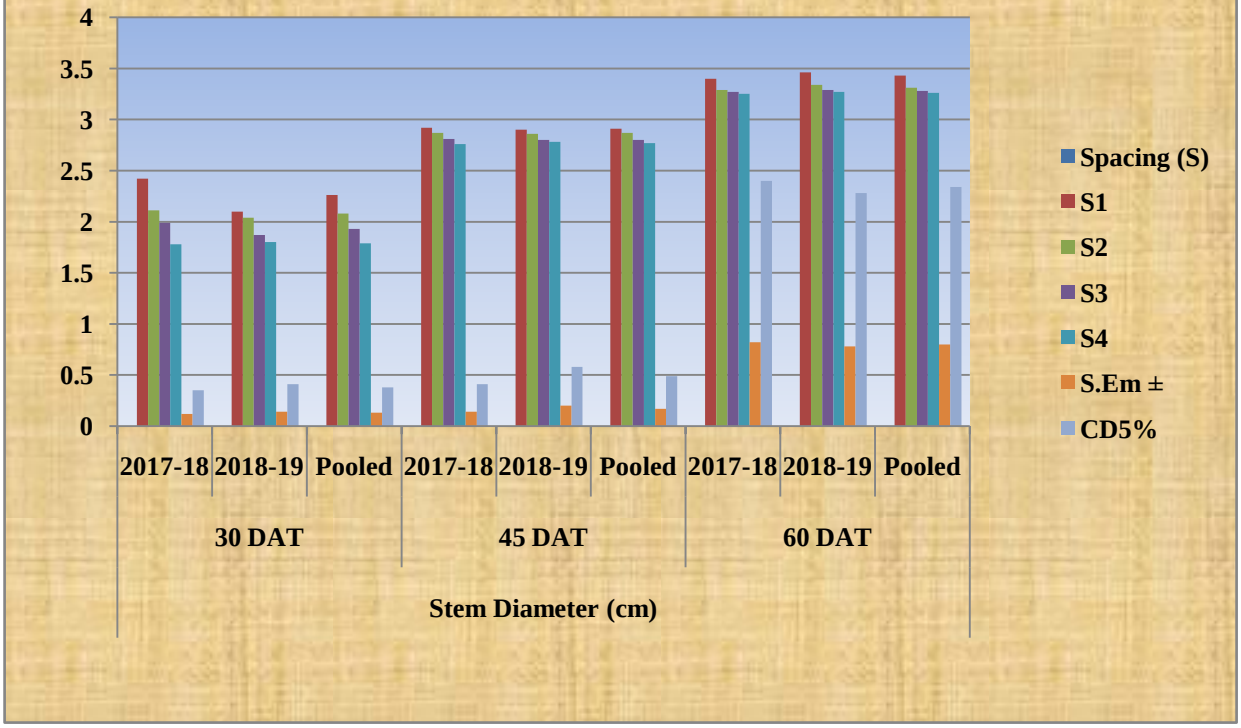
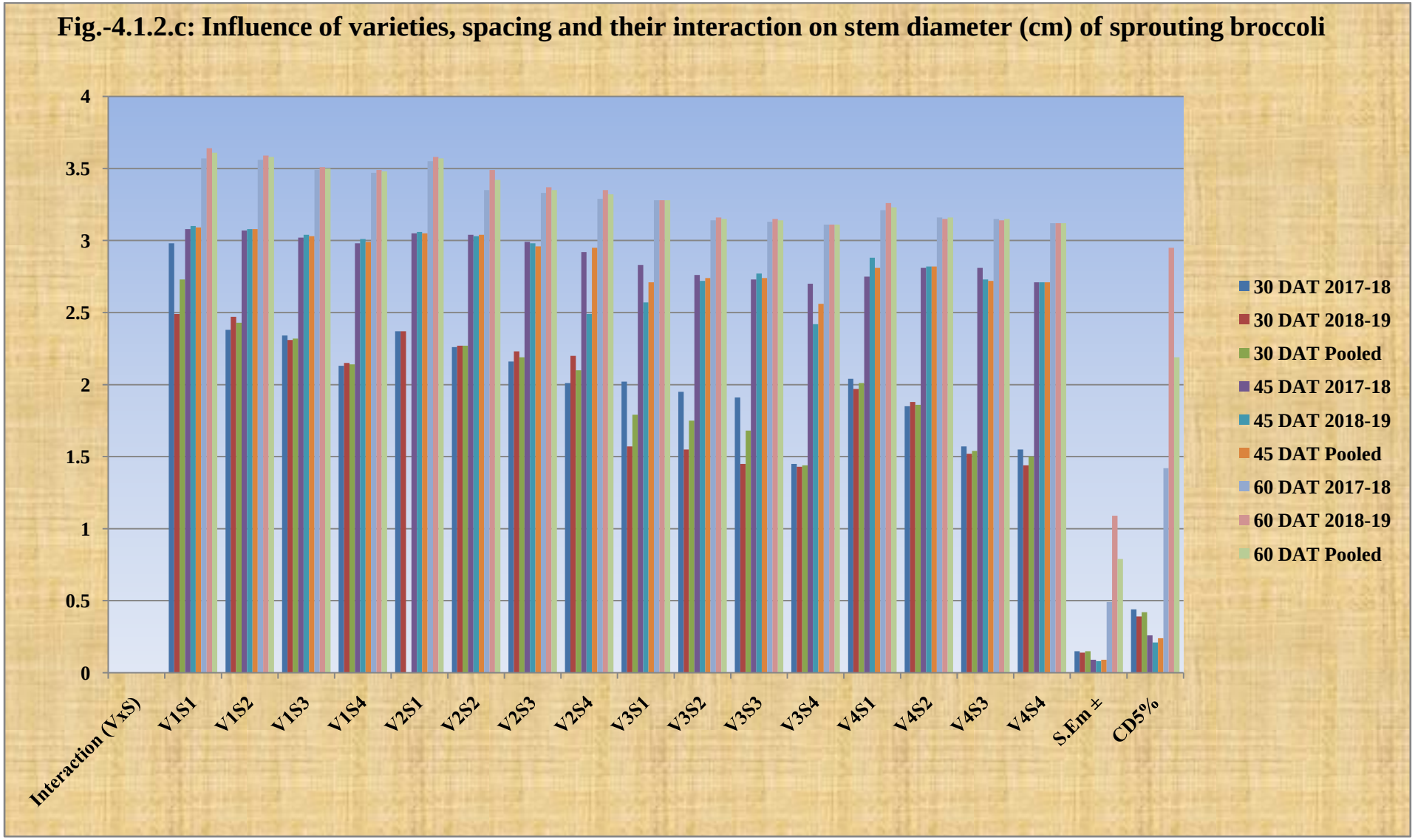


Fig.-4.1.2.c: Influence of varieties, spacing and their interaction on stem diameter (cm) of sprouting broccoli



4.1.3: Plant canopy spreading east-west direction (cm):

Among the two years (2017-18 & 2018-19) and pooled data plant canopy spreading (E-W) direction recorded at 30, 45 and days. The data presented in (Table & Fig.-4.1.3) revealed significant influence of varieties and spacing on plant spreading (E-W) direction at all stages.

The perusal data it is clear that maximum plant canopy spreading (E-W) recorded in varieties V_1 Pusa Broccoli KTS-1 showed (36.09 cm) in 1st year i.e. in (2017-18) and (36.22 cm) in 2nd year i.e. in (2018-19), respectively at 30 DAT followed by V_2 Palam Kanchan showed (35.73 and 35.23 cm, consequently) 1st year and 2nd year. Pooled value showed the highest plant canopy spreading (E-W) (36.03 cm) was measured in varieties V_1 Pusa Broccoli KTS-1 as compared to V_2 Palam Kanchan value (35.48 cm) and lowest in V_3 Palam Vichitra in 1st year (32.35 cm), 2nd year (32.35 cm) and pooled (32.35 cm) followed by V_4 Palam Samridhi in 1st year (32.52 cm), 2nd year (32.54 cm) and pooled (32.53 cm), respectively. The difference between V_1, V_2, V_3 and V_4 was significant at 30 DAT.

Plant spacing S_1 (60x45 cm) as found (34.90 cm) had recorded maximum plant canopy spreading (E-W) 1st year i.e. in (2017-18), (34.41 cm) in 2nd year i.e. in (2018-19), respectively at 30 DAT followed by S_2 (60x30 cm) showed (34.53 cm) and (34.26 cm) 1st year and 2nd year, respectively. Pooled value showed the topmost plant canopy spreading (E-W) (34.66 cm) was measured in varieties S_1 (60x45 cm) as compared to S_2 (60x30 cm) showed in (34.40 cm) and lowest plant canopy spreading (E-W) in S_4 (45x30 cm) in 1st year (33.12 cm), 2nd year (33.03 cm) and pooled data (33.08 cm) respectively followed by S_3 (45x45 cm) in 1st year (33.84 cm), 2nd year (34.02 cm) and pooled data (33.93 cm). The difference between S_1, S_2, S_3 and S_4 were significant at 30 DAT.

The combined influence of varieties and spacing on (interaction) recorded at 30 DAT was found maximum plant canopy spreading (E-W) V_1S_1 (37.08 cm) 1st year i.e. in (2017-18) and (37.59 cm) in 2nd year i.e. in (2018-19), respectively at 30 DAT followed by V_1S_2 showed (36.86 and 36.41 cm, respectively) 1st year and 2nd year, respectively. Pooled value showed the highest plant canopy spreading (E-W) (37.34cm) was measured in interaction V_1S_1 as compared to V_1S_2 (36.63 cm) and

lowest value in V_3S_4 in 1st year (31.04 cm), 2nd year (31.05 cm) and pooled data (31.05 cm) respectively followed by V_4S_4 in 1st year (31.77 cm), 2nd year (31.35 cm) and pooled data (31.56 cm) It showed significant effect on plant canopy spreading (E-W) at 30 DAT.

At 45 DAT Varieties V_1 Pusa Broccoli KTS-1 showed (49.77 cm) plant canopy spreading (E-W) in 1st year i.e. in (2017-18), (49.91 cm) in 2nd year i.e. in (2018-19) and polled data (49.79 cm), respectively followed by V_2 Palam Kanchan showed (49.43, 49.90 and 49.67 cm, consequently) 1st year, 2nd year and pooled value. The lowest value in V_3 Palam Vichitra in 1st year (47.36 cm), 2nd year (47.83 cm) and pooled data (47.60 cm) respectively followed by V_4 Palam Samridhi in 1st year (48.90 cm), 2nd year (48.32 cm) and pooled data (49.11 cm). The difference between V_1, V_2, V_3 and V_4 was significant at 45 DAT.

Plant spacing S_1 (60x45 cm) as found (50.23 cm) had recorded maximum plant canopy spreading (E-W) 1st year i.e. in (2017-18), (51.16 cm) in 2nd year i.e. in (2018-19), respectively at 45 DAT followed by S_2 (60x30 cm) showed (49.44 cm), (49.98 cm) 1st year and 2nd year, respectively. Pooled value showed the topmost plant canopy spreading (E-W) (50.70 cm) was measured in spacing S_1 (60x45 cm) as compared to S_2 (60x30 cm) showed (49.67 cm) and lowest value in S_4 (45x30 cm) in 1st year (47.49 cm), 2nd year (47.32 cm) and Pooled data (47.40 cm) respectively followed by S_3 (45x45 cm) in 1st year (48.23 cm), 2nd year (48.83 cm) and pooled data (47.40 cm). The plant canopy spreading (E-W) difference between S_1, S_2, S_3 and S_4 were significant at 45 DAT.

The combined influence of varieties and spacing on (interaction) recorded at 45 DAT was found maximum plant canopy spreading (E-W) V_1S_1 (50.33 cm) 1st year i.e. in (2017-18), (52.44 cm) in 2nd year i.e. in (2018-19) and polled data (51.39 cm), respectively at 45 DAT followed by V_1S_2 showed (50.32, 50.44, and 50.38 cm, consequently) 1st year, 2nd year and both year. The minimum value in V_3S_4 in 1st year (45.74 cm), 2nd year (45.61 cm) and pooled data (45.68 cm) consequently pursued by V_4S_4 in 1st year (47.35 cm), 2nd year (47.64 cm) and pooled data (47.49 cm). It showed significant effect on plant canopy spreading (E-W) at 45 DAT.

At 60 DAT varieties V_1 Pusa broccoli KTS-1 showed (61.38 cm) plant canopy spreading (E-W) in 1st year i.e. in (2017-18), (62.50 cm) in 2nd year i.e. in (2018-19)

and (61.94 cm) cumulative data consequently pursued by V_2 Palam Kanchan showed (61.35, 61.92 and 61.64 cm, respectively), 1st year, 2nd year and polled data. The lowest plant canopy spreading (E-W) was measured in V_3 Palam Vichitra 1st year (58.44 cm), 2nd year (56.94 cm) and combined data (57.69 cm) respectively followed by V_4 Palam Samridhi 1st year (58.61 cm), 2nd year (57.09 cm) and combined data (57.85 cm). The difference between V_1, V_2, V_3 and V_4 was significant at 60 DAT.

Plant spacing S_1 (60x45 cm) as found (62.54 cm) had recorded maximum plant canopy spreading (E-W) 1st year i.e. in (2017-18), (64.01 cm) in 2nd year i.e. in (2018-19), (63.28 cm) combined data respectively at 60 DAT followed by S_2 (60x30 cm) showed (60.45, 60.56 and 60.50 cm, respectively) 1st year, 2nd year and pooled data. Minimum plant canopy spreading (E-W) was measured in S_4 (45x30 cm) in 1st year (57.38 cm), 2nd year (54.56 cm) and pooled data (55.97 cm) consequently pursued by S_3 (45x45 cm) in 1st year (59.41 cm), 2nd year (59.32 cm) and pooled data (59.37 cm). The plant canopy spreading (E-W) difference between S_1 S_2, S_3 and S_4 were significant at 60 DAT.

The combined influence of varieties and spacing on (interaction) recorded at 60 DAT was found maximum plant canopy spreading (E-W) in V_1S_1 (64.12 cm) 1st year i.e. in (2017-18), (68.13 cm) in 2nd year i.e. in (2018-19) and combined data (66.13 cm) respectively at 60 DAT followed by V_1S_2 showed (63.81, 64.12 and 63.97 cm, consequently) 1st year, 2nd year and cumulative data. Minimum plant canopy spreading (E-W) was measured in V_3S_4 in 1st year (55.94 cm), 2nd year (51.06 cm) and pooled data (53.50 cm) consequently pursued by V_4S_4 (56.32 cm) 1st year i.e. in (2017-18), (54.96 cm) in 2nd year i.e. in (2018-19) and combined data (55.64 cm). It showed significant effect on plant canopy spreading (E-W) at 60 DAT.

Table -4.1.3: Influence of varieties, spacing and their interaction on plant canopy spreading east-west direction (cm) of sprouting broccoli.

Treatment	Plant canopy spreading east-west direction (cm)								
	30 DAT			45 DAT			60 DAT		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Varieties (V)									
V_1 (Pusa Broccoli KTS-1)	36.09	36.22	36.03	49.77	49.91	49.79	61.38	62.50	61.94
V_2 (Palam Kanchan)	35.73	35.23	35.48	49.43	49.90	49.67	61.35	61.92	61.64
V_3 (Palam Vichitra)	32.35	32.35	32.35	47.36	47.83	47.60	58.44	56.94	57.69
V_4 (Palam Samridhi)	32.52	32.54	32.53	48.90	48.32	49.11	58.61	57.09	57.85
S. Em ±	0.37	0.35	0.36	0.28	0.32	0.30	0.43	0.46	0.44
$CD_{5\%}$	1.07	1.01	1.04	0.81	0.92	0.86	1.25	1.33	1.29
Spacing (S)									
S_1 (60x45 cm)	34.90	34.41	34.66	50.23	51.16	50.70	62.54	64.01	63.28
S_2 (60x30 cm)	34.53	34.26	34.40	49.44	49.98	49.67	60.45	60.56	60.50
S_3 (45x45 cm)	33.84	34.02	33.93	48.23	48.83	48.53	59.41	59.32	59.37
S_4 (45x30 cm)	33.12	33.03	33.08	47.49	47.32	47.40	57.38	54.56	55.97
S.Em ±	0.36	0.38	0.37	0.34	0.32	0.33	0.41	0.39	0.40
$CD_{5\%}$	1.04	1.10	1.07	0.98	0.93	0.95	1.19	1.13	1.16
Interaction (VxS)									
V_1S_1	37.08	37.59	37.34	50.33	52.44	51.39	64.12	68.13	66.13
V_1S_2	36.86	36.41	36.63	50.32	50.44	50.38	63.81	64.12	63.97
V_1S_3	35.56	35.58	35.57	49.61	50.03	49.82	61.31	63.13	62.22
V_1S_4	34.89	35.32	35.10	48.80	46.74	47.77	56.32	54.65	55.48
V_2S_1	36.42	35.89	36.16	50.31	50.09	50.20	62.08	63.96	63.02
V_2S_2	36.42	35.86	36.14	50.25	50.32	50.29	61.29	63.67	62.48
V_2S_3	35.32	34.75	35.04	49.08	49.12	49.10	61.06	62.49	61.78
V_2S_4	34.80	34.43	34.62	48.10	49.10	48.60	60.98	57.58	59.28
V_3S_1	33.17	35.07	34.12	50.25	50.02	50.14	63.63	63.64	63.64
V_3S_2	33.05	33.03	33.04	46.89	50.32	48.60	57.24	57.34	57.24
V_3S_3	32.14	33.17	32.66	46.62	47.68	47.15	56.98	55.85	56.42
V_3S_4	31.04	31.05	31.05	45.74	45.61	45.68	55.94	51.06	53.50
V_4S_1	32.94	33.33	33.14	50.30	50.12	50.21	60.34	60.34	60.34
V_4S_2	32.81	32.94	32.88	50.32	48.86	49.59	59.47	57.22	58.35
V_4S_3	32.81	32.97	32.57	47.61	48.52	48.07	58.31	55.84	57.06
V_4S_4	31.77	31.35	31.56	47.35	47.64	47.49	56.32	54.96	55.64
S. Em ±	0.58	1.20	0.89	0.81	1.18	1.00	0.96	1.62	1.29
$CD_{5\%}$	1.69	3.48	2.59	2.34	3.44	2.89	2.79	4.71	3.75

Fig.-4.1.3.a: Influence of varieties on plant canopy spreading east-west direction (cm) of sprouting broccoli.

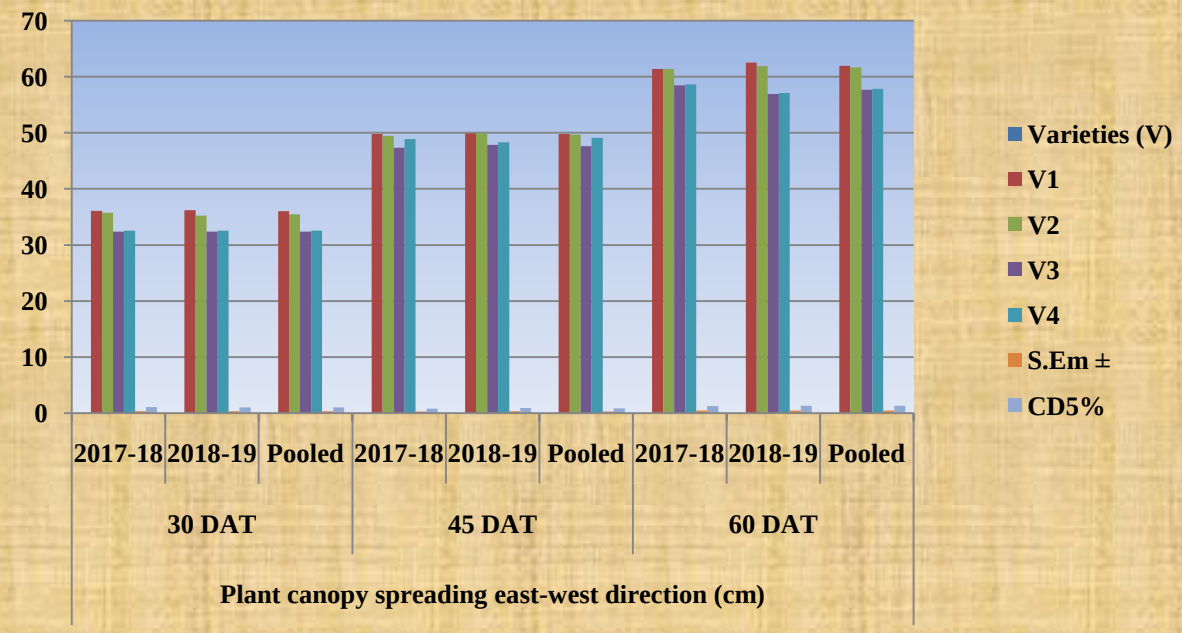


Fig.-4.1.3.b: Influence of spacing on plant canopy spreading east-west direction (cm) of sprouting broccoli.

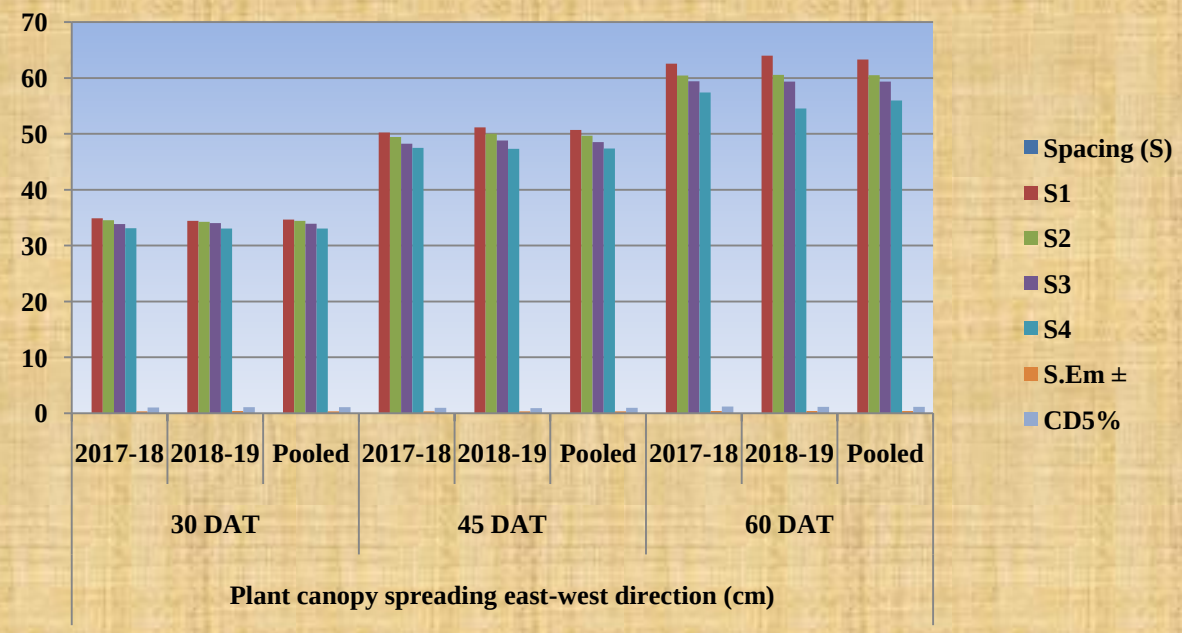
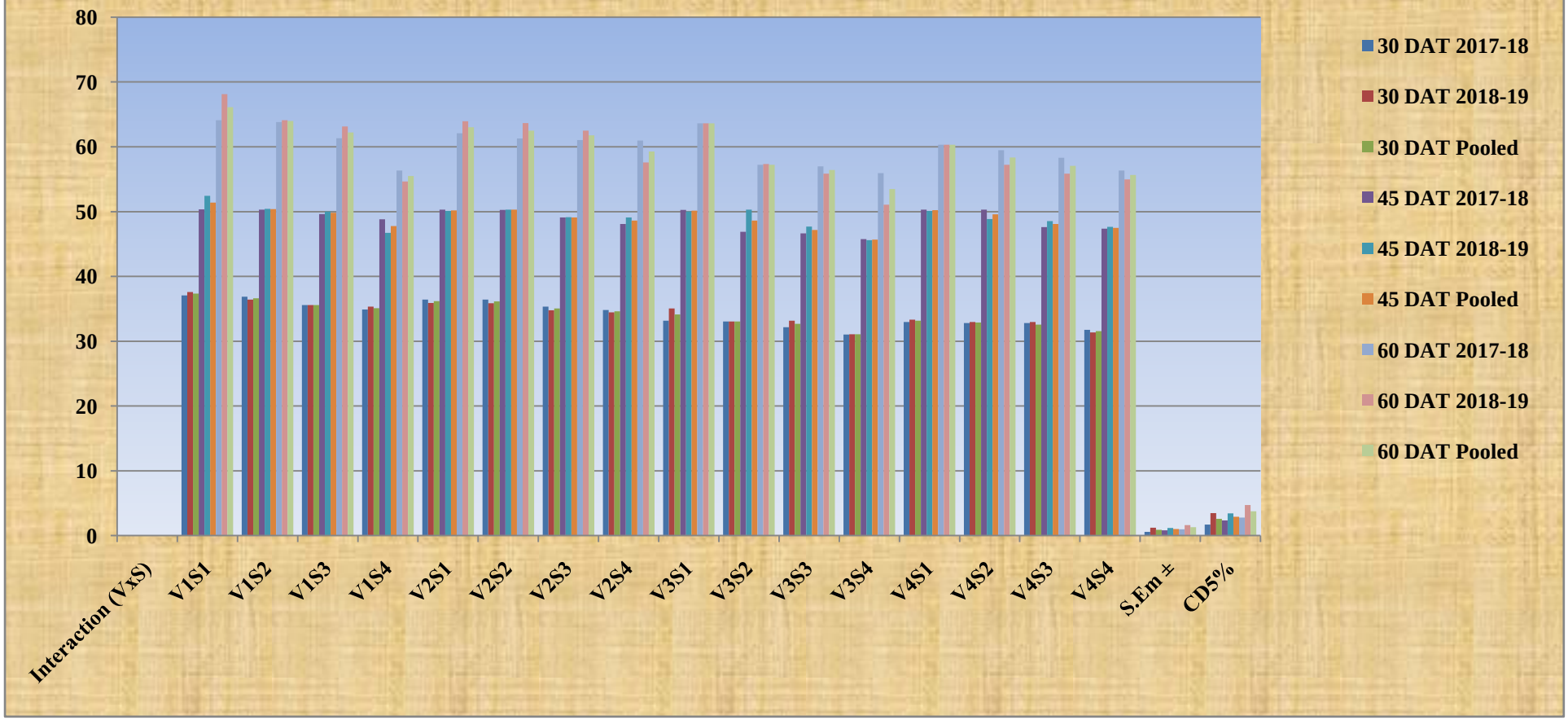


Fig.-4.1.3.c: Influence of varieties, spacing and their interaction on plant canopy spreading east-west direction (cm) of sprouting broccoli.



4.1.4: Plant canopy spreading north-south direction (cm):

Among the two years (2017-18 & 2018-19) and pooled data plant canopy spreading (N-S) direction observed at 30.45 and 60 days. The data presented in (Table & Fig.- 4.1.4) showed significant influence of varieties and spacing on plant canopy spreading (N-S) direction in all stages.

The perusal data it is clear that maximum plant plant canopy spreading (N-S) direction recorded in varieties V_1 Pusa Broccoli KTS-1 showed (34.47 cm) in 1st year i.e. in (2017-18) and (34.23 cm) in 2nd year i.e. in (2018-19), respectively at 30 DAT followed by V_2 Palam Kanchan showed (34.24, and 34.14 cm, respectively) 1st year and 2nd year. Pooled value showed the highest plant canopy spreading (N-S) direction (34.35 cm) was measured in varieties V_1 Pusa Broccoli KTS-1 as compared to V_2 Palam Kanchan value (34.14 cm) and lowest in V_3 Palam Vichitra in 1st year (31.40 cm), 2nd year (31.33 cm) and pooled (31.36 cm) followed by V_4 Palam Samridhi in 1st year (31.72 cm), 2nd year (31.99 cm) and pooled (31.85 cm), respectively. The difference between V_1, V_2, V_3 and V_4 was significant at 30 DAT.

Plant spacing S_1 (60x45 cm) as found (33.51 cm) had recorded maximum plant canopy spreading (N-S) direction 1st year i.e. in (2017-18), (33.39 cm) in 2nd year i.e. in (2018-19), respectively at 30 DAT followed by S_2 (60x30 cm) showed (33.14 cm) and (33.17 cm) 1st year and 2nd year, respectively. Pooled value showed the topmost plant canopy spreading (N-S) direction (33.45 cm) was measured in varieties S_1 (60x45 cm) as compared to S_2 (60x30 cm) showed in (33.15 cm) and lowest plant canopy spreading (N-S) direction in S_4 (45x30 cm) in 1st year (32.32 cm), 2nd year (32.22 cm) and pooled data (32.27 cm) respectively followed by S_3 (45x45 cm) in 1st year (32.88 cm), 2nd year (32.81 cm) and pooled data (32.34 cm). The difference between S_1, S_2, S_3 and S_4 were significant at 30 DAT.

The combined influence of varieties and spacing on (interaction) recorded at 30 DAT was found maximum plant canopy spreading (N-S) direction V_1S_1 (35.04 cm) 1st year i.e. in (2017-18) and (34.67 cm) in 2nd year i.e. in (2018-19), respectively at 30 DAT followed by V_2S_1 showed (34.89 and 34.81 cm, respectively) 1st year and 2nd year. Pooled value showed the highest plant canopy spreading (N-S) direction (34.85cm) was measured in interaction V_1S_1 as compared to V_2S_1 (34.81 cm) and lowest value in V_3S_4 in 1st year (30.78 cm), 2nd year (30.76 cm) and pooled data

(30.77 cm) respectively followed by V_4S_4 in 1st year (31.37 cm), 2nd year (31.67 cm) and pooled data (31.50 cm) It showed significant effect on plant canopy spreading (N-S) direction at 30 DAT.

At 45 DAT Varieties V_1 Pusa Broccoli KTS-1 showed (44.35 cm) plant canopy spreading (N-S) direction in 1st year i.e. in (2017-18), (44.62 cm) in 2nd year i.e. in (2018-19) and polled data (44.48 cm), respectively followed by V_2 Palam Kanchan showed (44.30, 43.93 and 49.11 cm, consequently) 1st year, 2nd year and pooled value. The lowest value in V_3 Palam Vichitra in 1st year (41.52 cm), 2nd year (41.55 cm) and pooled data (41.53 cm) respectively followed by V_4 Palam Samridhi in 1st year (41.75 cm), 2nd year (41.80 cm) and pooled data (41.77 cm). The difference between V_1, V_2, V_3 and V_4 was significant at 45 DAT.

Plant spacing S_1 (60x45 cm) as found (43.63 cm) had recorded maximum plant canopy spreading (N-S) direction 1st year i.e. in (2017-18), (43.84 cm) in 2nd year i.e. in (2018-19), respectively at 45 DAT followed by S_2 (60x30 cm) showed (43.18 cm), (43.98 cm) 1st year and 2nd year, respectively. Pooled value showed the topmost plant canopy spreading (N-S) direction (43.73 cm) was measured in spacing S_1 (60x45 cm) as compared to S_2 (60x30 cm) showed (43.22 cm) and lowest value in S_4 (45x30 cm) in 1st year (42.41 cm), 2nd year (42.08 cm) and pooled data (42.24 cm) respectively followed by S_3 (45x45 cm) in 1st year (42.71 cm), 2nd year (42.81 cm) and pooled data (42.39 cm). The plant canopy spreading (N-S) direction difference between S_1, S_2, S_3 and S_4 were significant at 45 DAT.

The combined influence of varieties and spacing on (interaction) recorded at 45 DAT was found maximum plant canopy spreading (N-S) direction V_1S_1 (45.35 cm) 1st year i.e. in (2017-18), (45.97 cm) in 2nd year i.e. in (2018-19) and polled data (45.66 cm), respectively at 45 DAT followed by V_2S_1 showed (44.69, 44.69 and 44.69 cm, consequently) 1st year, 2nd year and both year. The minimum value in V_3S_4 in 1st year (40.73 cm), 2st year (40.77 cm) and pooled data (40.75 cm) consequently pursued by V_4S_4 in 1st year (41.45 cm), 2nd year (41.52 cm) and pooled data (41.48 cm). It showed significant effect on plant canopy spreading (N-S) direction at 45 DAT.

At 60 DAT varieties V_1 Pusa Broccoli KTS-1 showed (54.27 cm) plant canopy spreading (N-S) direction in 1st year i.e. in (2017-18), (55.38 cm) in 2nd year i.e. in

(2018-19) and (54.82 cm) cumulative data consequently pursued by V_2 Palam Kanchan showed (54.03, 54.55 and 54.29 cm, respectively), 1st year, 2nd year and polled data. The lowest plant canopy spreading (N-S) direction was measured in V_3 Palam Vichitra 1st year (50.35 cm), 2nd year (49.42 cm) and combined data (49.88 cm) respectively followed by V_4 Palam Samridhi 1st year (50.41 cm), 2nd year (49.45 cm) and combined data (49.93 cm). The difference between V_1, V_2, V_3 and V_4 was significant at 60 DAT.

Plant spacing S_1 (60x45 cm) as found (52.88 cm) had recorded maximum plant canopy spreading (N-S) direction 1st year i.e. in (2017-18), (53.24 cm) in 2nd year i.e. in (2018-19), (53.06 cm) combined data respectively at 60 DAT followed by S_2 (60x30 cm) showed (52.49, 52.82 and 52.65 cm, respectively) 1st year, 2nd year and pooled data. Minimum plant canopy spreading (N-S) direction was measured in S_4 (45x30 cm) in 1st year (51.79 cm), 2st year (50.73 cm) and pooled data (51.26 cm) consequently pursued by S_3 (45x45 cm) in 1st year (52.06 cm), 2nd year (52.01 cm) and pooled data (52.03 cm). The plant canopy spreading (N-S) direction difference between S_1 S_2, S_3 and S_4 were significant at 60 DAT.

The combined influence of varieties and spacing on (interaction) recorded at 60 DAT was found maximum plant canopy spreading (N-S) direction in V_1S_1 (54.57 cm) 1st year i.e. in (2017-18), (55.67 cm) in 2nd year i.e. in (2018-19) and combined data (55.1cm), respectively at 60 DAT followed by V_2S_1 showed (54.49, 55.39 and 54.94 cm, consequently) 1st year, 2nd year, and cumulative data. Minimum plant canopy spreading (N-S) direction was measured in V_3S_4 in 1st year (48.52 cm), 2nd year (48.44 cm) and pooled data (48.48 cm) consequently pursued by V_4S_4 (49.56 cm) 1st year i.e. in (2017-18), (47.74 cm) in 2nd year i.e. in (2018-19) and combined data (48.65 cm). It showed significant effect on plant canopy spreading (N-S) direction at 60 DAT.

Table -4.1.4: Influence of varieties, spacing and their interaction on plant canopy spreading north-south direction (cm) of sprouting broccoli.

Treatment	Plant canopy spreading north-south direction (cm)								
	30 DAT			45 DAT			60 DAT		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Varieties (V)									
V_1 (Pusa Broccoli KTS-1)	34.47	34.23	34.35	44.35	44.62	44.48	54.27	55.38	54.82
V_2 (Palam Kanchan)	34.24	34.05	34.14	44.30	43.93	44.11	54.03	54.55	54.29
V_3 (Palam Vichitra)	31.40	31.33	31.36	41.52	41.55	41.53	50.35	49.42	49.88
V_4 (Palam Samridhi)	31.72	31.99	31.85	41.75	41.80	41.77	50.41	49.45	49.93
S. Em ±	0.28	0.30	0.29	0.34	0.31	0.33	0.13	0.17	0.15
$CD_{5\%}$	0.86	0.92	0.89	0.99	0.90	0.94	0.41	0.49	0.45
Spacing (S)									
S_1 (60x45 cm)	33.51	33.39	33.45	43.63	43.84	43.73	52.88	53.24	53.06
S_2 (60x30 cm)	33.14	33.17	33.15	43.16	43.29	43.22	52.49	52.82	52.65
S_3 (45x45 cm)	32.88	32.81	32.84	42.71	42.81	42.39	52.06	52.01	52.03
S_4 (45x30 cm)	32.32	32.22	32.27	42.41	42.08	42.24	51.79	50.73	51.26
S. Em ±	0.29	0.33	0.31	0.37	0.39	0.38	0.18	0.21	0.20
CD5%	0.84	0.96	0.88	1.07	1.13	1.10	0.52	0.61	0.56
Interaction (VxS)									
V_1S_1	35.04	34.67	34.85	45.35	45.97	45.66	54.57	55.67	55.12
V_1S_2	34.70	34.41	34.55	44.51	45.35	44.93	54.24	55.44	53.84
V_1S_3	34.48	34.15	34.31	43.90	44.95	44.42	54.23	55.38	54.80
V_1S_4	33.69	33.69	33.69	43.65	42.71	43.18	54.05	55.06	54.55
V_2S_1	34.89	34.73	34.81	44.69	44.69	44.69	54.49	55.39	54.94
V_2S_2	34.39	34.51	34.45	44.66	44.33	44.49	54.16	50.09	54.62
V_2S_3	34.24	34.29	34.26	44.03	43.39	43.21	54.04	54.24	54.14
V_2S_4	33.47	32.68	33.07	43.82	43.33	43.57	53.46	51.68	52.57
V_3S_1	32.05	32.05	32.05	42.29	42.38	42.33	51.01	50.44	50.72
V_3S_2	31.72	31.73	31.72	41.81	41.81	41.81	50.87	49.99	50.43
V_3S_3	31.05	31.79	31.52	41.65	41.65	41.65	49.99	48.81	49.40
V_3S_4	30.78	30.76	30.77	40.73	40.77	40.75	48.52	48.44	48.48
V_4S_1	32.06	32.12	32.09	42.19	42.33	42.26	51.45	50.47	50.96
V_4S_2	31.77	32.06	31.91	41.69	41.69	41.69	50.69	49.98	50.33
V_4S_3	31.70	32.04	31.87	41.67	41.67	41.67	49.98	49.62	49.80
V_4S_4	31.37	31.67	31.50	41.45	41.52	41.48	49.56	47.74	48.65
S. Em ±	0.49	0.65	0.57	0.63	0.86	0.75	0.75	1.48	1.12
$CD_{5\%}$	1.42	1.89	1.66	1.82	2.50	2.16	2.18	4.56	3.37

Fig.-4.1.4.a: Influence of varieties on plant canopy spreading north-south direction (cm) of sprouting broccoli

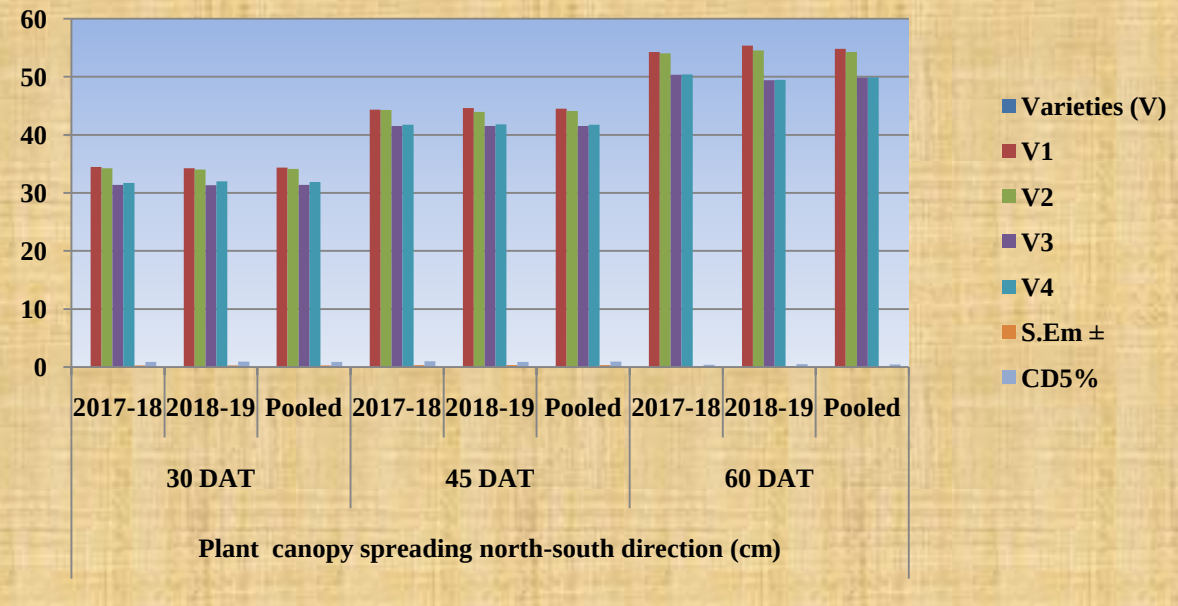


Fig.-4.1.4.b: Influence of spacing on plant canopy spreading north-south direction (cm) of sprouting broccoli

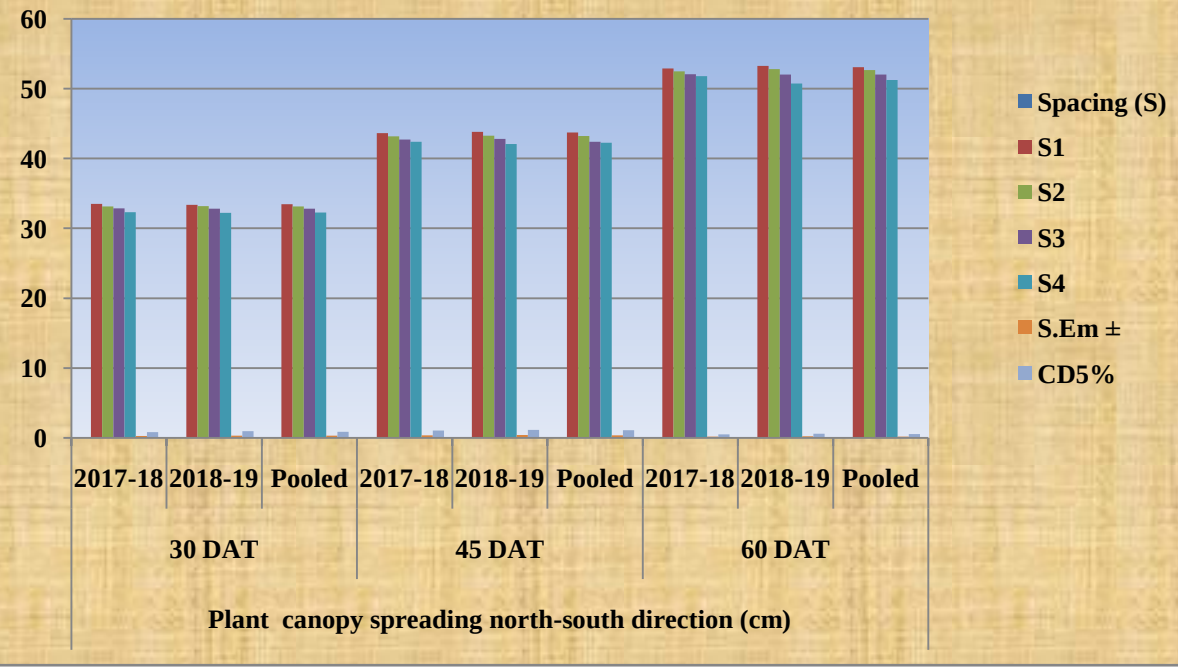
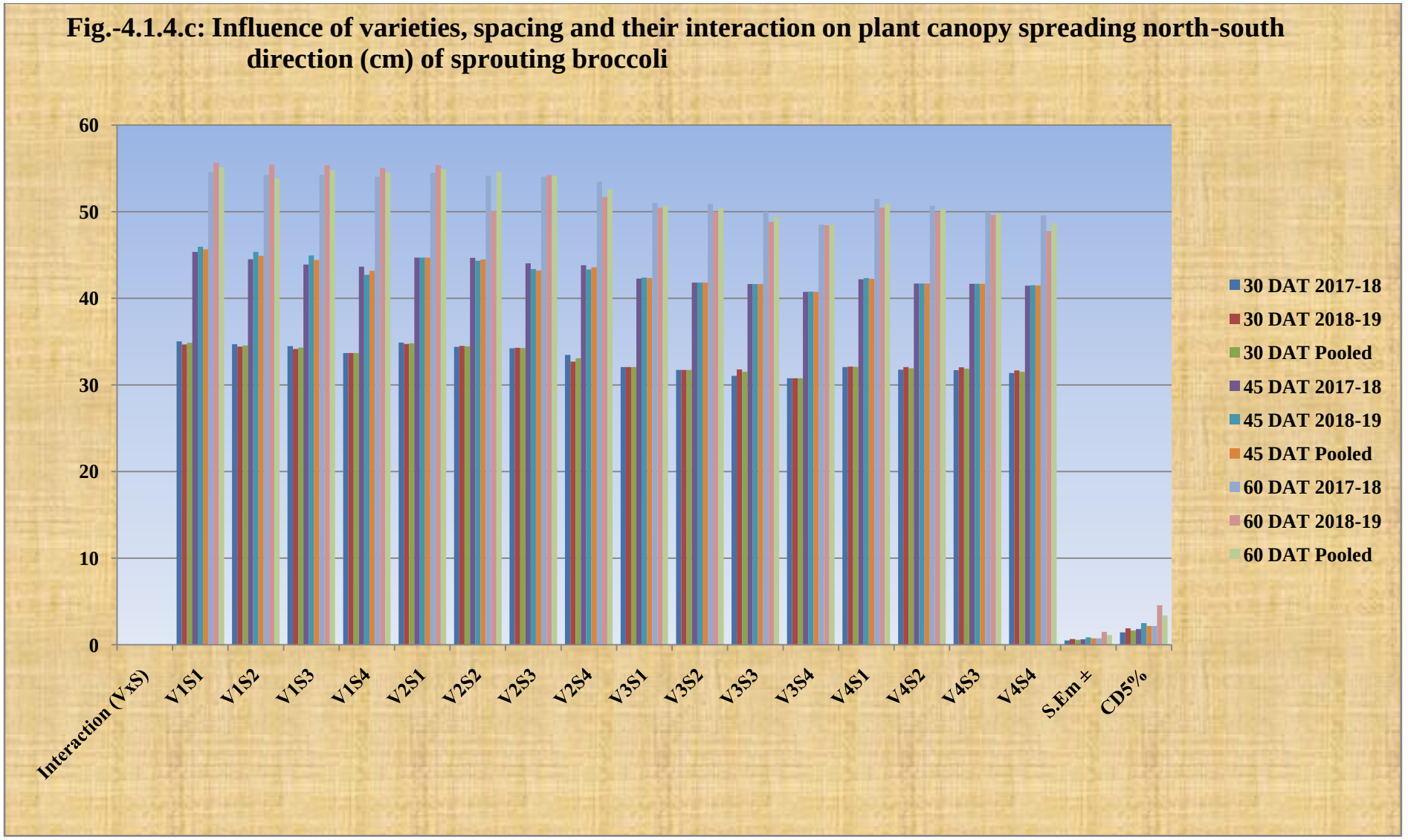


Fig.-4.1.4.c: Influence of varieties, spacing and their interaction on plant canopy spreading north-south direction (cm) of sprouting broccoli



4.1.5: Number of leaves per plant:

Among the two years (2017-18 & 2018-19) and pooled data recorded number of leaves per plant at 30, 45 and 60 days. The data presented in (Table & Fig.- 4.1.5) showed significant influence of varieties and spacing on number of leaves per plant at all stages.

The perusal data it is clear that maximum number of leaves per plant recorded in varieties V_1 Pusa Broccoli KTS-1 showed (8.35) in 1st year i.e. in (2017-18) and (8.27) in 2nd year i.e. in (2018-19), respectively at 30 DAT followed by V_2 Palam Kanchan showed (8.02) and (8.10) 1st year and 2nd year, respectively. Pooled value showed the highest number of leaves per plant (8.51) was measured in varieties V_1 Pusa Broccoli KTS-1 as compared to V_2 Palam Kanchan value (8.06) and lowest number of leaves per plant in V_3 Palam Vichitra in 1st year (7.90), 2nd year (7.78) and pooled (7.84) followed by V_4 Palam Samridhi in 1st year (7.92), 2nd year (7.98) and pooled (7.45), respectively. The difference between V_1, V_2, V_3 and V_4 was significant at 30 DAT.

Plant spacing S_1 (60x45cm) as found (8.44) had recorded maximum number of leaves per plant 1st year i.e. in (2017-18), (8.55) in 2nd year i.e. in (2018-19), respectively at 30 DAT followed by S_2 (60x30cm) showed (8.12) and (8.12) 1st year and 2nd year, respectively. Pooled value showed the highest number of leaves per plant (8.45) was measured in varieties S_1 (60x45cm) as compared to S_2 (60x30cm) showed in (8.12) and lowest number of leaves per plant in S_4 (45x30cm) in 1st year (7.71), 2nd year (7.61) and pooled data (7.66) respectively followed by S_3 (45x45cm) in 1st year (9.91), 2nd year (7.87) and pooled data (7.89). The difference between S_1, S_2, S_3 and S_4 were significant at 30 DAT.

The combined influence of varieties and spacing on (interaction) recorded at 30 DAT was found maximum number of leaves per plant V_1S_1 (8.92) 1st year i.e. in (2017-18) and (8.84) in 2nd year i.e. in (2018-19), respectively at 30 DAT followed by V_2S_1 showed (8.32), (8.64cm) 1st year and 2nd year, respectively. Pooled value showed the highest number of leaves per plant (8.88) was measured in interaction V_1S_1 as compared to V_2S_1 (8.48) and lowest value in V_3S_4 in 1st year (7.47), 2nd year (7.34) and pooled data (7.40) respectively followed by V_4S_4 in 1st year (7.54), 2nd year (7.42) and pooled data (7.48) It showed significant effect on number of leaves per

plant at 30 DAT.

At 45 DAT Varieties V_1 Pusa Broccoli KTS-1 showed (19.92) number of leaves per plant 1st year i.e. in (2017-18), (19.84) in 2nd year i.e. in (2018-19) and polled data (19.88), respectively followed by V_2 Palam Kanchan showed (19.68), (19.73) and (19.70) 1st year, 2nd year and pooled value, respectively. The lowest value in V_3 Palam Vichitra in 1st year (18.95), 2nd year (18.93) and pooled data (18.94) respectively followed by V_4 Palam Samridhi in 1st year (19.24), 2nd year (19.10) and pooled data (19.70). The difference between V_1, V_2, V_3 and V_4 was significant at 45 DAT.

Plant spacing S_1 (60x45cm) as found (19.75) had recorded maximum number of leaves per plant 1st year i.e. in (2017-18), (20.12) in 2nd year i.e. in (2018-19), respectively at 45 DAT followed by S_2 (60x30cm) showed (19.55), (19.50) 1st year and 2nd year, respectively. Pooled value showed the topmost number of leaves per plant (19.94) was measured in spacing S_1 (60x45cm) as compared to S_2 (60x30cm) showed (19.53) and lowest number of leaves per plant in S_4 (45x30cm) in 1st year (19.17), 2nd year (18.85) and Pooled data (19.01) respectively followed by S_3 (45x45cm) in 1st year (19.38), 2nd year (19.18) and pooled data (19.26). The number of leaves per plant difference between S_1, S_2, S_3 and S_4 were significant at 45 DAT.

The combined influence of varieties and spacing on (interaction) recorded at 45 DAT was found maximum number of leaves per plant in S_1 (20.13) 1st year i.e. in (2017-18), (20.69) in 2nd year i.e. in (2018-19) and polled data (20.41), respectively at 45 DAT followed by V_2S_1 showed (20.07), (20.54) and (20.30) 1st year, 2nd year and both year. The minimum number of leaves per plant in V_3S_4 in 1st year (18.27), 2nd year (18.12) and pooled data (18.20) consequently pursued by V_4S_4 in 1st year (18.96), 2nd year (18.64) and pooled data (18.80). It showed significant effect on number of leaves per plant at 45 DAT.

At 60 DAT varieties V_1 Pusa Broccoli KTS-1 showed (23.79) number of leaves per plant in 1st year i.e. in (2017-18), (23.98) in 2nd year i.e. in (2018-19) and (23.86) cumulative data consequently pursued by V_2 Palam Kanchan showed (23.69), (23.77) and (23.73), 1st year, 2nd year and polled data. The lowest number of leaves per plant was measured in V_3 Palam Vichitra 1st year (23.26), 2nd year (23.25) and combined data (23.56) respectively followed by V_4 Palam Samridhi 1st year (23.56), 2nd year

(23.72) and combined data (23.64). The difference between V_1, V_2, V_3 and V_4 was significant at 60 DAT.

Plant spacing S_1 (60x45 cm) as found (24.33) had recorded maximum number of leaves per plant 1st year i.e. in (2017-18), (24.54) in 2nd year i.e. in (2018-19), (24.44) combined data respectively at 60 DAT followed by S_2 (60x30 cm) showed (24.02), (24.03) and (24.03) 1st year, 2nd year and pooled data. Minimum number of leaves per plant was measured in S_4 (45x30cm) in 1st year (22.81), 2nd year (22.86) and Pooled data (22.84) consequently pursued by S_3 (45x45 cm) in 1st year (23.15), 2nd year (23.24) and Pooled data (23.20). The number of leaves per plant difference between S_1 S_2, S_3 and S_4 were significant at 60 DAT.

The combined influence of varieties and spacing on (interaction) recorded at 60 DAT was found maximum number of leaves per plant in V_1S_1 (24.72) 1st year i.e. in (2017-18), (24.92) in 2nd year i.e. in (2018-19) and combined data (24.82) respectively at 60 DAT followed by V_2S_1 showed (24.51, 24.76 and 24.64) 1st year, 2nd year, and cumulative data. Minimum number of leaves per plant was measured in V_3S_4 in 1st year (22.19), 2nd year (22.44) and pooled data (22.32) consequently pursued by V_4S_4 (22.98) 1st year i.e. in (2017-18), (23.02) in 2nd year i.e. in (2018-19) and combined data (23.00). It showed significant effect on number of leaves per plant at 60 DAT.

Table -4.1.5: Influence of varieties, spacing and their interaction on number of leaves per plant of sprouting broccoli.

Treatment	Number of leaves per plant								
	30 DAT			45 DAT			60 DAT		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Varieties (V)									
V1 (Pusa Broccoli KTS-1)	8.35	8.27	8.51	19.92	19.84	19.88	23.79	23.93	23.86
V2 (Palam Kanchan)	8.02	8.10	8.06	19.68	19.73	19.70	23.69	23.77	23.73
V3 (Palam Vichitra)	7.90	7.78	7.84	18.95	18.93	18.94	23.26	23.25	23.56
V4 (Palam Samridhi)	7.92	7.98	7.95	19.24	19.10	19.17	23.56	23.72	23.64
S. Em ±	0.24	0.26	0.25	0.05	0.07	0.06	0.12	0.15	0.14
CD5%	0.73	0.75	0.74	0.16	0.20	0.18	0.37	0.43	0.40
Spacing (S)									
S_1 (60x45 cm)	8.44	8.55	8.45	19.75	20.12	19.94	24.33	24.54	24.44
S_2 (60x30 cm)	8.12	8.12	8.12	19.55	19.50	19.53	24.02	24.03	24.03
S_3 (45x45 cm)	7.91	7.87	7.89	19.38	19.13	19.26	23.15	23.24	23.20
S_4 (45x30 cm)	7.71	7.61	7.66	19.17	18.85	19.01	22.81	22.86	22.84
S. Em ±	0.24	0.28	0.26	0.06	0.08	0.07	0.14	0.17	0.15
$CD_{5\%}$	0.73	0.81	0.77	0.17	0.23	0.20	0.40	0.49	0.44
Interaction (VxS)									
V_1S_1	8.92	8.84	8.88	20.13	20.69	20.41	24.72	24.92	24.82
V_1S_2	8.29	8.24	8.27	19.99	19.88	19.94	24.27	24.36	24.32
V_1S_3	8.08	7.99	8.04	19.80	19.42	19.61	23.14	23.44	23.29
V_1S_4	8.07	8.02	8.05	19.77	19.35	19.56	23.04	23.02	23.03
V_2S_1	8.32	8.64	8.48	20.07	20.54	20.30	24.51	24.76	24.64
V_2S_2	8.17	8.19	8.18	19.67	19.62	19.65	24.18	24.24	24.21
V_2S_3	7.83	7.94	7.89	19.54	19.44	19.49	23.06	23.10	23.08
V_2S_4	7.77	7.64	7.70	19.42	19.30	19.36	23.02	22.96	22.99
V_3S_1	8.30	8.16	8.23	19.34	19.56	19.45	23.96	24.02	23.99
V_3S_2	8.05	7.99	8.02	19.16	19.28	19.22	23.59	23.40	23.50
V_3S_3	7.81	7.64	7.73	19.08	18.76	18.92	23.33	23.12	23.28
V_3S_4	7.47	7.34	7.40	18.27	18.12	18.20	22.19	22.44	22.32
V_4S_1	8.20	8.54	8.37	19.45	19.68	19.57	24.12	24.44	24.25
V_4S_2	7.99	8.04	8.02	19.38	19.20	19.29	24.04	24.12	24.08
V_4S_3	7.95	7.90	7.93	19.16	18.88	19.02	23.08	23.98	23.18
V_4S_4	7.54	7.42	7.48	18.96	18.64	18.80	22.98	23.02	23.00
S. Em ±	0.28	0.15	0.22	0.33	0.75	0.54	0.90	0.96	0.93
$CD_{5\%}$	0.82	0.44	0.63	0.95	2.18	1.57	2.61	2.80	2.71

Fig.-4.1.5.a: Influence of varieties on number of leaves per plant of sprouting broccoli.

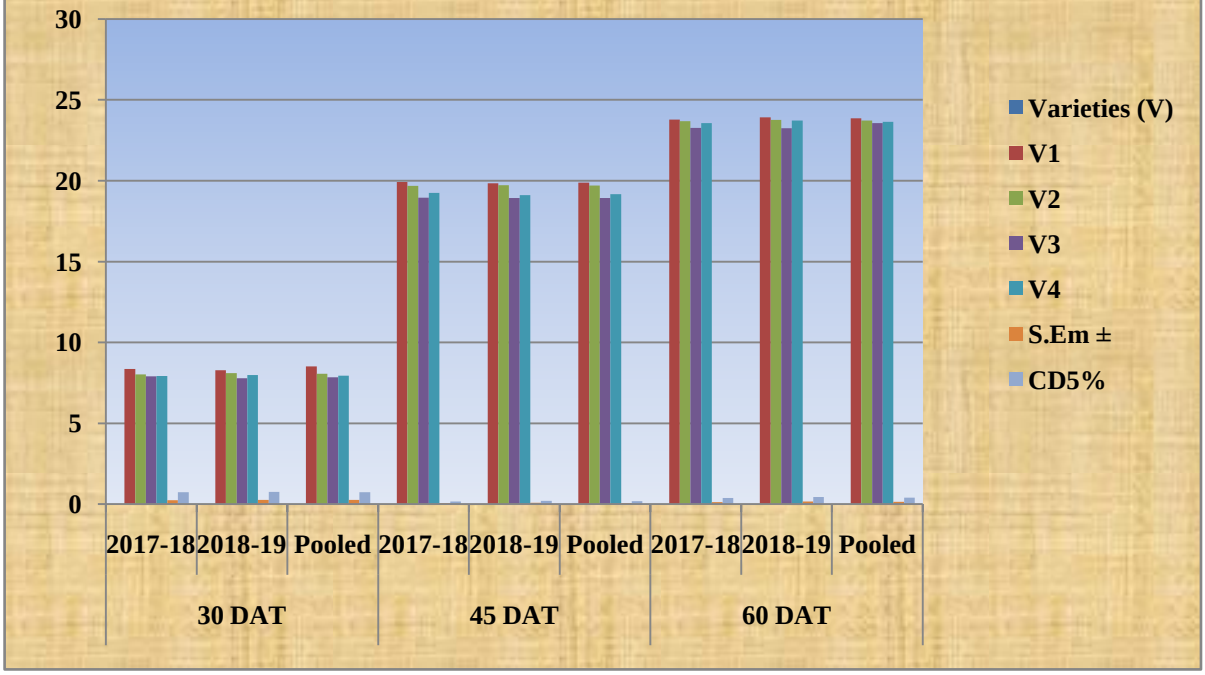


Fig.-4.1.5.b: Influence of spacing on number of leaves per plant of sprouting broccoli.

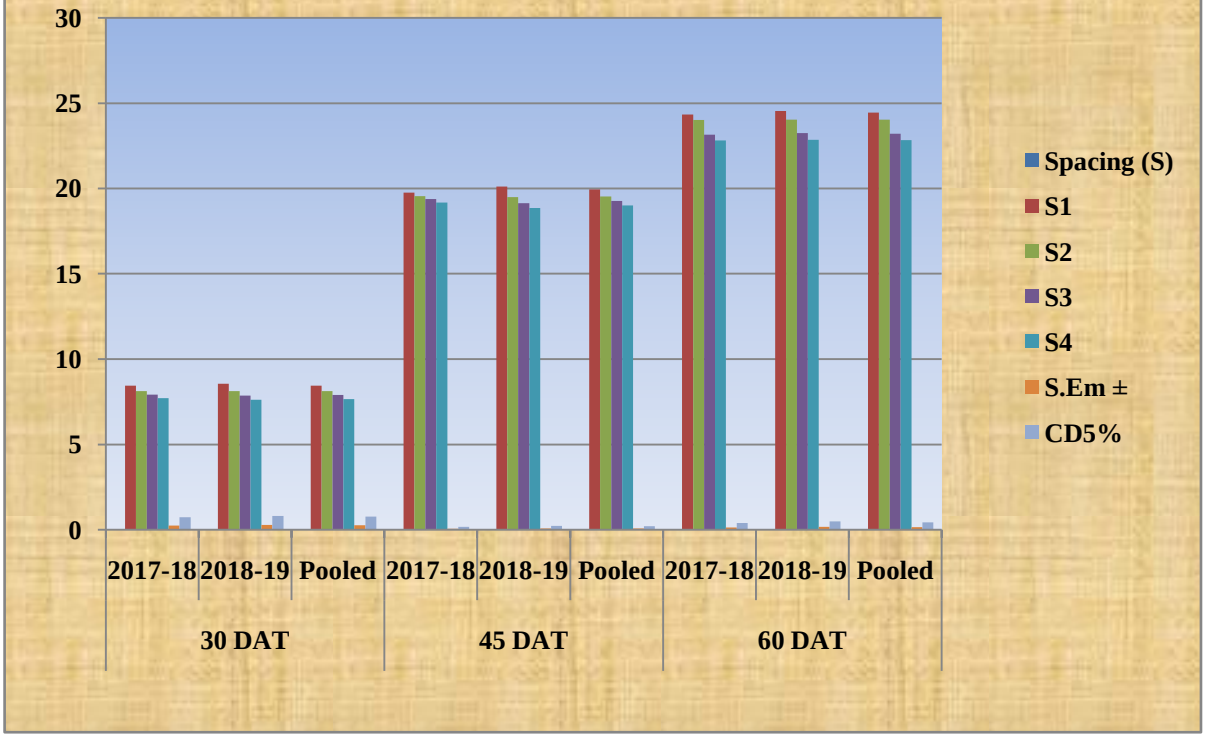
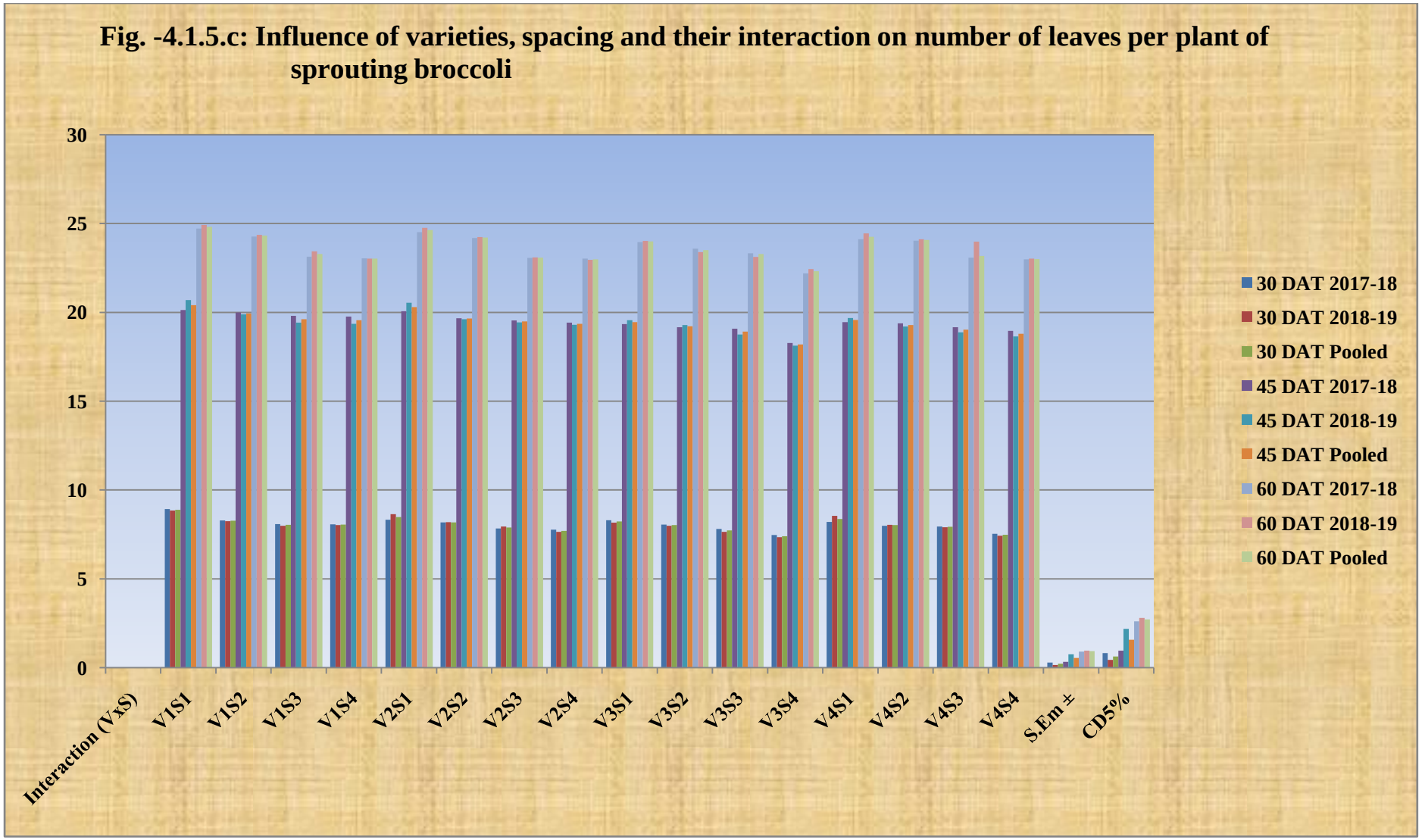


Fig. -4.1.5.c: Influence of varieties, spacing and their interaction on number of leaves per plant of sprouting broccoli



4.1.6: Length of leaves (cm):

Both the two years (2017-18 & 2018-19) and pooled data was observed length of leaves (cm) at 30, 45 and 60 days. The data presented in (Table & Fig. -4.1.6) showed significant influence of varieties and spacing on length of leaves per plant at all stages.

The perusal data it is clear that maximum length of leaves recorded in varieties V_1 Pusa Broccoli KTS-1 showed (33.45 cm) in 1st year i.e. in (2017-18) and (34.14 cm) in 2nd year i.e. in (2018-19), respectively at 30 DAT followed by V_2 Palam Kanchan showed (32.12 and 33.00 cm, respectively) 1st year and 2nd year. Pooled value showed the highest length of leaves (33.80 cm) was measured in varieties V_1 Pusa Broccoli KTS-1 as compared to V_2 Palam Kanchan value (32.56 cm) and lowest in V_3 Palam Vichitra in 1st year (29.69 cm), 2nd year (30.18 cm) and pooled (29.93 cm) followed by V_4 Palam Samridhi in 1st year (30.41 cm), 2nd year (31.69 cm) and pooled (30.90 cm), respectively. The difference between V_1, V_2, V_3 and V_4 was significant at 30 DAT.

Plant spacing S_1 (60x45 cm) as found (33.48 cm) had recorded maximum length of leaves 1st year i.e. in (2017-18), (34.45 cm) in 2nd year i.e. in (2018-19), respectively at 30 DAT followed by S_2 (60x30 cm) showed (31.52 and 32.45 cm, respectively) 1st year and 2nd year. Pooled value showed the topmost length of leaves (33.96 cm) was measured in varieties S_1 (60x45 cm) as compared to S_2 (60x30 cm) showed in (31.98 cm) and lowest length of leaves in S_4 (45x30 cm) in 1st year (29.99 cm), 2nd year (30.35 cm) and pooled data (30.17 cm) respectively followed by S_3 (45x45 cm) in 1st year (30.69 cm), 2nd year (31.47 cm) and pooled data (31.08cm). The difference between S_1, S_2, S_3 and S_4 were significant at 30 DAT.

The combined influence of varieties and spacing on (interaction) recorded at 30 DAT was found maximum length of leaves in V_1S_1 (34.37 cm) 1st year i.e. in (2017-18) and (35.14 cm) in 2nd year i.e. in (2018-19), respectively at 30 DAT followed by V_2S_1 showed (33.92, 34.94 cm, respectively) 1st year and 2nd year. Pooled value showed the highest length of leaves (34.75 cm) was measured in interaction V_1S_1 as compared to V_2S_1 (34.43 cm) and lowest value in V_3S_4 in 1st year (27.99 cm), 2nd year (28.12 cm) and pooled data (28.05 cm) respectively followed by V_4S_4 in 1st year (28.44 cm), 2nd year (29.14 cm) and pooled data (28.79 cm). It showed significant

effect on length of leaves at 30 DAT.

At 45 DAT Varieties V_1 Pusa Broccoli KTS-1 showed (40.91 cm) highest length of leaves 1st year i.e. in (2017-18), (40.38 cm) in 2nd year i.e. in (2018-19) and polled data (40.64 cm), respectively followed by V_2 Palam Kanchan showed (40.35 cm), (40.04 cm) and (40.19) 1st year, 2nd year and pooled value, respectively. The lowest value in V_3 Palam Vichitra in 1st year (38.76 cm), 2nd year (38.20 cm) and pooled data (38.48 cm) respectively followed by V_4 Palam Samridhi in 1st year (40.09 cm), 2nd year (39.93 cm) and pooled data (40.01 cm). The difference between V_1, V_2, V_3 and V_4 was significant at 45 DAT.

Plant spacing S_1 (60x45cm) as found (42.02 cm) had recorded maximum length of leaves 1st year i.e. in (2017-18), (41.93 cm) in 2nd year i.e. in (2018-19), respectively at 45 DAT followed by S_2 (60x30 cm) showed (40.60 and 40.37 cm, consequently) 1st year and 2nd year. Pooled value showed the topmost length of leaves (41.97 cm) was measured in spacing S_1 (60x45 cm) as compared to S_2 (60x30 cm) showed (40.48 cm) and lowest value in S_4 (45x30 cm) in 1st year (38.12 cm), 2nd year (37.66 cm) and pooled data (37.89 cm), respectively followed by S_3 (45x45 cm) in 1st year (39.36 cm), 2nd year (38.99 cm) and pooled data (39.17 cm). The length of leaves difference between S_1, S_2, S_3 and S_4 were significant at 45 DAT.

The combined influence of varieties and spacing on (interaction) recorded at 45 DAT was found maximum length of leaves V_1S_1 (42.81 cm) 1st year i.e. in (2017-18), (42.72 cm) in 2nd year i.e. in (2018-19) and polled data (42.76 cm), respectively at 45 DAT followed by V_2S_1 showed (42.24, 42.37 and 42.28 cm, respectively) 1st year, 2nd year and both year. The minimum length of leaves in V_3S_4 in 1st year (36.15 cm), 2nd year (34.55 cm) and pooled data (35.35 cm) consequently pursued by V_4S_4 in 1st year (37.48 cm), 2nd year (37.82 cm) and pooled data (37.65 cm). It showed significant effect on length of leaves at 45 DAT.

At 60 DAT varieties V_1 Pusa Broccoli KTS-1 showed (51.16 cm) length of leaves in 1st year i.e. in (2017-18), (51.15 cm) in 2nd year i.e. in (2018-19) and (51.16 cm) cumulative data consequently pursued by V_2 Palam Kanchan showed (50.80 cm), (50.92 cm) and (50.90 cm), 1st year, 2nd year and polled data. The lowest length of leaves was measured in V_3 Palam Vichitra 1st year (49.10 cm), 2nd year (49.04 cm) and combined data (49.70 cm) respectively followed by V_4 Palam Samridhi 1st year

(50.69 cm), 2nd year (50.79 cm) and combined data (50.74 cm). The difference between V_1, V_2, V_3 and V_4 was significant at 60 DAT.

Plant spacing S_1 (60x45 cm) as found (51.95 cm) had recorded maximum length of leaves 1st year i.e. in (2017-18), (52.03 cm) in 2nd year i.e. in (2018-19), (51.99 cm) combined data respectively at 60 DAT followed by S_2 (60x30 cm) showed (50.89, 50.95 and 50.92 cm, consequently) 1st year, 2nd year and pooled data. Minimum length of leaves was measured in S_4 (45x30 cm) in 1st year (48.77 cm), 2nd year (48.65 cm) and pooled data (48.71cm) consequently pursued by S_3 (45x45 cm) in 1st year (50.21 cm), 2nd year (50.28 cm) and pooled data (50.24 cm). The length of leaves difference between S_1 S_2, S_3 and S_4 were significant at 60 DAT.

The combined influence of varieties and spacing on (interaction) recorded at 60 DAT was found maximum length of leaves in V_1S_1 (52.79 cm) 1st year i.e. in (2017-18), (52.79 cm) in 2nd year i.e. in (2018-19) and combined data (52.67 cm), respectively at 60 DAT followed by V_2S_1 showed (52.44, 52.32 and 52.38 cm, consequently) 1st year, 2nd year, and cumulative data. Minimum length of leaves was measured in V_3S_4 in 1st year (47.76 cm), 2nd year (47.32 cm) and pooled data (47.54 cm) consequently pursued by V_4S_4 (49.12 cm) 1st year i.e. in (2017-18), (48.88 cm) in 2nd year i.e. in (2018-19) and combined data (49.00 cm). It showed significant effect on length of leaves at 60 DAT.

Table -4.1.6: Influence of varieties, spacing and their interaction on length of leaves (cm) of sprouting broccoli.

Treatment	Length of leaves per plant (cm)								
	30 DAT			45 DAT			60 DAT		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Varieties (V)									
V_1 (Pusa Broccoli KTS-1)	33.45	34.14	33.80	40.91	40.38	40.64	51.16	51.15	51.16
V_2 (Palam Kanchan)	32.12	33.00	32.56	40.35	40.04	40.19	50.80	50.92	50.90
V_3 (Palam Vichitra)	29.69	30.18	29.93	38.76	38.20	38.48	49.10	49.04	49.70
V_4 (Palam Samridhi)	30.41	31.69	30.90	40.09	39.93	40.01	50.69	50.79	50.74
S. Em ±	0.24	0.27	0.26	0.09	0.08	0.07	0.11	0.13	0.12
CD5%	0.73	0.78	0.76	0.28	0.23	0.26	0.31	0.38	0.34
Spacing (S)									
S_1 (60x45 cm)	33.48	34.45	33.96	42.02	41.93	41.97	51.95	52.03	51.99
S_2 (60x30 cm)	31.52	32.45	31.98	40.60	40.37	40.48	50.89	50.95	50.92
S_3 (45x45 cm)	30.69	31.47	31.08	39.36	38.99	39.17	50.21	50.28	50.24
S_4 (45x30 cm)	29.99	30.35	30.17	38.12	37.66	37.89	48.77	48.65	48.71
S. Em±	0.26	0.24	0.25	0.14	0.15	0.29	0.17	0.16	0.16
$CD_{5\%}$	0.75	0.73	0.74	0.40	0.43	0.41	0.49	0.46	0.48
Interaction (VxS)									
V_1S_1	34.37	35.14	34.75	42.81	42.72	42.76	52.79	52.55	52.67
V_1S_2	33.53	34.81	34.17	41.52	40.27	40.89	51.46	51.98	51.72
V_1S_3	33.46	33.76	33.61	39.73	39.37	39.55	51.04	50.72	50.88
V_1S_4	32.42	32.84	32.63	39.56	39.14	39.35	49.32	49.36	49.34
V_2S_1	33.92	34.94	34.43	42.24	42.32	42.28	52.44	52.32	52.38
V_2S_2	31.95	33.04	32.49	40.99	40.29	40.64	51.16	51.44	51.30
V_2S_3	31.52	32.74	32.13	38.85	40.02	39.93	57.02	50.88	50.95
V_2S_4	31.09	31.28	31.18	37.50	39.13	38.71	48.88	49.02	48.95
V_3S_1	32.80	33.74	33.27	41.03	40.79	40.91	50.42	51.02	50.72
V_3S_2	29.15	29.84	29.49	39.04	40.22	39.93	49.88	49.08	49.48
V_3S_3	28.83	29.02	28.92	38.83	37.22	38.02	48.32	48.74	48.53
V_3S_4	27.99	28.12	28.05	36.15	34.55	35.35	47.76	47.32	47.54
V_4S_1	32.84	33.96	33.40	41.98	41.88	41.93	52.14	52.22	52.18
V_4S_2	31.42	32.12	31.77	40.84	40.68	40.76	51.06	51.31	51.18
V_4S_3	28.95	30.34	29.64	39.04	39.34	39.19	50.44	50.76	50.60
V_4S_4	28.44	29.14	28.79	37.48	37.82	37.65	49.12	48.88	49.00
S. Em ±	1.54	1.61	1.58	1.47	1.38	1.43	1.46	1.43	1.45
$CD5_{\%}$	4.46	4.68	4.57	4.27	4.01	4.14	4.24	4.15	4.20

Fig.-4.1.6.a: Influence of varieties on length of leaves (cm) of sprouting broccoli.

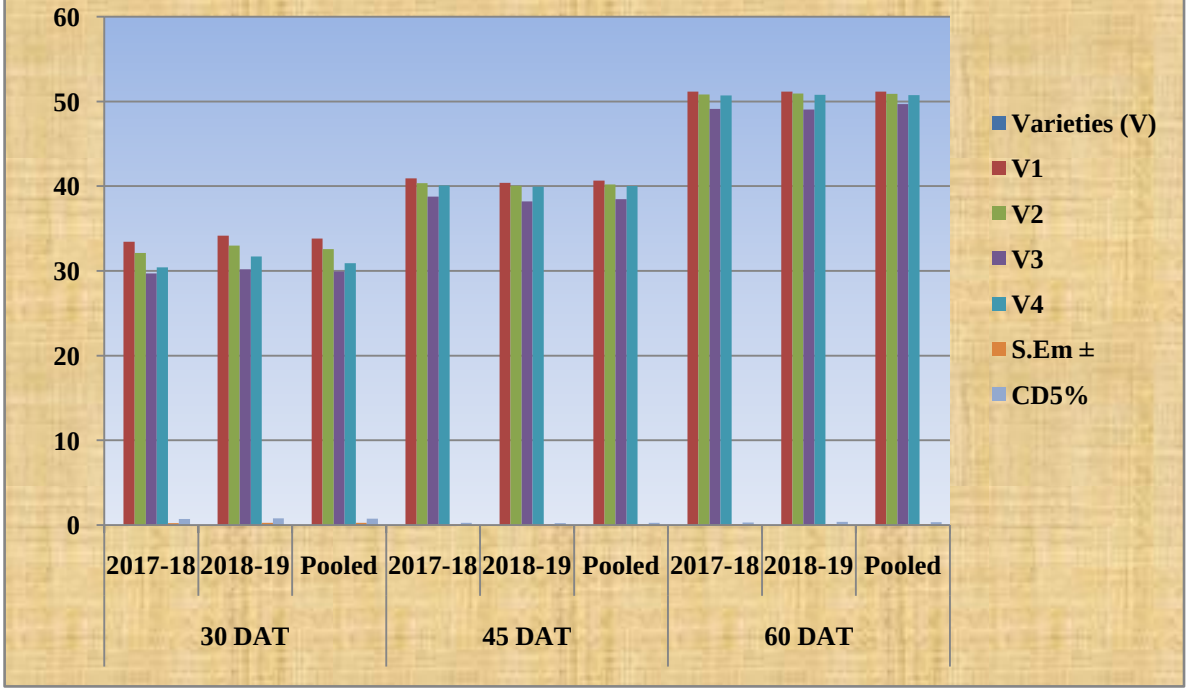


Fig.-4.1.6.b: Influence of spacing on length of leaves (cm) of sprouting broccoli.

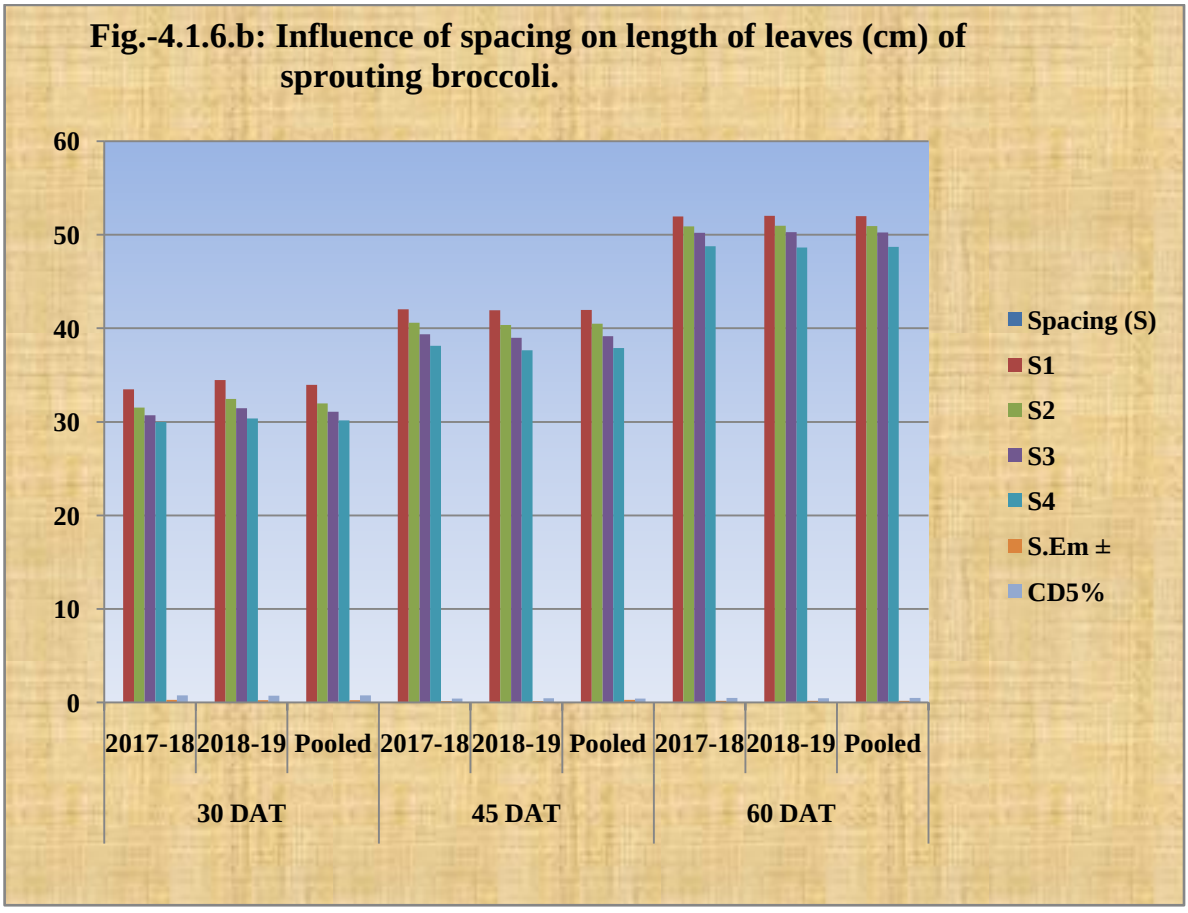
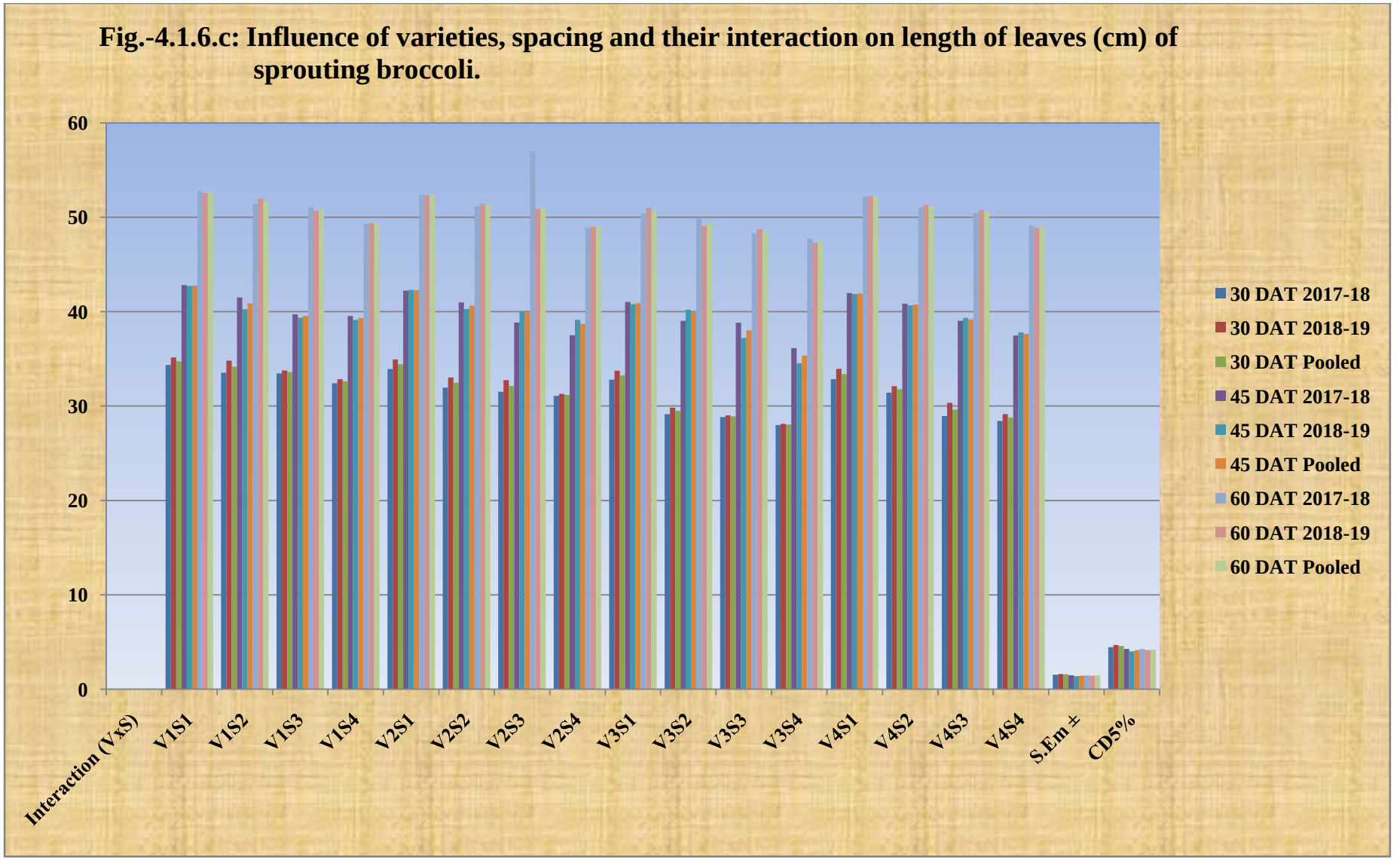


Fig.-4.1.6.c: Influence of varieties, spacing and their interaction on length of leaves (cm) of sprouting broccoli.



4.1.7: Width of leaves (cm):

Among the two years (2017-18 & 2018-19) and pooled data was observed on width of leaves (cm) at 30, 45 and 60 days. The data revealed in (Table & Fig.- 4.1.7) showed the significant influence of varieties and spacing on width of leaves at all stages.

The perusal data it is clear that maximum width of leaves recorded in varieties V_1 Pusa Broccoli KTS-1 showed (10.97 cm) in 1st year i.e. in (2017-18) and (11.11 cm) in 2nd year i.e. in (2018-19), respectively at 30 DAT followed by V_2 Palam Kanchan showed (10.52 and 10.84 cm, consequently) 1st year and 2nd year. Pooled value showed the highest width of leaves (11.04 cm) was measured in varieties V_1 Pusa Broccoli KTS-1 as compared to V_2 Palam Kanchan (10.68 cm) and lowest in V_3 Palam Vichitra in 1st year (9.63cm), 2nd year (9.67 cm) and pooled (9.65 cm) followed by V_4 Palam Samridhi in 1st year (10.37 cm), 2nd year (10.64 cm) and pooled (10.51 cm), respectively. The difference between V_1, V_2, V_3 and V_4 was significant at 30 DAT.

Plant spacing S_1 (60x45 cm) as found (11.08 cm) had recorded maximum width of leaves 1st year i.e. in (2017-18), (11.44 cm) in 2nd year i.e. in (2018-19), respectively at 30 DAT followed by S_2 (60x30 cm) showed (10.72 and 10.93 cm, respectively) 1st year and 2st year. Pooled value showed the topmost width of leaves (11.28 cm) was measured in varieties S_1 (60x45 cm) as compared to S_2 (60x30 cm) showed in (11.21 cm) and lowest width of leaves in S_4 (45x30 cm) in 1st year (9.50 cm), 2nd year (9.68 cm) and pooled data (9.59 cm) respectively followed by S_3 (45x45 cm) in 1st year (10.20 cm), 2nd year (10.21 cm) and pooled data (10.21 cm). The difference between S_1, S_2, S_3 and S_4 were significant at 30 DAT.

The combined influence of varieties and spacing on (interaction) recorded at 30 DAT was found maximum width of leaves V_1S_1 (11.49 cm) 1st year i.e. in (2017-18) and (11.44 cm) in 2nd year i.e. in (2018-19), respectively at 30 DAT followed by V_2S_1 showed (11.38 and 11.55 cm, respectively) 1st year and 2nd year. Pooled value showed the highest width of leaves (11.93 cm) was measured in interaction V_1S_1 as compared to V_2S_1 (11.47 cm) and lowest value in V_3S_4 in 1st year (8.72 cm), 2nd year (8.84 cm) and pooled data (8.78 cm), respectively followed by V_3S_3 in 1st year (9.45 cm), 2nd year (9.46 cm) and pooled data (9.46 cm) It showed significant effect on width of

leaves at 30 DAT.

At 45 DAT varieties V_1 Pusa Broccoli KTS-1 showed (17.02 cm) highest width of leaves 1st year i.e. in (2017-18), (16.65 cm) in 2nd year i.e. in (2018-19) and polled data (16.81 cm), respectively followed by V_2 Palam Kanchan showed (16.90, 16.26 and 16.58 cm, consequently) 1st year, 2nd year and pooled value. The lowest width of leaves in V_3 Palam Vichitra in 1st year (13.97 cm), 2nd year (15.30 cm) and pooled data (14.64 cm) respectively followed by V_4 Palam Samridhi in 1st year (15.33 cm), 2nd year (16.25 cm) and pooled data (15.79 cm). The difference between V_1, V_2, V_3 and V_4 was significant at 45 DAT.

Plant spacing S_1 (60x45 cm) as found (16.95 cm) had recorded maximum width of leaves 1st year i.e. in (2017-18), (17.21 cm) in 2nd year i.e. in (2018-19), respectively at 45 DAT followed by S_2 (60x30 cm) showed (16.20 cm), (16.62 cm) 1st year and 2nd year, respectively. Pooled value showed the topmost width of leaves (17.08 cm) was measured in spacing S_1 (60x45 cm) as compared to S_2 (60x30 cm) showed (16.41 cm) and lowest value in S_4 (45x30 cm) in 1st year (14.62 cm), 2nd year (15.03 cm) and pooled data (14.64 cm), respectively followed by S_3 (45x45 cm) in 1st year (15.45 cm), 2nd year (15.59 cm) and pooled data (15.52 cm). The width of leaves difference between S_1, S_2, S_3 and S_4 were significant at 45 DAT.

The combined influence of varieties and spacing on (interaction) recorded at 45 DAT was found maximum width of leaves V_1S_1 (17.72 cm) 1st year i.e. in (2017-18), (17.73 cm) in 2nd year i.e. in (2018-19) and polled data (17.73 cm), respectively at 45 DAT followed by V_2S_1 showed (17.68, 17.63 and 17.66 cm, consequently) 1st year, 2nd year and pooled. The minimum width of leaves in V_3S_4 in 1st year (12.11 cm), 2nd year (13.24 cm) and pooled data (12.68 cm), consequently pursued by V_3S_3 in 1st year (13.84 cm), 2nd year (15.49 cm) and pooled data (15.17 cm). It showed significant effect on width of leaves at 45 DAT.

At 60 DAT varieties V_1 Pusa Broccoli KTS-1 showed (30.33 cm) width of leaves in 1st year i.e. in (2017-18), (30.69 cm) in 2nd year i.e. in (2018-19) and (30.51 cm) cumulative data consequently pursued by V_2 Palam Kanchan showed (29.81, 30.18 and 29.99 cm, respectively) 1st year, 2nd year and polled data. The lowest width of leaves was measured in V_3 Palam Vichitra 1st year (29.49 cm), 2nd year (29.63 cm) and combined data (29.56 cm) respectively followed by V_4 Palam Samridhi 1st year

(29.80 cm), 2nd year (30.01 cm) and combined data (29.91 cm). The difference between V_1, V_2, V_3 and V_4 was significant at 60 DAT.

Plant spacing S_1 (60x45 cm) as found (31.02 cm) had recorded maximum width of leaves 1st year i.e. in (2017-18), (31.20 cm) in 2nd year i.e. in (2018-19), (31.11 cm) combined data respectively at 60 DAT followed by S_2 (60x30 cm) showed (30.56, 30.86 and 30.71 cm, consequently) 1st year, 2nd year and pooled data. Minimum width of leaves was measured in S_4 (45x30 cm) in 1st year (28.69 cm), 2nd year (28.59 cm) and pooled data (29.56 cm), consequently pursued by S_3 (45x45 cm) in 1st year (29.45 cm), 2nd year (29.87 cm) and pooled data (29.66 cm). The width of leaves difference between S_1 S_2, S_3 and S_4 were significant at 60 DAT.

The combined influence of varieties and spacing on (interaction) recorded at 60 DAT was found maximum width of leaves in V_1S_1 (31.35 cm) 1st year i.e. in (2017-18), (31.36 cm) in 2nd year i.e. in (2018-19) and combined data (31.11 cm) respectively at 60 DAT followed by V_2S_1 showed (31.16, 31.24 and 31.20 cm, consequently) 1st year, 2nd year, and cumulative data. Minimum width of leaves was measured in V_3S_4 in 1st year (28.02 cm), 2nd year (27.18 cm) and pooled data (27.60 cm) consequently pursued by V_4S_4 (28.42 cm) 1st year i.e. in (2017-18), (28.46 cm) in 2nd year i.e. in (2018-19) and combined data (28.44 cm). It showed significant effect on width of leaves at 60 DAT.

Table -4.1.7: Influence of varieties, spacing and their interaction on width of leaves (cm) of sprouting broccoli.

Treatment	Width of leaves (cm)								
	30 DAT			45 DAT			60 DAT		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Varieties (V)									
V_1 (Pusa Broccoli KTS-1)	10.97	11.11	11.04	17.02	16.65	16.81	30.33	30.69	30.51
V_2 (Palam Kanchan)	10.52	10.84	10.68	16.90	16.26	16.58	29.81	30.18	29.99
V_3 (Palam Vichitra)	9.63	9.67	9.65	13.97	15.30	14.64	29.49	29.63	29.56
V_4 (Palam Samridhi)	10.37	10.64	10.51	15.33	16.25	15.79	29.80	30.01	29.91
S. Em ±	0.19	0.21	0.20	0.29	0.33	0.31	0.33	0.31	0.32
$CD_{5\%}$	0.58	0.61	0.59	0.84	1.01	0.93	1.01	0.90	0.92
Spacing (S)									
S_1 (60x45 cm)	11.08	11.44	11.26	16.95	17.21	17.08	31.02	31.20	31.11
S_2 (60x30 cm)	10.72	10.93	10.83	16.20	16.62	16.41	30.56	30.86	30.71
S_3 (45x45 cm)	10.20	10.21	10.21	15.45	15.59	15.52	29.45	29.87	29.66
S_4 (45x30 cm)	9.50	9.68	9.59	14.62	15.03	14.83	28.69	28.59	28.64
S. Em ±	0.21	0.24	0.23	0.31	0.33	0.32	0.36	0.39	0.38
CD5%	0.61	0.70	0.66	0.90	0.96	0.93	1.04	1.13	1.08
Interaction (VxS)									
V_1S_1	11.49	12.36	11.93	17.72	17.73	17.73	31.35	31.36	31.36
V_1S_2	11.13	11.28	11.21	17.61	16.98	17.30	30.78	31.14	30.96
V_1S_3	10.95	10.73	10.84	16.50	16.02	16.26	30.02	30.42	30.22
V_1S_4	10.32	10.08	10.20	16.25	15.88	16.07	29.18	29.84	29.51
V_2S_1	11.38	11.55	11.47	17.68	17.63	17.66	31.16	31.24	31.20
V_2S_2	10.98	11.47	11.23	17.45	16.58	17.02	30.56	30.88	30.72
V_2S_3	10.28	10.32	10.30	16.42	15.76	16.09	29.34	29.76	29.55
V_2S_4	9.49	10.02	9.74	16.04	15.01	15.53	29.12	28.86	28.99
V_3S_1	10.34	10.42	10.38	15.60	16.48	16.04	30.48	31.02	30.75
V_3S_2	10.02	9.95	9.99	14.31	16.02	15.17	30.02	30.46	30.25
V_3S_3	9.45	9.46	9.46	13.84	15.49	14.64	29.44	29.88	29.66
V_3S_4	8.72	8.84	8.78	12.11	13.24	12.68	28.02	27.18	27.60
V_4S_1	11.12	11.42	11.27	16.81	17.04	16.93	31.12	31.18	31.15
V_4S_2	10.74	11.02	10.88	15.44	16.88	16.16	30.88	30.96	30.92
V_4S_3	10.12	10.34	10.23	15.02	15.12	15.08	29.02	29.42	29.22
V_4S_4	9.48	9.76	9.62	14.06	15.98	15.02	28.42	28.46	28.44
S. Em ±	1.18	1.23	1.21	1.03	1.04	1.04	0.96	1.00	0.98
$CD_{5\%}$	3.43	3.57	3.50	2.98	3.02	3.00	2.78	2.90	2.84

Fig.-4.1.7.a: Influence of varieties on width of leaves (cm) of sprouting broccoli

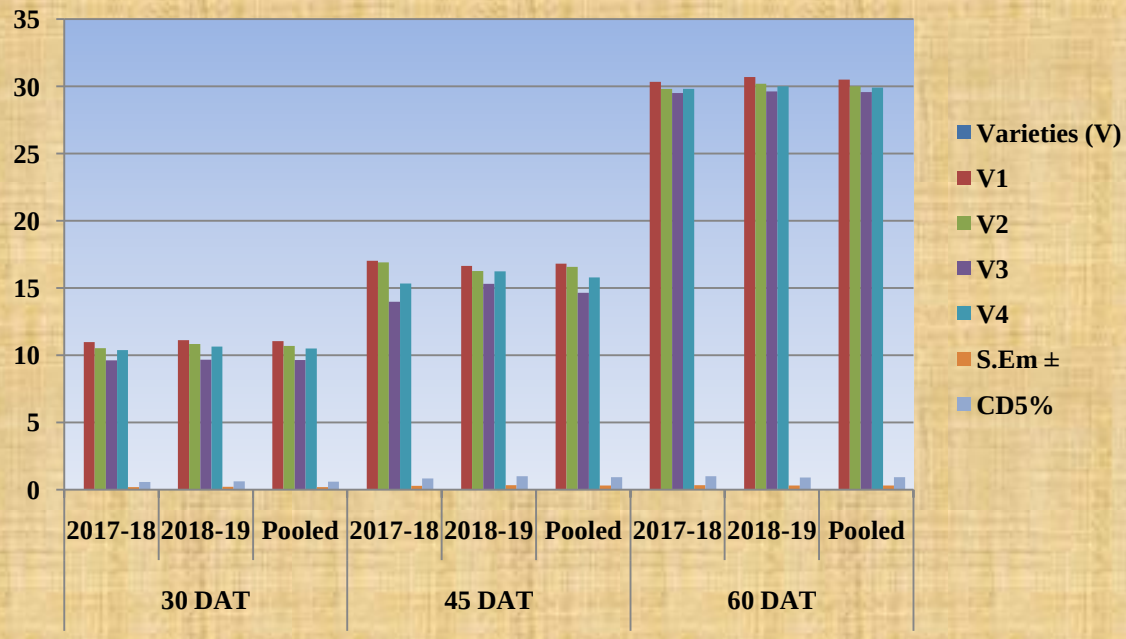


Fig.-4.1.7.b: Influence of spacing on width of leaves (cm) of sprouting broccoli

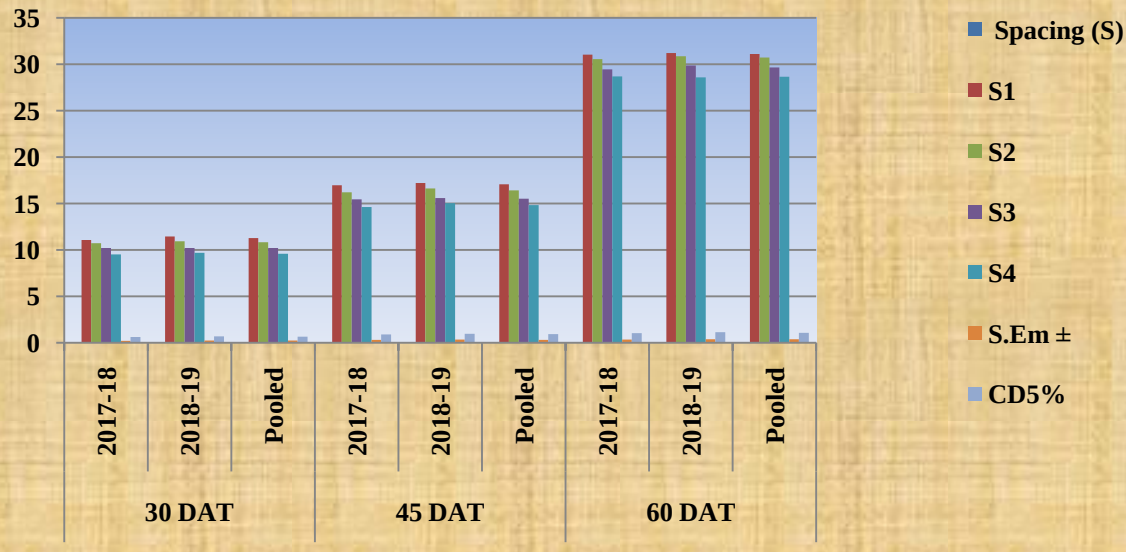
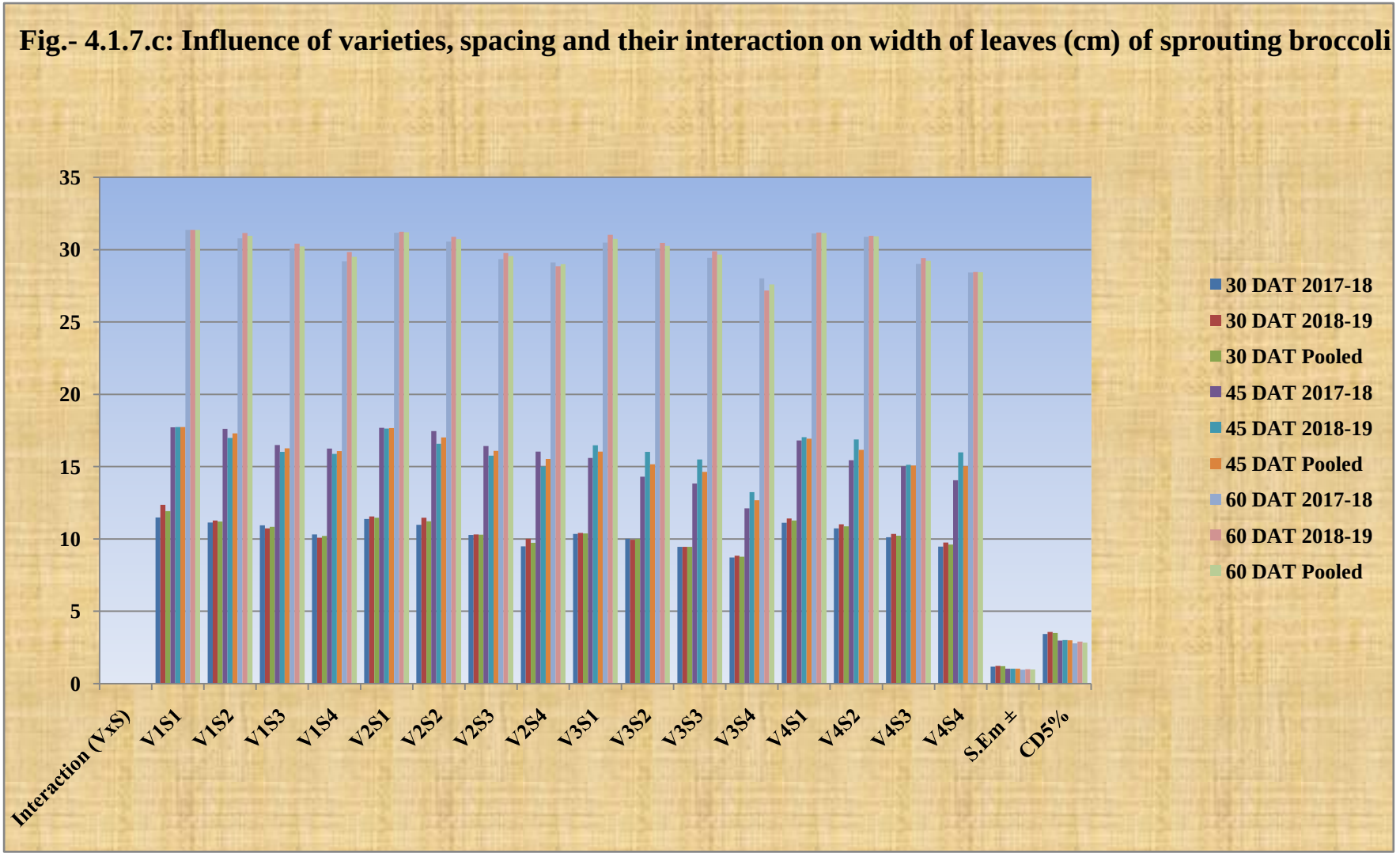


Fig.- 4.1.7.c: Influence of varieties, spacing and their interaction on width of leaves (cm) of sprouting broccoli



4.1.8: Dry weight of plant (g):

Both the two years (2017-18 & 2018-19) and pooled data was recorded dry weight of plant (g) at 30, 45, 60 and harvesting stage. The data presented in (Table & Fig.- 4.1.8) revealed significant influence of varieties and spacing on width of leaves.

The perusal data it is clear that maximum dry weight of plant recorded in variety V_2 Palam Kanchan showed value in (8.33 g) in 1st year i.e. in (2017-18) and (8.40 g) in 2nd year i.e. in (2018-19), respectively at 30 DAT followed by V_3 Palam Vichitra showed in (8.26 and 8.16 g, respectively) 1st year and 2nd year. Pooled value showed the maximum dry weight of plant was measured in variety V_2 Palam Kanchan (8.37 g) as compared to V_3 Palam Vichitra value in (8.21 g) and lowest dry weight in variety V_1 Pusa Broccoli KTS-1 1st year (7.06 g), 2nd year (6.92 g) and pooled data (6.99 g).The difference between V_1, V_2, V_3 and V_4 was significant at 30 DAT.

Plant spacing S_4 (45x30 cm) as found (8.28 g) had recorded maximum dry weight of plant in 1st year i.e. in (2017-18) and (8.30 g) in 2nd year i.e. in (2018-19), respectively at 30 DAT followed by S_3 (45x45 cm) showed in (7.92 and 7.77 g, consequently) in 1st year and 2nd year. Pooled value showed the highest dry weight of plant was measured in spacing S_4 (45x30 cm) showed in (8.29 g) as compared to S_3 (45x45 cm) value in (7.85 g) and lowest dry weight of plant in S_1 (60x45 cm) in 1st year (7.78 g), 2nd year (7.22 g) and cumulative data (7.50 g), consequently pursued by S_2 (60x30 cm) in 1st year (7.85 g), 2nd year (7.43 g) and cumulative data (7.64 g). The difference between S_1 S_2, S_3 and S_4 were significant at 30 DAT.

The combined influence of varieties and spacing on (interaction) recorded at 30 DAT was found maximum dry weight of plant V_4S_4 showed in (8.71 g) in 1st year i.e. in (2017-18), (8.72 g) in 2nd year i.e. in (2018-19), respectively at 30 DAT followed by V_2S_4 showed in (8.44 g) and (8.66 g) 1st year and 2nd year, respectively. Pooled value showed the highest dry weight of plant was measured in interaction V_4S_4 showed in (8.73 g) as compared to V_2S_4 (8.55 g) and lowest dry weight of plant in V_1S_1 in 1st year (6.83 g), 2nd year (6.34 g) and cumulative data (6.59 g) respectively followed by V_1S_2 in 1st year (6.90 g), 2nd year (6.48 g) and pooled data (6.69 g). It showed significant effect on dry weight of plant at 30 DAT.

The perusal data it is clear that maximum dry weight of plant recorded in variety V_2 Palam Kanchan showed value in (23.84 g) in 1st year i.e. in (2017-18) and (23.88 g) in 2nd year i.e. in (2018-19), respectively followed by V_3 Palam Vichitra showed in (21.51 g) and (22.70 g) 1st year and 2nd year, respectively. Pooled value showed the maximum dry weight of plant was measured in variety V_2 Palam Kanchan (23.86 g) as compared to V_3 Palam Vichitra value in (22.11 g) and lowest dry weight in variety V_1 Pusa Broccoli KTS-1 1st year (17.42 g), 2nd year (18.01 g) and pooled data (17.72 g) consequently pursued by V_4 Palam Samridhi 1st year (19.45 g), 2nd year (20.31 g) and pooled data (19.88 g).The difference between V_1, V_2, V_3 and V_4 was significant at 45 DAT.

Plant spacing S_4 (45x30 cm) as found (21.37 g) had recorded maximum dry weight of plant in 1st year i.e. in (2017-18) and (20.35 g) in 2nd year i.e. in (2018-19), respectively followed by S_3 (45x45 cm) showed in (20.35 g) and (21.60 g) in 1st year and 2nd year, respectively. Pooled value showed the highest dry weight of plant was measured in spacing S_4 (45x30 cm) showed in (21.81 g) as compared to S_3 (45x45 cm) value in (21.21 g) and lowest dry weight of plant in S_1 (60x45 cm) in 1st year (19.70 g), 2nd year (20.07 g) and cumulative data (19.89 g) consequently pursued by S_2 (60x30 cm) in 1st year (20.35 g), 2nd year (20.98 g) and cumulative data (20.67 g). The difference between S_1 S_2, S_3 and S_4 were significant at 45 DAT.

The combined influence of varieties and spacing on (interaction) recorded at 45 DAT was found maximum dry weight of plant V_2S_4 showed in (23.98 g) in 1st year i.e. in (2017-18), (24.76 g) in 2nd year i.e. in (2018-19), consequently pursued by V_2S_3 showed in (23.92 and 24.12 g, respectively) 1st year and 2nd year. Pooled value showed the highest dry weight of plant was measured in interaction V_2S_4 showed in (24.37 g) as compared to V_2S_3 (24.02 g) and lowest dry weight of plant in V_1S_1 in 1st year (16.55 g), 2nd year (17.04 g) and cumulative data (16.80 g), respectively followed by V_1S_2 in 1st year (17.12 g), 2nd year (17.84 g) and pooled data (17.48 g). It showed significant effect on dry weight of plant at 45 DAT.

The perusal data it is clear that maximum dry weight of plant recorded in variety V_2 Palam Kanchan showed value in (52.40 g) in 1st year i.e. in (2017-18) and (53.14 g) in 2nd year i.e. in (2018-19), respectively followed by V_3 Palam Vichitra showed in (50.65 and 51.59 g) 1st year and 2nd year, respectively. Pooled value

showed the maximum dry weight of plant was measured in variety V_2 Palam Kanchan (52.77 g) as compared to V_3 Palam Vichitra value in (51.12 g) and lowest dry weight in variety V_1 Pusa Broccoli KTS-1, 1st year (42.60 g), 2nd year (43.54 g) and pooled data (43.07 g), consequently pursued by V_4 Palam Samridhi 1st year (43.73 g), 2nd year (45.10 g) and pooled data (44.42 g). The difference between V_1, V_2, V_3 and V_4 was significant at 60 DAT.

Plant spacing S_4 (45x30 cm) as found (49.75 g) had recorded maximum dry weight of plant in 1st year i.e. in (2017-18) and (50.61 g) in 2nd year i.e. in (2018-19), respectively followed by S_3 (45x45 cm) showed in (48.16 and 48.62 g, consequently) in 1st year and 2nd year. Pooled value showed the highest dry weight of plant was measured in spacing S_4 (45x30 cm) showed in (50.18 g) as compared to S_3 (45x45 cm) value in (48.62 g) and lowest dry weight of plant in S_1 (60x45 cm) in 1st year (45.29 g), 2nd year (46.29 g) and cumulative data (45.79 g) consequently pursued by S_2 (60x30 cm) in 1st year (46.17 g), 2nd year (47.39 g) and cumulative data (46.78 g). The difference between S_1 S_2, S_3 and S_4 were significant at 60 DAT.

The combined influence of varieties and spacing on (interaction) recorded at 60 DAT was found maximum dry weight of plant V_2S_4 showed in (55.83 g) in 1st year i.e. in (2017-18), (55.98 g) in 2nd year i.e. in (2018-19), consequently pursued by V_2S_3 showed in (53.82 and 54.35 g, consequently) 1st year and 2nd year. Pooled value showed the highest dry weight of plant was measured in interaction V_2S_4 showed in (55.91 g) as compared to V_2S_3 (54.09 g) and lowest dry weight of plant in V_1S_1 in 1st year (40.41 g), 2nd year (41.53 g) and cumulative data (40.97 g), respectively followed by V_1S_2 in 1st year (41.92 g), 2nd year (42.98 g) and pooled data (42.45 g). It showed significant effect on dry weight of plant at 60 DAT.

The perusal data it is clear that maximum dry weight of plant recorded in at harvesting stage variety V_2 Palam Kanchan showed value in (190.38 g) in 1st year i.e. in (2017-18) and (198.02 g) in 2nd year i.e. in (2018-19), respectively followed by V_3 Palam Vichitra showed in (176.00 and 179.57 g) 1st year and 2nd year, respectively. Pooled value showed the maximum dry weight of plant was measured in variety V_2 Palam Kanchan (194.20 g) as compared to V_3 Palam Vichitra value in (177.79 g) and lowest dry weight in variety V_1 Pusa Broccoli KTS-1 1st year (109.15 g), 2nd year (115.65 g) and pooled data (112.40 g) consequently pursued by V_4 Palam Samridhi

1st year (114.80 g), 2nd year (121.76 g) and pooled data (118.28 g). The difference between V_1, V_2, V_3 and V_4 was significant at harvesting stage.

Plant spacing S_4 (45x30 cm) as found (164.85 g) had recorded maximum dry weight of plant in harvesting stage 1st year i.e. in (2017-18) and (169.22 g) in 2nd year i.e. in (2018-19), respectively followed by S_3 (45x45 cm) showed in (150.84 g) and (159.33 g) in 1st year and 2nd year, respectively. Pooled value showed the highest dry weight of plant was measured in spacing S_4 (45x30 cm) showed in (167.67 g) as compared to S_3 (45x45 cm) value in (155.09 g) and lowest dry weight of plant in S_1 (60x45 cm) in 1st year (133.41 g), 2nd year (137.80 g) and cumulative data (135.60 g) consequently pursued by S_2 (60x30 cm) in 1st year (143.96 g), 2nd year (148.56 g) and cumulative data (146.26 g). The difference between S_1 S_2, S_3 and S_4 were significant at harvesting stage.

The combined influence of varieties and spacing on (interaction) recorded at harvesting stage was found maximum dry weight of plant V_2S_4 showed in (201.34 g) in 1st year i.e. in (2017-18), (206.12 g) in 2nd year i.e. in (2018-19), consequently pursued by V_2S_3 showed in (194.36 and 204.34 g) 1st year and 2nd year, respectively. Pooled value showed the highest dry weight of plant was measured in interaction V_2S_4 showed in (203.73 g) as compared to V_2S_3 (199.35 g) and lowest dry weight of plant in V_1S_1 in 1st year (99.48 g), 2nd year (101.74 g) and cumulative data (100.61 g) respectively followed by V_4S_1 in 1st year (101.34 g), 2nd year (102.35 g) and pooled data (101.85 g). It showed significant effect on dry weight of plant at harvesting stage.

Table - 4.1.8: Influence of varieties, spacing and their interaction on dry weight of plant (g) of sprouting broccoli.

Treatment	Dry weight of plant (g)											
	30 DAT			45 DAT			60 DAT			At harvesting stage		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Varieties (V)												
V_1 (Pusa Broccoli KTS-1)	7.06	6.92	6.99	17.42	18.01	17.72	42.60	43.54	43.07	109.15	115.65	112.40
V_2 (Palam Kanchan)	8.33	8.32	8.33	23.84	23.88	23.86	52.40	53.14	52.77	190.38	198.02	194.20
V_3 (Palan Vichitra)	8.26	8.16	8.21	21.51	22.70	22.11	50.65	51.59	51.12	176.00	179.57	177.79
V_4 (Palam Samridhi)	8.18	7.40	7.79	19.45	20.31	19.88	43.73	45.10	44.42	114.80	121.76	118.28
S. Em ±	0.20	0.19	0.20	0.57	0.59	0.58	1.76	1.78	1.77	3.38	2.98	3.18
CD5%	0.59	0.55	0.57	1.69	1.71	1.70	5.18	5.16	5.17	9.91	8.64	9.27
Spacing (S)												
S_1 (60x45 cm)	7.78	7.22	7.50	19.70	20.07	19.89	45.29	46.29	45.79	133.41	137.80	135.60
S_2 (60x30 cm)	7.85	7.43	7.64	20.35	20.98	20.67	46.17	47.39	46.78	143.96	148.56	146.26
S_3 (45x45 cm)	7.92	7.77	7.85	20.81	21.60	21.21	48.16	49.07	48.62	150.84	159.33	155.09
S_4 (45x30 cm)	8.28	8.40	8.29	21.37	22.25	21.81	49.75	50.61	50.18	164.85	169.28	167.07
S. Em ±	0.34	0.32	0.33	0.99	1.01	1.00	3.06	3.11	3.09	5.85	4.88	5.36
$CD_{5\%}$	1.02	0.93	0.97	2.92	2.93	2.93	8.97	9.01	8.99	17.18	14.15	15.66
Interaction (VxS)												
V_1S_1	6.83	6.34	6.59	16.55	17.04	16.80	40.41	41.53	40.97	99.48	101.74	100.61
V_1S_2	6.90	6.48	6.69	17.12	17.84	17.48	41.92	42.98	42.45	107.77	110.34	109.06
V_1S_3	6.95	7.02	6.99	17.18	18.14	17.66	43.48	43.88	43.68	110.91	120.16	115.54
V_1S_4	7.55	7.84	7.70	18.84	19.02	18.93	44.56	45.76	45.16	119.34	130.34	124.85
V_2S_1	8.27	8.04	8.16	23.57	23.18	23.38	49.59	50.45	50.02	176.48	184.76	180.62
V_2S_2	8.29	8.12	8.21	23.88	23.46	23.67	50.34	51.78	51.06	189.34	196.84	193.09
V_2S_3	8.31	8.48	8.40	23.92	24.12	24.02	53.82	54.35	54.09	194.36	204.34	199.35
V_2S_4	8.44	8.66	8.55	23.98	24.76	24.37	55.83	55.98	55.91	201.34	206.12	203.73
V_3S_1	8.08	7.99	8.04	20.48	21.04	20.76	48.76	49.35	49.06	156.34	162.34	159.34
V_3S_2	8.23	8.04	8.14	21.04	22.84	21.94	49.64	50.76	50.20	174.18	175.34	174.76
V_3S_3	8.31	8.24	8.28	22.04	23.14	22.59	51.34	52.24	51.79	183.24	188.46	185.85
V_3S_4	8.40	8.38	8.39	22.48	23.76	23.12	52.84	53.98	53.41	190.24	192.11	191.18
V_4S_1	7.92	6.49	7.21	18.18	19.02	18.60	42.38	43.84	43.11	101.34	102.35	101.85
V_4S_2	7.98	7.08	7.53	19.34	19.76	19.55	42.76	44.04	43.40	104.56	111.78	108.17
V_4S_3	8.09	7.34	7.72	20.08	20.98	20.53	43.98	45.78	44.88	114.84	124.34	119.59
V_4S_4	8.71	8.72	8.73	20.18	21.46	20.82	45.78	46.72	46.25	138.46	148.56	143.51
S. Em ±	0.27	0.40	0.34	0.75	1.92	1.34	1.58	3.09	2.34	12.20	15.95	14.08
$CD_{5\%}$	0.79	1.15	0.97	2.19	5.56	3.88	4.59	8.94	6.77	35.41	46.29	40.85

Fig.- 4.1.8.a: Influence of varieties dry weight of plant (g) of sprouting broccoli

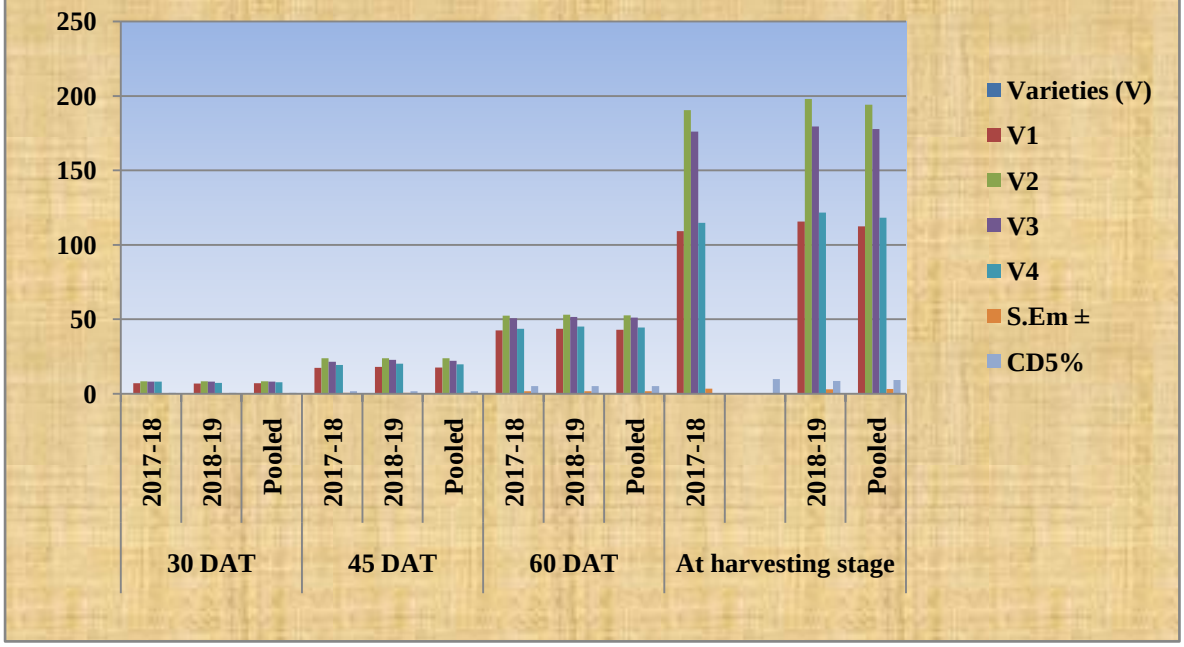


Fig.- 4.1.8.b: Influence of spacing on dry weight of plant (g) of sprouting broccoli

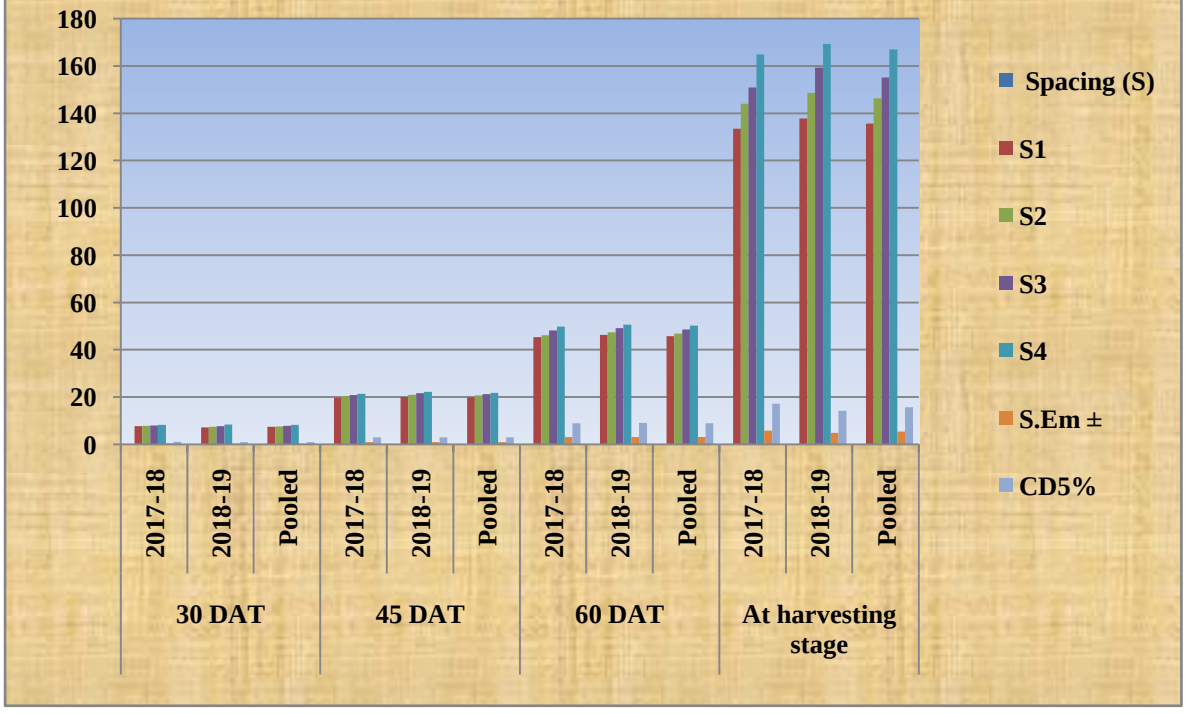
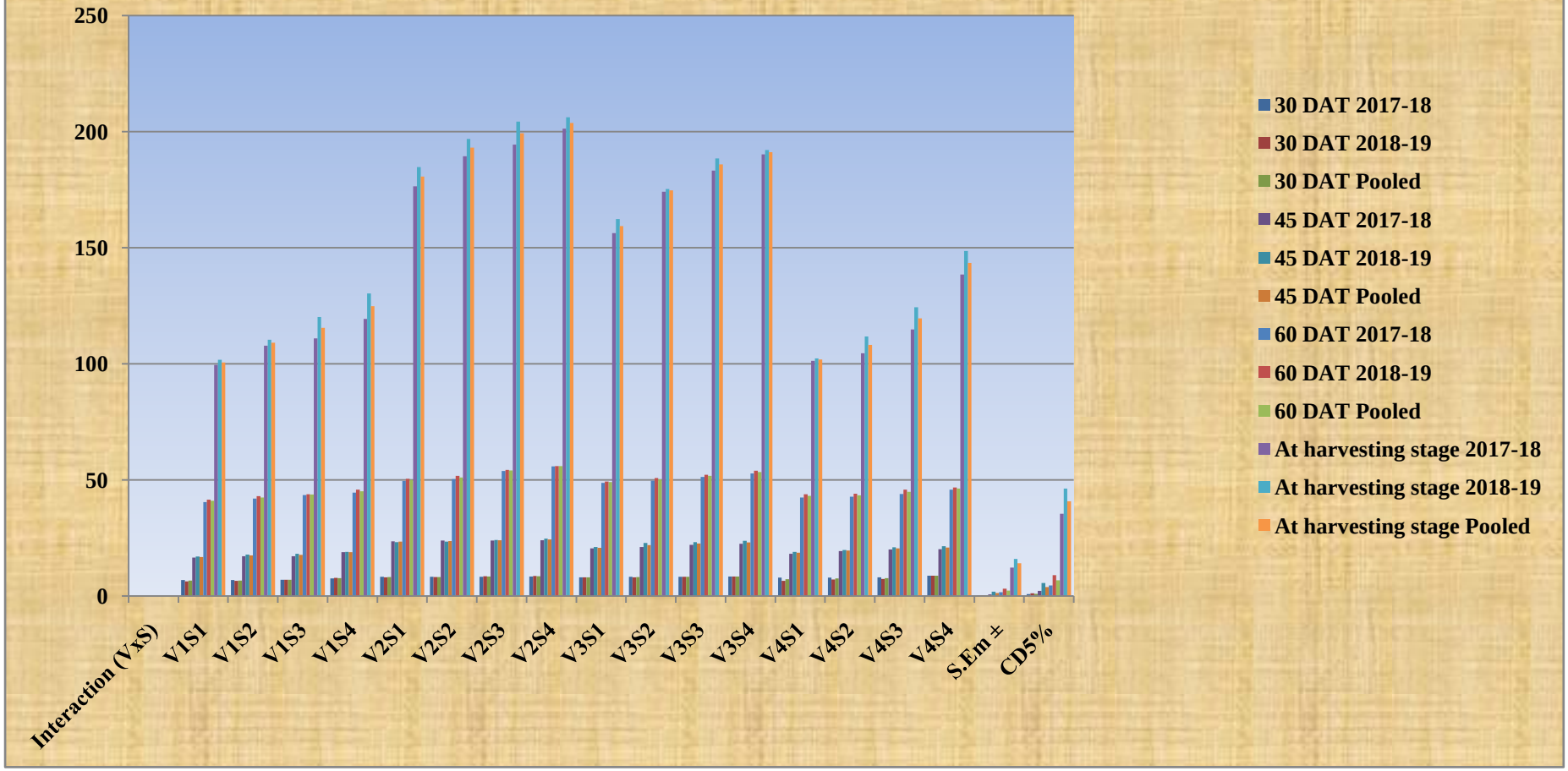


Fig.- 4.1.8.c: Influence of varieties, spacing and their interaction on dry weight of plant (g) of sprouting broccoli



4.2.1: Curd initiation days:

Among the two years (2017-18 & 2018-19) and pooled data curd initiation days recorded. The data presented in (Table & Fig.- 4.2.1) indicate significant influence of varieties and plant spacing on curd initiation days.

There was significant influence of variety V_1 Pusa Broccoli KTS-1 showed value in (47.57) had taken earliest curd initiation days 1st year i.e. in (2017-18) and (48.30) in 2nd year i.e. in (2018-19), consequently pursued by V_2 Palam Kanchan (48.16), (48.92) 1st year and 2nd year, respectively. Pooled value showed the earliest curd initiation days was measured in varieties V_1 Pusa Broccoli KTS-1 showed value in (47.99) as compared to V_2 Palam Kanchan value in (48.54) and highest curd initiation days measured in variety V_3 Palam Vichitra in 1st year (52.37), 2nd year (52.76) and pooled (52.56) respectively followed by V_4 Palam Samridhi in 1st year (50.27), 2nd year (51.05) and pooled (50.56). The difference between V_1, V_2, V_3 and V_4 was significant at curd initiation days.

Plant spacing S_1 (60x45 cm) as found (48.62) had taken earliest curd initiation days in 1st year i.e. in (2017-18) and (49.31) in 2nd year i.e. in (2018-19), respectively followed by S_2 (60x30 cm) (49.18) in 1st year i.e. in (2017-18) and (49.18) 2nd year i.e. in (2018-19), respectively. Pooled value measured earliest curd initiation days in spacing S_1 (60x45 cm) showed in (48.97) as compared to S_2 (60x30 cm) value in (49.50) and highest curd initiation days measured in S_4 (45x30 cm) in 1st year (50.80), 2nd year (51.24) and pooled (51.04) consequently pursued by S_4 (45x45 cm) in (49.76) 1st year i.e. in (2017-18) and (50.65) 2nd year i.e. in (2018-19) and cumulative data (50.21).

Combined influence of varieties and spacing on (interaction) had taken earliest curd initiation days V_1S_1 (46.02) 1st year i.e. in (2017-18) and (46.84) in 2nd year i.e. in (2018-19), respectively followed by V_1S_2 (46.94) in 1st year i.e. in (2017-18) and (48.04) 2nd year i.e. in (2018-19). Pooled value showed earliest curd initiation days (46.43) was measured in interaction V_1S_1 as compared to V_1S_2 (47.49) and highest curd initiation days measured in V_3S_4 (53.12) in 1st year i.e. in (2017-18) and (53.20), 2nd year i.e. in (2018-19) and pooled data (53.16) respectively followed by V_3S_3 in 1st year (52.52), 2nd year (53.04) and pooled data (52.78). It showed significant effect on curd initiation days.

Plate - 8: A general view of full growth stage of variety Pusa Broccoli KTS-1

Plate 9: A general view of full growth stage of variety Palam Kanchan

Plate 10: A general view of full growth stage of variety Palam Vichitra

Plate 11: A general view of full growth stage of variety Palam Samridhi

Pusa Broccoli KTS-1

Palam Kanchan

Palam Vichitra

Palam Samridhi

Plate 12: Performance of different varieties of sprouting broccoli.

Plate 13: A general view of measuring the width of leaves in broccoli crop

Plate 14: A general view of crop inspection by advisor and co-advisor in research field

4.2.2: Days taken to curd harvest after curd initiation:

Between the two years (2017-18 & 2018-19) and pooled data days taken to curd harvest after curd initiation. The data presented in (Table & Fig.- 4.2.1) indicate significant influence of varieties and plant spacing on days taken to curd harvest after curd initiation.

There was significant influence of variety V_1 Pusa Broccoli KTS-1 showed value in (22.70) had taken earliest days taken to curd harvest after curd initiation 1st year i.e. in (2017-18) and (22.47) in 2nd year i.e. in (2018-19), consequently pursued by V_2 Palam Kanchan (23.32) 1st year i.e. in (2017-18) and (22.48) in 2nd year i.e. in (2018-19). Pooled value showed the earliest days taken to curd harvest after curd initiation was measured in varieties V_1 Pusa Broccoli KTS-1 showed value in (22.58) as compared to V_2 Palam Kanchan value in (23.09) and highest days taken to curd harvest after curd initiation was measured in variety V_3 Palam Vichitra (24.87) in 1st year i.e. in (2017-18), (23.56) in 2nd year i.e. in (2018-19) and (24.21) pooled data respectively followed by V_4 Palam Samridhi in 1st year (23.45), 2nd year (22.54) and pooled (22.99). The difference between V_1, V_2, V_3 and V_4 was significant at days taken to curd harvest after curd initiation.

Plant spacing S_1 (60x45 cm) as found (22.98) had taken earliest days to curd harvest after curd initiation in 1st year i.e. in (2017-18) and (22.08) in 2nd year i.e. in (2018-19), consequently pursued by S_2 (60x30cm) (23.18) in 1st year i.e. in (2017-18) and (22.99) 2nd year i.e. in (2018-19). Pooled value measured earliest days to curd harvest after curd initiation in spacing S_1 (60x45 cm) showed in (22.53) as compared to S_2 (60x30 cm) value in (23.09) and highest days to curd harvest after curd initiation was measured in S_4 (45x30 cm) in 1st year (24.34), 2nd year (23.87) and pooled data (24.10) consequently pursued by S_4 (45x45 cm) in (23.34) 1st year i.e. in (2017-18) and (23.35) 2nd year i.e. in (2018-19) and cumulative data (23.60).

Combined influence of varieties and spacing on (interaction) had taken earliest days to curd harvest after curd initiation V_1S_1 (22.04) 1st year i.e. in (2017-18) and (21.08) in 2nd year i.e. in (2018-19), respectively followed by V_1S_2 (22.44) in 1st year i.e. in (2017-18) and (22.14) 2nd year i.e. in (2018-19). Pooled value showed earliest days to curd harvest after curd initiation (21.56) was measured in interaction V_1S_1 as compared to V_1S_2 (22.29) and highest days to curd harvest after curd initiation was

measured in V_3S_4 (25.98) in 1st year i.e. in (2017-18) and (24.56), 2nd year i.e. in (2018-19) and pooled data (25.27) respectively followed by V_3S_3 in 1st year (25.56), 2st year (23.89) and pooled data (24.78). It showed significant effect on curd harvest after curd initiation curd initiation.

4.2.3: Curd diameters (cm):

Among the two years (2017-18 & 2018-19) and pooled data curd diameter (mm) recorded. The data presented in (Table no. & Fig. no. 4.2.1) indicate significant influence of varieties and plant spacing on curd initiation days.

It is clear from the results and also has been recognized that curd diameter (mm) was significantly affected with varieties. The recorded data revealed that maximum curd diameter was found in varieties V_1 Pusa Broccoli KTS-1 showed value in (117.38 mm) in 1st year i.e. in (2017-18) and (120.45 mm) 2nd year i.e. in (2018-19), consequently pursued by V_3 Palam Vichitra value showed in (115.69mm) and (116.02 mm) 1st year and 2nd year, respectively. Pooled value showed the maximum curd diameter was measured in varieties V_1 Pusa Broccoli KTS-1 (118.92 mm) as compared to V_3 Palam Vichitra (115.86 mm) and minimum curd diameter measured in varieties V_4 Palam Samridhi (108.66 mm) in 1st year i.e. in (2017-18), (109.72 mm) in 2nd year i.e. in (2018-19) and (109.19 mm) pooled data respectively followed by V_2 Palam Kanchan in 1st year (113.09 mm), 2nd year (115.25 mm) and pooled value (114.17 mm). The difference between V_1, V_2, V_3 and V_4 was significant at curd diameter.

Plant spacing S_1 (60x45 cm) as found (22.98 mm) had taken maximum curd diameter (116.42 mm) in 1st year i.e. in (2017-18) and (117.34 mm) in 2nd year i.e. in (2018-19), consequently pursued by S_2 (60x30 cm) (115.42 mm) in 1st year i.e. in (2017-18) and (117.07 mm) 2nd year i.e. in (2018-19). Pooled value measured maximum curd diameter in spacing S_1 (60x45 cm) showed in (116.88 mm) as compared to S_2 (60x30 cm) value in (116.25 mm) and minimum curd diameter was measured in S_4 (45x30 cm) in 1st year (111.14 mm), 2nd year (111.61 mm) and pooled data (111.38 mm), consequently pursued by S_3 (45x45 cm) in (113.33 mm) 1st year i.e. in (2017-18) and (115.42 mm) 2nd year i.e. in (2018-19) and cumulative data (114.38 mm).

Combined influence of varieties and spacing on (interaction) had taken bighest curd diameter in V_1S_1 (120.84 mm) 1st year i.e. in (2017-18) and (121.34 mm) in 2nd year i.e. in (2018-19), respectively followed by V_1S_2 (120.06 mm) in 1st year i.e. in (2017-18) and (121.14 mm) 2nd year i.e. in (2018-19). Pooled value showed highest curd diameter was measured in interaction V_1S_1 (121.06 mm) as compared to V_1S_2 (120.60 mm) and smallest curd diameter was measured in V_4S_4 (107.34 mm) in 1st year i.e. in (2017-18) and (108.84 mm), 2nd year i.e. in (2018-19) and pooled data (108.09 mm) respectively followed by V_4S_3 in 1st year (108.76 mm), 2nd year (109.36 mm) and pooled data (109.06 mm). It showed significant effect on curd curd diameter.

Table - 4.2.1: Influence of varieties, spacing and their interaction on yield and yield attributing characters of sprouting broccoli.

Treatment	Curd initiation days			Day taken to curd harvest after curd initiation			Curd diameter (mm)		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Varieties (V)									
V_1 (Pusa Broccoli KTS-1)	47.57	48.30	47.94	22.70	22.47	22.58	117.38	120.45	118.92
V_2 (Palam Kanchan)	48.16	48.92	48.54	23.32	22.48	22.90	113.09	115.25	114.17
V_3 (Palam Vichitra)	52.37	52.76	52.56	24.87	23.56	24.21	115.69	116.02	115.86
V_4 (Palam Samridhi)	50.27	51.05	50.66	23.45	22.54	22.99	108.66	109.72	109.19
S. Em ±	2.57	1.98	2.27	0.10	0.12	0.11	0.45	0.49	0.47
CD5%	7.54	5.74	6.64	0.32	0.35	0.34	1.36	1.42	1.39
Spacing (S)									
S_1 (60x45 cm)	48.62	49.31	48.97	22.98	22.08	22.53	116.42	117.34	116.88
S_2 (60x30 cm)	49.18	49.82	49.50	23.18	22.99	23.09	115.42	117.07	116.25
S_3 (45x45 cm)	49.76	50.65	50.21	23.84	23.35	23.60	113.33	115.42	114.38
S_4 (45x30 cm)	50.80	51.24	51.02	24.34	23.87	24.10	111.14	111.61	111.38
S. Em ±	0.13	0.8	0.11	0.24	0.22	0.23	0.42	0.48	0.45
CD5%	0.41	0.26	0.33	0.73	0.69	0.71	1.22	1.39	1.30
Interaction (VxS)									
V_1S_1	46.02	46.84	46.43	22.04	21.08	21.56	120.84	121.34	121.10
V_1S_2	46.94	48.04	47.49	22.44	22.14	22.29	120.06	121.14	120.60
V_1S_3	48.34	48.98	48.66	23.01	23.54	23.28	111.88	120.98	116.43
V_1S_4	48.96	49.32	49.14	23.34	23.28	23.44	116.75	118.34	117.54
V_2S_1	46.98	48.12	47.55	22.98	22.04	22.51	117.34	118.34	117.84
V_2S_2	47.82	48.18	48.00	23.04	22.48	23.01	116.12	117.78	116.95
V_2S_3	48.04	49.32	48.68	23.24	23.02	23.13	110.54	115.98	113.26
V_2S_4	49.78	50.04	49.91	24.01	23.88	23.95	108.34	108.92	108.63
V_3S_1	51.74	52.12	51.93	23.88	22.16	23.02	118.14	119.32	118.73
V_3S_2	52.08	52.68	52.38	24.04	23.74	23.89	116.34	119.02	117.68
V_3S_3	52.52	53.04	52.78	25.56	23.89	24.73	116.12	115.38	115.75
V_3S_4	53.12	53.20	53.16	25.98	24.56	25.27	112.14	110.34	111.24
V_4S_1	49.74	50.16	49.95	23.02	22.34	22.58	109.34	111.36	110.35
V_4S_2	49.86	50.39	50.13	23.18	22.88	23.03	109.18	110.32	109.75
V_4S_3	50.12	51.26	50.69	23.56	22.96	23.26	108.76	109.36	109.06
V_4S_4	51.34	52.38	51.86	24.03	23.16	23.60	107.34	108.84	108.09
S. Em ±	1.51	1.25	1.38	1.13	1.46	1.30	3.77	2.90	3.34
$CD_{5\%}$	4.37	3.61	3.99	3.28	4.24	3.76	10.93	8.40	9.67

Fig.- 4.2.1.a: Influence of varieties on yield and yield attributing charactersof sprouting broccoli

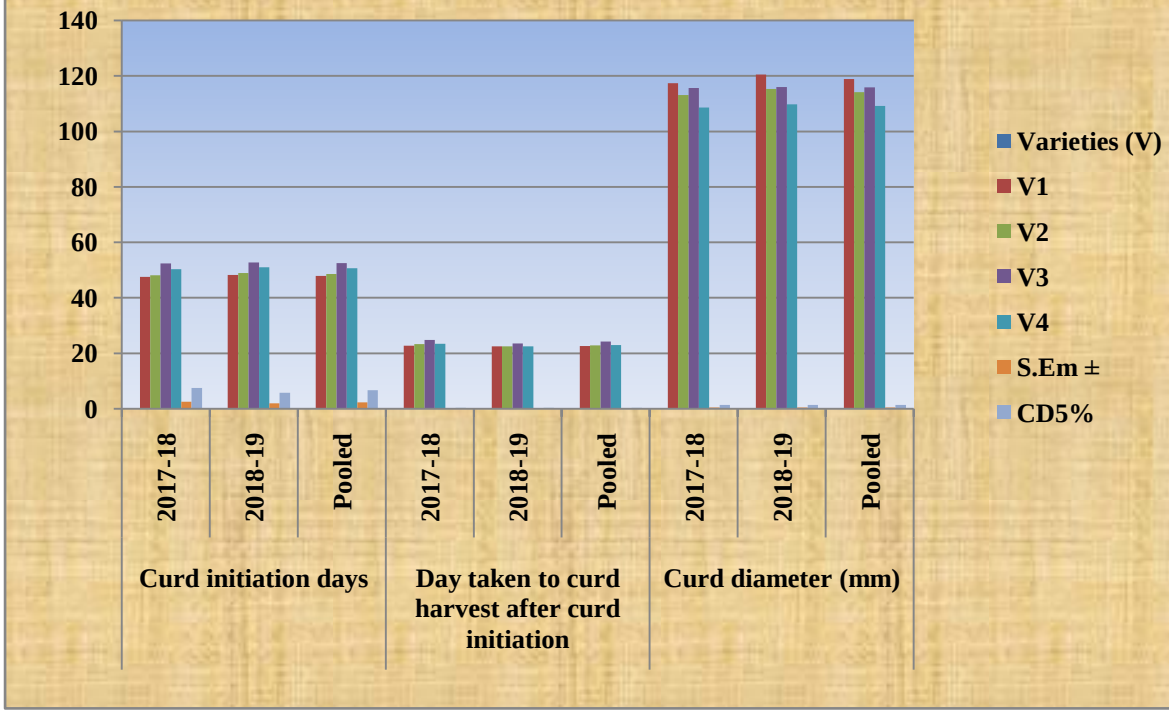


Fig.- 4.2.1.b: Influence spacing on yield and yield attributing characters of sprouting broccoli

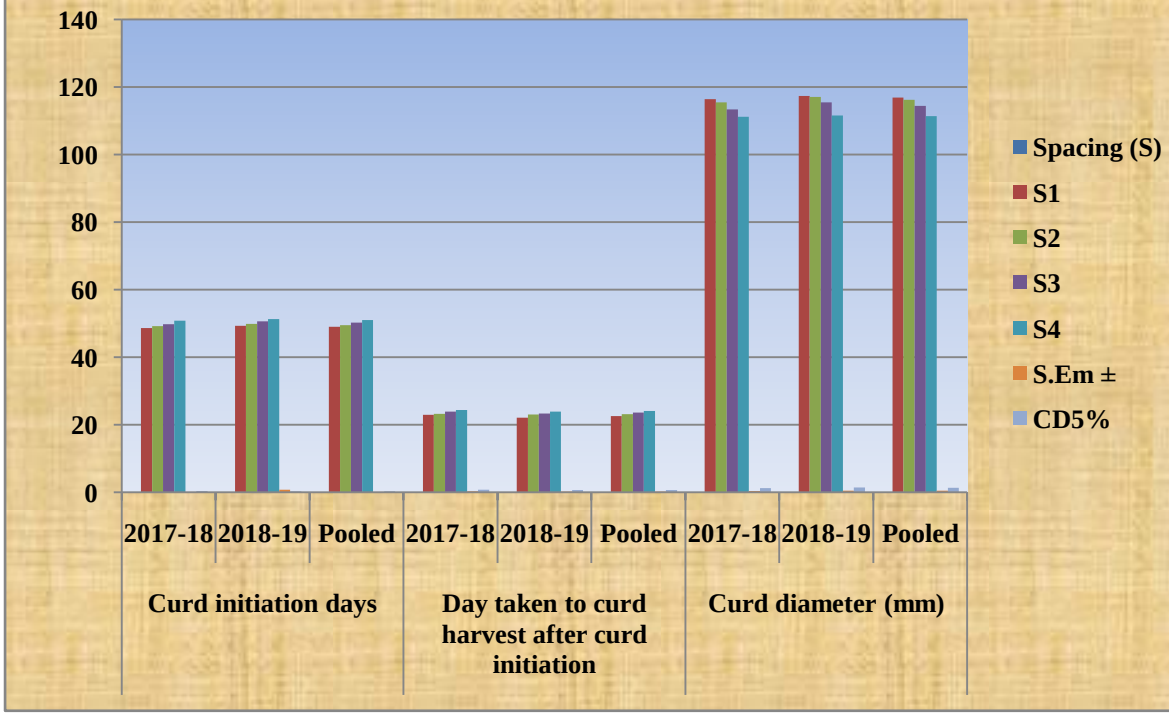
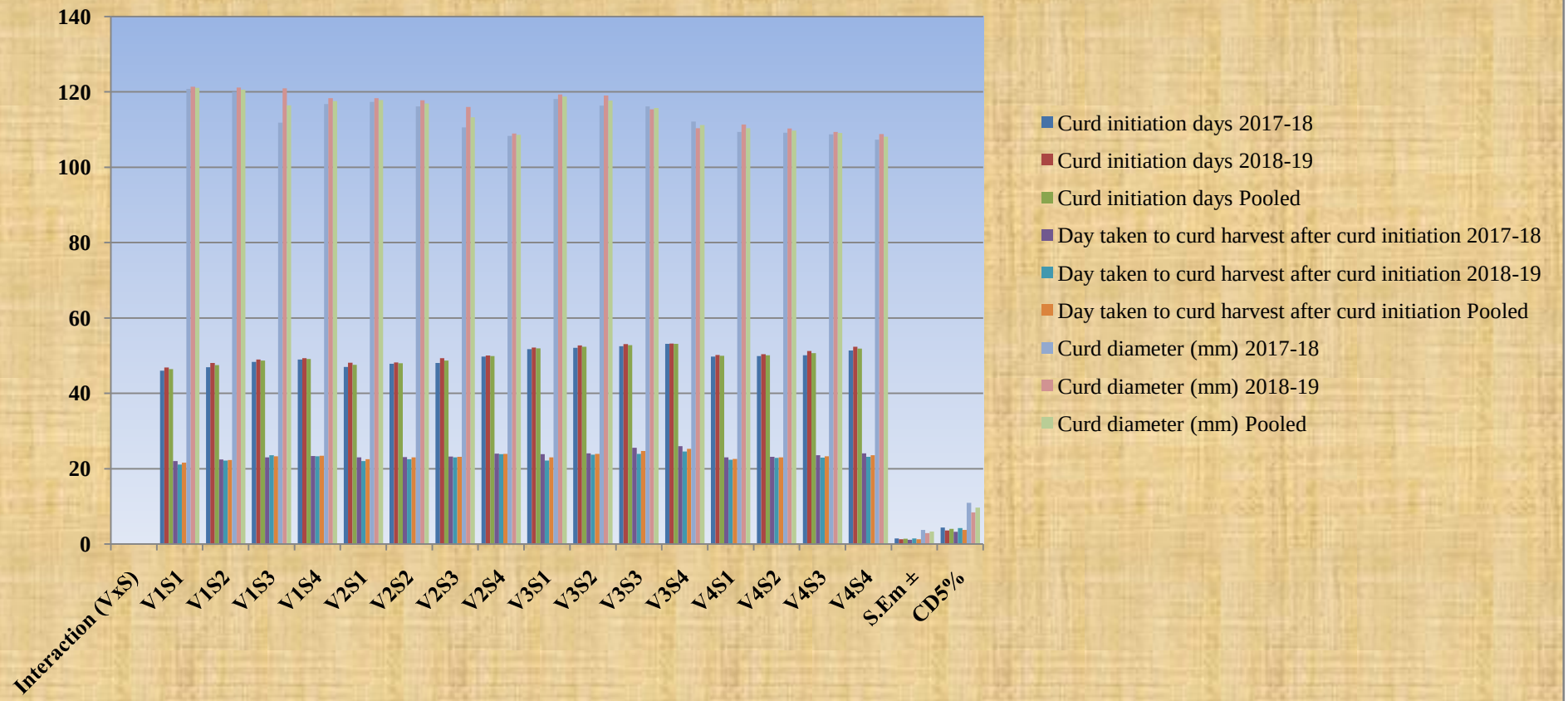


Fig. - 4.2.1.c: Influence of varieties, spacing and their interaction on yield and yield attributing characters of sprouting broccoli



4.2.4: Weight of curd with guard leaves (g):

Among the two years (2017-18 & 2018-19) and pooled data the weight of curd with guard leaves (g) was recorded during the laboratory experimentation and the data so obtained were subjected to statistical analysis. The mean results have represented in (Table & Fig.- 4.2.2).

It is clear from the results and also has been recognized that weight of curd with guard leaves was significantly affected with varieties. The recorded data revealed that maximum weight of curd with guard leaves was found in variety V_1 Pusa Broccoli KTS-1 showed value in (944.55 g) in 1st year i.e. in (2017-18) and (951.07 g) in 2st year i.e. in (2018-19), consequently pursued by V_3 Palam Vichitra value showed in (939.73 g) in 1st year and (946.73 g) in 2nd year, respectively. Pooled value showed the maximum weight of curd with guard leaves was measured in variety Pusa Broccoli KTS-1 showed value in (947.81 g) as compared to V_3 Palam Vichitra value in (943.23 g) and minimum weight of curd with guard leaves measured in variety V_4 Palam Samridhi (891.86 g) in 1st year i.e. in (2017-18), (898.74 g) in 2nd year i.e. in (2018-19) and (895.30 g) in consecutive years respectively followed by V_2 Palam Kanchan in 1st year (924.79 g), 2nd year (933.64 g) and pooled data (929.22 g). The difference between V_1, V_2, V_3 and V_4 was significant weight of curd with guard leaves.

Plant spacing S_1 (60x45 cm) had taken maximum weight of curd with gourd leaves (945.31 g) in 1st year i.e. in (2017-18) and (999.31 g) in 2nd year i.e. in (2018-19), consequently pursued by S_2 (60x30 cm) (979.91 g) in 1st year i.e. in (2017-18) and (984.39 g) 2nd year i.e. in (2018-19). Pooled value measured maximum weight of curd with gourd leaves in spacing S_1 (60x45 cm) showed in (997.31 g) as compared to S_2 (60x30 cm) value in (982.15 g) and minimum weight of curd with gourd leaves was measured in S_4 (45x30 cm) in 1st year (843.41 g), 2nd year (856.75 g) and consecutive years (850.08 g) consequently pursued by S_3 (45x45 cm) in (882.31 g) 1st year i.e. in (2017-18) and (889.61 g) 2nd year i.e. in (2018-19) and cumulative data (885.96 g).

Combined influence of varieties and spacing on (interaction) had taken the highest weight of curd with gourd leaves in V_1S_1 (1000.72 g) 1st year i.e. in (2017-18) and (1002.73 g) in 2nd year i.e. in (2018-19), respectively followed by V_1S_2 (998.48 g) in 1st year i.e. in (2017-18) and (1000.84 g) 2nd year i.e. in (2018-19). Pooled value

showed the highest weight of curd with gourd leaves was measured in interaction V_1S_1 (1001.73 g) as compared to V_1S_2 (999.66 g) and the lowest weight of curd with gourd leaves was measured in V_4S_4 (800.17 g) in 1st year i.e. in (2017-18) and (803.14 g), 2nd year i.e. in (2018-19) and combined data (801.66 g), consequently pursued by V_4S_3 in 1st year (833.34 g), 2nd year (841.42 g) and pooled data (837.38 g). It showed significant effect on weight of curd with gourd leaves.

4.2.5: Weight of curd without gourd leaves (g):

Among the two years (2017-18 & 2018-19) and pooled data the fresh weight of curd without guard leaves was recorded during the laboratory experimentation and the data so obtained were subjected to statistical analysis. The mean results have represented in (Table & Fig.- 4.2.2).

It is clear from the results and also has been recognized that weight of curd without guard leaves (g) was significantly affected with varieties. The recorded data revealed that maximum weight of curd without guard leaves was found in variety V_1 Pusa Broccoli KTS-1 showed value in (458.74 g) in 1st year i.e. in (2017-18) and (465.89 g) in 2nd year i.e. in (2018-19), consequently pursued by V_3 Palam Vichitra value showed in (452.50 g) in 1st year and (460.18 g) in 2nd year, respectively. Pooled value showed the maximum weight of curd without guard leaves was measured in variety Pusa Broccoli KTS-1 showed value in (462.32 g) as compared to V_3 Palam Vichitra value in (456.34 g) and minimum weight of curd without guard leaves measured in variety V_4 Palam Samridhi (435.36 g) in 1st year i.e. in (2017-18), (438.62 g) in 2nd year i.e. in (2018-19) and (436.99 g) in consecutive years respectively followed by V_2 Palam Kanchan in 1st year (439.36 g), 2nd year (444.15 g) and pooled data (441.76 g). The difference between V_1, V_2, V_3 and V_4 was significant weight of curd without guard leaves.

Plant spacing S_1 (60x45 cm) had taken maximum weight of curd without guard leaves (481.21 g) in 1st year i.e. in (2017-18) and (486.18 g) in 2nd year i.e. in (2018-19), consequently pursued by S_2 (60x30 cm) (465.83 g) in 1st year i.e. in (2017-18) and (472.38 g) 2nd year i.e. in (2018-19). Pooled value measured maximum weight of curd without guard leaves spacing S_1 (60x45 cm) showed in (483.70 g) as compared to S_2 (60x30 cm) value in (469.11 g) and minimum weight of curd without guard leaves was

measured in S_4 (45x30 cm) in 1st year (428.55 g), 2nd year (404.14 g) and consecutive years (416.35 g) consequently pursued by S_3 (45x45 cm) in (438.36 g) 1st year i.e. in (2017-18) and (446.15 g) 2nd year i.e. in (2018-19) and cumulative data (442.26 g).

Combined influence of varieties and spacing on (interaction) had taken weight of curd without guard leaves in V_1S_1 (499.80 g) 1st year i.e. in (2017-18) and (501.12 g) in 2nd year i.e. in (2018-19), respectively followed by V_1S_2 (487.92 g) in 1st year i.e. in (2017-18) and (494.13 g) 2nd year i.e. in (2018-19). Pooled value showed the highest weight of curd without guard leaves was measured in interaction V_1S_1 (500.46 g) as compared to V_1S_2 (491.03 g) and the lowest weight of curd without guard leaves was measured in V_4S_4 (384.92 g) in 1st year i.e. in (2017-18) and (390.14 g), 2nd year i.e. in (2018-19) and combined data (387.53 g) consequently pursued by V_2S_4 in 1st year (401.84 g), 2nd year (402.18 g) and pooled data (402.01 g). It showed significant effect on weight of curd without gourd leaves.

Table - 4.2.2: Influence of varieties, spacing and their interaction on yield and yield attributing characters of sprouting broccoli.

Treatment	Weight of curd with gourd leaves (g)			Weight of curd without gourd leaves (g)		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Varieties (V)						
V_1 (Pusa Broccoli KTS-1)	944.55	951.07	947.81	458.74	465.89	462.32
V_2 (Palam Kanchan)	924.79	933.64	929.22	439.36	444.15	441.76
V_3 (Pusa Vichitra)	939.73	946.73	943.23	452.50	460.18	456.34
V_4 (Pusa Samridhi)	891.86	898.74	895.30	435.36	438.62	436.99
S. Em ±	27.01	29.02	28.01	13.22	15.53	14.37
$CD_{5\%}$	79.22	85.12	82.17	38.73	45.55	42.14
Spacing (S)						
S_1 (60x45 cm)	995.31	999.31	997.31	481.21	486.18	483.70
S_2 (60x30 cm)	979.91	984.39	982.15	465.83	472.38	469.11
S_3 (45x45 cm)	882.31	889.61	885.96	438.36	446.15	442.26
S_4 (45x30 cm)	843.41	856.75	850.08	428.55	404.14	416.35
S.Em ±	29.01	31.13	30.07	14.69	17.12	15.90
$CD_{5\%}$	84.99	91.21	88.10	43.04	50.16	46.60
Interaction (VxS)						
V_1S_1	1,000.72	1,002.73	1001.73	499.80	501.12	500.46
V_1S_2	998.48	1,000.84	999.66	487.92	494.13	491.03
V_1S_3	913.35	916.36	914.86	439.11	456.18	447.65
V_1S_4	865.59	884.34	874.97	408.12	412.13	410.13
V_2S_1	998.07	999.38	998.73	472.14	478.13	475.14
V_2S_2	975.56	982.34	978.95	451.61	462.14	456.88
V_2S_3	880.36	896.74	888.55	431.86	434.16	433.01
V_2S_4	845.19	856.08	850.64	401.84	402.18	402.01
V_3S_1	998.21	1000.76	999.49	486.34	493.34	489.84
V_3S_2	996.38	998.36	997.37	462.98	472.16	467.57
V_3S_3	902.18	904.34	903.26	458.32	463.13	460.73
V_3S_4	862.13	883.45	872.79	402.36	412.12	407.24
V_4S_1	984.17	994.36	989.27	466.56	472.13	469.35
V_4S_2	949.23	956.03	952.63	460.83	461.10	460.97
V_4S_3	833.34	841.42	837.38	429.13	431.12	430.13
V_4S_4	800.17	803.14	801.66	384.92	390.14	387.53
S. Em ±	20.25	22.88	21.57	17.72	14.97	16.35
$CD_{5\%}$	58.77	66.40	62.59	51.42	43.43	47.43

Fig.- 4.2.2.a: Influence of varieties on yield and yield attributing characters of sprouting broccoli.

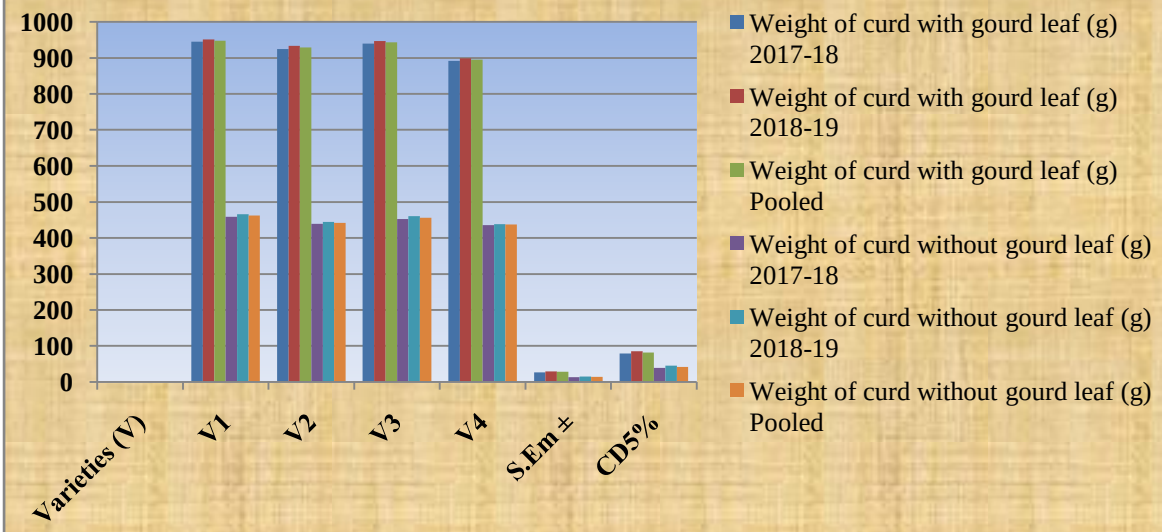


Fig.- 4.2.2.b: Influence of spacing on yield and yield attributing characters of sprouting broccoli.

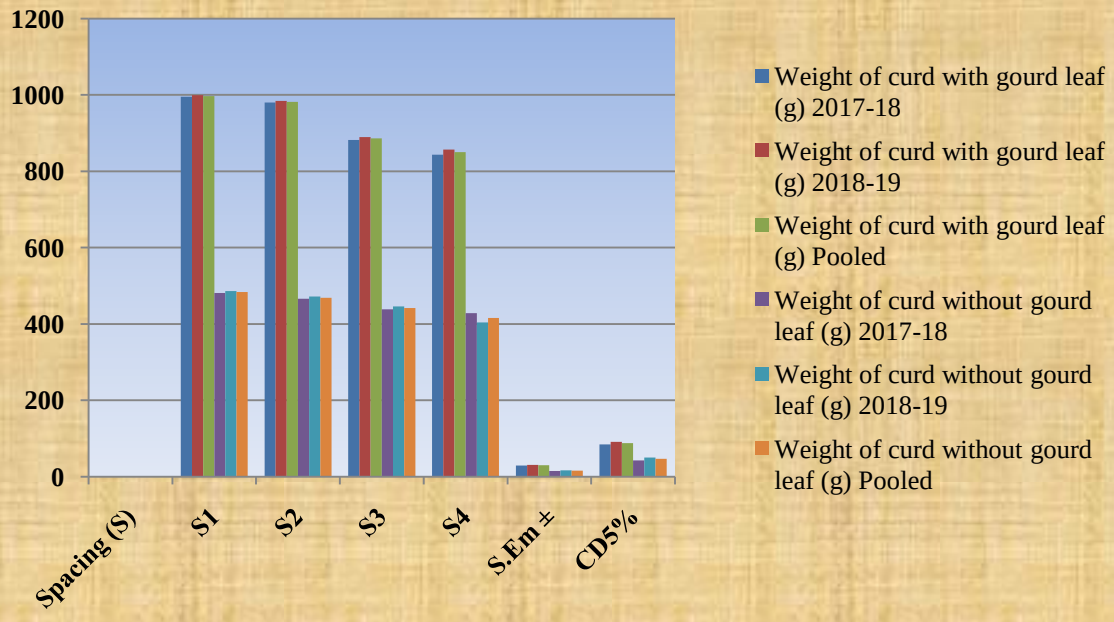
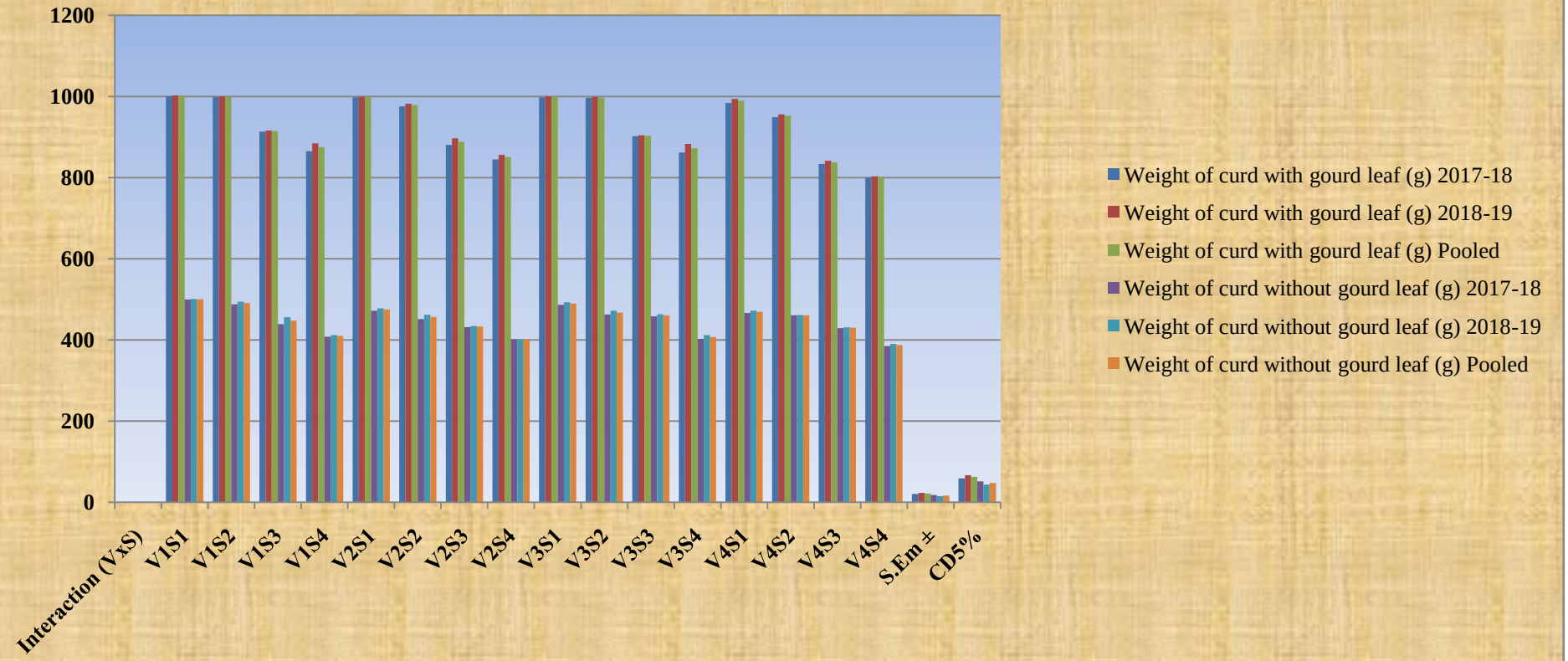


Fig.- 4.2.2.c: Influence of varieties, spacing and their interaction on yield and yield attributing characters of sprouting broccoli



4.2.6: Yield (kg/plot):

Among the two years (2017-18 & 2018-19) and pooled data yield (kg/plot) was calculated after the harvesting. After perusal of the data it is clear yield (kg/plot) was significantly co-related with the varieties under the different plant spacing. The recorded data which should be represented in following (Table & Fig.- 4.2.3).

Varieties showed significant effect on the yield. The recorded data revealed that the maximum yield was found variety V_1 Pusa Broccoli KTS-1 showed value in (7.90kg/plot) in 1st year i.e. in (2017-18) and (8.02 kg/plot) in 2nd year i.e. in (2018-19), consequently pursued by V_3 Palam Vichitra value showed in (7.79 kg/plot) in 1st year and (7.93 kg/plot) in 2nd year, respectively. Pooled value showed the maximum yield was measured in variety Pusa Broccoli KTS-1 showed value in (7.96 kg/plot) as compared to V_3 Palam Vichitra value in (7.86 kg/plot) and minimum yield was measured in variety V_4 Palam Samridhi (7.50 kg/plot) in 1st year i.e. in (2017-18), (7.56 kg/plot) in 2nd year i.e. in (2018-19) and (7.53 kg/plot) in consecutive years respectively followed by V_2 Palam Kanchan in 1st year (7.54 kg/plot), 2nd year (7.67 kg/plot) and pooled data (7.63 kg/plot). The difference between V_1, V_2, V_3 and V_4 was significant yield.

Plant spacing S_4 (45x30 cm) had taken maximum yield (9.59 kg/plot) in 1st year i.e. in (2017-18) and (9.69 kg/plot) in 2nd year i.e. in (2018-19), consequently pursued by S_2 (60x30 cm), (8.38 kg/plot) in 1st year i.e. in (2017-18) and (8.50 kg/plot) 2nd year i.e. in (2018-19). Pooled value measured maximum yield spacing S_4 (45x30 cm) showed in (9.64 kg/plot) as compared to S_2 (60x30 cm) value in (8.44 kg/plot) and minimum yield was measured in S_1 (60x45 cm) in 1st year (5.78 kg/plot), 2nd year (5.84 kg/plot) and consecutive years (5.81 kg/plot) consequently pursued by S_3 (45x45 cm) in (7.04 kg/plot) 1st year i.e. in (2017-18) and (7.14 kg/plot) 2nd year i.e. in (2018-19) and cumulative data (7.09 kg/plot).

Combined influence of varieties and spacing on (interaction) had taken highest yield in variety V_1S_4 (9.80 kg/plot) 1st year i.e. in (2017-18) and (9.89 kg/plot) in 2nd year i.e. in (2018-19), respectively followed by V_3S_4 (9.66 kg/plot) in 1st year i.e. in (2017-18) and (9.88 kg/plot) 2nd year i.e. in (2018-19). Pooled value showed the highest yield was measured in interaction V_1S_4 (9.84 kg/plot) as compared to V_3S_4 (9.77 kg/plot) and the lowest yield was measured in V_4S_1 (5.60 kg/plot) in 1st year i.e. in (2017-18) and (5.67 kg/plot), 2nd year i.e. in (2018-19) and combined data (5.63 kg/plot) consequently pursued

by V_2S_1 in 1st year (5.67 kg/plot), 2nd year (5.74 kg/plot) and pooled data (5.70 kg/plot). It showed significant effect on yield. The recorded data revealed that there was significant effect of varieties and plant spacing had been observed in our study.

4.2.7: Yield (q/ha):

Between the two years (2017-18 & 2018-19) and pooled data taken to yield .The data presented in (Table & Fig.- 4.2.3) indicate significant influence of varieties and plant spacing on yield (q/ha).

The yield was should be calculated after the harvesting. After perusal of the data it is clear yield was significantly co-related with the varieties under the different plant spacing. The recorded data revealed that the maximum yield was found variety V_1 Pusa Broccoli KTS-1 showed value in (243.90 q/ha) in 1st year i.e. in (2017-18) and (247.61 q/ha) in 2nd year i.e. in (2018-19), consequently pursued by V_3 Palam Vichitra value showed in (240.43 q/ha) in 1st year and (244.68 q/ha) in 2nd year, respectively. Pooled value showed the maximum yield was measured in variety Pusa Broccoli KTS-1 showed value in (245.75 q/ha) as compared to V_3 Palam Vichitra value in (242.55 q/ha) and minimum yield was measured in variety V_4 Palam Samridhi (231.48 q/ha) in 1st year i.e. in (2017-18), (233.26 q/ha) in 2nd year i.e. in (2018-19) and (232.37 q/ha) in consecutive years respectively followed by V_2 Palam Kanchan in 1st year (234.18 q/ha), 2nd year (236.57 q/ha) and pooled data (235.37 q/ha). The difference between V_1, V_2, V_3 and V_4 was significant yield.

Plant spacing S_4 (45x30 cm) had taken maximum yield (295.83 q/ha) in 1st year i.e. in (2017-18) and (299.23 q/ha) in 2nd year i.e. in (2018-19), consequently pursued by S_2 (60x30 cm), (258.72 q/ha) in 1st year i.e. in (2017-18) and (262.42 q/ha) 2nd year i.e. in (2018-19). Pooled value measured maximum yield spacing S_4 (45x30 cm) showed in (297.53 q/ha) as compared to S_2 (60x30 cm) value in (260.57 q/ha) and minimum yield was measured in S_1 (60x45 cm) in 1st year (178.32 q/ha), 2nd year (180.09 q/ha) and consecutive years (179.21 q/ha) consequently pursued by S_3 (45x45 cm) in (217.13 q/ha) 1st year i.e. in (2017-18) and (220.37 q/ha) 2nd year i.e. in (2018-19) and cumulative data (218.75 q/ha).

Combined influence of varieties and spacing on (interaction) had taken highest yield in variety V_1S_4 (302.46 q/ha) 1st year i.e. in (2017-18) and (305 q/ha) in 2nd year i.e. in

(2018-19), respectively followed by V_3S_4 (298.15 q/ha) in 1st year i.e. in (2017-18) and (304.94 q/ha) 2nd year i.e. in (2018-19). Pooled value showed the highest yield was measured in interaction V_1S_4 (303.85 q/ha) as compared to V_3S_4 (301.54 q/ha) and the lowest yield was measured in V_4S_1 (172.83 q/ha) in 1st year i.e. in (2017-18) and (175.00 q/ha), 2nd year i.e. in (2018-19) and combined data (173.91 q/ha) consequently pursued by V_2S_1 in 1st year (175.00 q/ha), 2nd year (177.16 q/ha) and pooled data (176.08 q/ha). It showed significant effect on yield. The recorded data revealed that there was significant effect of varieties and plant spacing had been observed in our study.

Plate 15: A general view of broccoli crop at harvesting stage

Table- 4.2.3: Influence of varieties, spacing and their interaction on yield and yield attributing characters of sprouting broccoli.

Treatment	Yield (kg/plot)			Yield (q/ha)		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Varieties (V)						
V_1 (Pusa Broccoli KTS-1)	7.90	8.02	7.96	243.90	247.61	245.75
V_2 (Palam Kanchan)	7.59	7.67	7.63	234.18	236.57	235.37
V_3 (Palam Vichitra)	7.79	7.93	7.86	240.43	244.68	242.55
V_4 (Palam Samridhi)	7.50	7.56	7.53	231.48	233.26	232.37
S. Em ±	0.21	0.23	0.22	0.39	0.38	0.39
$CD_{5\%}$	0.59	0.67	0.63	1.18	1.16	1.17
Spacing (S)						
S_1 (60x45 cm)	5.78	5.84	5.81	178.32	180.09	179.21
S_2 (60x30 cm)	8.38	8.50	8.44	258.72	262.42	260.57
S_3 (45x45 cm)	7.04	7.14	7.09	217.13	220.37	218.75
S_4 (45x30 cm)	9.59	9.69	9.64	295.83	299.23	297.53
S. Em ±	0.34	0.31	0.33	0.45	0.48	0.47
$CD_{5\%}$	1.02	0.91	0.96	1.36	1.41	1.38
Interaction (VxS)						
V_1S_1	6.00	6.01	6.01	185.18	185.49	185.33
V_1S_2	8.78	8.89	8.83	270.98	274.38	272.68
V_1S_3	7.03	7.30	7.17	216.97	225.31	221.14
V_1S_4	9.80	9.89	9.84	302.46	305.24	303.85
V_2S_1	5.67	5.74	5.70	175.00	177.16	176.08
V_2S_2	8.13	8.32	8.22	250.93	256.79	253.86
V_2S_3	6.91	6.95	6.93	213.27	214.50	213.88
V_2S_4	9.64	9.65	9.64	297.53	297.84	297.68
V_3S_1	5.84	5.92	5.88	180.25	182.72	181.48
V_3S_2	8.33	8.50	8.41	257.10	262.34	259.72
V_3S_3	7.33	7.41	7.37	226.23	228.70	227.46
V_3S_4	9.66	9.88	9.77	298.15	304.94	301.54
V_4S_1	5.60	5.67	5.63	172.83	175.00	173.91
V_4S_2	8.29	8.30	8.29	255.86	256.17	256.01
V_4S_3	6.87	6.90	6.88	212.03	212.96	212.49
V_4S_4	9.24	9.36	9.30	285.18	288.89	287.03
S. Em ±	0.49	0.53	0.51	0.46	0.49	0.48
$CD_{5\%}$	1.43	1.55	1.47	1.35	1.43	1.39

Fig.- 4.2.3.a: Influence of varieties on yield and yield attributing characters of sprouting broccoli.

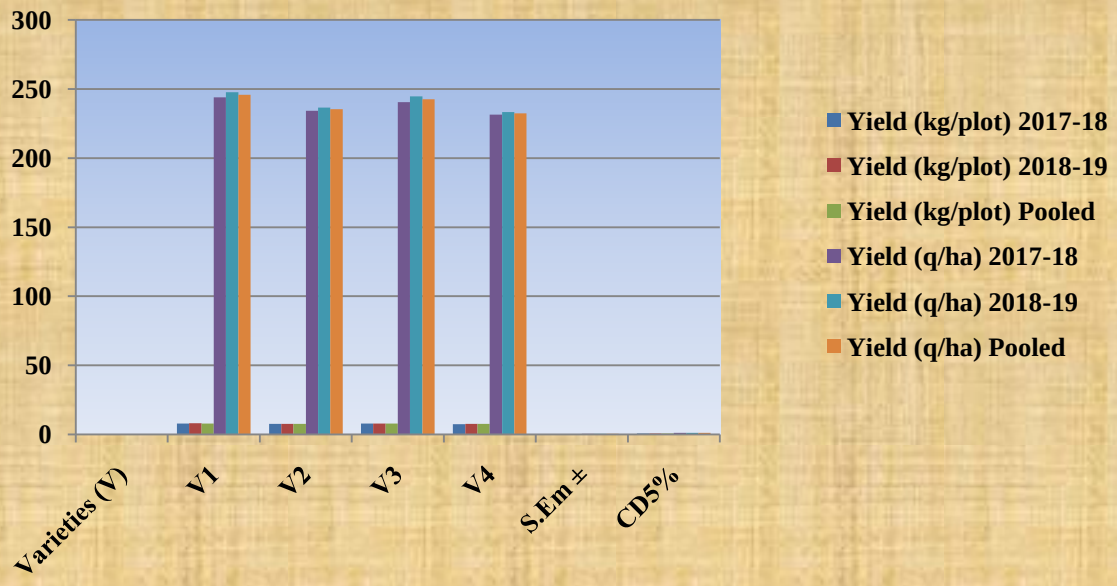


Fig.- 4.2.3.b: Studies on the influence of spacing on yield and yield attributing characters of sprouting broccoli.

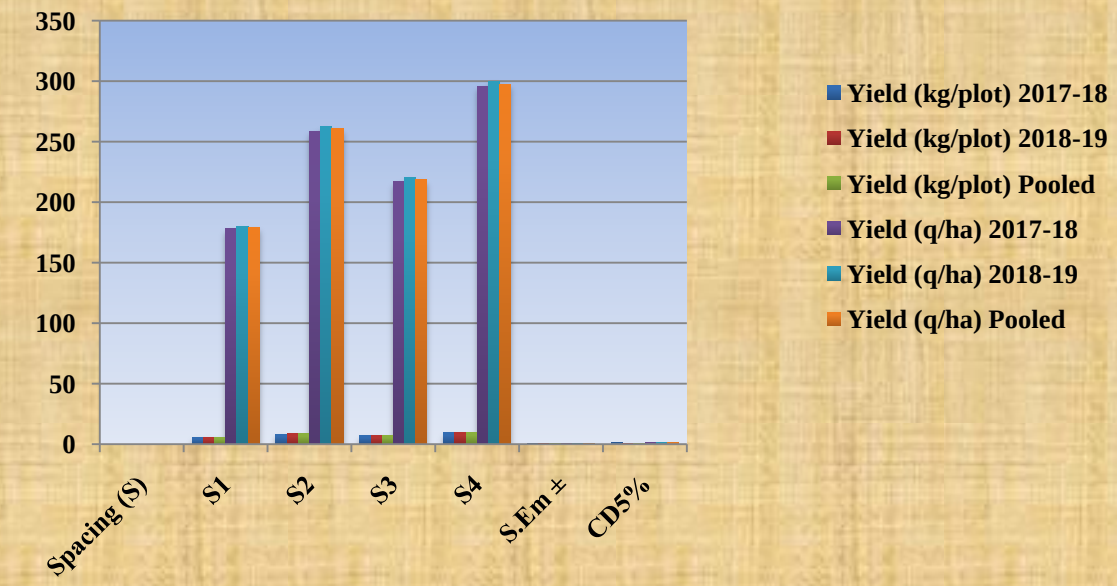
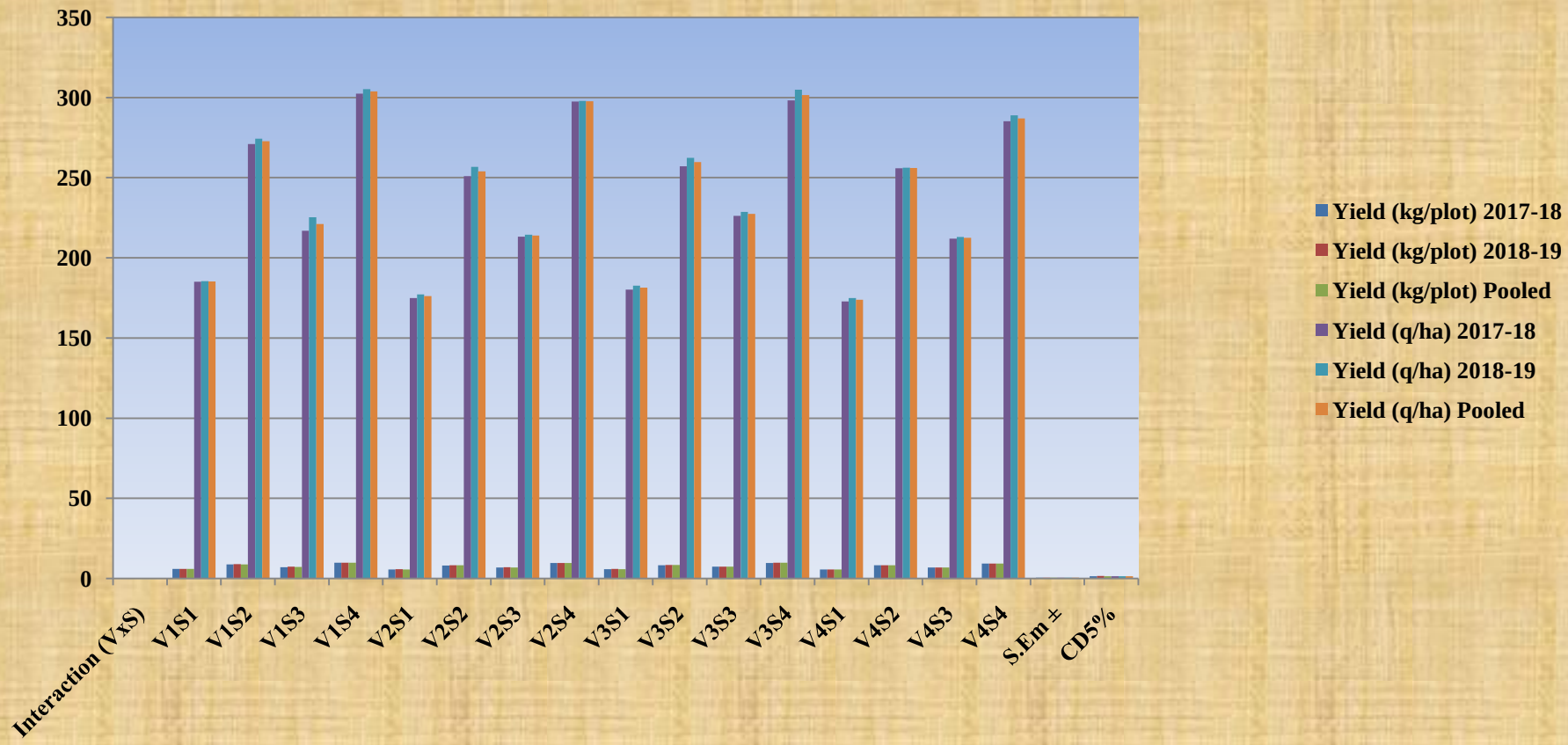


Fig.- 4.2.3.c: Influence of varieties, spacing and their interaction on yield and yield attributing characters of sprouting broccoli



4.3.1: Ascorbic acid (Vit.-C) (mg/100 g):

The ascorbic acid content was recorded during the laboratory experimentation and the recorded data was represented in the (Table & Fig.- 4.3.1).

The varieties showed significant effect on ascorbic acid content in sprouting broccoli in both the years (2017-18 & 2018-19) and pooled data. The ascorbic acid (mg/100g) was calculated after the harvesting. After perusal of the data it is clear ascorbic acid was significantly co-related with the varieties under the different plant spacing. The recorded data revealed that the maximum ascorbic acid (mg/100g) was found in varieties V_1 Pusa Broccoli KTS-1 showed value in (79.12 mg/100g) in 1st year i.e. in (2017-18) and (79.15 mg/100g) in 2nd year i.e. in (2018-19), consequently pursued by V_4 Palam Samridhi value showed in (78.58 mg/100g), (78.17 mg/100g) 1st year and 2nd year, respectively. Pooled value showed the maximum ascorbic acid was measured in varieties V_1 Pusa Broccoli KTS-1 showed value in (79.14 mg/100g) as compared to V_4 Palam Samridhi value in (78.38mg/100g) and minimum ascorbic acid measured in varieties V_3 Palam Vichitra (78.08 mg/100) in 1st year i.e. in (2017-18), (78.09 mg/100) in 2nd year i.e. in (2018-19) and (78.09 mg/100) in consecutive years respectively followed by V_2 Palam Kanchan in 1st year (78.45 mg/100), 2nd year (78.11 mg/100) and pooled data (78.28 mg/100).

Plant spacing S_2 (60x30 cm) as found (79.19 mg/100g) had taken maximum ascorbic acid in 1st year i.e. in (2017-18) and (79.09 mg/100g) in 2nd year i.e. in (2018-19), respectively followed by S_1 (60x45 cm) showed in (79.12 mg/100g), (78.85 mg/100g) in 1st year and 2nd year, respectively. Pooled value was measured maximum ascorbic acid in spacing S_2 (60x30 cm) showed in (79.10 mg/100g) as compared to S_1 (60x45 cm) value in (79.02 mg/100g) and minimum ascorbic acid was measured in S_4 (45x30 cm) in 1st year (77.58 mg/100g), 2nd year (77.53 mg/100g) and pooled data (77.56 mg/100g) consequently pursued by S_3 (45x45 cm) in 1st year (78.26 mg/100), 2nd year (78.05 mg/100) and pooled data (78.16 mg/100).

The combined influence of varieties and spacing on (interaction) had taken maximum ascorbic acid in V_1S_1 showed in (79.93 mg/100g) in 1st year i.e. in (2017-18) and (79.96 mg/100g) in 2nd year i.e. in (2018-19), followed by V_1S_2 showed in (79.69 mg/100g) and (79.80 mg/100g) 1st year and 2nd year, respectively. Pooled value was measured maximum ascorbic acid in interaction V_1S_1 showed in (79.95

mg/100g) as compared to V_1S_2 showed in (79.80 mg/100g). Minimum ascorbic acid was measured in V_3S_4 in 1st year (77.04 mg/100g), 2nd year (77.36 mg/100g) and pooled data showed in (77.20 mg/100g) consequently pursued by V_2S_4 1st year (77.14 mg/100), 2nd year (77.44 mg/100) and pooled data (77.30 mg/100).The recorded data revealed that there was significant effect of varieties and plant spacing had been observed in our study.

4.3.2: T.S.S (Total soluble solids) (^{0}Brix):

The Total soluble solids should be obtained during the laboratory experimentation, which was represented in (Table & Fig.- 4.3.1).

The varieties showed significant effect on total soluble solids (^{0}Brix) in sprouting broccoli in both the years (2017-18 & 2018-19) and pooled data. The total soluble solids was calculated after the harvesting. After perusal of the data it is clear total soluble solids was significantly co-related with the varieties under the different plant spacing. The recorded data revealed that the maximum total soluble solids was found in varieties V_1 Pusa Broccoli KTS-1 showed value in (8.57 ^{0}Brix) in 1st year i.e. in (2017-18) and (8.47 ^{0}Brix) in 2nd year i.e. in (2018-19), consequently pursued by V_2 Palam Kanchan value showed in (8.42 ^{0}Brix), (8.13 ^{0}Brix) 1st year and 2nd year, respectively. Pooled value showed the maximum total soluble solids was measured in varieties V_1 Pusa Broccoli KTS-1 showed value in (8.52 ^{0}Brix) as compared to V_2 Palam Kanchan value in (8.28 ^{0}Brix) and minimum total soluble solids was measured in varieties V_3 Palam Vichitra (7.92 ^{0}Brix) in 1st year i.e. in (2017-18), (7.90 ^{0}Brix) in 2nd year i.e. in (2018-19) and (7.91 ^{0}Brix) in consecutive years respectively followed by V_4 Palam Samridhi in 1st year (8.10 ^{0}Brix), 2nd year (7.97 ^{0}Brix) and pooled data (8.04 ^{0}Brix).

Plant spacing S_1 (60x45 cm) as found (8.49 ^{0}Brix) had taken maximum total soluble solids in 1st year i.e. in (2017-18) and (8.28 ^{0}Brix) in 2nd year i.e. in (2018-19), respectively followed by S_2 (60x30 cm) showed in (8.36 ^{0}Brix), (8.17 ^{0}Brix) in 1st year and 2nd year, respectively. Pooled value was measured maximum total soluble solids in spacing S_1 (60x45 cm) showed in (8.39 ^{0}Brix) as compared to S_2 (60x30 cm) value in (8.27 ^{0}Brix) and minimum total soluble solids was measured in S_4 (45x30 cm) in 1st year (8.00 ^{0}Brix), 2nd year (7.92 ^{0}Brix) and pooled data (7.99 ^{0}Brix)

consequently pursued by S_3 (45x45 cm) in 1st year (8.14 ^{0}Brix), 2nd year (8.05 ^{0}Brix) and pooled data (8.10 ^{0}Brix).

The combined influence of varieties and spacing on (interaction) had taken maximum total soluble solids in V_1S_1 showed in (8.88 ^{0}Brix) in 1st year i.e. in (2017-18) and (8.76 ^{0}Brix) in 2nd year i.e. in (2018-19), followed by V_1S_2 showed in (8.72 ^{0}Brix)) and (8.64 ^{0}Brix) 1st year and 2nd year, respectively. Pooled value was measured maximum total soluble solids in interaction V_1S_1 showed in (8.82 ^{0}Brix) as compared to V_1S_2 showed in (8.62 ^{0}Brix). Minimum total soluble solids was measured in V_3S_4 in 1st year (7.42 ^{0}Brix), 2nd year (7.56 ^{0}Brix) and pooled data showed in (7.49 ^{0}Brix) consequently pursued by V_4S_3 1st year (7.96 ^{0}Brix), 2nd year (7.88 ^{0}Brix) and pooled data (7.97 ^{0}Brix).The recorded data revealed that there was significant effect of varieties and plant spacing had been observed in our study.

4.3.3: Total sugar (%):

The total sugar in broccoli was recorded on fresh weight basis of curd, data was observed and further subjected to the statistical analysis which was represented as following (Table & Fig.- 4.3.1)

The varietal response to the total sugar (%) content was recorded. The pertaining data was revealed that the maximum total sugar was found in varieties V_3 Palam Vichitra showed value in (3.98 %) in 1st year i.e. in (2017-18) and (3.98 %) in 2nd year i.e. in (2018-19), consequently pursued by V_1 Pusa Broccoli KTS-1 value showed in (3.96 %), (3.80 %) 1st year and 2nd year, respectively. Pooled value showed the maximum total sugar was measured in variety V_3 Palam Vichitra showed value in (3.98 %) as compared to V_1 Pusa Broccoli KTS-1 value in (3.88 %) and minimum total sugar measured in varieties V_2 Palam Kanchan in 1st year (3.73), 2nd year (3.72 %) and pooled data (3.73 %) subsequently followed by V_4 Palam Samridhi in 1st year (3.84 %), 2nd year (3.77 %) and pooled data (3.81 %).

Plant spacing S_2 (60x30 cm) as found (3.91 %) had taken maximum total sugar in 1st year i.e. in (2017-18) and (3.85 %) in 2nd year i.e. in (2018-19), respectively followed by S_3 (45x45 cm) showed in (3.90 %), (3.84 %) in 1st year and 2nd year, respectively. Pooled value was measured maximum total sugar in spacing S_2 (60x30 cm) showed in (3.88 %) as compared to S_3 (45x45 cm) value in (3.87 %) and

minimum total sugar was measured in S_1 (60x45 cm) in 1st year (3.83 %), 2nd year (3.83 %) and pooled data (3.83 %) consequently pursued by S_4 (45x30 cm) in 1st year (3.89 %), 2nd year (3.89 %) and pooled data (3.86 %) respectively.

The combined influence of varieties and spacing on (interaction) had taken maximum total sugar in V_3S_2 showed in (4.08 %) in 1st year i.e. in (2017-18) and (4.06 %) in 2nd year i.e. in (2018-19), followed by V_3S_3 showed in (4.02 %), (4.03 %) 1st year and 2nd year, respectively. Pooled value was measured maximum total sugar in interaction V_3S_2 showed in (4.07 %) as compared to V_3S_3 showed in (4.03 %). Minimum total sugar was measured in V_2S_1 in 1st year (3.54 %), 2nd year (3.58 %) and pooled data showed in (3.56 %) respectively followed by V_2S_2 in 1st year (3.56 %), 2nd year (3.52 %) and pooled data showed in (3.59 %) in our study.

Table- 4.3.1: Influence of varieties, spacing and their interaction on quality characters of curd of sprouting broccoli.

Treatment	Vitamin-C(mg/100g)			T.S.S. (Total soluble solids) (^{0}Brix)			Total sugars(%)		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Varieties (V)									
V_1 (Pusa Broccoli KTS-1)	79.12	79.15	79.14	8.57	8.47	8.52	3.96	3.80	3.88
V_2 (Palam Kanchan)	78.45	78.11	78.28	8.42	8.13	8.28	3.73	3.72	3.73
V_3 (Palam Vichitra)	78.08	78.09	78.09	7.92	7.90	7.91	3.98	3.98	3.98
V_4 (Palam Samridhi)	78.58	78.17	78.38	8.10	7.97	8.04	3.84	3.77	3.81
S. Em ±	0.32	0.36	0.34	0.34	0.36	0.35	0.06	0.11	0.09
$CD_{5\%}$	0.97	1.02	1.00	0.99	1.05	1.03	0.16	0.32	0.24
Spacing (S)									
S_1 (60x45 cm)	79.12	79.09	79.10	8.49	8.28	8.39	3.83	3.83	3.83
S_2 (60x30 cm)	79.19	78.85	79.02	8.36	8.17	8.27	3.91	3.85	3.88
S_3 (45x45 cm)	78.26	78.05	78.16	8.14	8.05	8.10	3.90	3.84	3.87
S_4 (45x30 cm)	77.58	77.53	77.56	8.00	7.92	7.99	3.89	3.82	3.86
S. Em ±	0.32	0.35	0.34	0.36	0.34	0.35	0.16	0.19	0.18
$CD_{5\%}$	0.97	1.02	1.00	1.05	1.00	1.03	0.47	0.56	0.52
Interaction (VxS)									
V_1S_1	79.93	79.96	79.95	8.88	8.76	8.82	4.01	4.02	4.02
V_1S_2	79.69	79.92	79.80	8.72	8.64	8.68	3.98	3.84	3.91
V_1S_3	78.74	78.88	78.81	8.62	8.14	8.38	4.00	3.60	3.80
V_1S_4	78.13	77.84	77.99	8.04	8.32	8.18	3.86	3.76	3.81
V_2S_1	79.34	79.88	79.61	8.63	8.51	8.57	3.54	3.58	3.56
V_2S_2	79.12	78.12	78.62	8.56	7.98	8.27	3.56	3.62	3.59
V_2S_3	78.18	77.96	78.62	7.98	8.04	8.01	3.84	3.68	3.76
V_2S_4	77.14	77.44	77.30	8.52	7.99	8.26	3.96	4.00	3.98
V_3S_1	78.15	78.48	78.32	8.14	7.98	8.06	3.98	3.88	3.93
V_3S_2	79.05	79.02	79.04	8.09	8.02	8.05	4.08	4.06	4.07
V_3S_3	78.08	77.48	77.78	7.99	8.04	8.02	4.02	4.03	4.03
V_3S_4	77.04	77.36	77.20	7.42	7.56	7.49	3.84	3.96	3.90
V_4S_1	79.04	79.02	79.03	8.34	7.88	8.11	3.80	3.84	3.82
V_4S_2	78.88	78.34	78.61	8.08	8.02	8.05	3.91	3.88	3.90
V_4S_3	78.04	77.86	77.95	7.96	7.97	7.92	3.76	3.62	3.69
V_4S_4	78.02	77.45	77.73	8.02	8.01	8.02	3.88	3.74	3.81
S. Em ±	2.84	2.74	2.79	0.35	0.43	0.39	0.17	0.22	0.20
$CD_{5\%}$	8.24	7.94	8.09	1.01	1.25	1.13	0.50	0.63	0.57

Fig.- 4.3.1.a: Studies on the influence of varieties on quality characters of curd of sprouting broccoli.

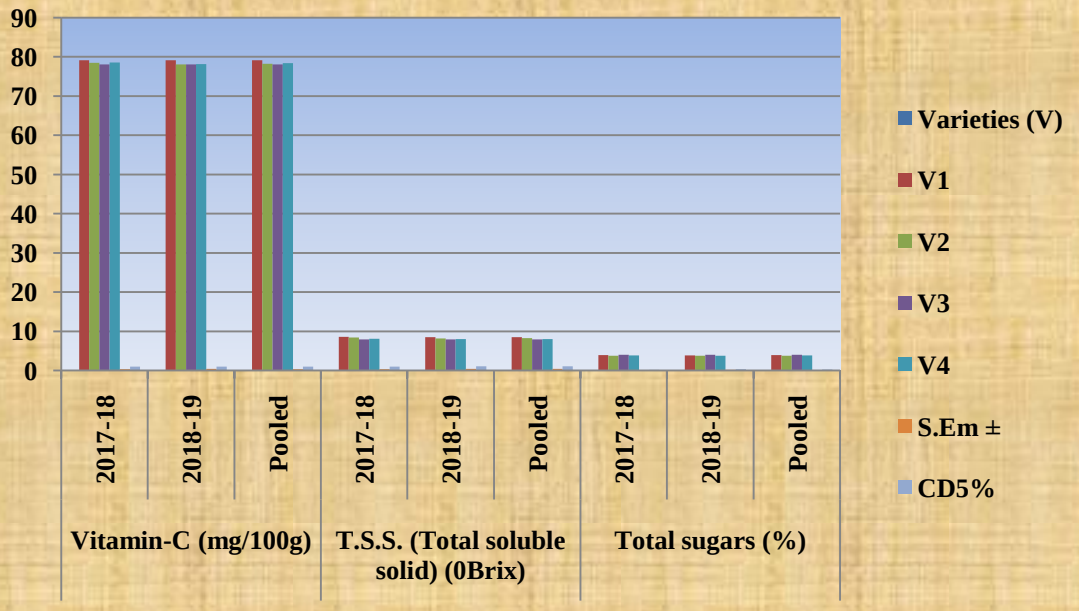


Fig.- 4.3.1.b: Influence of spacing on quality charactersof curd of sprouting broccoli.

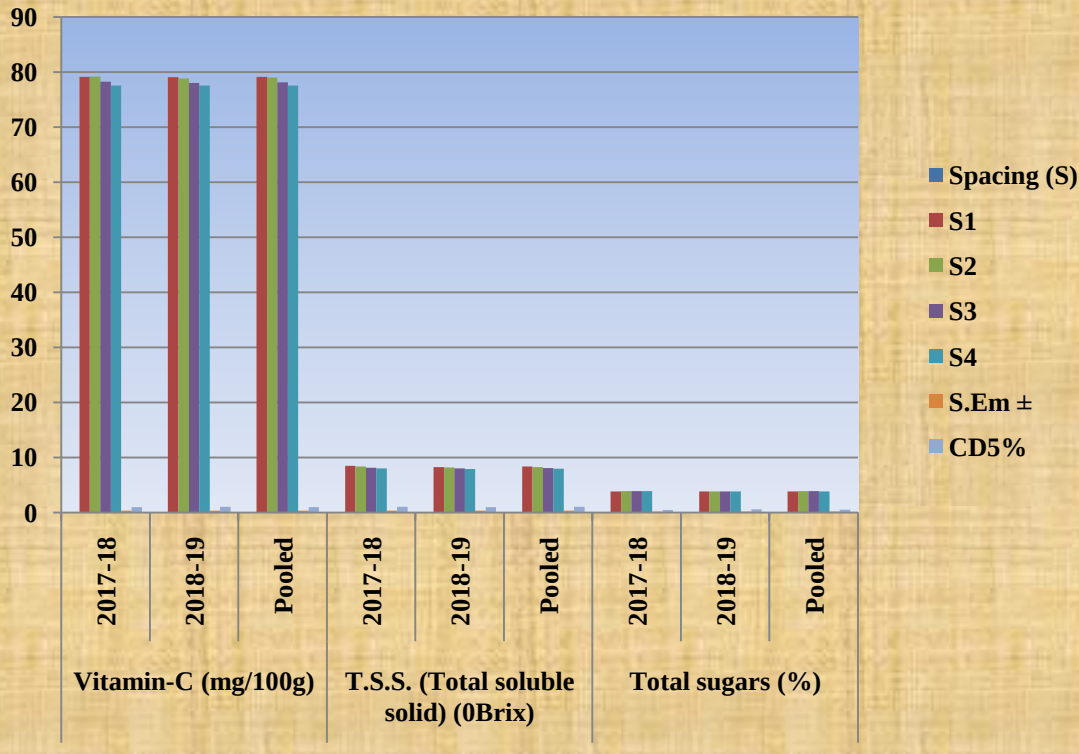
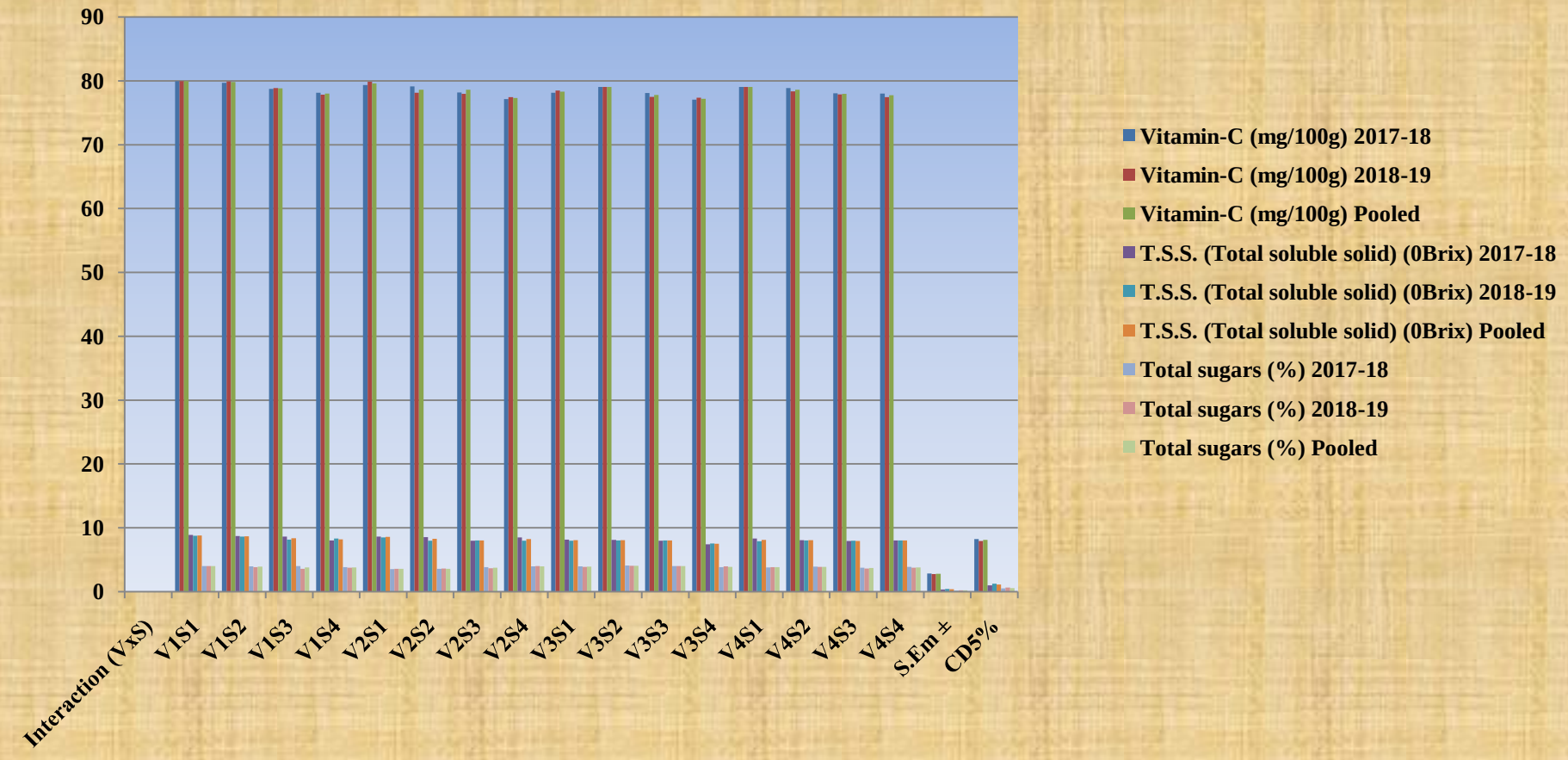


Fig.- 4.3.1.c: Studies on the influence of varieties, spacing and their interaction on quality characters of curd of sprouting broccoli.



4.3.4: Reducing sugar (%):

The reducing sugar content in curd was recorded during the experimentation and recorded data was presented in the following (Table & Fig.- 4.3.2)

There was significant effect of varieties on reducing sugar (%) content was observed. The pertaining data was revealed that the maximum reducing sugar was found in variety V_3 Palam Vichitra showed value in (3.38 %) in 1st year i.e. in (2017-18) and (3.38 %) in 2nd year i.e. in (2018-19), consequently pursued by V_4 Pusa Samridhi value showed in (3.30 %), (3.31 %) 1st year and 2nd year, respectively. Pooled value showed the maximum reducing sugar was measured in variety V_3 Palam Vichitra showed value in (3.38 %) as compared to V_2 Pusa Kanchan value in (3.31 %) and minimum reducing sugar measured in varieties V_1 Pusa Broccoli in 1st year (3.28 %), 2nd year (3.25 %) and pooled data (3.27 %), subsequently followed by V_2 Palam Kanchan in 1st year (3.29 %), 2nd year (3.28 %) and pooled data (3.28 %).

Plant spacing S_2 (60x30 cm) as found (3.30 %) had taken maximum reducing sugar in 1st year i.e. in (2017-18) and (3.32 %) in 2nd year i.e. in (2018-19), respectively followed by S_3 (45x45 cm) showed in (3.29 %), (3.31 %) in 1st year and 2nd year, respectively. Pooled value was measured maximum reducing sugar in spacing S_2 (60x30 cm) showed in (3.31 %) as compared to S_3 (45x45 cm) value in (3.30 %) and minimum reducing sugar was measured in S_1 (60x45 cm) in 1st year (3.27 %), 2nd year (3.26 %) and pooled data (3.27 %) consequently pursued by S_4 (45x30 cm) in 1st year (3.28 %), 2nd year (3.28 %) and pooled data (3.28 %), respectively.

The combined influence of varieties and spacing on (interaction) had taken maximum reducing sugar in V_3S_2 showed in (3.58 %) in 1st year i.e. in (2017-18) and (3.52 %) in 2nd year i.e. in (2018-19), followed by V_2S_1 showed in (3.57 %) and V_3S_3 value in (3.47 %) 1st year and 2nd year, respectively. Pooled value was measured maximum reducing sugar in interaction V_3S_2 showed in (3.50 %) as compared to V_3S_3 showed in (3.45 %). Minimum reducing sugar was measured in V_2S_2 in 1st year (3.19 %), 2nd year (3.18 %) and pooled data showed in (3.20 %) Consequently pursued by V_1S_2 in 1st year (3.23 %), 2nd year (3.27 %) and pooled data showed in (3.23 %) respectively in our study.

4.3.5: Non-reducing sugar (%):

Non-reducing sugar is broccoli was recorded on fresh weight basis during the laboratory experimentation the data present (Table & Fig.- 4.3.2) indicated significant influence of varieties& plant spacing on non-reducing sugar (%) in curd. It is clear from the result that maximum non- reducing sugar in variety V_3 Palam Vichitra showed value in (0.72 %) in 1st year i.e. in (2017-18) and (0.68 %) in 2nd year i.e. in (2018-19), consequently pursued by V_1 Pusa Broccoli KTS-1 value showed in (0.64 %), (0.65 %) 1st year and 2nd year, respectively. Pooled value showed the maximum non-reducing sugar was measured in variety V_3 Palam Vichitra showed value in (0.70 %) as compared to V_1 Pusa Broccoli KTS-1 value in (0.65 %) and minimum non-reducing sugar measured in varieties V_2 Pusa Kanchan in 1st year (0.52 %), 2nd year (0.52 %) and pooled data (0.52 %), subsequently followed by V_4 Palam Samridhi in 1st year (0.59 %), 2nd year (0.60 %) and pooled data (0.60 %).

Plant spacing S_2 (60x30 cm) as found (0.64 %) had taken maximum non-reducing sugar in 1st year i.e. in (2017-18) and (0.65 %) in 2nd year i.e. in (2018-19), respectively followed by S_3 (45x45 cm) showed in (0.63 %), (0.64 %) in 1st year and 2nd year, respectively. Pooled value was measured maximum non-reducing sugar in spacing S_2 (60x30 cm) showed in (0.65 %) as compared to S_3 (45x45 cm) value in (0.64 %) and minimum non-reducing sugar was measured in S_4 (45x30 cm) in 1st year (0.56 %), 2nd year (0.50 %) and pooled data (0.56 %) consequently pursued by S_1 (60x45 cm) in 1st year (0.61 %), 2nd year (0.57 %) and pooled data (0.57 %) respectively.

The combined influence of varieties and spacing on (interaction) had taken maximum non-reducing sugar in V_3S_2 showed in (0.88 %) in 1st year i.e. in (2017-18) and (0.82 %) in 2nd year i.e. in (2018-19), followed by V_3S_3 showed in (0.76 %) and V_3S_3 value in (0.72 %) 1st year and 2nd year, respectively. Pooled value was measured maximum non-reducing sugar in interaction V_3S_2 showed in (0.85 %) as compared to V_3S_3 showed in (0.75 %). Minimum non-reducing sugar was measured in V_2S_1 in 1st year (0.44 %), 2nd year (0.42 %) and pooled data showed in (0.43 %), consequently pursued by V_2S_2 in 1st year (0.48 %), 2nd year (0.48 %) and pooled data showed in (0.48 %) respectively in our study.

Table - 4.3.2: Influence of varieties, spacing and their interaction on quality characters of curd of sprouting broccoli.

Treatment	Reducing sugar (%)			Non-reducing sugar (%)		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Varieties (V)						
V_1 (Pusa Broccoli KTS-1)	3.28	3.28	3.28	0.64	0.65	0.65
V_2 (Palam Kanchan)	3.29	3.25	3.27	0.52	0.52	0.52
V_3 (Palam Vichitra)	3.38	3.38	3.38	0.72	0.68	0.70
V_4 (Palam Samridhi)	3.30	3.31	3.31	0.59	0.60	0.60
S. Em ±	0.16	0.18	0.17	0.04	0.03	0.04
$CD_{5\%}$	0.47	0.53	0.50	0.12	0.09	0.11
Spacing (S)						
S_1 (60x45 cm)	3.27	3.26	3.27	0.61	0.50	0.56
S_2 (60x30 cm)	3.30	3.32	3.31	0.64	0.65	0.65
S_3 (45x45 cm)	3.29	3.31	3.30	0.63	0.64	0.64
S_4 (45x30 cm)	3.28	3.28	3.28	0.56	0.57	0.57
S. Em ±	0.18	0.19	0.19	0.06	0.05	0.06
$CD_{5\%}$	0.53	0.56	0.54	0.17	0.15	0.16
Interaction (VxS)						
V_1S_1	3.28	3.31	3.30	0.62	0.58	0.60
V_1S_2	3.23	3.23	3.23	0.58	0.64	0.61
V_1S_3	3.31	3.30	3.31	0.72	0.71	0.72
V_1S_4	3.29	3.28	3.29	0.63	0.65	0.64
V_2S_1	3.57	3.18	3.38	0.44	0.42	0.43
V_2S_2	3.19	3.21	3.20	0.48	0.46	0.47
V_2S_3	3.44	3.38	3.41	0.63	0.58	0.61
V_2S_4	3.34	3.23	3.29	0.54	0.62	0.58
V_3S_1	3.31	3.22	3.27	0.66	0.62	0.64
V_3S_2	3.58	3.52	3.50	0.88	0.82	0.85
V_3S_3	3.42	3.47	3.45	0.76	0.74	0.75
V_3S_4	3.32	3.30	3.31	0.58	0.52	0.55
V_4S_1	3.31	3.32	3.32	0.71	0.70	0.71
V_4S_2	3.28	3.30	3.29	0.54	0.62	0.58
V_4S_3	3.27	3.28	3.28	0.62	0.58	0.60
V_4S_4	3.24	3.32	3.28	0.50	0.48	0.49
S. Em ±	0.17	0.23	0.20	0.06	0.08	0.07
$CD_{5\%}$	0.49	0.67	0.58	0.17	0.23	0.20

Fig.- 4.3.2.a: Studies on the influence of varieties on quality characters of curd of sprouting broccoli.

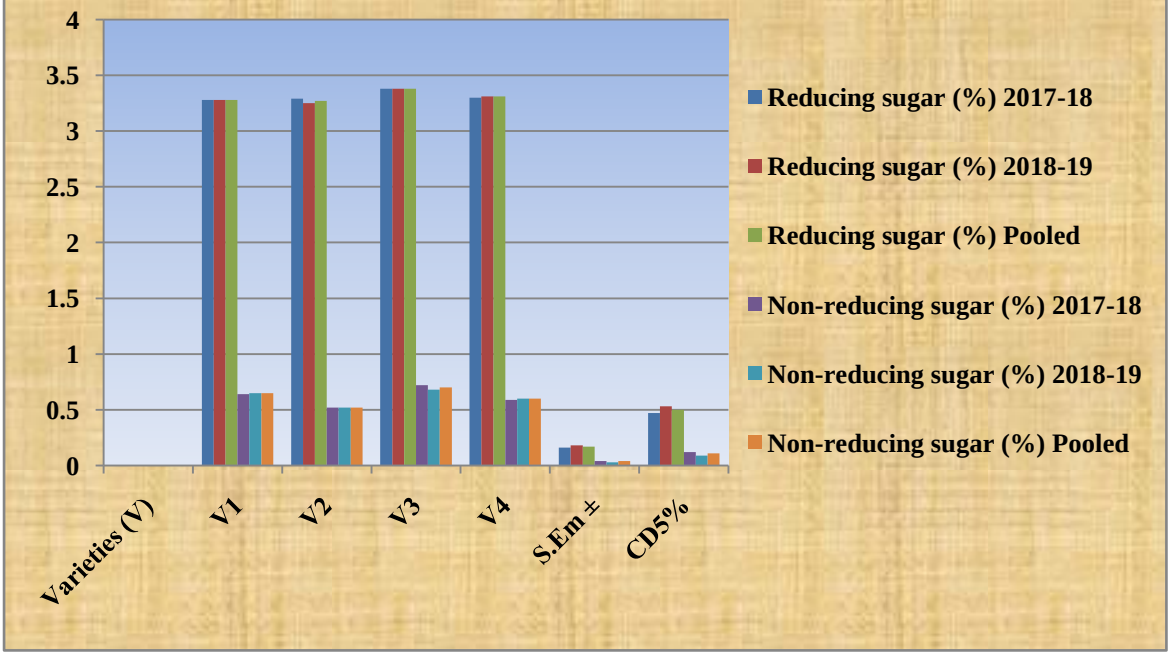


Fig.- 4.3.2.b: Studies on the influence of spacing on quality characters of curd of sprouting broccoli

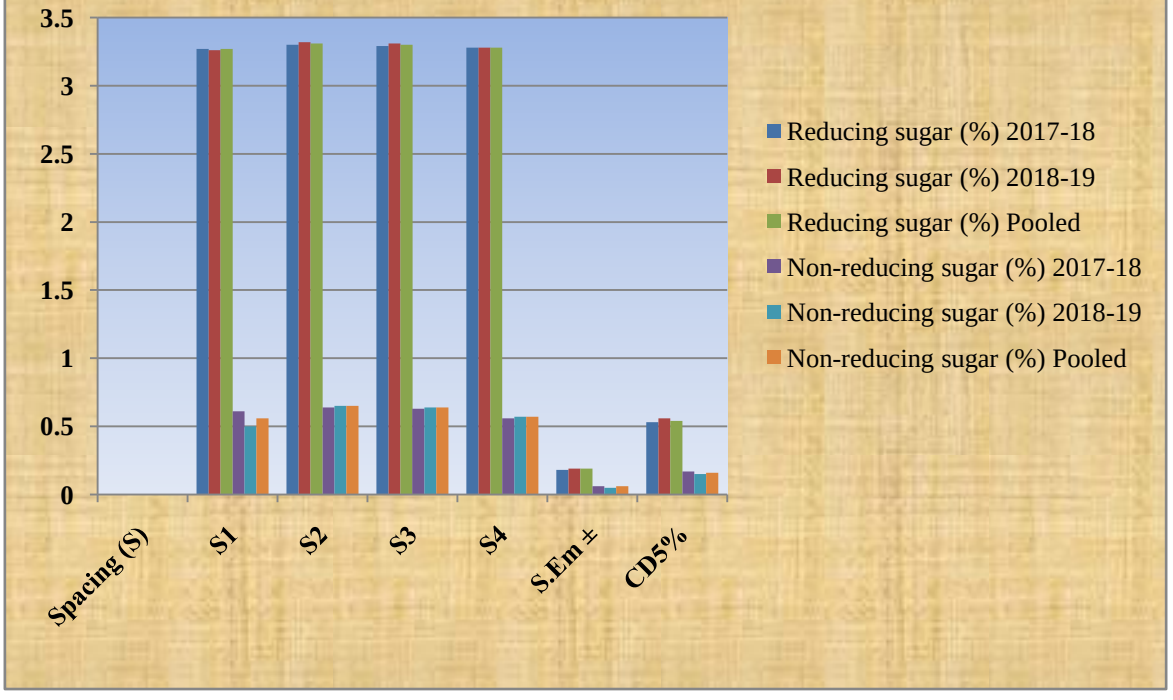
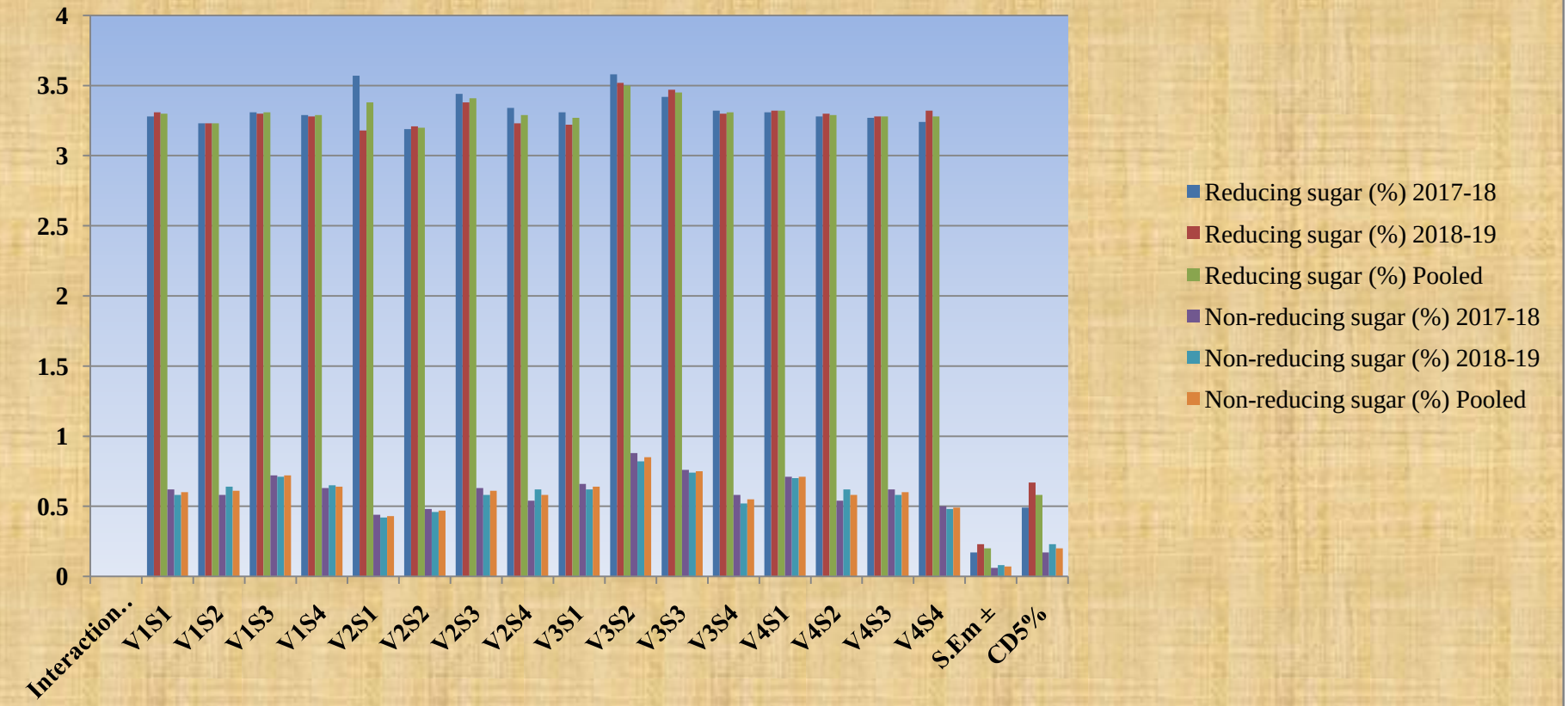


Fig.- 4.3.2.c: Influence of varieties, spacing and their interaction on quality characters of curd of sprouting broccoli



4.4: Economic Analysis:

4.4.1: Economics of the different treatments of sprouting broccoli production:

Data presented in (Table & Fig.- 4.3.3) the economics of broccoli cultivation i.e. price per quintal, gross income (Rs./ha), cost of cultivation, net income (Rs./ha) and B: C ratio during both the years of study (20017-18 and 2018-19) were significantly affected with varieties, plant spacing as well as with their interaction.

Influence of varieties:

Varieties V_1 Pusa Broccoli KTS-1 resulted in maximum gross income (365850.00, Rs./ha) in 1st year i.e. in (2017-18) and (371415.00, Rs./ha) in 2nd year i.e. in (2018-19), consequently. Pooled value showed the maximum gross income (368632.50, Rs./ha) was observed in variety V_1 Pusa Broccoli KTS-1. It was significantly superior over V_3 Palam Vichitra.

The actual costs, which include production cost (nursery preparation, seed, field preparation, labour charges, fertilizer, insecticide/ pesticide, miscellaneous etc.), marketing cost and FYM cost (90550.00, Rs./ha).

The (Table no. & Fig no.- 4.3.3) revealed that the net income were higher (275300.00, Rs./ha) in 1st year i.e. in (2017-18) and (280865.00, Rs./ha) in 2nd year i.e. in (2018-19) and pooled data (278082.50, Rs./ha) in varieties V_1 Pusa Broccoli KTS-1, respectively followed by varieties V_3 Palam Vichitra whereas, it was found to be lowest net income in variety V_4 Palam Samridhi in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data, respectively.

The highest cost benefit ratio also indicates that higher market value which directly co-related with market demand. Highest cost benefit ratio was observed in (1:4.05) in 1st year i.e. in (2017-18) and (1:4.11) in 2nd year i.e. in (2018-19) and pooled data (1:4.08) in varieties V_1 Pusa Broccoli KTS-1, respectively followed by varieties V_3 Palam Vichitra whereas, it was observed to be lowest C:B ratio in variety V_4 Palam Samridhi in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data, consequently.

Influence of spacing:

Plant spacing registered remarkable influence on economics of broccoli. Maximum gross income in spacing S_4 (45x30 cm) (443745.00, Rs./ha) in 1st year i.e. in (2017-18) and (446295.00, Rs./ha) in 2nd year i.e. in (2018-19), consequently. Pooled value showed the maximum gross income (446295.00, Rs./ha) was observed in spacing S_4 (45x30 cm). It was significantly superior over spacing S_2 (60x30 cm).The minimum gross income resulted in spacing S_1 (60x45 cm) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data, respectively.

The net income were higher (353195.00, Rs./ha) in 1st year i.e. in (2017-18) and (358295.00, Rs./ha) in 2nd year i.e. in (2018-19) and pooled data (355745.00, Rs./ha) in spacing S_4 (45x30 cm), respectively followed by S_2 (60x30 cm).whereas, it was found to be lowest net income in spacing S_1 (60x45 cm) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data, respectively.

The highest cost benefit ratio was also observed in (1:4.90) in 1st year i.e. in (2017-18) and (1:4) in 2nd year i.e. in (2018-19) and pooled data (1:4.93) in spacing S_4 (45x30 cm), respectively followed by S_2 (60x30 cm). whereas, it was observed to be lowest C:B ratio in spacing S_1 (60x45 cm) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data, respectively.

Influence of interaction (varieties and spacing's):

Combined effect of varieties and plant spacing denoted significant influence on gross income (Rs./ha), net income (Rs./ha) and B: C ratio. Among treatment combinations V_1S_4 had highest gross income (453690.00, Rs./ha) in 1st year i.e. in (2017-18) and (455775.00, Rs./ha) in 2nd year i.e. in (2018-19), consequently. Pooled value showed the maximum gross income (455775.00, Rs./ha) was observed in combinations V_1S_4. It was significantly superior over combinations V_3S_4. Therefore, minimum gross income was obtained in (259245.00, Rs./ha) in 1st year i.e. in (2017-18) and (262500.00, Rs./ha) in 2nd year i.e. in (2018-19) and pooled data (260872, Rs./ha) in combinations V_4S_1.

The maximum net income was calculated in (363140.00, Rs./ha) in 1st year i.e. in (2017-18) and (367310.00, Rs./ha) in 2nd year i.e. in (2018-19) and (365225.00, Rs./ha) in pooled data, respectively was observed in combinations V_1S_4 respectively

followed by interaction V_1S_4. Therefore, minimum net income was resulted in (168695.00, Rs./ha) in 1st year i.e. in (2017-18) and (171950.00, Rs./ha) in 2nd year i.e. in (2018-19) and pooled data (170322.50, Rs./ha) in combinations V_4S_1.

The benefit cost ratio ranged from (1: 2.88 to 1:5.04, B:C). Benefit cost ratio of broccoli cultivation in different combinations revealed that highest in V_1S_4, (1:5.01, B:C) in 1st year i.e. in (2017-18) and (1:5.06, B:C) in 2nd year i.e. in (2018-19), consequently. Pooled value showed the maximum benefit cost ratio (1:5.04, B:C) was observed in combinations V_1S_4. It was significantly superior over combinations V_3S_4. Therefore, minimum benefit cost ratio was analyzed in (1:2.86, B:C) in 1st year i.e. in (2017-18) and (1:2.90, B:C) in 2nd year i.e. in (2018-19) and pooled data (1:2.88, B:C) in combinations V_4S_1.

Table - 4.4: Influence of varieties, spacing and their interaction on economic analysis of broccoli cultivation.

Treatment	Yield (q/ha)			Price/ quintal	Gross income (Rs./ha)			Cast of cultivation			Net income (Rs./ha)			Cost : Benefit ratio		
	2017-18	2018-19	Pooled		2017-18	2018-19	Pooled	Cast/ ha^{-1}	FYM cast	Total cast	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Varieties (V)																
V_1	243.90	247.61	245.75	1500	365850	371415	368632.50	74550	16000	90550	275300	280865	278082.50	1:4.05	1:4.11	1:4.08
V_2	234.18	236.57	235.37	1500	351270	354855	353062.50	74550	16000	90550	260720	264305	262512.50	1:3.88	1:3.92	1:3.90
V_3	240.43	244.68	242.55	1500	360645	367020	363832.50	74550	16000	90550	270095	276470	273282.50	1:3.98	1:4.05	1:4.02
V_4	231.48	233.26	232.37	1500	347220	349890	348555.00	74550	16000	90550	256670	259340	258005.00	1:3.83	1:3.86	1:3.85
S. Em ±	0.39	0.38	0.39	-	754.35	752.24	753.30	-	-	-	1540.01	1856.07	1698.04	0.11	0.10	0.11
$CD_{5\%}$	1.18	1.16	1.17	-	2189.28	2181.49	2185.39	-	-	-	4469.40	5386.65	4928.03	0.31	0.30	0.31
Spacing (S)																
S_1	178.32	180.09	179.21	1500	267480	270135	268807.50	74550	16000	90550	176930	179585	178257.50	1:2.95	1:2.98	1:2.97
S_2	258.72	262.42	260.57	1500	388080	393630	390855.00	74550	16000	90550	297530	303080	300305.00	1:4.29	1:4.35	1:4.32
S_3	217.13	220.37	218.75	1500	325695	330555	328125.00	74550	16000	90550	235145	240005	237575.00	1:3.60	1:3.65	1:3.63
S_4	295.83	299.23	297.53	1500	443745	448845	446295.00	74550	16000	90550	353195	358295	355745.00	1:4.90	1:4.96	1:4.93
S. Em ±	0.45	0.48	0.47	-	754.35	753.48	753.92	-	-	-	1540.00	1856.06	1698.03	0.10	0.11	0.11
$CD_{5\%}$	1.36	1.41	1.38	-	2189.28	2185.09	2187.18	-	-	-	4469.37	5386.64	4928.01	0.30	0.31	0.33
Interaction (VxS)																
V_1S_1	185.18	185.49	185.33	1500	277770	278235	278002.50	74550	16000	90550	187220	187685	187452.50	1:3.07	1:3.07	1:3.07
V_1S_2	270.98	274.38	272.68	1500	406470	411570	409020.00	74550	16000	90550	315920	321020	318470.00	1:4.49	1:4.55	1:4.52
V_1S_3	216.97	225.31	221.14	1500	325455	337965	331710.00	74550	16000	90550	234905	247415	241160.00	1:3.59	1:3.73	1:3.66
V_1S_4	302.46	305.24	303.85	1500	453690	457860	455775.00	74550	16000	90550	363140	367310	365225.00	1:5.01	1:5.06	1:5.04
V_2S_1	175.00	177.16	176.08	1500	262500	265740	264120.00	74550	16000	90550	171950	175190	173570.00	1:2.90	1:2.93	1:2.92
V_2S_2	250.93	256.79	253.86	1500	376395	385185	380790.00	74550	16000	90550	285845	294635	290240.00	1:4.16	1:4.25	1:4.21
V_2S_3	213.27	214.50	213.88	1500	319905	321750	320827.50	74550	16000	90550	229355	231200	230277.50	1:3.53	1:3.55	1:3.54
V_2S_4	297.53	297.84	297.68	1500	446295	446760	446527.50	74550	16000	90550	355745	356210	355977.50	1:4.93	1:4.93	1:4.93
V_3S_1	180.25	182.72	181.48	1500	270375	274080	272227.50	74550	16000	90550	179825	183530	181677.50	1:2.99	1:3.03	1:3.01
V_3S_2	257.10	262.34	259.72	1500	385650	393510	389580.00	74550	16000	90550	295100	302960	299030.00	1:4.26	1:4.35	1:4.31
V_3S_3	226.23	228.70	227.46	1500	339345	343050	341197.50	74550	16000	90550	248795	252500	250647.50	1:3.75	1:3.79	13.77
V_3S_4	298.15	304.94	301.54	1500	447225	457410	452317.50	74550	16000	90550	356675	366860	361767.50	1:4.94	1:5.05	1:5.00
V_4S_1	172.83	175.00	173.91	1500	259245	262500	260872.50	74550	16000	90550	168695	171950	170322.50	1:2.86	1:2.90	1:2.88
V_4S_2	255.86	256.17	256.01	1500	383790	384255	384022.50	74550	16000	90550	293240	293705	293472.50	1:4.24	1:4.24	1:4.24
V_4S_3	212.03	212.96	212.49	1500	318045	319440	318742.50	74550	16000	90550	227495	228890	228192.50	1:3.51	1:3.53	1:3.52
V_4S_4	285.18	288.89	287.03	1500	427770	433335	430552.50	74550	16000	90550	337220	342785	340002.50	1:4.72	1:4.79	1:4.76
S. Em ±	0.46	0.49	0.48	-	755.34	754.32	754.83	-	-	-	1541.08	1855.24	1698.16	0.11	0.10	0.11
$CD_{5\%}$	1.35	1.43	1.39	-	2190.48	2187.53	2189.01	-	-	-	4469.13	5380.20	4924.57	0.31	0.30	0.31

Fig.- 4.4.a: Influence of varieties on economic analysis of broccoli cultivation

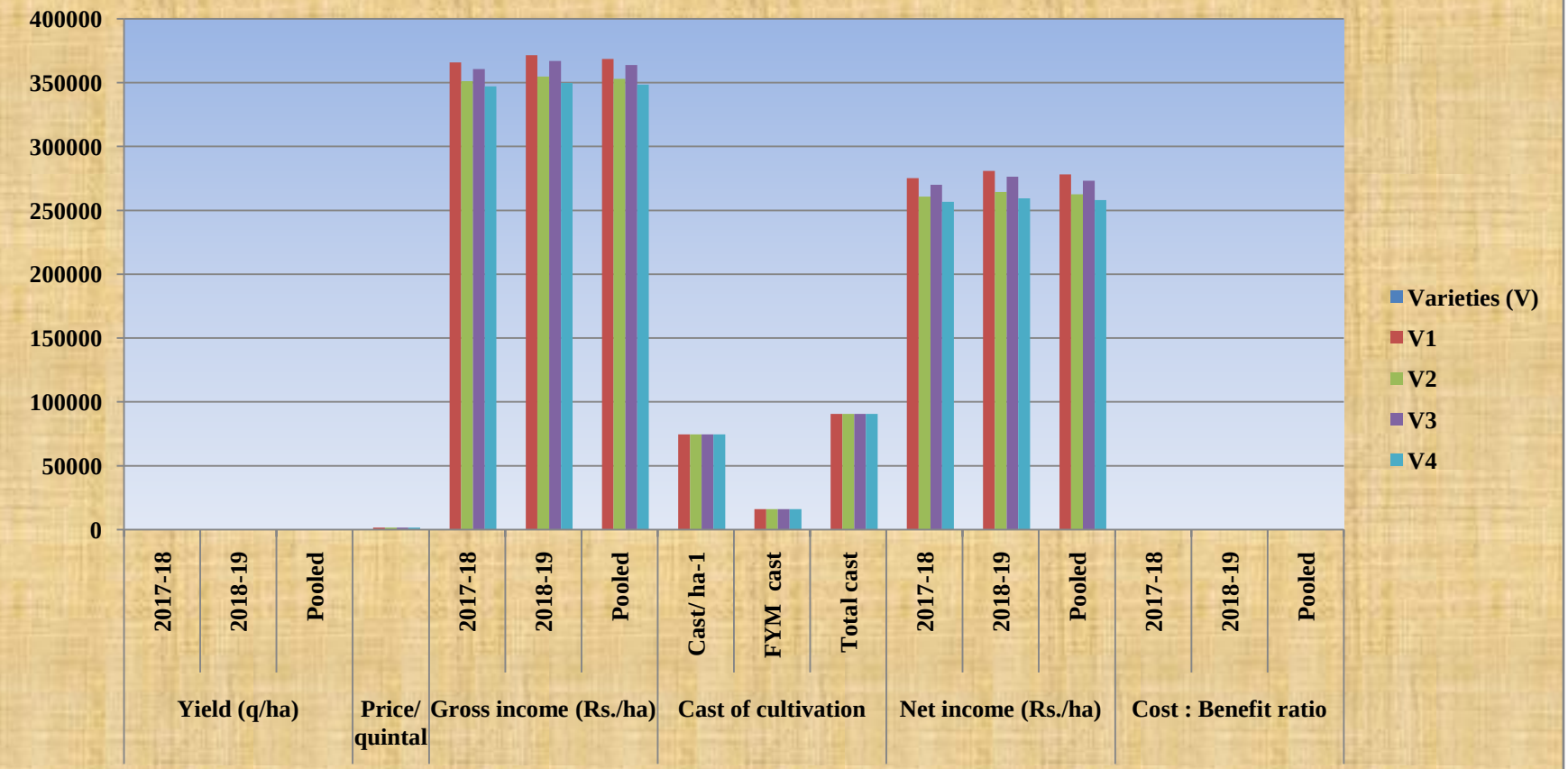


Fig .- 4.4.b: Influence of spacing on economic analysis of broccoli cultivation

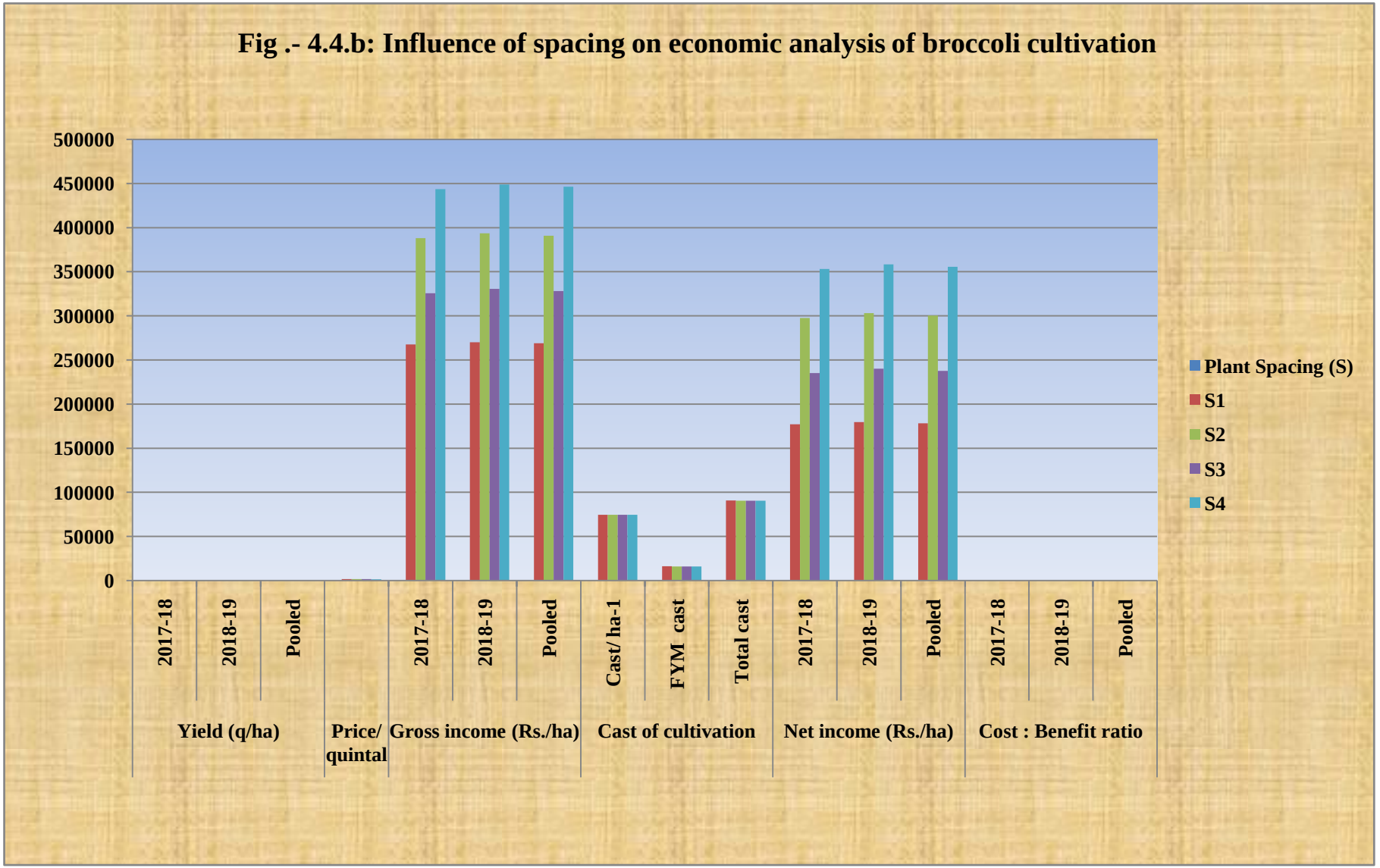
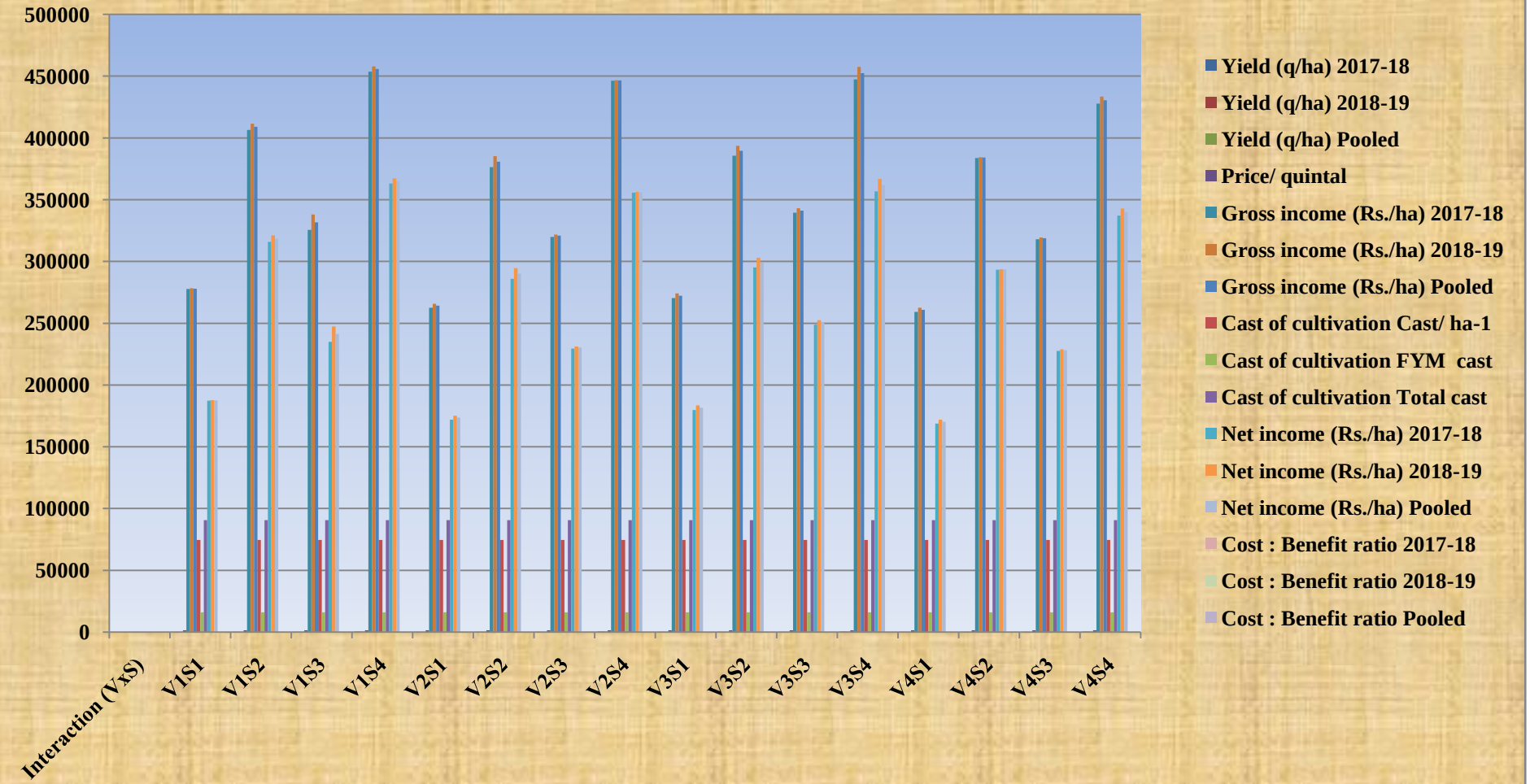


Fig.- 4.4.c: Influence of varieties, spacing and their interaction on economic analysis of broccoli cultivation



Chapter-5

Discussion

CHAPTER -5

DISCUSSION

The present investigation entitled **"Studies on the influence of varieties and spacing on growth, yield and quality traits of sprouting broccoli (*Brassica oleracea* L. var. *italica* Plenck)"** was carried out at Horticulture Research Farm, Department of Applied Plant Science (Horticulture), School for Bio-sciences and Biotechnology, Babasaheb Bhimrao Ambedkar University (A Central University), Vidya Vihar, Raebareli Road, Lucknow 226025 (U.P.), India, during the rabi season of (2017-18 & 2018-19). The response of vegetative growth, yield and quality characters of sprouting broccoli. The results are discussed in the light of literature available and research works reported by earlier workers on sprouting broccoli and other related plants relevant and logical explanation have been given wherever possible.

5.1: Influence of varieties on growth characters of sprouting broccoli:

From the observations made during both years, data revealed significant influence of varieties on vegetative growth of broccoli. The growth characters were recorded for the two different seasons as (2017-18, 2018-19 and pooled data). The growth was found significant effect in case of different varieties. Varieties V_1 Pusa Broccoli KTS-1 was recorded (66.78, 67.21 and 67.00 cm, respectively) the highest plant height in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data, which was followed by variety V_2 Palam Kanchan (66.50, 67.12 and 66.81 cm, respectively) in both years. While minimum results were obtained in variety V_3 Palam Vichitra (66.08, 66.01 and 66.05 cm, consequently). Maximum stem diameter was measured in (3.52, 3.55 and 3.53 cm, respectively), plant canopy spreading (E-W direction) (61.38, 62.50 and 61.64 cm, respectively) and plant canopy spreading (N-S direction), (54.27, 55.38 and 54.82 cm, respectively) were recorded in variety V_1 Pusa Broccoli KTS-1 in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data, which was consequently pursued by variety V_2 Palam Kanchan, whereas, minimum values were recorded in V_3 Palam Vichitra. Variety V_1 Pusa Broccoli KTS-1 recorded maximum number of leaves per plant (23.79, 23.93 and 23.86), length of leaves (51.16, 51.15 and 51.16 cm, respectively and width of leaves (30.33, 30.69 and 30.51 cm, respectively) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data respectively. Minimum

values were recorded in varieties V_3 Palam Vichitra, respectively. These results are close conformity with the results of **(Bhangre *et al.*, 2011)** directed an investigation to contemplate the impact of different varieties (Ganesh broccoli and Pusa KTS-1). The information uncovered that cv. Plant height (66.78 cm), stem diameter (3.05 cm), number of leaves (22.21) and plant canopy spreading (60.12 cm) cv. Pusa KTS-1 recorded essentially most elevated qualities for growth parameters. Varieties V_2 Palam Kanchan (190.38 g) the highest dry weight of plant in 1st year i.e. in (2017-18) and (198.02 g) in 2nd year i.e. in (2018-19), consequently pursued by V_3 Palam Vichitra. While minimum results were obtained in variety V_1 Pusa Broccoli KTS-1, whereas all growth parameters recorded maximum in variety V_1 Pusa Broccoli KTS-1 except dry weight of plant (g).Similar results finding have been cited by **(Thakur *et al.*, 2016)** considered the exhibition of six varieties (Palam Haritika, Palam Kanchan, Palam Samridhi, Palam Vichitra, MSB-12 and Ganesh) of broccoli with two environmental conditions (open field and normally ventilated polyhouse). Among the varieties maximum dry weight of plant at curd stage (161.92 g) and harvesting stage (279.33 g) were found in Palam Kanchan.

5.2: Influence of spacing on growth characters of sprouting broccoli:

The data presented that growth parameters were significantly affected by different spacing. Plant spacing S_1 (60x45 cm) as found (67.37 cm) had recorded maximum plant height 1st year i.e. in (2017-18), (68.44 cm) in 2nd year i.e. in (2018-19) and (67.91 cm) in pooled data, consequently pursued by S_2 (60x30 cm) value (67.32, 67.48 and 67.40 cm, respectively) 1st year, 2nd year and pooled data, whereas, minimum results were obtained in spacing S_4 (45x30 cm) (64.63, 65.12 and 64.88 cm, respectively). At the end of experiment, maximum stem diameter (3.40, 3.46 and 3.43 cm, respectively), plant canopy spreading (E-W direction), (62.54, 64.01 and 63.28 cm, respectively) and plant canopy spreading (N-S direction), (52.88, 53.24 and 53.06 cm, respectively) were recorded in spacing S_1 (60x45 cm) during 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data consequently, which was followed by spacing S_4 (45x30 cm). Minimum values were recorded in spacing S_4 (45x30 cm). These results are in close conformity with results of (**Solunke *et al.*, 2011)** examine the effect of three spacing viz., 60 × 30 cm, 60 × 45 cm and 60 × 60 cm on growth and yield of broccoli. The broccoli transplanted on the spacing 60×60

cm showed significantly maximum stem diameter. Spacing S_1 (60x45 cm) recorded maximum number of leaves per plant (24.33, 24.54 and 24.44), length of leaves (51.95, 52.03 and 51.99 cm, respectively) and width of leaves (31.02. 31.20 and 31.11 cm, respectively) 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data, while minimum values were recorded in spacing S_4 (45x30 cm). These results are similar to (**Munro *et al.*, 2007),** (**Kumar *et al.,* 2007)**, (**Saikia *et al.,* 2010)** and (**Bhangre *et al.,* 2001)** in broccoli. Plant spacing S_1 (60x45 cm) as found (164.85 g) had recorded maximum dry weight of plant (g) 1st year i.e. in (2017-18) and (169.28 g) in 2nd year i.e. in (2018-19), respectively at harvesting stage. The difference between S_1 S_2, S_3 and S_4 were significant at all growth stage of broccoli.

5.3: Influence of interaction (varieties x spacing) on growth characters of sprouting broccoli:

According to experimental finding data show that growth parameters significantly the combined influence of varieties and spacing on (interaction) recorded at harvesting stage was found maximum for plant height in interaction V_1S_1 (68.37 cm) 1st year i.e. in (2017-18), (68.85 cm) in 2nd year i.e. in (2018-19) and (68.51 cm) in pooled data. At the end of experiment, significantly maximum stem diameter in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data was obtained (3.57, 3.64 and 3.61 cm, respectively), plant canopy spreading (E-W direction), (64.12, 68.13 and 66.13 cm, respectively), plant canopy spreading (N-S direction), (54.57, 55.67 and 55.12 cm, consequently) pursued by stem diameter (cm) and plant canopy spreading (N-S direction) in V_1S_2, 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data, whereas minimum value was observed in V_3S_4 respectively. Interaction V_1S_1 was observed in maximum number of leaves per plant (24.72, 24.92 and 24.82), length of leaves (52.79, 52.69 and 52.67 cm, respectively) and width of leaves (31.35, 31.36 and 31.36 cm, respectively), followed by interaction V_2S_1. Similar kind of results were also observed by **(Saikia *et al.*, 2010)** led probe broccoli variety Pusa Broccoli KTS-1 to assess six planting distances viz., 30 cm × 30 cm, 45 cm × 30 cm, 45 cm ×45 cm, 45 cm × 60 cm, 60cm × 60cm and 75 cm × 60 cm. Accordingly, it tends to be inferred that for growth parameters of broccoli var. 'Pusa Broccoli KTS-1' planting on center piece of October by keeping up a planting distance of 45cm × 60cm between and within rows is most favorable under the climate conditions of Jorhat (Assam).While minimum value

number of leaves per plant, length of leaves and width of leaves was observed V_3S_4. Maximum dry weight of plant was observed in V_2S_4 value in (201.34 g) 1st year i.e. in (2017-18) and (206.12 g) in 2nd year i.e. in (2018-19), respectively at harvesting stage followed by V_2S_3 showed in (194.36 g) 1st year and (204.34 g) 2nd year, respectively, whereas, minimum dry weight of plant was calculated in V_1S_1. These results are similar to **(Bhangre *et al.*, 2011)** evaluated the impact of various assortments (Pusa KTS-1 and Pusa Samridhi) with five spacing (60×60 cm, 60×45 cm, 45×45 cm, 60×30 cm & 45×30 cm). Connection impact of various varieties and spacing was found non critical however numerically the collaboration impact of V_1S_1 and V_4S_3 was the best among the all treatment.

5.4: Influence of varieties on yield and quality characters of sprouting broccoli:

According to experimental finding yield and quality characters were recorded in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data. It was observed that the earliest days of curd initiation in varieties V_1 Pusa Broccoli KTS-1 (47.57, 48.30 and 47.94), earliest days taken to curd harvest after curd initiation (22.70, 22.47 and 22.58) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data respectively which was followed by variety V_2 Palam Kanchan both years and average data, whereas, the highest days of curd initiation, day taken to curd harvest after curd initiation variety V_3 Palam Vichitra consequently pursued by variety V_4 Palam Samridhi. Varieties V_1 Pusa Broccoli KTS-1 significantly maximum curd diameter (117.38, 120.45 and 118.92 mm, respectively), weight of curd with gourd leaf (0.94, 0.95 and 0.95 kg, consequently), weight of curd without gourd leaf (0.45, 0.46 and 0.46 kg, respectively) and yield per hectare (24.39, 24.76 and 24.57 t ha^{-1}, consequently) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data consequently pursued by V_3 Palam Vichitra, whereas minimum data was observed in variety V_4 Palam Samridhi respectively. These results are close conformity with the results of **(Bhangre *et al.*, 2011)** directed an investigation to contemplate the impact of different varieties (Palam Kanchan and Pusa KTS-1). The investigation showed that cv. Pusa KTS-1 performed better compression to cv. Palam Kanchan with earliest days to curd initiation (53.4 days), day taken to curd harvested after curd initiation (20.24 days), curd diameter (10.81 cm), average weight of curd (154.80 g) and yield

per hectare (70.75 q) while, cv. Palam Kanchan recorded maximum growth and yield parameters.

It was observed that the maximum ascorbic acid (79.12, 79.15 and 79.14 mg/100g, respectively), total soluble solids (8.57, 8.47 and 8.52 ^{0}Brix, consequently) in varieties V_1 Pusa Broccoli KTS-1, 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data, respectively, which was followed by variety V_3 Palam Vichitra in vitamin C and V_2 Palam Kanchan in total soluble solids (^{0}Brix), while minimum values were recorded in variety V_3 Palam Vichitra respectively. These finding are in close conformity with **(Singhal *et al*., 2009)** reported that there was no any significant affect of spacing on ascorbic acid content on broccoli. Significantly higher value of total sugar (3.98, 3.98 and 3.98 %) and non-reducing sugar (0.72, 0.68 and 0.70 %, consequently) in variety V_3 Palam Vichitra 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data consequently pursued by varieties V_1 Pusa Broccoli KTS-1, whereas, minimum data was observed in V_2 Palam Kanchan, respectively. Varieties V_3 Palam Vichitra (3.38 %) the maximum reducing sugar in 1st year i.e. in (2017-18) and (3.38 %) in 2st year i.e. in (2018-19) and (3.38) in pooled data subsequently followed by variety V_4 Palam Samridhi. While minimum results were obtained in variety V_2 Palam Kanchan.

5.5: Influence of spacing on yield and quality characters of sprouting broccoli:

Yield and quality parameters were significantly affected two different seasons as (2017-18 and 2018-19). It was observed that the earliest days of curd initiation in spacing S_1 (60x45 cm) was recorded (48.62, 49.31 and 48.97, days), earliest days taken to curd harvest after curd initiation (22.98, 22.08 and 22.53, days) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data respectively which was followed by spacing S_2 (60x30 cm) both years and pooled data, whereas, the highest days of curd initiation, day taken to curd harvest after curd initiation were observed in spacing S_4 (45x30 cm) consequently pursued by spacing S_3 (45x45 cm**).** Significantly maximum curd diameter (116.42, 117.34 and 116.88 mm, significantly), weight of curd with gourd leaf (0.99, 0.99 and 0.99 kg, consequently), weight of curd without gourd leaf (0.48, 0.48 and 0.48 kg, significantly) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data in spacing S_1 (60x45 cm) consequently pursued by spacing S_2 (60x30 cm**)**, whereas minimum data was observed in spacing S_4 (45x30 cm**)** respectively followed by

spacing S_3 (45x45 cm**)**. These finding are in close conformity with the results of **(Gariya *et al.,* 2016)** explored the impact of spacing in sprouting broccoli. The medicines comprised of three spacing (60 × 30 cm, 60 × 40 cm and 60 × 50 cm) and plant crisp weight (1.96 kg) and it was intently trailed by spacing (60 × 40 cm). The time taken to head commencement from the date of transplanting was fundamentally affected by plant geometry. Least days to head inception (57.22) were recorded in plant spacing of (60×50 cm) and factually it differed altogether with other dispersing. The most extreme load of heads (344.68 g) was additionally recorded in a similar planting geometry i. e. (60×50 cm). Difference to this, the best return of heads (168.40 q/ha) was acquired in least plant spacing of (60×30 cm). Yield attributes was significantly affected by spacing. Spacing S_4 (45x30 cm**)**, yield per hectare (29.58, 29.92 and 29.75 t ha^{-1}, respectively) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data consequently pursued by spacing S_2 (60x30 cm**)**, as well as minimum data was observed in spacing S_1 (60x45 cm**)** respectively followed by spacing S_3 (45x45cm**)**. These results are close conformity with the results of **(Solunke *et al*., 2011)** examine the effect of three spacing viz., 60x30 cm, 45x45 cm and 45x30 cm on growth and yield of broccoli. The broccoli transplanted on the spacing 45×30 cm showed significantly yield attributes characters. The maximum yield per plot was found superior at higher plant density which was possibly due to more number of plants per unit area; higher ground covers of leaf area resulted in higher light interception and hence, higher assimilate production. Similar results have been reported by (**Agarwal *et al.*, 2007)** in broccoli.

It was observed that the maximum ascorbic acid (79.19, 79.09 and 79.14 mg/100g, consequently) and total soluble solids (8.49, 8.28 and 8.39 ^{0}Brix, respectively) in spacing S_1 (60x45 cm**)**, 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data respectively which was followed by spacing S_2 (60x30 cm**)**, while minimum values were recorded in spacing S_4 (45x30 cm**)** respectively. These finding are in close conformity with **(Singhal *et al*., 2009)** reported that there was no any significant affect of spacing on ascorbic acid content on broccoli. Significantly higher value of total sugar (3.91, 3.85 and 3.88 % consequently), reducing sugar (3.30, 3.32 and 3.31 %, respectively) and non-reducing sugar (0.64, 0.65 and 0.65 %, consequently) in spacing S_2 (60x30 cm**)**, 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data consequently pursued by spacing S_3 (45x45

cm**)**, whereas, minimum values were recorded in spacing S_1 (60x45 cm**)** in total sugar (%) and reducing sugar (%).

5.6: Influence of interaction (varieties x spacing) on yield and quality characters of sprouting broccoli:

In the present investigation data revealed that yield and quality parameters were significantly affected two different seasons as (2017-18 and 2018-19). It was observed that the earliest days of curd initiation in interaction V_1S_1 was recorded (46.02, 46.84 and 46.43), earliest days taken to curd harvest after curd initiation (22.04, 21.08 and 21.56) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data respectively which was followed by interaction V_1S_2 in both years and pooled data, whereas, the highest days of curd initiation (53.12, 53.20 and 53.16), day taken to curd harvest after curd initiation (25.98, 24.56 and 25.27) were observed in interaction V_3S_4 consequently pursued by interaction V_3S_3. Significantly maximum curd diameter (120.84, 121.34 and 121.10 mm, respectively), weight of curd with gourd leaf (1.01, 1.01 and 1.01 kg, consequently) and weight of curd without gourd leaf (0.49, 0.50 and 0.50 kg, respectively) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data in interaction V_1S_1 consequently pursued by interaction V_1S_2, as well as minimum value was observed in interaction V_4S_4 respectively. These results are close conformity with the results of **(Bhangre *et al.*, 2011)** evaluated the effect of various combination (Ganesh Broccoli and Pusa KTS-1) with five spacing (60x60 cm, 60x45 cm, 45x45 cm, 60x30 cm and 45x30 cm). Interaction impact of various varieties and spacing was observed non critical however, statistically the interaction impact of V_1S_1 was the best among the all treatment combination except yield per hectare. Yield attributes was significantly affected by interaction. Interaction (variety x spacing**)**, maximum yield per hectare (30.24, 30.52 and 30.38 t ha^{-1}, respectively) were observed in interaction V_1S_4, 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data consequently pursued by interaction V_4S_1, whereas, minimum yield per hectare (17.28, 17.50 and 17.39 t ha^{-1}, consequently) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data subsequently followed by interaction V_2S_1. It was observed that the maximum ascorbic acid (79.93, 79.96 and 79.95 mg/100g, consequently) and total soluble solids (8.88, 8.76 and 8.82 ^{0}Brix, respectively) in interaction V_1S_1, 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data respectively which was

followed by interaction V_1S_2, as well as minimum values were recorded in interaction V_3S_4, ascorbic acid (77.04, 77.36 and 77.20 mg/100g, consequently) and total soluble solids (7.42, 7.56 and 7.49 ^{0}Brix, respectively) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data respectively. These finding are in close conformity with **(Singhal *et al*., 2009)** reported that there was no any significant affect of spacing on ascorbic acid content on broccoli. Significantly higher value of total sugar (4.08, 4.06 and 4.07 %, respectively), reducing sugar (3.58, 3.52 and 3.50 %, consequently) and non-reducing sugar (0.88, 0.82 and 0.85 %, respectively) in interaction V_3S_2, 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data consequently pursued by in interaction V_3S_3, whereas, minimum values were recorded in interaction V_2S_1. **(Dogra and Awasthi, 2009)** assessed the fresh edible portion of heads of four cultivars of broccoli for different biochemical constituents at pre-harvest, collect and post-harvest stages. Wide variation in quality parameters viz., vitamins-c, T.S.S, Total sugar, reducing sugar, dampness, protein, complete lipids, sugars, all out chlorophyll, absolute carotenoids, ascorbic corrosive, all out phenols, glucosinolates, calcium, iron, sodium, potassium and phosphorus content was seen to extend from 89.09 to 89.49%, 2.08 to 2.71%, 183.3 to 196.9 mg/100g, 4.2 to 4.6%, 0.06 to 0.23 mg/g, 0.10 to 0.60 mg/g, 50.69 to 69.40 mg/100g, 0.58 to 0.89%, 125.5 to 249.2 mg/100g, 46.93 to 76.90 mg/100g, 0.70 to 1.10 mg/100g, 17.00 to 21.00 mg/100g, 117.31 to 318.00 mg/100g and 47.00 to 74.00 mg/100g at pre-gather stage and 89.56 to 91.24%, 3.16 to 3.86%, 243.3 to 288.3 mg/100g, 5.4 to 5.6%, 0.13 to 0.42 mg/g, 0.36 to 1.40 mg/g, 58.80 to 81.31 mg/100g, 0.87 to 1.18%, 264.1 to 344.2 mg/100g, 54.00 to 79.88 mg/100g, 0.90 to 1.61 mg/100g, 23.00 to 26.00 mg/100g, 123.82 to 324.66 mg/100g and 52.00 to 79.00 mg/100g at collect organize, as needs be. At post-harvest stage, variation in the above expressed quality parameters was seen from 88.44 to 87.78%, 3.02 to 3.75%, 228.6 to 276.6 mg/100g, 4.8 to 5.1%, 0.04 to 0.30 mg/g, 0.29 to 1.33 mg/g, 47.24 to 71.04 mg/100g, 1.32 to 1.49%, 250.1 to 329.8 mg/100g, 53.31 to 78.83 mg/100g, 0.90 to 1.60 mg/100g, 22.16 to 25.60 mg/100g, 122.00 to 324.50 mg/100g and 52.00 to 79.00 mg/100g, separately. In view of genotypic rating at various gather organizes, the heads of cultivar(s) Palam Vichitra developed to be the best followed by Palam Haritika, Palam Samridhi and Palam Kanchan and collect stage 129 DAT rose out to be the best harvest stage.

Chapter-6

Summary & Conclusion

CHAPTER -6

SUMMARY AND CONCLUSION

The present investigation entitled **"Studies on the influence of varieties and spacing on growth, yield and quality traits of sprouting broccoli (*Brassica oleracea* L. var. *italica* Plenck)"** was carried out at Horticulture Research Farm, Department of Applied Plant Science (Horticulture), School for Bio-sciences and Biotechnology, Babasaheb Bhimrao Ambedkar University (A Central University), Vidya Vihar, Raebareli Road, Lucknow (U.P.), India, during rabi season of (2017-18 & 2018-19). The experimental material consisted of 16 treatments with 3 replication of four varieties viz. V_1-(Pusa Broccoli KTS-1), V_2-(Palam Kanchan), V_3-(Palam Vichitra), V_4-(Palam Samridhi), Four plant spacing viz.- S_1- (60x45 cm), S_2 – (60×30 cm), S_3 – (45×45 cm), S_4 – (45×30 cm) and combined influence of varieties and spacing interaction in factorial Randomized Block Design. The salient features of the experiment are summarized below:

1. The highest plant height was measured in variety V_1 Pusa Broccoli KTS-1 was recorded (66.78, 67.21 and 67.00 cm, respectively) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data. Lowest in V_3 Palam Vichitra in 1st year (66.08 cm), 2nd year (66.01 cm) and united (66.05cm) respectively. Maximum plant height (67.37, 68.44 and 67.91 cm, consequently) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data was measured in spacing S_1 (60x45cm) and lowest in S_4 (45x30cm) in 1st year (64.63 cm), 2nd year (65.12 cm) and pooled data (64.88 cm). The highest plant height (68.37, 68.85 and 68.61 cm, respectively) was estimated in correlation V_1S_1 and least in V_3S_4 in 1st year (64.35 cm), 2nd year (64.49 cm) and pooled (64.42 cm).

2. The topmost stem diameter in variety V_1 Pusa Broccoli KTS-1 was recorded (3.52, 3.55 and 3.53 cm, respectively) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data. Lowest in V_3 Palam Vichitra in 1st year (3.16 cm), 2nd year (3.17 cm) and pooled (3.16 cm) respectively. The highest stem diameter was measured in spacing S_1 (60x45cm) (3.40, 3.46 and 3.43 cm, consequently) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19), pooled data and lowest in S_4 (45x30cm) in 1st year (3.26 cm), 2nd year (3.27 cm) and pooled value in (3.27

cm), consequently. The uppermost stem diameter (3.57, 3.64 and 3.61 cm, respectively) was estimated in interaction V_1S_1 and lowest in V_3S_4 in 1st year value in (3.11 cm), 2nd year value in (3.11 cm) and pooled data measured in (3.11 cm) respectively.

3. The maximum plant spreading (E-W) direction in variety V_1 Pusa Broccoli KTS-1 was recorded (61.38, 62.50 and 61.94 cm, respectively) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data. Minimum observation was taken in V_3 Palam Vichitra, 1st year (58.44 cm), 2nd year (56.94 cm) and pooled (57.69 cm) respectively. The highest plant spreading (E-W) direction was measured in spacing S_1 (60x45cm) (62.54, 64.01 and 63.28 cm, consequently) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19), pooled data and lowest in S_4 (45x30cm) in 1st year (57.38 cm), 2nd year (54.56 cm) and pooled value in (55.97 cm), consequently. The maximum plant spreading (E-W) direction (64.12, 68.13 and 66.13 cm, respectively) was estimated in interaction V_1S_1 and minimum in V_3S_4 in 1st year value in (55.94 cm), 2nd year value in (51.06 cm) and pooled data measured in (53.50 cm) respectively.

4. The maximum plant spreading (N-S) direction in variety V_1 Pusa Broccoli KTS-1 was recorded (54.27, 55.38 and 54.82 cm, respectively) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data. Minimum observation was taken in V_3 Palam Vichitra, 1st year (50.35 cm), 2nd year (49.42 cm) and pooled (49.93 cm) respectively. The highest plant spreading (N-S) direction was measured in spacing S_1 (60x45cm) (52.88, 53.24 and 53.06 cm, consequently) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19), pooled data and lowest in S_4 (45x30cm) in 1st year (51.79 cm), 2nd year (50.73 cm) and pooled value in (51.26 cm), consequently. The maximum plant spreading (N-S) direction (54.57, 55.67 and 55.12 cm, respectively) was estimated in interaction V_1S_1 and minimum in V_3S_4 in 1st year value in (48.52 cm), 2nd year value in (48.44 cm) and pooled data measured in (48.48 cm) respectively.

5. The highest number of leaves per plant was observed in variety V_1 Pusa Broccoli KTS-1 was recorded (23.79, 23.93 and 23.86, respectively) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data. The lowest observation was taken in V_3 Palam Vichitra, 1st year (23.26), 2nd year (23.25) and pooled (23.26)

respectively. The maximum number of leaves per plant was measured in spacing S_1 (60x45cm) (24.33, 24.54 and 24.44, consequently) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19), pooled data and minimum in S_4 (45x30cm) in 1st year (22.81), 2nd year (22.86) and pooled value in (22.84), consequently. The maximum number of leaves per plant (24.72, 24.92 and 24.82, respectively) was estimated in interaction V_1S_1 and minimum in V_3S_4 in 1st year value in (22.19), 2nd year value in (22.44 cm) and pooled data measured in (22.32) respectively.

6. The maximum length of leaves was observed in variety V_1 Pusa Broccoli KTS-1 was recorded (51.16, 51.15 and 51.16 cm, respectively) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data. Minimum observation was taken in V_3 Palam Vichitra, 1st year (49.10 cm), 2nd year (49.04 cm) and pooled (49.70 cm) respectively. The highest length of leaves was measured in spacing S_1 (60x45cm) (51.95, 52.03 and 51.99 cm, consequently) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19), pooled data and lowest in S_4 (45x30cm) in 1st year (48.77 cm), 2nd year (48.65 cm) and pooled value in (48.71 cm), consequently. The maximum length of leaves (52.79, 52.79 and 52.79 cm, respectively) was estimated in interaction V_1S_1 and minimum length of leaves was taken in V_3S_4 in 1st year value in (47.76 cm), 2nd year value in (47.32 cm) and pooled data measured in (47.54 cm) respectively.

7. The maximum width of leaves was observed in variety V_1 Pusa Broccoli KTS-1 was recorded (30.33, 30.69 and 30.51 cm, respectively) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data. Minimum observation was taken in V_3 Palam Vichitra, 1st year (29.49 cm), 2nd year (29.63 cm) and pooled (29.56 cm) respectively. The highest width of leaves was measured in spacing S_1 (60x45cm) (31.02, 31.20 and 31.11 cm, consequently) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19), pooled data and lowest in S_4 (45x30cm) in 1st year (28.69 cm), 2nd year (28.59 cm) and pooled value in (28.64 cm), consequently. The maximum width of leaves (31.35, 31.36 and 31.36 cm, respectively) was estimated in interaction V_1S_1 and minimum width of leaves was taken in V_3S_4 in 1st year value in (28.02 cm), 2nd year value in (27.18 cm) and pooled data measured in (27.60 cm) respectively.

8. The highest dry weight of plant was measured in variety V_2 Palam Kanchan recorded (190.38, 198.02 and 194.20 g, respectively) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data. Lowest in V_3 Palam Vichitra in 1st year (109.15 g), 2nd year (115.65 g) and united (112.40 g) respectively. Maximum dry weight of plant (164.85, 169.28 and 167.67 g, consequently) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data was measured in spacing S_4 (45x30 cm) and lowest dry weight of plant was taken in S_1 (60x45 cm) in 1st year (133.41 g), 2nd year (137.80 g) and pooled data (135.60 g). The highest dry weight of plant (201.34, 206.12 and 203.73 g, respectively) was estimated in correlation V_2S_4 and least data was measured in V_1S_1 in 1st year (99.48 g), 2nd year (101.74 g) and pooled value (100.61 g), consequently.

9. Varieties V_1 Pusa Broccoli KTS-1 showed in (47.57, 48.30 and 47.94 days, consequently) had taken earliest curd initiation 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled value. The highest curd initiation days measured in varieties V_3 PalamVichitra in 1st year (52.37), 2nd year (52.76) and pooled data (52.56). Plant spacing S_1 (60x45cm) as found (48.62, 49.31 and 48.97 days, respectively) had taken earliest curd initiation in 1st year i.e. in (2017-18), in 2nd year i.e. in (2018-19) and pooled data was measured earliest curd initiation days. The highest curd initiation days was measured in S_4 (45x30cm) in 1st year (54.80), 2nd year (51.24) and pooled value (51.02). The combined influence of varieties and spacing interaction V_1S_1 was taken earliest curd initiation (46.02, 46.84 and 46.43 days, consequently) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and united value. The highest curd initiation days measured inV_3S_4 in 1st year (53.12), 2nd year (53.20) and pooled data showed in (53.16), respectively.

10. Varieties V_1 Pusa Broccoli KTS-1 showed in (22.70, 22.43 and 22.58 days, consequently) had taken earliest curd initiation 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled value. The highest curd initiation days measured in varieties V_3 PalamVichitra in 1st year (24.87), 2nd year (23.56) and pooled data (24.21). Plant spacing S_1 (60x45cm) as found (22.98, 22.08 and 22.53 days, respectively) had taken earliest curd initiation in 1st year i.e. in (2017-18), in 2nd year i.e. in (2018-19) and pooled data was measured earliest curd initiation days. The highest curd initiation days was measured in S_4 (45x30cm) in 1st year

(24.34), 2nd year (23.87) and pooled value (24.10). The combined influence of varieties and spacing interaction V_1S_1 was taken earliest curd initiation (22.04, 21.08 and 21.56 days, consequently) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and united value. The highest curd initiation days measured inV_3S_4 in 1st year (25.98), 2nd year (24.56) and pooled data showed in (25.27), respectively.

11. The recorded data revealed that maximum curd diameter was found in varieties V_1 Pusa Broccoli KTS-1 showed in (117.38, 120.45 and 118.92 mm, respectively) in 1st year i.e. in (2017-18), 2st year i.e. in (2018-19) and pooled data. Minimum curd diameter measured in varieties V_4 Palam Samridhi in 1st year (108.66 mm), 2nd year (109.72 mm) and pooled data (109.19 mm). Plant spacing S_1 (60x45mm) as found (116.42, 117.34 and 116.88 mm, consequently) had taken maximum curd diameter in 1st year, 2nd year and collective value and minimum curd diameter was measured in S_4 (45x30cm) in 1st year (111.14 mm), 2nd year (111.61 mm) and pooled data (111.38 mm). The combined influence of varieties and spacing interaction had taken maximum curd diameter in V_1S_1 showed in (120.84, 121.34 and 121.10 mm, respectively) in 1st year, 2nd year and pooled value. Interaction V_4S_4 showed minimum curd diameter was measured 1st year (107.34 mm), 2nd year (108.84 mm) and pooled data showed in (108.09 mm), respectively.

12. The recorded data revealed that maximum weight of curd with guard leaves in varieties V_1 Pusa Broccoli KTS-1 showed in (944.55, 951.07 and 947.81 g, respectively) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data. Minimum weight of curd with guard leaves was taken in varieties V_4 Palam Samridhi in 1st year (891.86 g), 2nd year (898.74 g) and pooled data (895.30 g). Plant spacing S_1 (60x45mm) as found (995.31, 999.31 and 997.31 g, consequently) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data. Minimum was weight of curd with guard leaves measured in S_4 (45x30cm) in 1st year (843.41 g), 2nd year (856.75 g) and pooled (850.08 g) respectively. The combined influence of varieties and spacing interaction had taken maximum weight of curd with guard leaves in V_1S_1 showed in (1000.72, 1002.73 and 1001.73 g, respectively) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19), united value and minimum weight of curd with guard leaves was measured in

V_4S_4 in 1st year (800.17 g), 2nd year (803.14 g) and in pooled data showed in (801.66 g), consequently.

13. The recorded data revealed that maximum weight of curd without guard leaves in varieties V_1 Pusa Broccoli KTS-1 showed in (458.74, 465.89 and 462.32 g, respectively) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data. Minimum weight of curd without guard leaves was taken in varieties V_4 Palam Samridhi in 1st year (435.36 g), 2nd year (438.62 g) and pooled data (436.99 g). Plant spacing S_1 (60x45mm) as found (481.21, 486.18 and 483.70 g, consequently) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled data. Minimum was weight of curd without guard leaves measured in S_4 (45x30cm) in 1st year (428.55 g), 2nd year (404.14 g) and pooled data (416.35 g) respectively. The combined influence of varieties and spacing interaction had taken maximum weight of curd without guard leaves in V_1S_1 showed in (499.80, 501.12 and 500.46 g, respectively) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19), united value and minimum weight of curd without guard leaves was measured in V_4S_4 in 1st year (384.92 g), 2nd year (390.14 g) and in pooled data showed in (387.53 g), consequently.

14. The recorded data revealed that the maximum yield was found in varieties V_1 Pusa Broccoli KTS-1 showed value in (7.90, 8.02 and 7.96 kg/plot, consequently) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19), collective data and minimum yield measured in varieties V_4 Palam Samridhi in 1st year (7.50 kg/plot), 2nd year (7.56 kg/plot) and pooled data (7.53 kg/plot). Plant spacing S_4 (45x30mm) as found (9.59, 9.69 and 9.64 kg/plot, respectively) had taken in 1st year, 2nd year and pooled value was measured maximum yield. Minimum yield was measured in S_1 (60x45cm) in 1st year (5.78 kg/plot), 2nd year (5.84 kg/plot) and pooled data (5.81 kg/plot) respectively. The combined influence of varieties and spacing interaction had taken maximum yield in V_1S_4 showed in (9.80, 9.89 and 9.84 kg/plot, respectively) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and collective value. Minimum yield was measured in V_4S_1 in 1st year (5.60 kg/plot), 2nd year (5.67 kg/plot) and pooled data showed in (5.63 kg/plot), respectively.

15. The recorded data revealed that the maximum yield was found in varieties V_1 Pusa Broccoli KTS-1 showed value in (243.90, 247.61 and 245.75 q/ha, consequently) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19), collective data and minimum yield measured in varieties V_4 Palam Samridhi in 1st year (231.48 q/ha), 2nd year (233.26 q/ha) and pooled data (232.37 q/ha). Plant spacing S_4 (45x30mm) as found (295.83, 299.23 and 297.53 q/ha, respectively) had taken in 1st year, 2nd year and pooled value was measured maximum yield. Minimum yield was measured in S_1 (60x45cm) in 1st year (178.32 q/ha), 2nd year (180.09 q/ha) and pooled data (179.21 q/ha) respectively. The combined influence of varieties and spacing interaction had taken maximum yield in V_1S_4 showed in (302.46, 305.24 and 303.85 q/ha, respectively) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and collective value. Minimum yield was measured in V_4S_1 in 1st year (172.83 q/ha), 2nd year (175.00 q/ha) and pooled data showed in (173.91 q/ha), respectively.

16. The maximum ascorbic acid was observed in varieties V_1 Pusa Broccoli KTS-1 showed value in (79.12, 79.15 and 79.14 mg/100g, respectively) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19), collective data and minimum ascorbic acid measured in varieties V_3 Palam Vichitra in 1st year (78.08 mg/100g), 2nd year (78.09 mg/100g) and pooled data (78.09 mg/100g). Plant spacing S_2 (60x30 cm) had taken (79.19, 79.09 and 79.10 mg/100g, consequently) had taken maximum ascorbic acid in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled value. Minimum ascorbic acid was measured in S_4 (45x30 cm) in 1st year (77.58 mg/100g), 2nd year (77.53 mg/100g) and pooled data (77.56 mg/100g) respectively. The combined influence of varieties and spacing interaction had taken maximum ascorbic acid in V_1S_1 showed in (79.93, 79.96 and 79.95 mg/100g, respectively) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19), collective data and minimum was measured in V_3S_4 in 1st year (77.04 mg/100g), 2nd year (77.36 mg/100g) and pooled data showed in (77.20 mg/100g) respectively in our study.

17. The highest total soluble solid content was recorded in varieties V_1 Pusa Broccoli KTS-1 showed in (8.57, 8.47 and 8.52 ^{0}Brix, respectively) 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and collective data. Minimum was measured in

varieties V_3 Palam Vichitra in 1st year (7.92 ^{0}Brix), 2nd year (7.90 ^{0}Brix) and pooled data (7.91 ^{0}Brix). Plant spacing S_1 (60x45 cm) had taken maximum total soluble solid (8.49, 8.28 and 8.39 ^{0}Brix, consequently) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19), mutual value and minimum total soluble solid was measured in S_4 (45x30 cm) in 1st year (8.00 ^{0}Brix), 2nd year (7.92 ^{0}Brix) and pooled data (7.99 ^{0}Brix), respectively. The combined influence of varieties and spacing interaction had taken maximum total soluble solid in V_1S_1 showed in (8.88, 8.76 and 8.82 ^{0}Brix, consequently) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled value. Minimum total soluble solid was measured in V_3S_4 in 1st year (7.42 ^{0}Brix), 2nd year (7.56 ^{0}Brix) and pooled data showed in (7.49 ^{0}Brix) respectively.

18. The pertaining data was revealed that the maximum total sugar was found in varieties V_3 Palam Vichitra showed in (3.98, 3.98 and 3.98 %, respectively) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and collective value. Minimum total sugar was measured in varieties V_2 Palam Kanchan in 1st year (3.73 %), 2nd year (3.72 %) and pooled data (3.73 %). The highest total sugar had taken in spacing S_2 (60x30 cm) as found (3.91, 3.85 and 3.88 %, consequently) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19), pooled value and minimum total sugar was measured in S_1 (60x45 cm) in 1st year (3.83 %), 2nd year (3.83 %) and pooled (3.83 %) respectively. The combined influence of varieties and spacing interaction had taken maximum total sugar in V_3S_2, (4.08, 4.06 and 4.07 %, respectively) in 1st year, 2nd year and pooled value. Minimum total sugar (%) was measured in V_2S_1 in 1st year (3.54 %), in 2nd year (3.58 %) and pooled data showed in (3.56 %) respectively.

19. The maximum reducing sugar was observed in varieties V_3 Palam Vichitra showed in (3.38, 3.38 and 3.38 %, consequently) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19), united value and minimum data was measured in varieties V_1 Pusa Broccoli KTS-1 in 1st year (3.28 %), 2nd year (3.25 %) and pooled data (3.28 %). Spacing S_2 (60x30 cm) as found (3.30, 3.32 and 3.31 %, respectively) had taken maximum reducing sugar in 1st year, 2nd year and pooled value. Minimum reducing sugar was measured in S_1 (60x45 cm) in 1st year (3.27 %), 2nd year (3.26 %) and pooled (3.27 %), respectively. The combined influence of varieties and spacing interaction had taken maximum reducing sugar in V_3S_2 showed in (3.58, 3.52 and

3.55 %, consequently) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19), collective value and minimum reducing sugar was measured in V_2S_2 in 1st year (3.19 %), 2nd year (3.18 %) and pooled data (3.19 %) respectively in our study.

20. It is clear from the result that maximum non- reducing sugar in varieties V_3 Palam Vichitra showed in (0.72, 0.68 and 0.70 %, consequently) in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19) and pooled value and minimum non-reducing sugar was measured in varieties V_2 Palam Kanchan in 1st year (0.52 %), 2nd year (0.52 %) and pooled data (0.52 %). Spacing S_2 (60x30 cm) as found (0.64, 0.65 and 0.65 %, respectively had taken maximum non-reducing sugar in 1st year i.e. in (2017-18), 2nd year i.e. in (2018-19), joint value and minimum non-reducing sugar was measured in S_4 (45x30cm) in 1st year (0.56 %), S_1 (60x45cm), 2nd year (0.50 %) and S_1 (60x45 cm) pooled (0.56 %) respectively. The combined influence of varieties and spacing interaction had taken maximum non-reducing sugar in V_3S_2 showed in (0.88, 0.82 and 0.85 %, consequently) in 1st year, 2nd year, pooled value and minimum non-reducing sugar (%) was measured in V_2S_1 in 1st year (0.44 %), 2nd year (0.42 %) and pooled data (0.43 %) respectively in our study.

CONCLUSION

The varieties and spacing showed significant variation among the different treatments. When the distance between plants increased the growth related parameters were increased. Generally, the wider the plant spacing the better is the performance of the broccoli. On the basis of above result obtained in the present investigation. Hence, it can be concluded from the study that variety V_1 Pusa Broccoli KTS-1, spacing S_1 (60x45 cm) and interaction (variety x spacing) V_1S_1 significantly affected that maximum plant height (cm), stem diameter (cm), plant canopy spreading (E-W) (cm), Plant canopy spreading (N-S)(cm), number of leaves per plant, length of leaves (cm), width of leaves (cm), early days of curd initiation, early days taken to curd harvest and maximum curd diameter (mm), weight of curd with gourd leaf (kg), weight of curd without gourd leaf (kg) and total soluble solids (^{0}Brix).Therefore, it may be recommended that variety V_1 Pusa Broccoli KTS-1, spacing S_1 (60x45cm) and interaction (variety x spacing) V_1S_1 for maximum growth and better quality characters under Lucknow condition.

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Appendices

APPENDICES

MECHANICAL AND CHEMICAL ANALYSIS OF SOIL

Before sowimg soil sample were drawn out by random method from different places in the field and a composite sample was prepared and subjected to mechanical and chemical analysis the samples were sieved with 0.55 mm sieves. The mechanical, chemical and physical analysis of soils are given as under:

Analysis of the soil (Experimental field)

Constituents	Values (%)
Sand	58.21
Silt	21.26
Clay	20.53

Chemical Analysis

Contituents	Values (%)	Method
Total N_2	0.0380	Kjeldhal Method
Available P_2O_5 kg/ha	18.60	Olsen Method
Available K_2O	238.00	Morgan Mathod
Organic Carban	0.64	Black Method

Physical Characters

Items	Values(%)
pH	7.60
EC	0.30
Bulk Density	1.48
Particle Density	2.56
Pore Space	41.88
Permeability	5.06
M.E.	21.20

Appendix-1: Analysis of variance of plant height (cm) at 30 DAT of sprouting broccoli in (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	39.534			
Factor A	3	3.500	1.167	0.226	0.87773
Factor B	3	2.297	0.766	0.148	0.93005
Intraction (AxB)	9	1.123	0.125	0.024	1.00000
Error	30	155.023	5.167		
Total	47	201.477			

Appendix-2: Analysis of variance of plant height (cm) at 30 DAT of sprouting broccoli in (2018-19).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	39.737			
Factor A	3	2.946	0.982	0.190	0.90259
Factor B	3	3.112	1.037	0.200	0.89527
Intraction (AxB)	9	1.364	0.152	0.029	1.00000
Error	30	155.286	5.176		
Total	47	202.445			

Appendix-3: Analysis of variance of plant height (cm) at 45 DAT of sprouting broccoli in (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	132.129			
Factor A	3	12.291	4.097	0.233	0.87234
Factor B	3	11.903	3.968	0.226	0.87750
Intraction (AxB)	9	9.584	1.065	0.061	0.99993
Error	30	526.497	17.550		
Total	47	692.404			

Appendix-4: Analysis of variance of plant height (cm) at 45 DAT of sprouting broccoli in (2018-19).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	131.176			
Factor A	3	9.338	3.113	0.179	0.90962
Factor B	3	11.048	3.683	0.212	0.88723
Intraction (AxB)	9	6.579	0.731	0.042	0.99999
Error	30	520.896	17.363		
Total	47	679.036			

Appendix-5: Analysis of variance of plant height (cm) at 60 DAT of sprouting broccoli in (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	250.077			
Factor A	3	11.776	3.925	0.119	0.94823
Factor B	3	27.376	9.125	0.277	0.84177
Intraction (AxB)	9	2.829	0.314	0.010	1.00000
Error	30	989.546	32.985		
Total	47	1281.604			

Appendix-6: Analysis of variance of plant height (cm) at 60 DAT of sprouting broccoli in (2018-19).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	252.723			
Factor A	3	10.760	3.587	0.108	0.95566
Factor B	3	43.522	14.507	0.438	0.72776
Intraction (AxB)	9	3.464	0.385	0.012	1.00000
Error	30	994.670	33.156		
Total	47	1305.139			

Appendix-7: Analysis of variance of plant height (cm) at harvesting stage of sprouting broccoli in (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	307.790			
Factor A	3	9.570	3.190	0.079	0.97078
Factor B	3	53.699	17.900	0.445	0.72293
Intraction (AxB)	9	7.688	0.854	0.021	1.00000
Error	30	1207.994	40.266		
Total	47	1586.742			

Appendix-8: Analysis of variance of plant height (cm) at harvesting stage of sprouting broccoli in (2018-19).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	313.413			
Factor A	3	9.511	3.170	0.078	0.97155
Factor B	3	77.955	25.985	0.637	0.59685
Intraction (AxB)	9	5.267	0.585	0.014	1.00000
Error	30	1223.106	40.770		
Total	47	1629.251			

Appendix-9: Analysis of variance of stem diameter (cm) at 30 DAT of sprouting broccoli in (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	0.334			
Factor A	3	3.890	1.297	31.948	0.00000
Factor B	3	2.013	0.671	16.534	0.00000
Intraction (AxB)	9	0.501	0.056	1.372	0.24419
Error	30	1.218	0.041		
Total	47	7.956			

Appendix-10: Analysis of variance of stem diameter (cm) at 30 DAT of sprouting broccoli in (2018-19).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	0.300			
Factor A	3	6.350	2.117	66.199	0.00000
Factor B	3	0.690	0.230	7.196	0.00089
Intraction (AxB)	9	0.248	0.028	0.861	0.56901
Error	30	0.959	0.032		
Total	47	8.547			

Appendix-11: Analysis of variance of stem diameter (cm) at 45 DAT of sprouting broccoli in (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	0.600			
Factor A	3	0.801	0.267	3.617	0.02430
Factor B	3	0.074	0.025	0.332	0.80233
Intraction (AxB)	9	0.026	0.003	0.040	0.99999
Error	30	2.215	0.074		
Total	47	3.716			

Appendix-12: Analysis of variance of stem diameter (cm) at 45 DAT of sprouting broccoli (2018-19).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	0.554			
Factor A	3	1.206	0.402	5.626	0.00350
Factor B	3	0.529	0.176	2.466	0.08138
Intraction (AxB)	9	0.421	0.047	0.654	0.74203
Error	30	2.144	0.071		
Total	47	4.853			

Appendix-13: Analysis of variance of stem diameter (cm) at 60 DAT of sprouting broccoli (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	0.790			
Factor A	3	1.120	0.373	3.856	0.01908
Factor B	3	0.163	0.054	0.560	0.64580
Intraction (AxB)	9	0.042	0.005	0.048	0.99997
Error	30	2.904	0.097		
Total	47	5.019			

Appendix-14:Analysis of variance of stem diameter (cm) at 60 DAT of sprouting broccoli (2018-19).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	0.808			
Factor A	3	1.387	0.462	1.387	0.462
Factor B	3	0.213	0.071	0.213	0.071
Intraction (AxB)	9	0.022	0.002	0.022	0.002
Error	30	2.968	0.099	2.968	0.099
Total	47	5.397			

Appendix-15: Analysis of variance of plant canopy spreading east-west direction (cm) at 30 DAT of sprouting broccoli (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	84.567			
Factor A	3	144.151	48.050	4.619	0.00900
Factor B	3	24.603	8.201	0.788	0.50990
Intraction (AxB)	9	2.681	0.298	0.029	1.00000
Error	30	312.070	10.402		
Total	47	568.072			

Appendix-16: Analysis of variance of plant canopy spreading (east-west) direction (cm) at 30 DAT of sprouting broccoli (2018-19).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	84.442			
Factor A	3	105.481	35.160	3.305	0.03349
Factor B	3	36.799	12.266	1.153	0.34387
Intraction (AxB)	9	9.057	1.006	0.095	0.99957
Error	30	319.138	10.638		
Total	47	554.917			

Appendix-17: Analysis of variance of plant canopy spreading (east-west) direction (cm) at 45 DAT of sprouting broccoli (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	167.004			
Factor A	3	40.206	13.402	0.628	0.60248
Factor B	3	55.881	18.627	0.873	0.46594
Intraction (AxB)	9	18.185	2.021	0.095	0.99957
Error	30	640.034	21.334		
Total	47	921.309			

Appendix-18: Analysis of variance of plant canopy spreading (east-west) direction (cm) at 45 DAT of sprouting broccoli (2018-19).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	172.960			
Factor A	3	18.217	6.072	0.271	0.84595
Factor B	3	79.415	26.472	1.180	0.33370
Intraction (AxB)	9	27.859	3.095	0.138	0.99809
Error	30	672.753	22.425		
Total	47	971.205			

Appendix-19: Analysis of variance of plant canopy spreading (east-west) direction (cm) at 60 DAT of sprouting broccoli (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	256.942			
Factor A	3	97.067	32.356	0.997	0.40785
Factor B	3	165.835	55.278	1.703	0.18756
Intraction (AxB)	9	91.014	10.113	0.311	0.96501
Error	30	973.961	32.465		
Total	47	1584.820			

Appendix-20: Analysis of variance of plant canopy spreading (east-west) direction (cm) at 60 DAT of sprouting broccoli (2018-19).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	259.647			
Factor A	3	324.706	108.235	3.334	0.03251
Factor B	3	551.461	183.820	5.662	0.00339
Intraction (AxB)	9	109.398	12.155	0.374	0.93832
Error	30	973.932	32.464		
Total	47	2219.143			

Appendix-21: Analysis of variance of plant canopy spreading (north-south) direction (cm) at 30 DAT of sprouting broccoli (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	77.631			
Factor A	3	94.972	31.657	3.283	0.03428
Factor B	3	8.960	2.987	0.310	0.81817
Intraction (AxB)	9	0.944	0.105	0.011	1.00000
Error	30	289.316	9.644		
Total	47	471.824			

Appendix-22: Analysis of variance of plant canopy spreading (north-south) direction (cm) at 30 DAT of sprouting broccoli (2018-19).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	76.302			
Factor A	3	68.191	22.730	2.343	0.09299
Factor B	3	9.874	3.291	0.339	0.79706
Intraction (AxB)	9	2.785	0.309	0.032	1.00000
Error	30	291.044	9.702		
Total	47	448.197			

Appendix-23: Analysis of variance of plant canopy spreading (north-south) direction (cm) at 45 DAT of sprouting broccoli (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	130.929			
Factor A	3	83.814	27.938	1.674	0.19357
Factor B	3	9.658	3.219	0.193	0.90039
Intraction (AxB)	9	1.950	0.217	0.013	1.00000
Error	30	500.650	16.688		
Total	47	727.001			

Appendix-24: Analysis of variance of plant canopy spreading (north-south) direction (cm) at 45 DAT of sprouting broccoli (2018-19).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	131.563			
Factor A	3	85.978	28.659	1.718	0.18442
Factor B	3	19.674	6.558	0.393	0.75884
Intraction (AxB)	9	7.807	0.867	0.052	0.99996
Error	30	500.467	16.682		
Total	47	745.489			

Appendix-25: Analysis of variance of plant canopy spreading (north-south) direction (cm) at 60 DAT of sprouting broccoli (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	193.185			
Factor A	3	183.068	61.023	2.490	0.07929
Factor B	3	14.550	4.850	0.198	0.89697
Intraction (AxB)	9	5.479	0.609	0.025	1.00000
Error	30	735.097	24.503		
Total	47	1131.379			

Appendix-26: Analysis of variance of plant canopy spreading (north-south) direction (cm) at 60 DAT of sprouting broccoli (2018-19).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	191.277			
Factor A	3	301.770	100.590	4.212	0.01338
Factor B	3	33.507	11.169	0.468	0.70700
Intraction (AxB)	9	40.116	4.457	0.187	0.99401
Error	30	716.395	23.880		
Total	47	1283.065			

Appendix-27: Analysis of variance of number of leaves per plant at 30 DAT of sprouting broccoli (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	4.665			
Factor A	3	1.469	0.490	0.821	0.49275
Factor B	3	3.443	1.148	1.923	0.14715
Intraction (AxB)	9	0.468	0.052	0.087	0.99970
Error	30	17.904	0.597		
Total	47	27.949			

Appendix-28: Analysis of variance of number of leaves per plant at 30 DAT of sprouting broccoli (2018-19).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	4.613			
Factor A	3	1.542	0.514	0.865	0.46989
Factor B	3	5.748	1.916	3.225	0.03639
Intraction (AxB)	9	0.370	0.041	0.069	0.99988
Error	30	17.822	0.594		
Total	47	30.094			

Appendix-29: Analysis of variance of number of leaves per plant at 45 DAT of sprouting broccoli (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	26.464			
Factor A	3	6.711	2.237	0.651	0.58878
Factor B	3	2.650	0.883	0.257	0.85582
Intraction (AxB)	9	0.799	0.089	0.026	1.00000
Error	30	103.156	3.439		
Total	47	139.780			

Appendix-30: Analysis of variance of number of leaves per plant at 45 DAT of sprouting broccoli (2018-19).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	26.859			
Factor A	3	7.275	2.425	0.702	0.55854
Factor B	3	10.764	3.588	1.038	0.38993
Intraction (AxB)	9	0.873	0.097	0.028	1.00000
Error	30	103.700	3.457		
Total	47	149.471			

Appendix-31: Analysis of variance of number of leaves per plant at 60 DAT of sprouting broccoli (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	39.060			
Factor A	3	1.866	0.622	0.121	0.94694
Factor B	3	18.428	6.143	1.196	0.32790
Intraction (AxB)	9	1.710	0.190	0.037	0.99999
Error	30	154.028	5.134		
Total	47	215.092			

Appendix-32: Analysis of variance of number of leaves per plant at 60 DAT of sprouting broccoli (2018-19).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	39.526			
Factor A	3	3.645	1.215	0.237	0.86969
Factor B	3	19.185	6.395	1.249	0.30965
Intraction (AxB)	9	1.683	0.187	0.037	0.99999
Error	30	153.666	5.122		
Total	47	217.706			

Appendix-33: Analysis of variance of length of leaves (cm) at 30 DAT of sprouting broccoli (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	71.386			
Factor A	3	103.065	34.355	3.920	0.01788
Factor B	3	82.314	27.438	3.131	0.04014
Intraction (AxB)	9	17.097	1.900	0.217	0.98972
Error	30	262.892	8.763		
Total	47	536.754			

Appendix-34: Analysis of variance of length of leaves (cm) at 30 DAT of sprouting broccoli (2018-19).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	74.844			
Factor A	3	109.444	36.481	3.991	0.01667
Factor B	3	108.976	36.325	3.974	0.01696
Intraction (AxB)	9	16.278	1.809	0.198	0.99260
Error	30	274.257	9.142		
Total	47	583.799			

Appendix-35: Analysis of variance of length of leaves (cm) at 45 DAT of sprouting broccoli (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	111.886			
Factor A	3	27.592	9.197	0.632	0.60021
Factor B	3	126.333	42.111	2.893	0.05157
Intraction (AxB)	9	7.255	0.806	0.055	0.99995
Error	30	436.671	14.556		
Total	47	709.737			

Appendix-36: Analysis of variance of length of leaves (cm) at 45 DAT of sprouting broccoli (2018-19).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	114.110			
Factor A	3	39.789	13.263	0.912	0.44694
Factor B	3	120.816	40.272	2.769	0.05884
Intraction (AxB)	9	22.347	2.483	0.171	0.99570
Error	30	436.338	14.545		
Total	47	733.400			

Appendix-37: Analysis of variance of length of leaves (cm) at 60 DAT of sprouting broccoli (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	176.749			
Factor A	3	66.218	22.073	0.944	0.43186
Factor B	3	75.072	25.024	1.070	0.37660
Intraction (AxB)	9	77.688	8.632	0.369	0.94090
Error	30	701.655	23.389		
Total	47	1097.383			

Appendix-38: Analysis of variance of length of leaves (cm) at 60 DAT of sprouting broccoli (2018-19).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	177.463			
Factor A	3	33.694	11.231	0.488	0.69316
Factor B	3	72.236	24.079	1.046	0.38640
Intraction (AxB)	9	2.125	0.236	0.010	1.00000
Error	30	690.376	23.013		
Total	47	975.895			

Appendix-39: Analysis of variance of width of leaves (cm) at 30 DAT of sprouting broccoli (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	7.758			
Factor A	3	11.175	3.725	3.891	0.01841
Factor B	3	16.921	5.640	5.892	0.00275
Intraction (AxB)	9	0.658	0.073	0.076	0.99982
Error	30	28.717	0.957		
Total	47	65.229			

Appendix-40: Analysis of variance of width of leaves (cm) at 30 DAT of sprouting broccoli (2018-19).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	8.179			
Factor A	3	14.233	4.744	4.790	0.00763
Factor B	3	21.755	7.252	7.322	0.00080
Intraction (AxB)	9	1.157	0.129	0.130	0.99850
Error	30	29.713	0.990		
Total	47	75.036			

Appendix-41: Analysis of variance of width of leaves (cm) at 45 DAT of sprouting broccoli (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	18.377			
Factor A	3	75.340	25.113	11.479	0.00004
Factor B	3	36.180	12.060	5.512	0.00388
Intraction (AxB)	9	4.965	0.552	0.252	0.98260
Error	30	65.634	2.188		
Total	47	200.495			

Appendix-42: Analysis of variance of width of leaves (cm) at 45 DAT of sprouting broccoli (2018-19).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	18.709			
Factor A	3	11.733	3.911	1.629	0.20351
Factor B	3	35.073	11.691	4.869	0.00708
Intraction (AxB)	9	8.780	0.976	0.406	0.92176
Error	30	72.037	2.401		
Total	47	146.332			

Appendix-43: Analysis of variance of width of leaves (cm) at 60 DAT of sprouting broccoli (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	62.877			
Factor A	3	4.491	1.497	0.181	0.90865
Factor B	3	40.481	13.494	1.629	0.20347
Intraction (AxB)	9	2.543	0.283	0.034	0.99999
Error	30	248.512	8.284		
Total	47	358.904			

Appendix-44: Analysis of variance of width of leaves (cm) at 60 DAT of sprouting broccoli (2018-19).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	63.509			
Factor A	3	6.916	2.305	0.273	0.84405
Factor B	3	49.574	16.525	1.960	0.14124
Intraction (AxB)	9	6.493	0.721	0.086	0.99972
Error	30	252.907	8.430		
Total	47	379.399			

Appendix-45: Analysis of variance of dry weight of plant (g) at 30 DAT of sprouting broccoli (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	4.208			
Factor A	3	12.998	4.333	7.146	0.00093
Factor B	3	1.767	0.589	0.971	0.41919
Intraction (AxB)	9	0.631	0.070	0.116	0.99905
Error	30	18.190	0.606		
Total	47	37.793			

Appendix-46: Analysis of variance of dry weight of plant (g) at 30 DAT of sprouting broccoli (2018-19).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	4.043			
Factor A	3	15.586	5.195	9.069	0.00020
Factor B	3	9.617	3.206	5.596	0.00360
Intraction (AxB)	9	3.639	0.404	0.706	0.69888
Error	30	17.186	0.573		
Total	47	50.070			

Appendix-47: Analysis of variance of dry weight of plant (g) at 45 DAT of sprouting broccoli (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	28.069			
Factor A	3	272.817	90.939	21.709	0.00000
Factor B	3	18.133	6.044	1.443	0.24990
Intraction (AxB)	9	6.131	0.681	0.163	0.99642
Error	30	125.672	4.189		
Total	47	450.823			

Appendix-48: Analysis of variance of dry weight of plant (g) at 45 DAT of sprouting broccoli (2018-19).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	29.995			
Factor A	3	244.600	81.533	17.878	0.00000
Factor B	3	31.016	10.339	2.267	0.10099
Intraction (AxB)	9	2.996	0.333	0.073	0.99985
Error	30	136.815	4.560		
Total	47	445.421			

Appendix-49: Analysis of variance of dry weight of plant (g) at 60 DAT of sprouting broccoli (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	150.911			
Factor A	3	865.087	288.362	12.832	0.00001
Factor B	3	144.968	48.323	2.150	0.11469
Intraction (AxB)	9	12.965	1.441	0.064	0.99991
Error	30	674.187	22.473		
Total	47	1848.118			

Appendix-50: Analysis of variance of dry weight of plant (g) at 60 DAT of sprouting broccoli (2018-19).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	156.773			
Factor A	3	805.613	268.538	11.534	0.00003
Factor B	3	129.202	43.067	1.850	0.15948
Intraction (AxB)	9	7.726	0.858	0.037	0.99999
Error	30	698.495	23.283		
Total	47	1797.809			

Appendix-51: Analysis of variance of dry weight of plant (g) at harvesting stage of sprouting broccoli (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	1469.345			
Factor A	3	62083.512	20694.504	79.044	0.00000
Factor B	3	5309.319	1769.773	6.760	0.00128
Intraction (AxB)	9	760.082	84.454	0.323	0.96091
Error	30	7854.298	261.810		
Total	47	77476.556			

Appendix-52: Analysis of variance of dry weight of plant (g) at harvesting stage of sprouting broccoli (2018-19).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	1578.312			
Factor A	3	61214.223	20404.741	74.072	0.00000
Factor B	3	6642.964	2214.321	8.038	0.00045
Intraction (AxB)	9	835.490	92.832	0.337	0.95519
Error	30	8264.205	275.473		
Total	47	78535.193			

Appendix-53: Analysis of variance of curd initiation days of sprouting broccoli (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	164.473			
Factor A	3	171.770	57.257	2.440	0.08369
Factor B	3	31.284	10.428	0.444	0.72299
Intraction (AxB)	9	5.207	0.579	0.025	1.00000
Error	30	703.879	23.463		
Total	47	1076.612			

Appendix-54: Analysis of variance of curd initiation days of sprouting broccoli (2018-19).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	168.983			
Factor A	3	150.482	50.161	2.088	0.12281
Factor B	3	26.355	8.785	0.366	0.77828
Intraction (AxB)	9	3.771	0.419	0.017	1.00000
Error	30	720.787	24.026		
Total	47	1070.378			

Appendix-55: Analysis of variance of day taken to curd harvest after curd initiation of sprouting broccoli (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	36.787			
Factor A	3	29.963	9.988	1.884	0.15361
Factor B	3	14.049	4.683	0.883	0.46087
Intraction (AxB)	9	2.968	0.330	0.062	0.99992
Error	30	159.058	5.302		
Total	47	242.827			

Appendix-56: Analysis of variance of day taken to curd harvest after curd initiation of sprouting broccoli (2018-19).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	35.180			
Factor A	3	7.488	2.496	0.508	0.67951
Factor B	3	22.453	7.484	1.524	0.22840
Intraction (AxB)	9	5.164	0.574	0.117	0.99900
Error	30	147.300	4.910		
Total	47	217.585			

Appendix-57: Analysis of variance of curd diameter (cm) of sprouting broccoli (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	913.858			
Factor A	3	520.053	173.351	1.435	0.25219
Factor B	3	244.981	81.660	0.676	0.57366
Intraction (AxB)	9	138.367	15.374	0.127	0.99861
Error	30	3624.939	120.831		
Total	47	5442.198			

Appendix-58: Analysis of variance of curd diameter (cm) of sprouting broccoli (2018-19).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	942.737			
Factor A	3	664.888	221.629	1.796	0.16918
Factor B	3	263.421	87.807	0.712	0.55272
Intraction (AxB)	9	93.035	10.337	0.084	0.99974
Error	30	3701.695	123.390		
Total	47	5665.776			

Appendix-59: Analysis of variance of weight of curd with gourd leaf (g) of sprouting broccoli (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	62270.626			
Factor A	3	20460.060	6820.020	0.828	0.48901
Factor B	3	197488.142	65829.381	7.990	0.00046
Intraction (AxB)	9	4206.833	467.426	0.057	0.99995
Error	30	247158.346	8238.612		
Total	47	531584.007			

Appendix-60: Analysis of variance of weight of curd with gourd leaf (g) of sprouting broccoli (2018-19).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	62948.381			
Factor A	3	20283.517	6761.172	0.813	0.49692
Factor B	3	176713.217	58904.406	7.080	0.00098
Intraction (AxB)	9	6617.908	735.323	0.088	0.99996
Error	30	249577.555	8319.252		
Total	47	516140.578			

Appendix-61: Analysis of variance of weight of curd without gourd leaf (g) of sprouting broccoli (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	14109.458			
Factor A	3	4331.278	1443.759	0.746	0.53320
Factor B	3	46239.659	15413.220	7.964	0.00047
Intraction (AxB)	9	2305.623	256.180	0.132	0.99837
Error	30	58061.428	1935.381		
Total	47	125047.445			

Appendix-62: Analysis of variance of weight of curd without gourd leaf (g) of sprouting broccoli (2018-19).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	14487.967			
Factor A	3	6001.867	2000.622	1.010	0.40202
Factor B	3	46895.273	15631.758	7.891	0.00050
Intraction (AxB)	9	981.397	109.044	0.055	0.99996
Error	30	59431.149	1981.038		
Total	47	127797.653			

Appendix-63: Analysis of variance of yield (kg/plot) of sprouting broccoli (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	4.177			
Factor A	3	1.219	0.406	0.815	0.49578
Factor B	3	97.822	32.607	65.385	0.00000
Intraction (AxB)	9	0.685	0.076	0.153	0.99719
Error	30	14.961	0.499		
Total	47	118.865			

Appendix-64: Analysis of variance of yield (kg/plot) of sprouting broccoli (2018-19).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	4.287			
Factor A	3	1.711	0.570	1.119	0.35704
Factor B	3	100.521	33.507	65.740	0.00000
Intraction (AxB)	9	0.318	0.035	0.069	0.99988
Error	30	15.291	0.510		
Total	47	122.128			

Appendix-65: Analysis of variance of yield (q/ha) of sprouting broccoli (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	3967.953			
Factor A	3	1162.262	387.421	0.816	0.49493
Factor B	3	93245.844	31081.948	65.505	0.00000
Intraction (AxB)	9	647.801	71.978	0.152	0.99725
Error	30	14234.929	474.498		
Total	47	113258.789			

Appendix-66: Analysis of variance of yield (q/ha) of sprouting broccoli (2018-19).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	4074.884			
Factor A	3	1630.250	543.417	1.119	0.35695
Factor B	3	95802.763	31934.254	65.757	0.00000
Intraction (AxB)	9	304.766	33.863	0.070	0.99988
Error	30	14569.178	485.639		
Total	47	116381.841			

Appendix-67: Analysis of variance of ascorbic acid (mg/100g) of sprouting broccoli (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	427.140			
Factor A	3	6.803	2.268	0.040	0.98905
Factor B	3	21.031	7.010	0.124	0.94513
Intraction (AxB)	9	3.173	0.353	0.006	1.00000
Error	30	1694.589	56.486		
Total	47	2152.736			

Appendix-68: Analysis of variance of ascorbic acid (mg/100g) of sprouting broccoli (2018-19).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	428.747			
Factor A	3	8.646	2.882	0.051	0.98443
Factor B	3	23.724	7.908	0.140	0.93507
Intraction (AxB)	9	5.377	0.597	0.011	1.00000
Error	30	1690.972	56.366		
Total	47	2157.465			

Appendix-69: Analysis of variance of T.S.S. (^{o}Brix) of sprouting broccoli (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	4.907			
Factor A	3	3.211	1.070	1.725	0.18307
Factor B	3	1.790	0.597	0.961	0.42376
Intraction (AxB)	9	1.467	0.163	0.263	0.97999
Error	30	18.616	0.621		
Total	47	29.991			

Appendix-70: Analysis of variance of T.S.S. (^{o}Brix) of sprouting broccoli (2018-19).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	4.696			
Factor A	3	2.265	0.755	1.252	0.30830
Factor B	3	0.678	0.226	0.375	0.77148
Intraction (AxB)	9	1.139	0.127	0.210	0.99082
Error	30	18.080	0.603		
Total	47	26.859			

Appendix-71: Analysis of variance of total sugar (%) of sprouting broccoli (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	1.049			
Factor A	3	0.509	0.170	1.188	0.33113
Factor B	3	0.035	0.012	0.081	0.96973
Intraction (AxB)	9	0.541	0.060	0.421	0.91348
Error	30	4.286	0.143		
Total	47	6.420			

Appendix-72: Analysis of variance of total sugar (%) of sprouting broccoli (2018-19).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	1.010			
Factor A	3	0.469	0.156	1.097	0.36551
Factor B	3	0.128	0.043	0.299	0.82566
Intraction (AxB)	9	0.654	0.073	0.510	0.85566
Error	30	4.278	0.143		
Total	47	6.540			

Appendix-73: Analysis of variance of reducing sugar (%) of sprouting broccoli (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	0.776			
Factor A	3	0.179	0.060	0.554	0.64969
Factor B	3	0.039	0.013	0.121	0.94695
Intraction (AxB)	9	0.352	0.039	0.364	0.94321
Error	30	3.225	0.108		
Total	47	4.571			

Appendix-74: Analysis of variance of reducing sugar (%) of sprouting broccoli (2018-19).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	0.741			
Factor A	3	0.110	0.037	0.350	0.78970
Factor B	3	0.068	0.023	0.216	0.88456
Intraction (AxB)	9	0.200	0.022	0.212	0.99046
Error	30	3.141	0.105		
Total	47	4.260			

Appendix-75: Analysis of variance of non-reducing sugar (%) of sprouting broccoli (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	0.024			
Factor A	3	0.251	0.084	17.591	0.00000
Factor B	3	0.087	0.029	6.100	0.00228
Intraction (AxB)	9	0.229	0.025	5.347	0.00022
Error	30	0.142	0.005		
Total	47	0.733			

Appendix-76: Analysis of variance of non-reducing sugar (%) of sprouting broccoli (2018-19).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	0.025			
Factor A	3	0.169	0.056	12.501	0.00002
Factor B	3	0.061	0.020	4.514	0.00996
Intraction (AxB)	9	0.274	0.030	6.759	0.00003
Error	30	0.135	0.005		
Total	47	0.663			

Appendix-77: Analysis of variance of gross income (Rs./ha) of sprouting broccoli (2017-18).

Source of Variations	D. F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	120458481.125			
Factor A	3	290501864.063	96833954.688	14.180	0.00001
Factor B	3	23311728051.563	7770576017.188	1137.930	0.00000
Intraction (AxB)	9	161852742.188	17983638.021	2.634	0.02237
Error	30	204860792.875	6828693.096		
Total	47	24089401931.813			

Appendix-78: Analysis of variance of gross income (Rs./ha) of sprouting broccoli (2018-19).

Source of Variations	D. F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	147256882.292			
Factor A	3	1165063118.750	388354372.917	2.240	0.10400
Factor B	3	22720475093.750	7573491697.917	43.684	0.00000
Intraction (AxB)	9	1673421518.750	185935724.306	1.072	0.41047
Error	30	5201142808.375	173371426.946		
Total	47	30907359421.917			

Appendix-79: Analysis of variance of net income (Rs./ha) of sprouting broccoli (2017-18).

Source of Variations	D. F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	78870530.792			
Factor A	3	290501864.063	96833954.688	3.403	0.03028
Factor B	3	23311728051.563	7770576017.188	273.041	0.00000
Intraction (AxB)	9	161852742.187	17983638.021	0.632	0.76075
Error	30	853781689.875	28459389.663		
Total	47	24696734878.479			

Appendix-80: Analysis of variance of net income (Rs./ha) of sprouting broccoli (2018-19).

Source of Variations	D. F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	152529396.167			
Factor A	3	407472126.563	135824042.188	3.286	0.03418
Factor B	3	23951359139.063	7983786379.688	193.125	0.00000
Intraction (AxB)	9	76357842.187	8484204.687	0.205	0.99155
Error	30	1240197410.500	41339913.683		
Total	47	25827915914.479			

Appendix-81: Analysis of variance of cost : benefit ratioof sprouting broccoli (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	1.089			
Factor A	3	0.325	0.108	0.830	0.48769
Factor B	3	25.577	8.526	65.443	0.00000
Intraction (AxB)	9	0.183	0.020	0.156	0.99691
Error	30	3.908	0.130		
Total	47	31.082			

Appendix-82: Analysis of variance of cost : benefit ratioof sprouting broccoli (2017-18).

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	1.118			
Factor A	3	0.456	0.152	1.140	0.34874
Factor B	3	26.331	8.777	65.799	0.00000
Intraction (AxB)	9	0.083	0.009	0.069	0.99988
Error	30	4.002	0.133		
Total	47	31.990			