

**“Performance of Different Cauliflower (*Brassica oleracea*
var. botrytis) Hybrid / Varieties Under the Vindhyan
Plateau of Madhya Pradesh ”**

THESIS



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By

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2020

CERTIFICATE - I

This is to certify that the thesis entitled “**Performance of different cauliflower (*Brassica oleracea var. botrytis*) hybrid / varieties under the Vindhiyan plateau of Madhya Pradesh** ” submitted in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **Department of Horticulture (Vegetable Science)** of Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (M.P.) is a record of the bonafide research work carried out by **Neha Dohare ID/Roll No. 16131407** under my guidance and supervision. The subject of the thesis has been approved by the Student’s Advisory Committee and the Director of Instruction.

No part of the thesis has been submitted for any other degree or diploma or has been published. All the assistance and help received during the course of this investigation has been acknowledged by the scholar.

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This is to certify that the thesis entitled “**Performance of different cauliflower (*Brassica oleracea var. botrytis*) hybrid / varieties under the Vindhiyan plateau of Madhya Pradesh**” submitted by **Miss Neha Dohare** to the Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior in partial fulfillment of the requirements for the degree of Master of Science in AGRICULTURE (**Vegetable Science**) in the Department of **Horticulture** has been accepted after evaluation by the External Examiner and approved by the Student’s Advisory Committee after an oral examination of the same.

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List of Symbols/Abbreviations

Symbol	Abbreviation	Stands for
/	-	Per
@	-	At the rate of
%	-	Percentage
°C	-	Degree Celsius
&	-	And
	Amt.	Amount
-	ANOVA	Analysis of variance
-	C : B	Cost benefit ratio
-	CD	Critical difference
-	Cm	Centimeter
-	CV	Coefficient of variance
-	cv.	Cultivar
-	DAT	Days After Transplanting
-	D.f.	Degree of freedom
	EMS	Error mean sum of square
	ESS	Error sum of square
-	<i>et al.</i>	et-alai
-	Fig.	Figure
-	G	Gram
-	Ha	Hectare
	Hrs.	Hours
-	<i>i.e.</i>	That is
-	Kg	Kilogram
	l	Liter
	Max.	Maximum
-	m ²	Meter square
-	Mg	Milli Gram
-	Min.	Minimum
-	NS	Non significant
-	Q	Quintal
	RDF	Recommended Dose of Fertilizer
-	RVSKVV	Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya
	Rs.	Rupees
-	SEm	Standard Error of Means
-	spp.	Species
-	TSS	Total soluble solids
	TMS	Treatments mean sum of square
	TSS	Treatments sum of square
	Var.	Variety
-	<i>Viz.</i>	Videlicet (Namely)

CHAPTER – I

INTRODUCTION

Cauliflower (*Brassica oleracea* var. *botrytis* L.) is an important cole crop in the world originated from a single plant wild cliff-cabbage (*Brassica oleracea* var. *sylvestris*) in Mediterranean region. Over the last two decades crops in the Brassicaceae (formerly Cruciferae) have been the focus of intense research based on their human health benefits (Traka and Mithen, 2009).

It is a diploid with $2n=2x=18$, stem is short and thicker to the same extent as that of cabbage. The edible part of cauliflower is known as curd which is made up of numerous divided hypertrophic branches which terminate the main stem of the plant. It is highly suppressed and extremely ramified hypertrophied flower stalk. At first, young curd is covered with foliage. After attaining full size, curd is to be harvested when it is still compact.

Cauliflower fresh curd are highly nutritive and contain fibre (1.2 g), moisture (90.8 g), protein (2.6 g), carbohydrates (4.0 g), Ca (33 mg), P (57 mg), iron (1.5 mg), riboflavin (0.10 mg), carotene (30 mg), thiamine (0.04 mg), niacin (1.0 mg), vitamin-C (56 mg) 100^{-1} gm of edible portion (Jood and Neelam 2011).

Prime cauliflower growing states in India are West Bengal, Bihar, Maharashtra, Madhya Pradesh, Orissa, Gujarat, Haryana, Chhattisgarh, Assam and Uttar Pradesh. In India, cauliflower is produced in an total area of (452.0 K ha) with the production of (8499 k MT) and productivity (18.8 MT) hectare⁻¹ (Anonymous, 2017a). In Madhya Pradesh the annual production of cauliflower is 913.42 thousand metric tonnes from an area of (45.04 k), with the productivity of (20.28 MT) hectare⁻¹ in 2016-17 (Anonymous, 2017b).

Cauliflower is a highly thermo-sensitive crop requiring different genotypes for commercial cultivation at different periods of the year. Accordingly in Northern India, cauliflower is classified into four maturity groups, viz., I –maturing from late August to early November, II - maturing from mid November to early December, III - maturing from mid December to early January and IV - maturing from mid January to early March. First three groups are the Indian cauliflowers which are early maturing annual types, tolerant to high temperature and humid conditions

and have originated from winter types like Cornish or by inter-crossing of Cornish and other European types. Maturity Group IV is called 'Snowball' varieties or the summer cauliflower of Europe and has been developed from Erfurts and Alpha types. The seeds of first three maturity groups can be freely raised in North Indian plains, such as Rajasthan, Uttar Pradesh, Bihar, Punjab, Haryana, Delhi and in Southern states but the seeds of maturity group IV are raised only in the hills, like Solan and Kullu valley of Himachal Pradesh and Kashmir. Cultivars of cauliflower belonging to the mid-group do well in mid hills of Himachal Pradesh where these are grown commercially as an off season crop during summer-rainy season resulting in high economic returns to the farmers.

The foremost challenge to the existence of mankind has always been to produce adequate quantity of food from the available acreage to meet the requirements of ever expanding world population. The rate of yield gain in crop improvement programme must match the rate of population growth so, as to avoid malnutrition and hunger.

A lot of cauliflower hybrids/varieties are being grown by the farmer's, but best performing hybrids/varieties of cauliflower having desirable quantitative and qualitative characters such as adoptability to adverse environments and resistance to biotic and abiotic stresses resulting into better monetary return to the vegetable growers. Keeping in view, it is essential to work out on the appropriate quantitative and qualitative characters of cauliflower crop so that maximum yield and high quality produce could be obtained. This is common fact that the genotypes showing better performance under one locality may not be suitable for another locality or region. So that the main aim of experiment is to find out the better performance of a particular cauliflower hybrid/variety in Vindhyan plateau and also screen out to which hybrid/variety well adopted and produced maximum yield to another variety under Vindhyan plateau.

Keeping the above facts in view, an experiment entitled "Performance of different cauliflower (*Brassica oleracea* var. *botrytis*) hybrid / varieties under the vindhyan plateau of Madhya Pradesh was conducted at Research Field,

Department of Vegetable Science, R. A. K. College of Agriculture, Sehore (M. P.)
with the following objectives :

1. To find out the cauliflower varieties on growth, yield and quality attributing character.
2. To identify suitable hybrid and improved variety of cauliflower.
3. To work out the economics of the treatments.

CHAPTER II

REVIEW OF LITERATURE

The attempt has been made to study the “**Performance of different cauliflower (*Brassica oleracea* var. *botrytis*) hybrid / varieties under the Vindhyan plateau Madhya Pradesh.**” It is now beyond doubt that exploitation of new improved hybrid/varieties with high yield potential has increased the yield of cauliflower. Production and profitability of cauliflower in India and abroad but very meager information is available on these aspects in relation to clay loam Vertisol soils particularly under Vindhyan plateau. Efforts are, therefore, made to present in this chapter, a brief summary of results of the studies carried out at various places, more or less related to the present investigation. Since, the literature on the varietal performance and economics is very meager. Attempts have been made to compile the research work done on these aspects in present chapter under different heads.

2.1 Performance of different cauliflower hybrids / varieties.

2.2 Economics

2.1 Performance of different cauliflower hybrids / varieties.

Sharma *et al.* (2006) reported that the harvest index, curd size index, net curd weight and curd breadth should be given emphasis while selection of genotype for high curd yields in cauliflower. The results of the present study pointed out that temperature is an important factor contributing to curd yield. The critical duration of high temperature exposure ranged from 27.5 °C and 37.4 °C and caused limited growth in cauliflower. The recorded curd weight and curd height of NS 133 was 800 g and 13.93 cm respectively in hilly region. NS 60N recorded highest curd weight 82 g and curd height 8.15 cm compared to all the other genotypes raised in plains.

Rahman *et al.* (2007) reported that the effect of different plant spacing on the production of cauliflower was conducted at Horticulture Research Area, Faculty of Agriculture, Gomal University, Dera Ismail Khan, NWFP, Pakistan. Six different plant spacing viz., 30, 35, 40, 45, 50 and 55 cm were used. The results revealed significant variations in all the parameters and amongst various plant spacing, 45

cm spacing showed the best response for all the parameters. Maximum plant height (49.33 cm), curd diameter (19.13 cm), maximum curd weight (1.23 kg plant⁻¹) and yield (30.77 t ha⁻¹) were recorded in the plots where the plants were spaced 45 cm apart.

Dhatt and Garg (2008) reported that the marketable curd weight, net curd weight, gross curd weight exhibited considerable genetic variability while days to curd maturity was the least variable character in 36 genotypes of November maturing cauliflower.

Ara *et al.* (2009) reported that the plant height of cauliflower varied from 48.3 cm to 68.4 cm. The perusal of data revealed that plant height was maximum (68.4 cm) during the year of 2015-16 in case of variety *Sabouragrim* and minimum plant height was observed with farmer practice during all the years. It was also found that *Sabouragrim* variety showed highly significant effect on plant height. Maximum plant height with new variety might be attributed to the prevailing conducive climatic conditions.

Kodithuwakku and Kirthisinghe (2009) studies revealed that the average cauliflower curd yield in the field varied between 90 - 125 g plant⁻¹ (3.6–5.0 t ha⁻¹). The results revealed the possibility of increasing N dosage up to 125% of the recommendation for obtaining larger curds and a higher curd yield. Significant difference was not observed ($p > 0.05$) among the treatments in any of the curd quality parameters measured. Even though no significant difference was observed among the post harvest quality, curds of the 50% nitrogen fertilizer treatment stored at room condition and in polythene bags could be kept 6 days & 9 days longer than other treatments, without decay.

Kumar *et al.* (2010) observed that the significant differences among various genotypes in early Indian cauliflower for yield and quality characters, they found that genotypes DC-98-4, DC-98-10 and DC-124 were superior over other genotypes with respect to yield and quality characters, where yield was negatively correlated with duration of curd availability and days to 50% curd formation. Significant differences were observed among genotypes suggesting sufficient variability for yield and quality characters. They also observed that the highest

ascorbic acid content (103.23 mg/100 g of fresh weight) in the genotype DC-98-10 and lowest in CC-12 (17.68 mg/100 g of fresh weight).

Meena *et al.* (2010) studies revealed that the yield and its component characters are polygenic in nature, hence influenced by the environmental factors. The genotypes, Basant, NS 133 and Pusa Meghna did not perform well in the plains which is evident from the low yield recorded ranges from 0.78-0.87 Kg /16 m².

Singh *et al.* (2011) studies revealed that the significant differences for antioxidant content (carotenoids and ascorbic acid) and horticultural traits such as stalk length, head compactness, gross plant weight, net head weight, dry matter, core length, plant height, equatorial diameter, days to 50% maturity, number of non-wrapper leaves, frame spread, harvest index and head compactness among 36 diverse cabbage genotypes revealed the presence of sufficient variability which could be exploited for developing nutritionally and antioxidant rich cultivars.

Singh *et al.* (2013a) reported that the results of a study carried out during *rabi* 2010-12 to characterized some already released cauliflower cultivars in Varanasi, Uttar Pradesh, India. A total of 15 cultivars, namely Pusa Paushja, Pusa Sharad, Pusa Himjyoti, Pusa Shukti, Pusa Meghna, Pusa Deepali, Kashi Kunwari, Kashi Agahani, CCS-80, Pant Gobhi-3, Pusa Subhra, Pusa Snow Ball-1, PSBK-1, PSB-16 and PSBK-25, were evaluated for 28 DUS qualitative and quantitative characters listed in the National DUS test guidelines descriptors for cauliflower, i.e. seedling: anthocyanin colouration of hypocotyl, outer stem (stalk) length (up to insertion of first leaf); leaf attributes, i.e. attitude, length, width, shape, lobe, colour, waxiness, torsion of tip, profile of upper side of blade, puckering, crimping near main vein and degree of undulation of margin; curd characteristics, i.e. initiation (days to 50% of the plants with curd initiation from sowing of seed), covering by inner leaves, polar diameter, equatorial diameter, shape in longitudinal section, doming, colour, knobbing, texture, compactness, anthocyanin colouration at maturity and maturity group; and flower colour and stalk length. The DUS descriptors can be effectively used for identification and grouping of cultivars, and satisfying the DUS criteria for these morphological

descriptors could be registered under PPV and FR Act. There are indications that novel and useful traits can be successfully combined from related cultivars. Further, these cultivars can be used in varietal improvement programme depending upon the desired characteristics.

Singh *et al.* (2013b) reported that the analysis of variance revealed the significant differences among the genotypes used in the present investigation for all the characters studied *viz.*, plant height, stem diameter, number of leaves, leaf length, leaf width, fresh weight of leaf, total weight of the plant, days taken to curd initiation, days taken to curd maturity, diameter of the curd, average weight of curd with guard leaves, curd weight without guard leaves, vitamin C and yield of curd with guard leaves. A wide range of variation was recorded for all the characters suggesting presence of high genetic variability. The genotypes Pusa Snowball K-1 showed high genotypic co-efficient of variability for vitamin C followed by Pusa Sharad and Pusa Hybrid-2, while the genotype K-1 showed low genotypic and phenotypic co-efficient of variability for number of leaves plant⁻¹.

Elavarasan *et al.* (2013) reported that to identify genotype and analyze the physical characteristics among the cultivated genotypes (Namdhari Seeds 183, Namdhari Seeds 160, Namdhari Seeds 35 and Tropical Sun Plus) grown under hills and plains of Kerala, India. In this study, significant differences were observed in yield of cabbage which ranged from 22.6 – 29.3 kg /16m² in hills and 1.27 – 22.06 kg /16m² in plains. Among the cabbage genotypes, NS 183 was found to be the best for hilly region in early yield and yield attributes. The cabbage genotype Tropical Sun Plus exhibited better performance in plains in terms of high head yield (22.06 Kg /16m²), head weight (729.6 g) and head height (11.1 cm). In general, harvest maturity was delayed by 39 – 45 days in the plains as compared to higher altitudes. The cabbage genotypes which exhibited superior performance in hills and plains were selected for further sensory evaluation studies. In this study cabbage genotype Tropical Sun Plus recorded superior organoleptic qualities when grown in plains than hilly region. However in the case of genotype NS 183, the differences in sensory qualities between produce from hills and plains were not significant.

Elavarasan *et al.* (2014) reported that to identify genotype and analyze the physical characteristics among the cultivated genotypes (Namdhari Seeds 60 N, Namdhari Seeds 133, Pusa Meghna and Basant) grown under hills and plains of Kerala, India. In this study, significant differences were observed in yield of cauliflower which ranged from 21 – 26.4 kg /16 m² in hills and 0.78 – 1.43 kg /16 m² in plains. Among the cauliflower genotypes, NS 133 was found to be the best for hilly region in early yield and yield attributes. The cauliflower genotype NS 133 exhibited better performance in hills in terms of high curd yield (26.4 Kg /16 m²), curd weight 800 g and curd height 13.93 cm. In general, harvest maturity was delayed by 39 – 45 days in the plains as compared to higher altitudes. The cauliflower genotypes which exhibited superior performance in hills and plains were selected for further sensory evaluation studies. In this study cauliflower genotype NS 60N recorded superior organoleptic qualities when grown in plains than hilly region. However in the case of genotype NS 133, the differences in sensory qualities between produce from hills and plains were not significant.

Nimkar and Korla (2014) evaluated late cauliflower in compact family block design with three replications for eight horticultural and three quality traits F₄ 11-119-BP, F₄ 11-111-BP, F₄ 11-113-BP, F₄ 5-109-BP and F₄ 2-77-BP and F₄ 4-92-MP, F₄ 4-94-MP, F₄ 11-120-MP, F₄ 3- 84-MP and F₄ 11-112-MP possessed good yield and quality traits.

Thakur (2014) reported that the cauliflower groups early var. 'Pusa Himjyoti', mid late variety 'Swati' and late group variety 'PSB K-1' were planted at a gap of one month at different planting dates for two consecutive years during 2009-10 and 2010-11 to find out the effect of varying temperatures on net curd yield and other associated characters in each maturity group. The varieties varied in their performance for net curd yield as per the maturity group and temperature regime and it was found that early maturing varieties gave high net curd yield under high temperature planting dates, whereas, mid late and late maturing varieties gave high net curd yield under the mild temperature regimes. Curd diameter in early cauliflower was found to be maximum under increasing temperatures, whereas, mild temperature range helped in producing maximum

curd size in mid group variety. Late group variety also produced maximum curd diameter when temperature increased from freezing to 10-15°C. The plant leaf number plant⁻¹ was found to be maximum under higher temperatures for all the maturity group varieties. Cauliflower curds irrespective of maturity group took more time to maturity at lower temperature regimes as compared to the high temperature regimes for every maturity group and planting date. The best production cycle for year round production of cauliflower in the mid hills was, therefore, found to be June-July (early group); October (late group); followed by February planting of mid late group varieties which can give higher net curd yield besides ensuring best quality curd supply to the markets.

Santhosha *et al.* (2014) reported that out of 51 early cauliflower genotypes characterized, high coefficient of variation (C.V) was observed for yield characters like, gross curd weight (26.03 %), net curd weight (26.02 %) followed by curd size index (24.95 %) suggesting that these traits should be given top priority during selection programme. Genotypes viz., IIHR-272, IIHR-263, IIHR-266 and IIHR-390 showed superior performance for above parameters, hence these lines may be directly used for cultivation or as a source of desirable traits in a breeding programme for the improvement of curd yield and quality in cauliflower. A wide range of variability was observed among the genotypes for number of leaves (11.4-19.3), leaf length (20.3-37.6 cm), leaf width (10.8-19.1cm), days to 50% curd initiation (36-47 days), days to 50% curd maturity (48-58.5), curd maturity duration (10-20 days), curd length (3.3-7 cm), curd breadth (4.8-10.3 cm), curd size index (16.6-54.3 cm²), gross curd weight (256-816 g), marketable curd weight (147.5-464.5 g), net curd weight (70.4-250.7g), stalk length (2.6-5.2 cm), harvest index (19.4-38.9%), riceyness (0-5%) and 1000 seed weight (1.9-5.2 g) indicating the scope for selection of suitable initial material for breeding, in the improvement of early cauliflower.

Kibar *et al.* (2014) reported that the experiment was carried out in fourteen inbred lines of cabbage in Samsun, Turkey during 2011–2012. A wide range of variation was observed among the cabbage genotypes for all the economic traits such as plant height, plant diameter, width of outer leaf, length of outer leaf, head weight, head

diameter, head length, diameter of interior stem and yield except days to maturity and core length.

Meena *et al.* (2014) reported that the studies on inter-trait association and genetic variability assessment were carried out in 30 diverse cabbage genotypes for 11 quantitative characters. The study showed high range for marketable yield, days to maturity and leaf length.

Thakur (2015) reported that the difference between the two is in their adaptability to different temperature conditions, tropical types form curds at temperatures around 20°C or above, while the temperate annual require temperature range between 10°C and 16°C for curd formation. Further, the tropical's are resistant to high rainfall conditions, especially during the vegetative phase. Development of cultivars like Pusa Himjyoti, and Pusa Early Synthetics and existence of a large pool of varieties in different maturity groups have made it possible to produce cauliflowers more intensively and throughout the year in the mid hills of the state. Therefore, maturity of the varieties needs more attention in year round production to ensure continuous supply of quality curds. Few studies have however been made to determine the environmental factors which can influence the maturity characteristics of the crop and not many quantitative data are available on this aspect. Therefore, a study was conducted in this background with a simple objective to determine the relationship between the time of planting and curd maturity at different altitudes.

Chittora and Singh (2015) reported that the genetic variability was studied for eighteen quantitative characters and five qualitative characters in forty genotypes of early cauliflower. Analysis of variance revealed significant differences among the genotypes for all the characters except for days to curd initiation, days to curd maturity and curd depth. The genotypes *viz.*, PCF-95, PCF-106, Inb-9-5 and Inb-10-1 were found promising as they had more than one desirable quantitative and qualitative traits. PCF-95 had maximum curd yield per hectare (271.87 q) while PCF-101 exhibited earliest harvestable curd maturity (115.33 days).

Manaware *et al.* (2017) Conducted an experiment on genetic diversity assessment for growth and yield traits in cauliflower (*Brassica oleracea var. botrytis* L.)” at Horticulture Complex, Department of Horticulture, College of Agriculture JNKVV, Jabalpur (M.P.) during the year 2015-16. The mean performance of the genotypes revealed a wide range of variability for all the traits. The variation was highest for total plant weight (572.27-1220.87 g), curd weight (238.58-508.83 g), net curd weight (169.80-392.97 g), marketable curd yield (76.86-169.13 g), curd yield per hectare (79.21-172.45 q), curd circumference (9.17-40.40 cm), days to 50% curd formation (25.00-47.33 days), days to harvest (40.67-59.33 days) and curd length (3.40-14.88 cm).

Kumar *et al.* (2017) studied genetic variability for sixteen quantitative traits in fifty seven genotypes of mid-season cauliflower. Analysis of variance studies revealed significant difference for majority of the characters except plant spread, curd length and curd size index. Variation was observed lid between leaf length (27.54-64.94 cm), leaf width (13.00-28.50 cm), Petiole length (05.47-19.47 cm), plant height (32.31-70.31 cm), plant spread (40.57-71.95 cm), number of leaves per plant (12.16-16.00), stalk length (03.12-10.60 cm), days to curd maturity (84.70-123.75), gross plant weight (271.95-2101.75 g), marketable curd weight (213.90-905.50 g), net curd weight (144.90-514.50 g), curd length (05.54-14.04 cm), curd breadth (08.96-14.42 cm), harvest index (17.98-56.78 %), curd sixe index (54.44-141.38 cm²) and curd yield per hectare (63.95-271.5 q/ha). The genotypes viz. INBPCF 120, 2013/CAUMVAR-6, PCF- 93, PG-5, PCF- 7, INBPCF 117 were found more promising as they had more than one desirable traits. INBPCF 120 had highest curd yield hectare⁻¹ (192.5 q) whereas, PCF 29 requires least days to maturity (85).

Sharma *et al.* (2017) evaluated twenty five genotypes of cauliflower along with one check Madhuri for yield and some yield contributing morpho physiological components in cauliflower. Further, the investigation was done to find out interrelationships among different characters and their direct and indirect contribution towards yield. Estimates of phenotypic and genotypic correlation coefficient revealed that marketable yield plant⁻¹ was significantly and positively

correlated with curd size index, gross weight plant⁻¹, curd solidity, curd compactness, curd diameter, stalk length, number of leaves plant⁻¹ and harvest index.

Sharma *et al.* (2018) reported that to assess the variability, heritability and genetic advance in late maturing group of cauliflower. Experiment was undertaken in Randomized Block Design (RBD) with three replications at the Experimental Farm of the Department of Vegetable Science and Floriculture, CSK HPKV Palampur. Twenty five genotypes of cauliflower were evaluated including Madhuri as check during Rabi season of 2014-15. Analysis of variance revealed significant variability for most of the traits. Wide range of variability was exhibited to days to curd initiation from transplanting (93.0-112.0 days), days to marketable curd maturity from date of transplanting (107.33-128.0 days), gross weight plant⁻¹ (940.20-1413.15 g), marketable yield plant⁻¹ (529.31-1021.78 g), curd depth (6.51-9.15 cm), curd diameter (10.0-13.27 cm), curd size index (65.65-112.8 cm²), per cent marketable curds (78.33-100.0%), curd compactness (105.83-115.22⁰), curd solidity (66.78-125.30 g cm⁻¹), stalk length (2.67-4.78 cm), number of leaves plant⁻¹ (10.67-13.33), plant height (36.40-47.69 cm), dry matter content (7.0-10.67%), total soluble solids (5.43-7.40⁰Brix) and harvest index (47.25-80.93%).

Kumar *et al.* (2018) reported that to study the genetic diversity among the different lines taken all the genotypes were divided into four different clusters. Cluster I was the largest and cluster III and IV were the smallest cluster classified. In the present investigation, cluster IV contains genotype with early curd initiation (73.25 days) and curd maturity (84.75 days). The cluster with highest net curd weight was found to be in cluster IV (304.08 g), while the lowest curd weight was in cluster I (212.38 g). It is may be concluded that crossing between genotypes of cluster IV and I are likely to be exploited for high heterosis for net curd weight, marketable curd weight in cauliflower.

Ahmad *et al.* (2018) reported that the effect of curd size on seed quality and yield of cauliflower (*Brasica oleraceae* var. *botrytis* L.) using cultivar 'Hansa' was conducted at vegetable experimental area, Institute of Horticultural

Sciences, University of Agriculture, Faisalabad during 2016-2017. Five different head sizes were used as treatments comprising of T₁ (Very small curd size 0-5 cm), T₂ (small curd size 5-10 cm), T₃ (medium curd size 10-15 cm), T₄ (large curd size 15-20 cm), T₅ (extra-large curd size 20-30 cm). Data for different seed yield and quality parameters was recorded and mean values were analyzed at a level of 5% probability. Maximum values for 1000 seed weight (3.82gm), germination percentage (91.60%), root length (5.78cm), shoot length (8.32cm), seedling length (14.10cm), seedling fresh weight (0.45gm), seedling dry weight (0.06gm) were recorded for T₅ (extra-large curd size 20-30 cm). Electrical conductivity of seeds (0.33 dsm) was recorded in case of T₄ (large curd size 15-20 cm). Maximum values for number of pods plant⁻¹ (408.80), number of seeds pod⁻¹ (12.60), length of pod (6.48cm), seed yield plant⁻¹ (13.68gm), seed yield (496.01 kg ha⁻¹) were recorded for T₅ (extra-large curd size 20-30 cm). Significant difference between seed yield and quality of seed was noticed among varying size of curd of cauliflower. Extra-large and large curd size performed better than other treatments in terms of seed yield and quality of seed.

2.2 Economics

Chaurasia *et al.* (2009) revealed that the maximum curd yield, maximum net profit and C:B ratio and minimum loss in weight and spoilage was noted with application of Pressmud alone or in combination with 50% NPK (60:30:30: kg ha⁻¹) and planted at 45 x 60cm spacing during both the years of experimentations.

Bala *et al.* (2011) reported that the costs and returns structure has been reported for the production of major off-season vegetables, viz. tomato, cabbage cauliflower and peas in two vegetable-dominated developmental blocks of the district Kullu. Primary data have been collected through survey method for the agricultural year 2007-08. The study has revealed that per hectare cost A1 was highest for tomato, followed by cabbage, cauliflower and lowest for peas, among the selected vegetables. However, per quintal cost of cultivation has been found to be highest for peas, followed by cauliflower, tomato and cabbage. Costs on plant protection measures have been the major constituents of cost A1 in all the

crops, followed by expenditure on seed and fertilizers. Vegetables being the labour-intensive crops, have incurred significantly high costs on human labour, 13200-15600 ha⁻¹. Gross returns as well as net returns hectare⁻¹ have been observed to be highest for tomato, followed by cauliflower, cabbage and peas. The study has suggested that to promote this enterprise, niche areas for off-season vegetable cultivation need to be identified and efforts to tap irrigation potential in those areas should be enhanced. Education of farmers for scientific management of crops and provision of improved tools for efficient use of labour have also been suggested to lower production costs and make the vegetable cultivation more beneficial to farmers, particularly to the small and marginal farmers in the state.

Kumar *et al.* (2011) reported that the Pendimethalin 1.5 kg ha⁻¹ was observed to be best weed management treatment in terms of average curd weight, total curd yield and net returns.

CHAPTER III

MATERIALS AND METHODS

This chapter comprises the details about the materials used and the methods adopted during the course of present investigation entitled **“Performance of different cauliflower (*Brassica oleracea* var. *botrytis*) hybrid/ varieties under the Vindhyan plateau of Madhya Pradesh”** was carried out during the year 2017-18.

3.1 Experimental site

The present experiment was laid out in the field of the Horticulture Research Farm, Department of Horticulture, R.A.K. College of Agriculture, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Sehore, during 2017-2018. The land topography of the experimental site was almost uniform with an adequate surface drainage. The internal drainage of the experimental site is medium.

3.2 Location and climate

Sehore is situated at the latitude of 27.05⁰ East and an altitude of 497.8 meters above the mean sea level. It lies in the western track of Vindhyan Plateau agro-climatic zone of Madhya Pradesh and enjoy sub tropical climate. The average annual rainfall is 1031 mm, which is mostly received during July and August. The average maximum temperature is 46⁰C and minimum temperature 6.8⁰C. The average annual relative humidity is 74%.

The meteorological parameter during the crop season such as minimum and maximum temperature, relative humidity, rainfall and wind speed were recorded at Meteorological observatory R.A.K. College of Agriculture, Sehore (M.P.) are presented in Table 3.1.

Table 3.1:- Meteorological data during the crop season of 2017 at R.A.K. College of Agriculture (RVSKVV), Sehore (M.P.)

Month	SMW	Week	Temperature		Relative Humidity (%)	Rainfall (mm)	No of rainy days
			Max.	Min.			
August	34	20-26	26.9	23.0	86.0	114.1	4
	35	27-2	25.9	21.4	84.0	66.6m	4
September	36	3-9	29.6	22.8	69.0	0.0	0
	37	10-16	30.4	23.4	86.0	231.0	7
	38	17-23	30.3	19.3	78.0	89.0	4
	39	24-30	33.3	21.5	59.0	0.0	0
October	40	1-7	35.2	20.3	67.0	0.0	0
	41	8-14	32.1	23.3	60.0	32.0	2
	42	15-21	34.0	18.6	52.0	0.0	0
	43	22-28	30.19	15.93	58.0	0.0	0
November	44	29-4	29.4	13.9	77.2	24.7	0
	45	5-11	28.1	12.3	79.1	23.4	0
	46	12-18	26.7	16.0	76.3	27.9	0
	47	19-25	26.7	9.8	78.5	21.2	0
	48	26-2	26.1	10.6	74.3	27.1	0
December	49	3-9	24.9	11.5	64.5	28.6	0
	50	10-16	24.4	13.1	78.5	37.5	0
	51	17-23	24.5	7.6	73.8	29.3	0
	52	24-31	24.7	8.1	85.4	29.2	0
January	1	1-7	23.6	7.5	76.4	29.8	0
	2	8-14	25.1	10.7	66.4	25.2	0
Total						836.6	21
Average							

Source: Meteorological observatory, R.A.K. College of Agriculture, Sehore (M.P.).

3.3 Soil

The soil of the experimental field was clay loam Vertisol with 42.6% clay, 31.8% silt and 21.5% sand with pH ranging from 6.9. The soil was very low in available nitrogen, medium in available phosphorus and high in available potassium. In order to determine the textural class and fertility status of the experimental area, the soil samples were collected randomly from each plot with the help of soil auger before sowing from the experimental field. Primary samples were mixed to prepare a composite soil sample from each replication was drawn to study physico-chemical properties of the experimental

field. The data pertaining to various physico-chemical properties have been presented in Table 3.2.

Table 3.2: Physico-chemical properties of soil collected from the experimental field

SN	Composition	Content	Category	Method used
A. Mechanical composition				
1	Sand (%)	21.50	-	Bouyoucos Hydrometer method (Piper, 1967)
2	Silt (%)	31.80	-	
3	Clay (%)	42.60	-	
4	Textural class		Clayey	
B. Chemical composition				
S.N	Analysis	Values	Category	Method adopted
1.	Soil pH	6.9	Normal	Glass electrode method (pH meter) (Jackson, 1967)
2.	Electrical conductivity (ds/m)	0.49	Normal	Conductivity meter at 25°C (Jackson, 1967)
3.	Organic carbon (%)	0.42	Low	Wakley and Black rapid titration method (Wakley and Black 1934)
4.	Available Nitrogen (kg N /ha)	149.8	Very low	Alkaline permanganate method (Jackson 1967)
5.	Available phosphorus (kg P ₂ O ₅ /ha)	12.10	Medium	Olsen's method (Jackson, 1967)
6.	Available potash (kg K ₂ O /ha)	346.5	High	Flame photometer (Jackson, 1967)

The physico-chemical analysis of soil showed that the soil of experimental site was predominantly clayey in texture. The organic carbon content (0.42%) and available nitrogen (149.8 kg ha⁻¹) were very low. The available phosphorus (12.10 kg ha⁻¹) and potash (346.5 kg ha⁻¹) were medium and high respectively. The soil pH was (6.9) normal. Electrical conductivity (0.49 dS m⁻¹) of soil was found normal (Table 3.2).

3.4 Cropping history of the experimental field

The knowledge about previous crops on experimental field is essential to know its previous history. The experimental field was planted to different crops

during past 3 years. A brief history of crops sequence followed during the last three years is shown in the Table 3.3.

Table 3.3: Cropping history of experimental field

Year	Kharif	Rabi	Summer
2014-2015	Cowpea	Tomato	Fallow
2015- 2016	Okra	Tomato	Fallow
2016-2017	Brinjal	Garlic	-
2017-2018	-	Present experiment	

3.5 Experimental material

The experimental materials for this study comprised 10 treatments (hybrids/varieties) are presented in Table 3.4

Table 3.4: Details of treatments used in the study

S. No.	Treat. Symb.	Treatments	Sources
1.	T ₁	Barkha (Hy)	Seminis seed company
2.	T ₂	Girija (Hy)	Seminis seed company
3.	T ₃	Suhasini (Hy)	Syngenta seed company
4.	T ₄	White excel (Hy)	Suttons seed company
5.	T ₅	PS -666 (Hy)	Pahuja seed company
6.	T ₆	Versha	Dr. seed Pvt. Ltd
7.	T ₇	Sitara – 70	Ujjawala seed company
8.	T ₈	Early special	H.M. clause India Pvt. Ltd.
9.	T ₉	Ganga-60	Local
10	T ₁₀	Nandani	Local

3.6 Experimental details

3.6.1 Design of experiment

The experiment was laid out in Randomized Completely Block Design (RCBD) with three replications. Each replication consists of 10 treatments. All the treatments were randomized separately in each replication. The plan of layout is given in Fig. 2 and other details are given as below:-

Design	: Randomized Completely Block Design
Replication	: 3
Treatment	: 10
Total number of plots	: 30

Gross plot size : 3.0 X 2.70 sq.m.
 Row to row distance : 60 cm
 Plant to plant distance : 45 cm
 Number of rows in each plot : 5
 Gross area of experimental field : 310.5 sq.m
 Net area of experiment field : 243.0 sq.m
 Number of plants for observation : 5
 per plot
 Plot to plot distance : 1.0 m.
 Distance between replication : 1.0 m
 Crop : Cauliflower (*Brassica oleracea* var. *botrytis*)
 Season : 2017-18
 Date of sowing : 23 – 08 – 2017
 Date of transplanting : 06 – 10 – 2017

Plan of layout

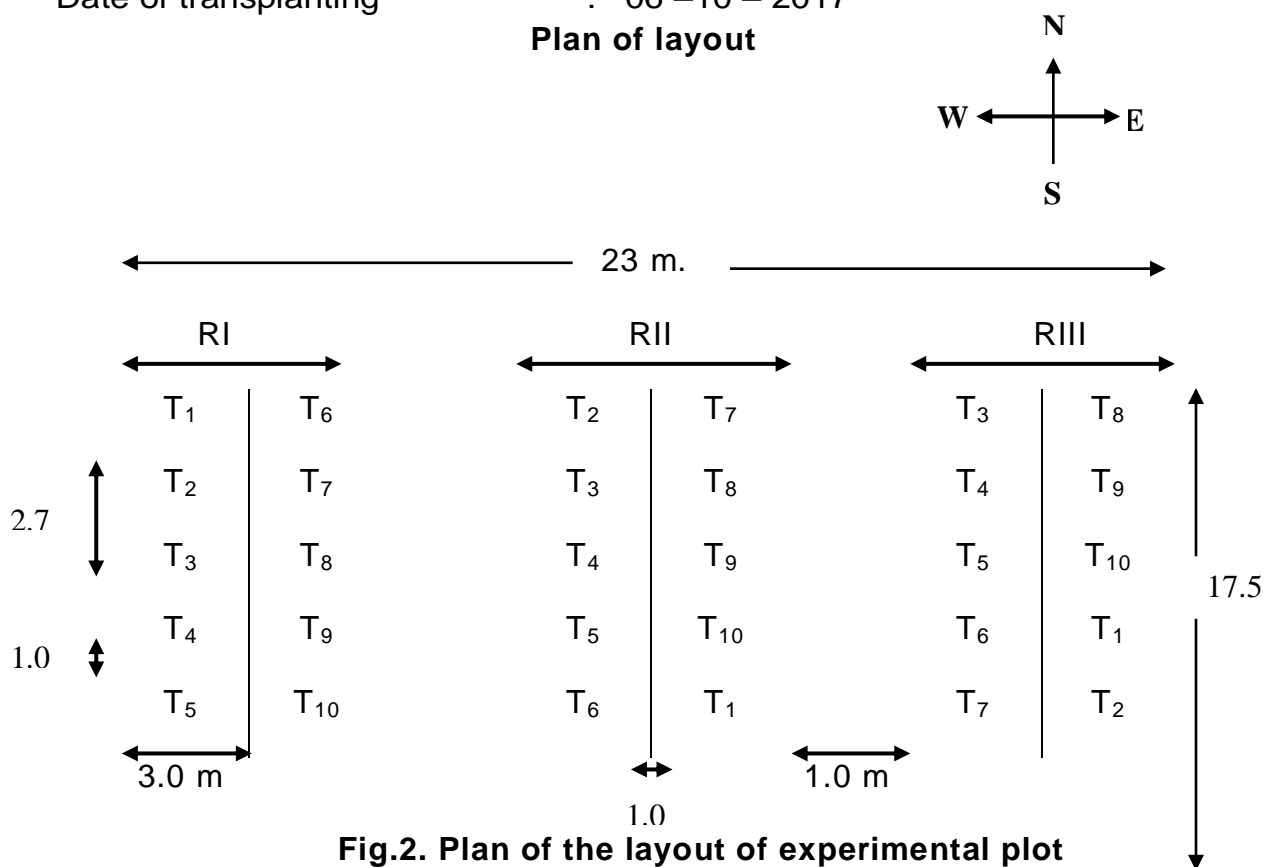


Fig.2. Plan of the layout of experimental plot

3.7 Agronomical Operations

3.7.1 Raising of seedlings

The nursery beds were dug and prepared thoroughly. All the grass, roots, bricks, pieces, residue of previous crop, weeds and other undesirable

material if any were removed from the beds. The nursery beds were prepared 1m wide and 3m long and elevated up to 20 cm from ground level. Seeds were sown on the nursery beds in rows 5 cm apart. After sowing seeds were covered with a thin layer of sieved FYM and then paddy straw. Sprinkling of water with water cans was done immediately. This practice was repeated frequently as and when required to make the beds well moisturized till the germination. After germination of seeds, cover of dry paddy straw was removed. Weeding was done manually as and when weeds appeared in the nursery beds, without disturbing the seedlings.

3.7.2 Land preparation and transplanting

The experimental area was ploughed and harrowed in order to bring the soil in well-pulverized condition. FYM was applied @ 20t ha⁻¹. Plots were made according to the layout plan after leveling. Seedlings were uprooted from the nursery bed and transplanted in the plots at a spacing of 60 cm row to row and 45 cm plant to plant. Transplanting was done in the afternoon hours immediately followed by irrigation for proper establishment of the seedlings.

A week after transplanting gap filling was done. All the other recommended package of practices was followed to raise a healthy crop.

3.7.3 Irrigation

The first irrigation was given immediately after transplanting to ensure proper establishment of plant. Subsequent irrigation was given at 10 days interval.

3.7.4 Intercultural operations

The experimental plots were kept weed free. Three hand weeding was done.

3.7.5 Fertilizer Application

Nitrogen, phosphorus and potassium were applied, through urea, single super phosphate and murate of potash respectively. A uniform dose of 100 kg N ha⁻¹, 60 kg P ha⁻¹ and 40 kg K ha⁻¹ was applied to all the treatments. Full quantity of phosphorus and potassium fertilizer along with one-third of nitrogen was

applied before transplanting the seedlings. While, the rest of the nitrogen was applied in two equal splits 25 and 50 days after transplanting.

3.7.6 Plant protection measures:

The crop was sprayed with imidachlorprid 0.005% or thiomethoxan 0.025% for control of Aphids and Jassid, alternate to keep the crop free from pest during crop growth period.

3.8 Sampling

Sampling was done at 30, 45 and 60 days after transplanting for growth analysis. Five plants were randomly selected from each treatments and replication for the study.

3.9 Observation recorded

The observations were recorded on 5 randomly selected plants in each plot and their mean values were worked out on the following traits:

3.9.1 Growth parameters

3.9.1.1 Stalk length (cm)

The stalk length of five-tagged plant in each experimental plot was measured at 30, 45 and 60 days after transplanting and average was worked out.

3.9.1.2 Number of leaves plant⁻¹

The number of leaves of five-tagged plant in each experimental plot was counted at 30, 45 and 60 days after transplanting and average was worked out.

3.9.1.3 Leaf length (cm)

Length of leaves of five-tagged plants was measured at 30, 45 and 60 days after transplanting and mean was calculated for each treatment.

3.9.1.4 Fresh weight of plant (g)

The fresh weight of five randomly selected plants (including vegetative parts and curd) at harvesting stage was determined using weighing balance. The fresh weight of plant was expressed in grams/plant.

3.9.1.5 Curd maturity duration (days)

Curd maturity duration was calculated through days taken to 50% curd initiation to days taken to 50% curd maturing after transplanting in each plot.

Curd maturity duration = (Days taken to 50% curd maturity after transplanting)
- (Days taken to 50% curd initiation after transplanting)

3.9.2 Yield parameters

3.9.2.1 Curd length (cm)

A curd length was measured of five-tagged (randomly selected) plants through scale and mean was calculated for each treatment.

3.9.2.2 Curd width (cm)

Curd width of five-tagged (randomly selected) plant was measured and mean was calculated for each treatment.

3.9.2.3 Average curd weight (g plant⁻¹)

To calculate the average curd weight, curds of five randomly selected plants in each plot, whole were weighed on electronic balance after cutting the leaves and stalk. Finally, average weight of curd in each plot was calculated in grams.

3.9.2.4 Marketable curd yield (q ha⁻¹)

Marketable curd was weighed on electronic balance and marketable curd yield per plot was recorded in kilogram which was converted into quintal per hectare as given below:

$$\text{Marketable curd yield (q ha}^{-1}\text{)} = \frac{\text{Marketable curd yield (kg plot}^{-1}\text{)}}{\text{Area of plot (m}^2\text{) x 100}} \times 10,000$$

3.9.2.5 Total curd yield (q ha⁻¹)

Total curd was weighed on electronic balance and total curd yield per plot was recorded in kilogram which was converted into quintal per hectare as given below:

$$\text{Total curd yield (q/ha)} = \frac{\text{Total curd yield (kg plot}^{-1}\text{)}}{\text{Area of plot (m}^2\text{) x 100}} \times 10,000$$

3.9.2.6 Harvest index (%)

The harvest index was calculated as a ratio of curd weight per plant to the gross plant weight per plant and expressed in percentage.

$$\text{Harvest index (\%)} = \frac{\text{Curd weight (g)}}{\text{Gross weight of plant (g)}} \times 100$$

3.9.3 Quality parameters

3.9.3.1 Total soluble solids (⁰Brix):

Whole curd was 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 ⁰Brix by hand Refractometer. Few drops of juice were placed on the surface of prism. The hinged part was placed back. The refractometer was then placed against the sun. The reading was noted by revolving the eyepiece at room temperature (A.O.A.C., 1970)

3.9.3.2 Shelf life

Shelf life of curd was recorded after harvesting at room temperature.

3.9.4. Economics

3.9.4.1 Computation of Economics of treatments

Several economic indices are available to evaluate the profitability of cropping systems. No single index is capable of giving good comparison of different treatments and so a number of indices are used together to assess the economic viability of the system. Since the price of farm products changes from year to year and season to season and also place to place, the profitability of the system also changes accordingly. The procedures used for working out economics of different treatments under consideration was as suggested by Yang *et al.* (1989)

3.9.4.2 Gross Monetary Returns (₹ ha⁻¹)

Gross returns are the total monetary value of economic produce and byproducts obtained from the crop raised in the different treatments is calculated based on the local market prices.

3.9.4.3 Cost of Cultivation (₹ ha⁻¹)

Cost of cultivation is the total expenditure incurred for raising crop in a treatment. The cost included for this purpose consists of own or hired human labour, owned or hired bullock labour, value of seed, manures, fertilizers,

pesticides and irrigation charges etc. A poor farmer may choose a practice with lesser cost of cultivation though it gives lesser profit, because of limited resources.

3.9.4.4 Net Monetary Returns (₹ ha⁻¹)

It is computed by subtracting cost of cultivation from gross returns. It is good indicator of suitability of a cropping system since this represents the actual income of the farmer. Monetary returns for different treatments were calculated with the help of prevailing market rates of produce and different inputs used in the experiments.

Net Monetary Returns(Rs ha⁻¹)=Gross return(Rs ha⁻¹)– Cost of cultivation(Rsha⁻¹)

3.9.4.5 Benefit cost ratio:

It is the ratio of gross returns to cost of cultivation. It is expressed as returns per ₹ invested. This index provides an estimate of the benefit a farmer derives for the expenditure he incurs in adopting a particular cropping system. Any value above 2.0 is considered safe as the farmer gets ₹ 2 for every rupee invested.

Benefit cost ratio = Gross return (₹ha⁻¹) / Cost of cultivation (₹ ha⁻¹)

3.10 Soil analysis

The soil of the field was medium black soil with almost uniform topography and a depth of 150 cm,

In order to determine the textural class and fertility of the experimental area the soil samples were collected after the land preparation and before transplanting of the crop to a depth of 0-30 cm with the help of auger. Each sample was dried in shade and ground, passed through 2 mm sieve. The physicochemical properties of the soil were determined as per standard methods,

3.10.1 Mechanical analysis of soil

The mechanical composition of soil samples was determined by the bouyoucos hydrometer method as described by Piper (1967) and reported in percent.

3.10.2 Chemical analysis

Collection and preparation of soil sample

Soil samples were collected randomly from plough layer depth with the help of soil sampling tube before transplanting of crops from each plot and finally composite soil samples were made. The samples were mixed thoroughly and dried in air, crushed, sieved through 2 mm sieve. The soil samples so prepared were subjected to chemical analysis for evaluating soil fertility status following standard procedures. Different methods adopted for chemical analysis of soil samples have been briefly described as below.

(a) Soil pH

The soil reaction was determined from soil sample paste 1:2 (soil: water ratio) using systronics pH meter model-326,

(b) Electrical conductivity

Electrical conductivity was also determined by electrical conductivity meter in 1:2 soil water suspensions at 25°C and it is expressed as dS /m (deci Seimens per meter).

(c) Organic carbon

Organic carbon was determined by Walkley and Black (1934) wet digestion method. Organic carbon content in soil is expressed in percent of soil (Piper, 1967).

(d) Available nitrogen (kg ha^{-1})

Determination of available nitrogen was done by alkaline permanganate method suggested by Subbiah and Asija (1956).

(e) Available phosphorus (kg ha^{-1})

The estimation of available P was done by using Olsen's extract (0.5 N sodium bicarbonates solution of pH 8.5) as referenced by Olsen *et al.* (1954). It was determined as stannous chloride reduced blue colour. The extraction procedure adopted was as described by Black (1965) and developing the colour in the extract (Motiramani and Wankhede, 1964) using "UV visible Spectro Photometer".

(f) Exchangeable potassium (kg ha⁻¹)

The available amount of potassium was determined by using normal neutral ammonium acetate Flame photometer (Black, 1965).

3.11 Statistical analysis

The data obtained in respect of all the characters has been subjected to the following statistical analysis.

3.11.1 Mean: It was calculated by using following formula.

$$\text{Mean} = \frac{\sum x}{n}$$

where,

$\sum x$ = Sum of all the observation

n = Number of observation

3.11.2 Analysis of variance

The data based on the mean of individual plants selected for observation were statistically analysed described by Panse and Sukhatme (1985) to find out overall total variability present in the material under study for each character and for all the populations. The first and foremost step is to carry out analysis of variance to test the significance of differences among the populations. The skeleton of analysis of variance used was as follows:

Table 3.5: ANOVA for Randomized Completely Block Design

Source of variation	D.F.	Sum of square	Mean sum of square	F value	F _t 5% or 1% table value
Replication	r-1	RSS	RMS	RMS/EMS	-
Treatments	T-1	TSS	TMS	TMS/EMS	-
Error	(r-1)(T-1)	ESS	EMS	-	-
Total	rt-1	TSS	-	-	-

where,

r = Number of replications

T = Number of treatments

D.F. = Degree of freedom

RSS = Replication sum of square

TSS = Treatments sum of square

ESS = Error sum of square

TSS = Total sum of square

RMS = Replication mean sum of square

TMS = Treatments mean sum of square

EMS = Error mean sum of square

A significant value of F test indicates that the test entries differ significantly among themselves, which requires computing.

$$C.V. = \frac{\sqrt{EMS}}{GM} \times 100$$

$$SE\ m \pm = \sqrt{\frac{EMS}{r}}$$

$$SE\ diff = \sqrt{\frac{2\ EMS}{r}}$$

CD at 5% prob. Level = SE diff x $t_{5\%}$ table value

where,

C.V. = Coefficient of variation

SEm \pm = Standard error of means

S E diff = Standard error of difference

GM = Grand mean

C.D. = Critical difference

t 5% = t, table value 5% probability level at error d.f.



Preparation of Seed Bed and Sowing



Observation Field



T₁ = Barkha (Hy)



T₂ = Girija (Hy)



T₃ = Suhasini (Hy)



T₄ = White excel (Hy)



T₅ = PS - 666 (Hy)



T₆ = Versha



T₇ = Sitara - 70



T₈ = Early special



T₉ = Ganga-60



T₁₀ = Nandani

Hybrids /Varieties of Cauliflower (*Brassica oleracea* var. botrytis)

CHAPTER IV

RESULTS

The Present experiment was carried out to study “**Performance of different cauliflower (*Brassica oleracea* var. botrytis) hybrids / varieties under the Vindhyan plateau of Madhya Pradesh**”.

The data was statistically analyzed as per Randomized Complete Block design and the “ANOVA” table is given in the appendix I to III. The findings of different characters as influenced by various hybrids / varieties of cauliflower are presented in forgoing pages.

4.1 Growth parameters

4.1.1 Stalk length (cm)

The stalk length of cauliflower as influenced by different hybrids / varieties is given in Table 4.1. Stalk length was recorded at 30, 45 and 60 days after transplanting. Its graphical presentation has been shown in Fig. 3 and the ANOVA is given in Appendix – I.

The stalk length increased significantly with the increased in days to transplanting.

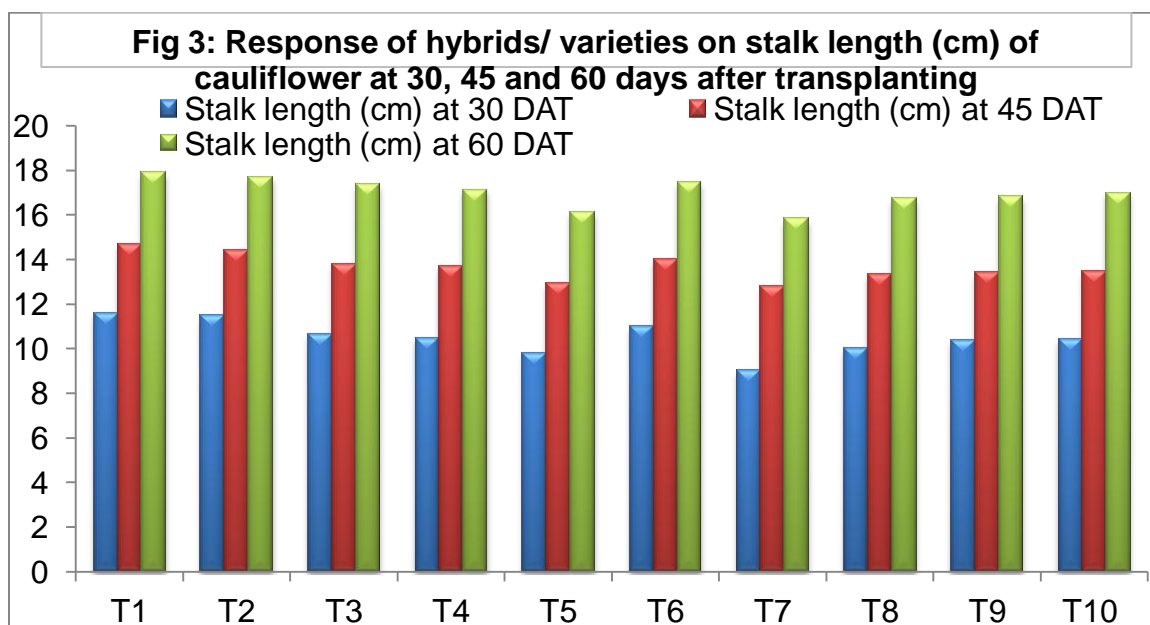
At 30 days after transplanting, the maximum stalk length 11.60 cm was recorded in hybrid Barkha followed by Girija (11.47 cm), variety Versha (11.0 cm) and Hy Suhasini (10.67 cm) and which were at par with each other. While, the minimum stalk length (9.0 cm) was observed in variety Sitara – 70.

Incase of 45 days after transplanting, the hybrid Barkha exhibited maximum stalk length 14.67 cm which were closely followed by Girija (14.40 cm) and variety Versha (14.0 cm) and at par with each other. Whereas, Sitara – 70 was noted minimum 12.80 cm stalk length.

Table 4.1: Response of hybrids/ varieties on stalk length (cm) of cauliflower at 30, 45 and 60 days after transplanting

Treat. Symb.	Treatments	Stalk length (cm) at		
		30 DAT	45 DAT	60 DAT
T ₁	Barkha (Hy)	11.60	14.67	17.87
T ₂	Girija (Hy)	11.47	14.40	17.67
T ₃	Suhasini (Hy)	10.67	13.80	17.37
T ₄	White excel (Hy)	10.47	13.73	17.13
T ₅	PS -666 (Hy)	9.80	12.93	16.13
T ₆	Versha	11.00	14.00	17.47
T ₇	Sitara – 70	9.00	12.80	15.80
T ₈	Early special	10.00	13.33	16.73
T ₉	Ganga-60	10.33	13.40	16.80
T ₁₀	Nandani	10.40	13.47	17.00
	S.Em±	0.36	0.26	0.22
	C.D. (P 0.05) level	1.07	0.77	0.66

As regards to 60 days after transplanting, the highest 17.87, 17.67, 17.47 and 17.37 cm stalk length were recorded in hybrid Barkha, Girija, variety Versha and Hy Suhasini respectively and which



were at par with each other. However, the lowest (15.80 cm) stalk length was found in Sitara – 70.

4.1.2 Number of leaves plant⁻¹

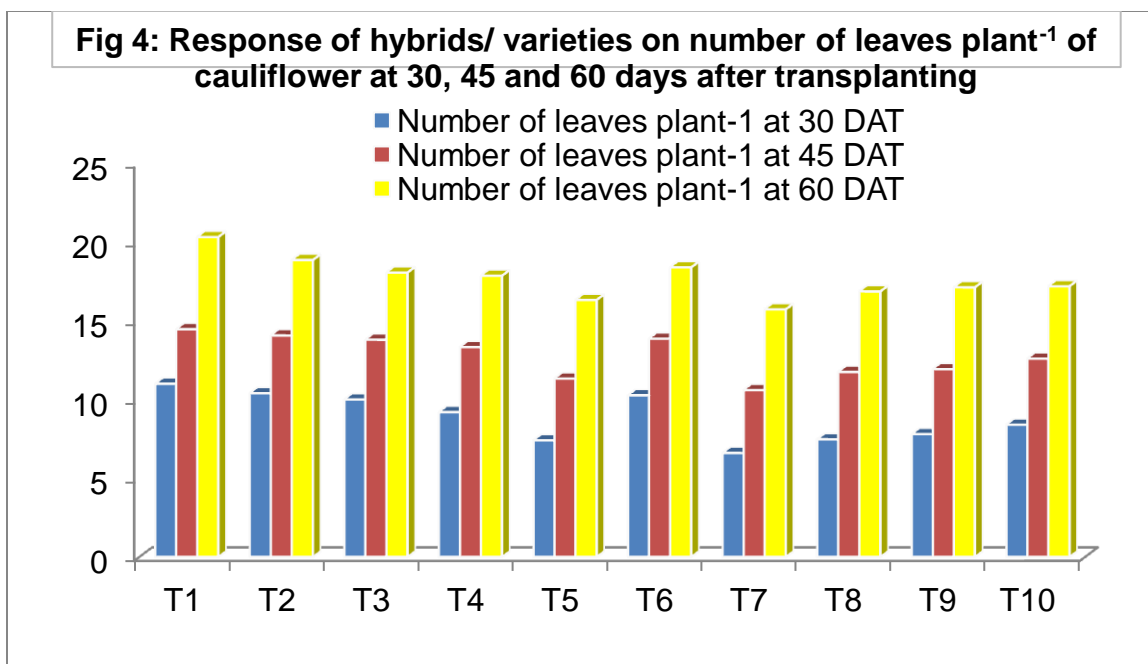
The average number of leaves plant⁻¹ of successive stages of growth (at 30, 45 and 60 days after transplanting), depicted in Table 4.2 and Fig. 4. The analysis of variance is also given in Appendix – I.

The data clearly indicated that the number of leaves plant⁻¹ of cauliflower plant responded significantly to various hybrids / varieties at all the growth stages (30, 45 and 60 days after transplanting), under study.

At 30 days after transplanting the maximum 11.0 number of leaves plant⁻¹ were observed under hybrid Barkha, followed by Girija, (10.40), variety Versha (10.27) and Hy Suhasini (10.0) and which were at par with each other. Whereas, the minimum 6.60 leaves plant⁻¹ was observed in Sitara – 70.

Table 4.2: Response of hybrids/ varieties on number of leaves plant⁻¹ of cauliflower at 30, 45 and 60 days after transplanting

Treat. Symb.	Treatments	Number of leaves plant ⁻¹ at		
		30 DAT	45 DAT	60 DAT
T ₁	Barkha (Hy)	11.00	14.47	20.33
T ₂	Girija (Hy)	10.40	14.07	18.87
T ₃	Suhasini (Hy)	10.00	13.80	18.07
T ₄	White excel (Hy)	9.20	13.33	17.87
T ₅	PS -666 (Hy)	7.40	11.33	16.33
T ₆	Versha	10.27	13.87	18.40
T ₇	Sitara – 70	6.60	10.60	15.73
T ₈	Early special	7.47	11.75	16.87
T ₉	Ganga-60	7.80	11.93	17.13
T ₁₀	Nandani	8.40	12.60	17.20
	S.Em±	0.58	0.56	0.64
	C.D. (P 0.05) level	1.73	1.65	1.89



At 45 days after transplanting, the maximum 14.47, 14.07, 13.87, 13.80 and 13.33 leaves plant⁻¹ were recorded in the hybrid Barkha, Girija, variety Versha, Hy Suhasini and Hy White excel respectively and which were at par with each other. While, the minimum 10.60 leaves plant⁻¹ was noted in Sitara – 70.

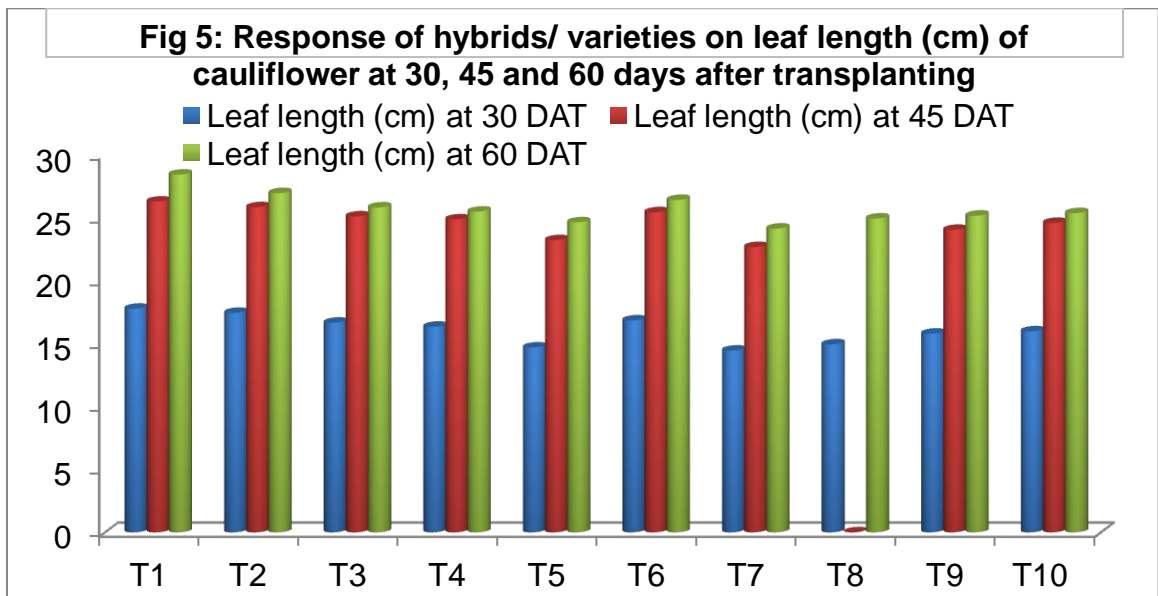
As regards to 60 days after transplanting, the hybrid Barkha was found significantly superior (20.33 leaves plant⁻¹) and which was at par with Girija (18.87 leaves plant⁻¹) as compare to rest of the treatments. However, Sitara – 70 was observed minimum 15.73 leaves plant⁻¹.

4.1.3 Leaf length (cm)

The leaf length was recorded and has been presented in table 4.3 and diagrammatically exhibited in Fig. 5. The analysis of variance is also given in Appendix – I.

Table 4.3: Response of hybrids/ varieties on leaf length (cm) of cauliflower at 30, 45 and 60 days after transplanting

Treat. Symb.	Treatments	Leaf length (cm) at		
		30 DAT	45 DAT	60 DAT
T ₁	Barkha (Hy)	17.78	26.30	28.45
T ₂	Girija (Hy)	17.45	25.85	26.97
T ₃	Suhasini (Hy)	16.67	25.12	25.83
T ₄	White excel (Hy)	16.35	24.88	25.50
T ₅	PS -666 (Hy)	14.70	23.23	24.65
T ₆	Versha	16.85	25.45	26.43
T ₇	Sitara – 70	14.45	22.68	24.15
T ₈	Early special	14.95	23. 82	24.95
T ₉	Ganga-60	15.80	24.05	25.18
T ₁₀	Nandani	15.98	24.60	25.38
	S.Em±	0.69	0.55	0.54
	C.D. (P 0.05) level	2.04	1.63	1.62



At 30 days after transplanting, the maximum 17.78, 17.45, 16.85, 16.67, 16.35, 15.98 and 15.80 cm leaf length were recorded in the hybrid Barkha, Girija, variety Versha, Hy Suhasini, Hy White excel, variety Nandani and Ganga-60

respectively and which were at par with each other. While, the minimum 14.45 cm leaf length was noted in Sitara – 70.

At 45 days after transplanting the maximum 26.30 cm leaf length was observed under the hybrid Barkha followed by hybrid Girija (25.85 cm), variety Versha (25.45 cm), Hy Suhasini (25.12 cm), Hy White excel (24.88 cm) and which were at par with each other. While, the minimum 22.68 cm leaf length was observed in Sitara – 70.

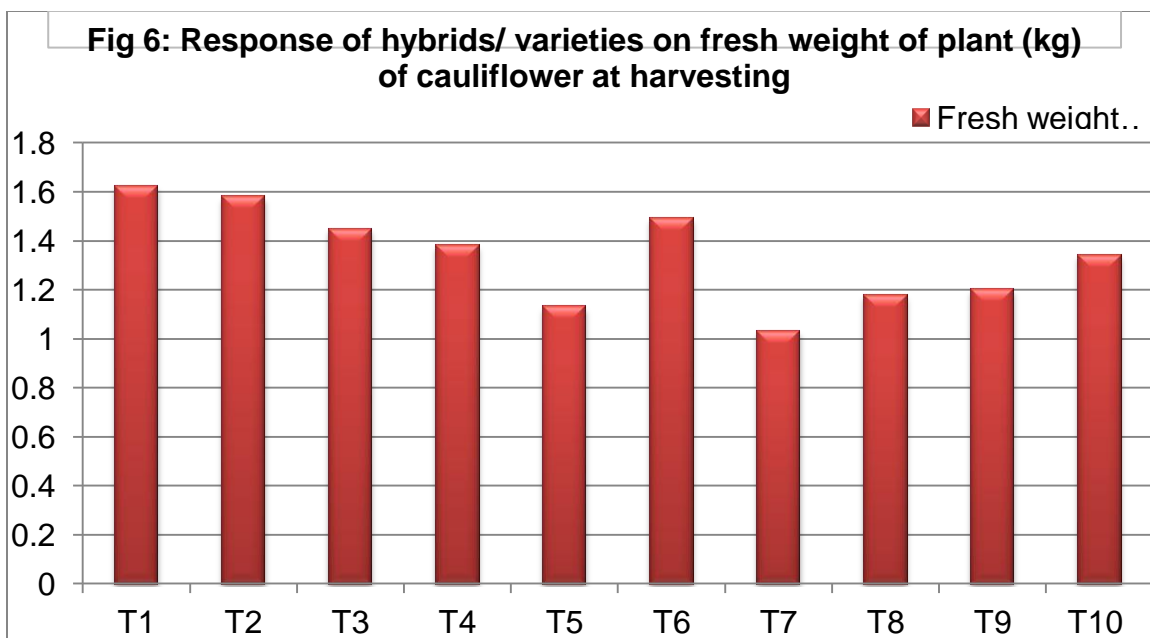
In case of 60 days after transplanting, the hybrid Barkha was found significantly superior (28.45 cm) and which was at par with hybrid Girija (26.97 cm) as compare to rest of the treatments. However, Sitara – 70 was observed minimum 24.15 cm leaf length.

4.1.4 Fresh weight of plant (kg)

The fresh weight of plant was recorded and has been presented in table 4.4 and diagrammatically exhibited in Fig. 6. The analysis of variance is also given in Appendix – I.

Table 4.4: Response of hybrids/ varieties on fresh weight of plant (kg) of cauliflower at harvesting

Treat. Symb.	Treatments	Fresh weight of plant (kg)
T ₁	Barkha (Hy)	1.62
T ₂	Girija (Hy)	1.58
T ₃	Suhasini (Hy)	1.45
T ₄	White excel (Hy)	1.38
T ₅	PS -666 (Hy)	1.13
T ₆	Versha	1.49
T ₇	Sitara – 70	1.03
T ₈	Early special	1.18
T ₉	Ganga-60	1.20
T ₁₀	Nandani	1.34
	S.Em±	0.03
	C.D. (P 0.05) level	0.09



Hybrid Barkha was found significantly superior and which recorded 1.62 kg fresh weight of plant was at par with hybrid Girija (1.58 kg) as compare to other treatments. However, Sitara – 70 was observed minimum 1.03 kg fresh weight of plant.

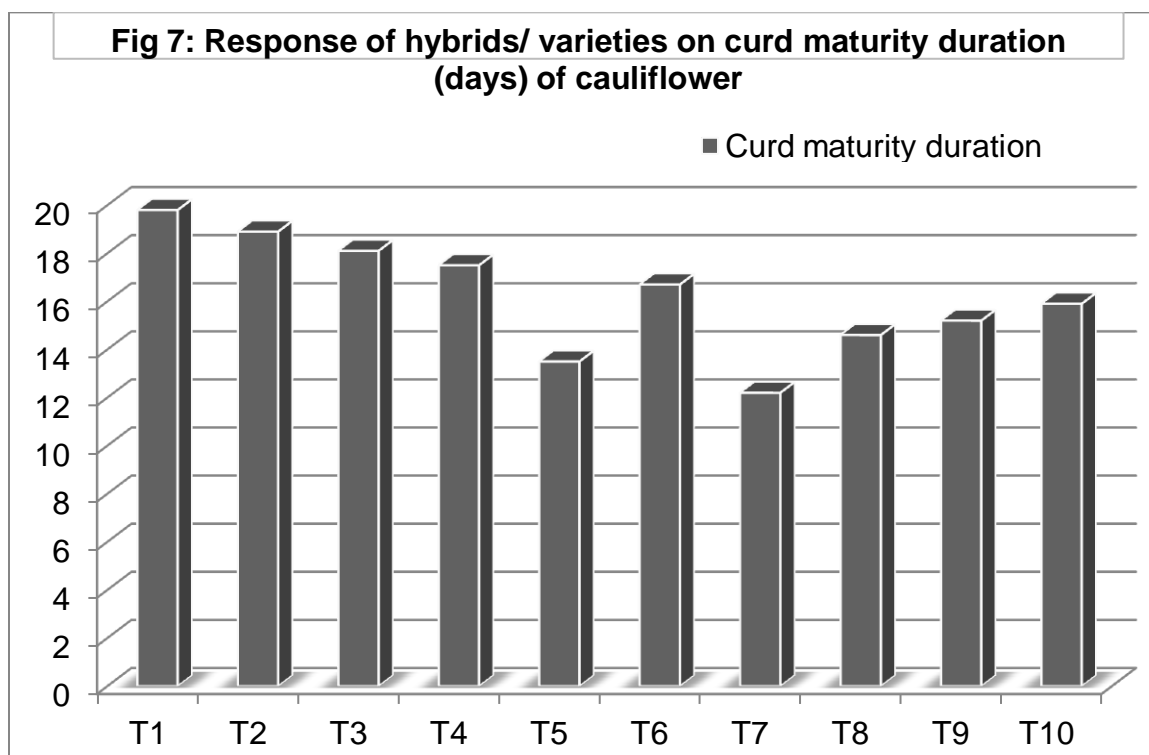
4.1.5 Curd maturity duration

The curd maturity duration was recorded and has been presented in table 4.5 and diagrammatically exhibited in Fig. 7. The analysis of variance is also given in Appendix – I.

Significantly maximum 19.8 days curd maturity duration was observed in the hybrid Barkha, followed by Hy Girija, (18.9 days) and Hy Suhasini (18.1 days) and which were at par with each other. Whereas, the minimum 12.2 days curd maturity duration was observed in Sitara – 70.

Table 4.5: Response of hybrids/ varieties on curd maturity duration (days) of cauliflower

Treat. Symb.	Treatments	Curd maturity duration (days)
T ₁	Barkha (Hy)	19.8
T ₂	Girija (Hy)	18.9
T ₃	Suhasini (Hy)	18.1
T ₄	White excel (Hy)	17.5
T ₅	PS -666 (Hy)	13.5
T ₆	Versha	16.7
T ₇	Sitara – 70	12.2
T ₈	Early special	14.6
T ₉	Ganga-60	15.2
T ₁₀	Nandani	15.9
	S.Em±	0.63
	C.D. (P 0.05) level	1.87



4.2 Yield parameters and yield

4.2.1 Curd length (cm)

The data for various treatments with respect to the curd length are summarized in Table 4.6 and illustrated in Fig. 8. The analysis of variance as

presented in Appendix – II, indicated that the treatments exert significant impact on the character.

Significantly maximum 13.13, 12.97, 12.67, 12.27, 12.13, and 11.73 cm curd length were recorded in the hybrid Barkha, Girija, variety Versha, Hy Suhasini, Hy White excel and variety Nandani respectively and which were at par with each other. While, the minimum 9.13 cm curd length was noted in Sitara – 70.

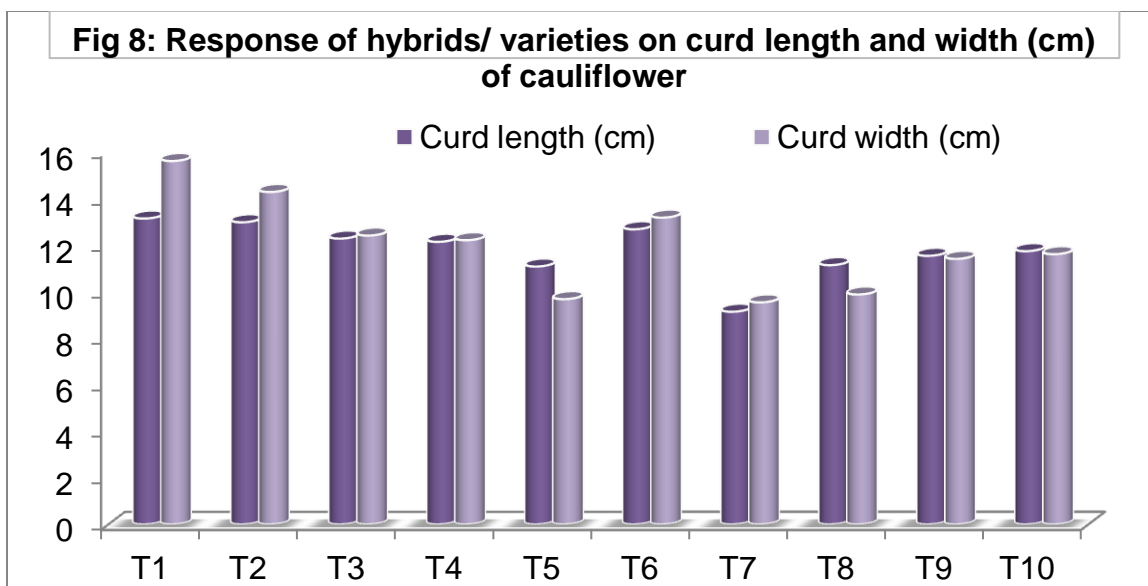
Table 4.6: Response of hybrids/ varieties on curd length and width (cm) of cauliflower

Treat. Symb.	Treatments	Curd length (cm)	Curd width (cm)
T ₁	Barkha (Hy)	13.13	15.60
T ₂	Girija (Hy)	12.97	14.27
T ₃	Suhasini (Hy)	12.27	12.40
T ₄	White excel (Hy)	12.13	12.20
T ₅	PS -666 (Hy)	11.07	9.67
T ₆	Versha	12.67	13.17
T ₇	Sitara – 70	9.13	9.53
T ₈	Early special	11.13	9.87
T ₉	Ganga-60	11.53	11.40
T ₁₀	Nandani	11.73	11.60
	S.Em±	0.50	0.57
	C.D. (P 0.05) level	1.48	1.69

4.2.2 Curd width (cm)

The curd width was recorded and has been presented in table 4.6 and diagrammatically exhibited in Fig. 8. The analysis of variance is also given in Appendix – II.

Hybrid Barkha was found significantly superior and which was recorded 15.60 cm curd width at par with hybrid Girija (14.27 cm) as compare to other treatments. However, Sitara – 70 was observed minimum 9.53 cm curd width.



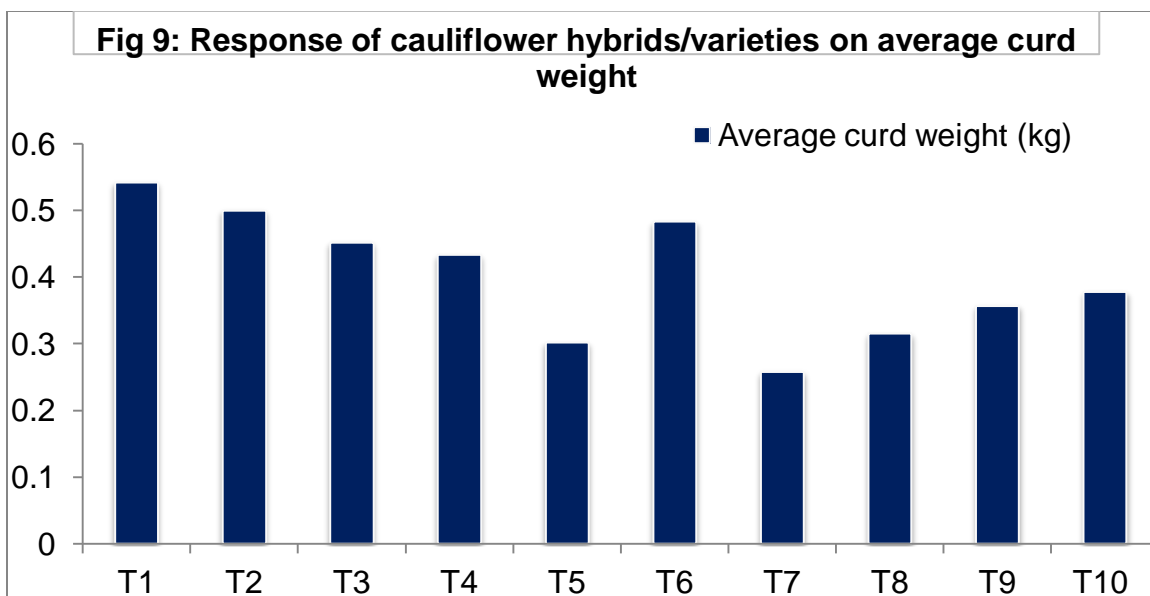
4.2.3 Average curd weight (kg)

The average curd weight has been shown in Table 4.7 and their graphical representation has shown in Fig. 9. The analysis of variance has also been presented in Appendix – II. It is explicit from the perusal of the Table 4.7 that this character responded significantly to different treatments.

Significantly maximum (0.542 kg) average curd weight was observed in Hybrid Barkha at par with hybrid Girija (0.500 kg) and variety Versha (0.483 kg). While, the minimum 0.258 kg average curd weight was recorded in Sitara – 70.

Table 4.7: Response of cauliflower hybrids/varieties on average curd weight

Treat. Symb.	Treatments	Average curd weight (kg)
T ₁	Barkha (Hy)	0.542
T ₂	Girija (Hy)	0.500
T ₃	Suhasini (Hy)	0.452
T ₄	White excel (Hy)	0.433
T ₅	PS -666 (Hy)	0.302
T ₆	Versha	0.483
T ₇	Sitara – 70	0.258
T ₈	Early special	0.315
T ₉	Ganga-60	0.357
T ₁₀	Nandani	0.378
	S.Em±	.03
	C.D. (P 0.05) level	0.08



4.2.4 Marketable curd yield plot⁻¹ (kg)

Marketable curd yield plot⁻¹ was recorded treatment wise and the mean values are depicted in Table 4.8 and diagrammatically exhibited in Fig. 10. The analysis of variance is shown in Appendix – II.

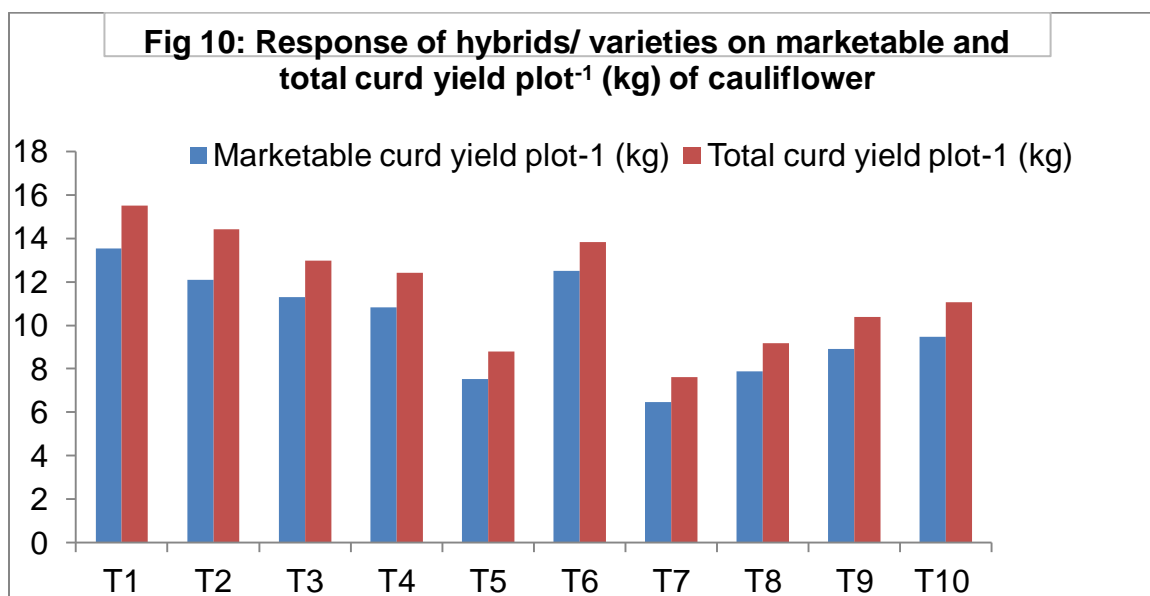
The data clearly indicate that there is significant difference under various treatments. Hybrid Barkha (13.542 kg plot⁻¹) was observed to be significantly superior among all the treatments followed by hybrid Girija (12.083 kg plot⁻¹) and variety Versha (12.500 kg plot⁻¹) as compare to other treatments. The minimum (6.458 kg plot⁻¹) marketable curd yield plot⁻¹ was recorded in Sitara – 70.

4.2.5 Total curd yield plot⁻¹ (kg)

The total curd yield plot⁻¹ has been shown in Table 4.8 and their graphical representation has shown in Fig. 10. Analysis of variance has also been presented in Appendix – II.

Table 4.8: Response of hybrids/ varieties on marketable and total curd yield plot⁻¹ (kg) of cauliflower

Treat. Symb.	Treatments	Marketable curd yield plot ⁻¹ (kg)	Total curd yield plot ⁻¹ (kg)
T ₁	Barkha (Hy)	13.542	15.498
T ₂	Girija (Hy)	12.083	14.413
T ₃	Suhasini (Hy)	11.292	12.982
T ₄	White excel (Hy)	10.833	12.417
T ₅	PS -666 (Hy)	7.542	8.793
T ₆	Versha	12.500	13.833
T ₇	Sitara – 70	6.458	7.602
T ₈	Early special	7.875	9.175
T ₉	Ganga-60	8.917	10.377
T ₁₀	Nandani	9.458	11.065
	S.Em±	0.81	0.85
	C.D. (P 0.05) level	2.41	2.52



Hybrid Barkha was found significantly superior and which was noted (15.498 kg plot⁻¹) total curd yield followed by hybrid Girija (14.413 kg plot⁻¹) and variety Versha (13.833 kg plot⁻¹) as compare to other treatments. However, Sitara – 70 was observed minimum (7.602 kg plot⁻¹) total curd yield.

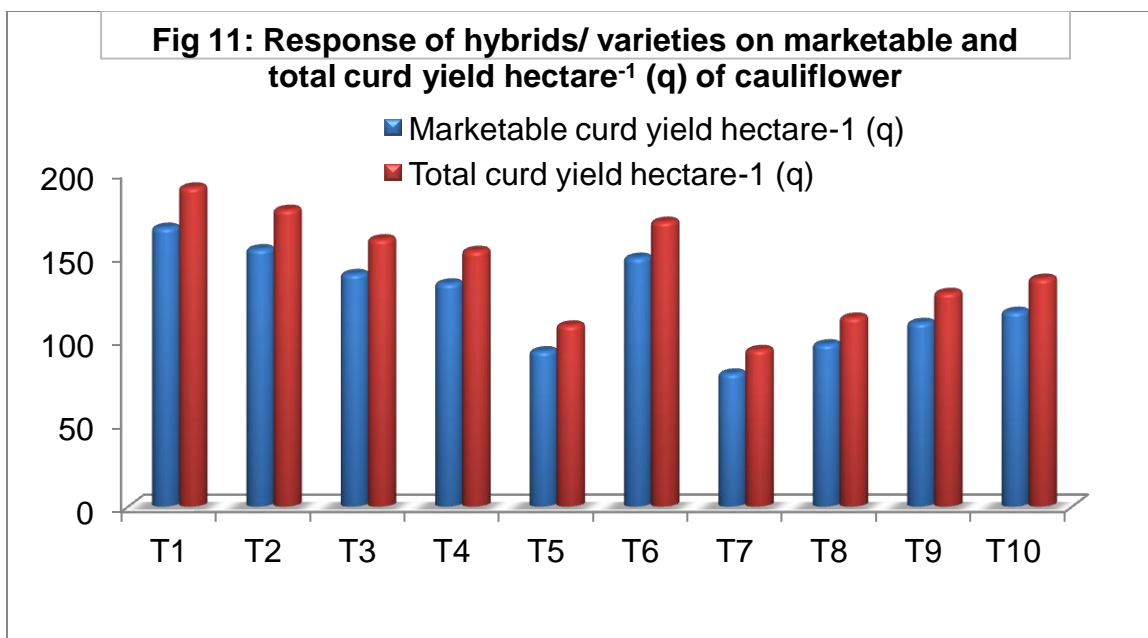
4.2.6 Marketable curd yield hectare⁻¹ (q)

The yield of any crop is the final index of the experiment which indicates the success or failure of any treatment with this view the curd yield of cauliflower was recorded. The data for the curd yield plot⁻¹ under different treatments were recorded and converted into curd yield q ha⁻¹.

Marketable curd yield hectare⁻¹ was recorded treatment wise and the mean values were subjected to statistical analysis (Appendix – II). The data have been depicted in Table 4.9 & diagrammatically exhibited in Fig. 11.

Table 4.9: Response of hybrids/ varieties on marketable and total curd yield hectare⁻¹ (q) of cauliflower

Treat. Symb.	Treatments	Marketable curd yield hectare ⁻¹ (q)	Total curd yield hectare ⁻¹ (q)
T ₁	Barkha (Hy)	167.11	191.25
T ₂	Girija (Hy)	154.25	177.86
T ₃	Suhasini (Hy)	139.34	160.19
T ₄	White excel (Hy)	133.69	153.22
T ₅	PS -666 (Hy)	93.07	108.51
T ₆	Versha	149.11	170.71
T ₇	Sitara – 70	79.70	93.80
T ₈	Early special	97.18	113.22
T ₉	Ganga-60	110.03	128.05
T ₁₀	Nandani	116.72	136.54
	S.Em±	10.01	10.47
	C.D. (P 0.05) level	29.74	31.09



Among the different treatments significantly maximum marketable curd yield hectare⁻¹ was recorded in hybrid Barkha (167.11 q ha⁻¹) followed by hybrid Girija (154.25 q ha⁻¹), variety Versha (149.11 q ha⁻¹) and Hy Suhasini (139.34 q ha⁻¹) and which were at par with each other. However, the minimum (79.70 q ha⁻¹) marketable curd yield was recorded in variety Sitara – 70.

4.2.7 Total curd yield hectare⁻¹ (q)

Total curd yield hectare⁻¹ was recorded treatment wise and the mean values were subjected to statistical analysis (Appendix – II). The data have been depicted in Table 4.9 and diagrammatically exhibited in Fig. 11.

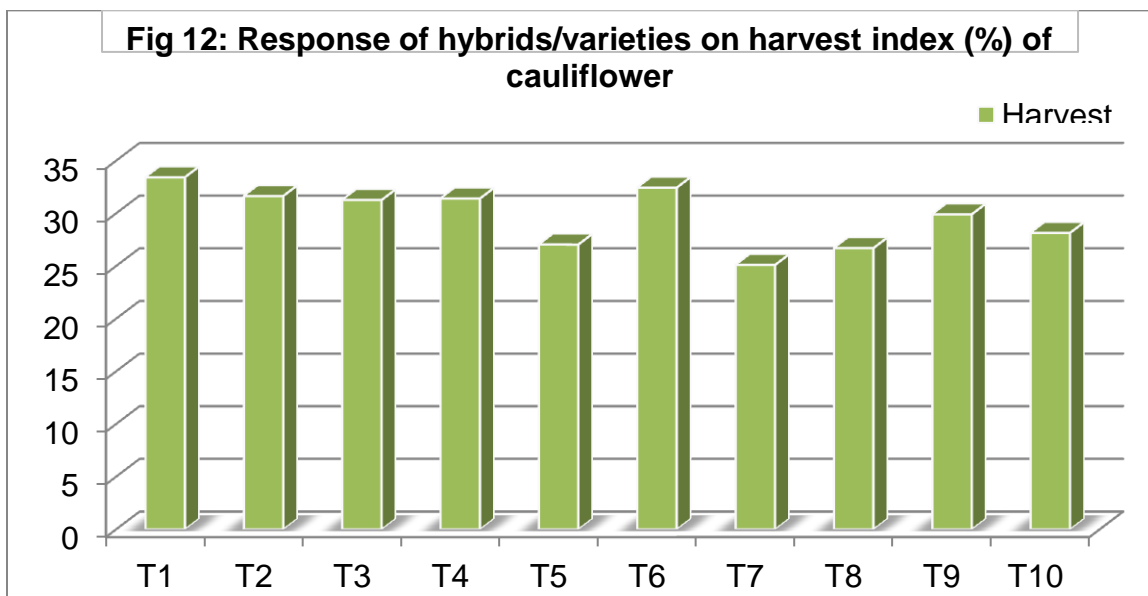
Significantly maximum total curd yield hectare⁻¹ was recorded in hybrid Barkha (191.25 q ha⁻¹) followed by hybrid Girija (177.86 q ha⁻¹), variety Versha (170.71 q ha⁻¹) and Hy Suhasini (160.19 q ha⁻¹) and which were at par with each other. However, the minimum (93.80 q ha⁻¹) total curd yield was recorded in variety Sitara – 70.

4.2.8 Harvest index (%)

The harvest index was observed treatment wise and data have been depicted in Table 4.10 & diagrammatically exhibited in Fig 12. Analysis of variance has been presented in Appendix – II.

Table 4.10: Response of hybrids/varieties on harvest index (%) of cauliflower

Treat. Symb.	Treatments	Harvest index (%)
T ₁	Barkha (Hy)	33.43
T ₂	Girija (Hy)	31.65
T ₃	Suhasini (Hy)	31.27
T ₄	White excel (Hy)	31.41
T ₅	PS -666 (Hy)	27.04
T ₆	Versha	32.44
T ₇	Sitara – 70	25.10
T ₈	Early special	26.70
T ₉	Ganga-60	29.91
T ₁₀	Nandani	28.15
	S.Em±	1.06
	C.D. (P 0.05) level	3.15



Significantly maximum (33.43%) harvest index was recorded in hybrid Barkha followed by hybrid Girija (31.65%), variety Versha (32.44%), Hy Suhasini (31.27%) and Hy White excel (31.41%). However, the minimum (25.10%) harvest index was recorded in variety Sitara – 70.

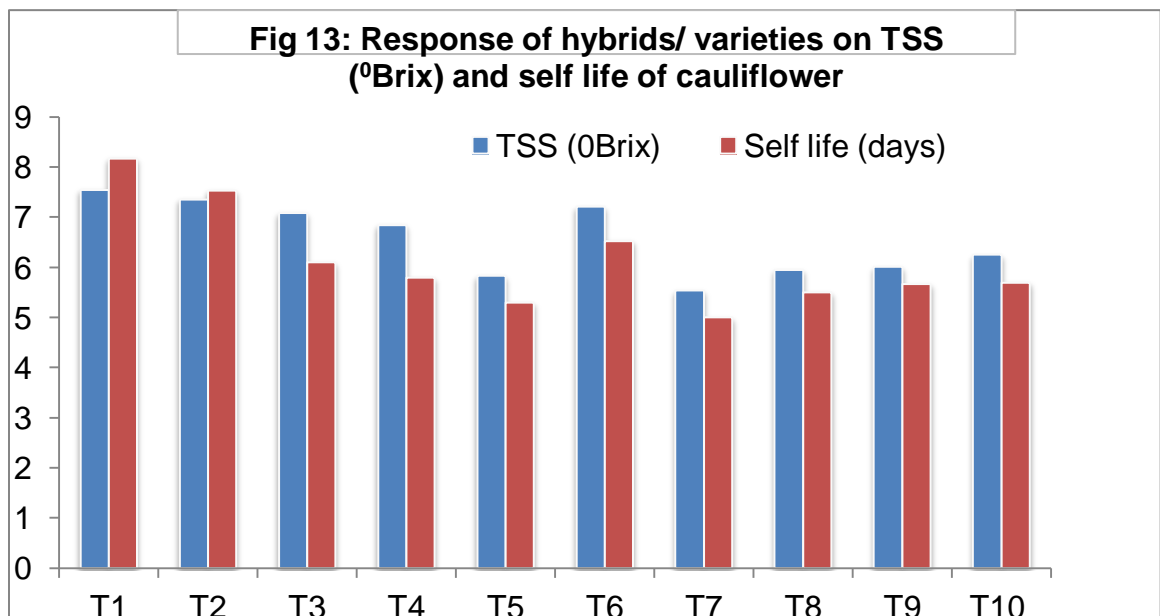
4.3 Quality parameters

4.3.1 TSS (⁰Brix)

The average TSS was recorded and has been presented in Table 4.11 and Fig. 13. The analysis of variance is also given in Appendix – III.

Table 4.11: Response of hybrids/ varieties on TSS (⁰Brix) and shelf life of cauliflower

Treat. Symb.	Treatments	TSS (⁰ Brix)	Shelf life (days)
T ₁	Barkha (Hy)	7.55	8.17
T ₂	Girija (Hy)	7.36	7.53
T ₃	Suhasini (Hy)	7.09	6.10
T ₄	White excel (Hy)	6.85	5.80
T ₅	PS -666 (Hy)	5.83	5.30
T ₆	Versha	7.21	6.53
T ₇	Sitara – 70	5.54	5.00
T ₈	Early special	5.95	5.50
T ₉	Ganga-60	6.01	5.67
T ₁₀	Nandani	6.25	5.70
	S.Em±	0.42	0.35
	C.D. (P 0.05) level	1.25	1.05



It is obvious from table 4.11 that the TSS was significantly influenced by the different treatments. Hybrid Barkha was observed highest TSS (7.55⁰Brix)

which was statistically at par with hybrid Girija (7.36⁰Brix), variety Versha (7.21⁰Brix), Hy Suhasini (7.09⁰Brix) and Hy White excel (6.85⁰Brix). Whereas, the lowest TSS (5.54⁰Brix) was found in Sitara – 70.

4.3.2 Shelf life (days)

The shelf life was recorded and has been presented in Table 4.11 and Fig. 13. The analysis of variance is also given in Appendix – III.

It is obvious from table 4.11 that the average shelf life was significantly influenced by the different treatments. Hybrid Barkha and Girija were observed highest shelf life 8.17 and 7.53 days, respectively and which were statistically at par with each other. Whereas, the lowest self life (5.0 days) was found in the Sitara – 70.

4.4 Economics

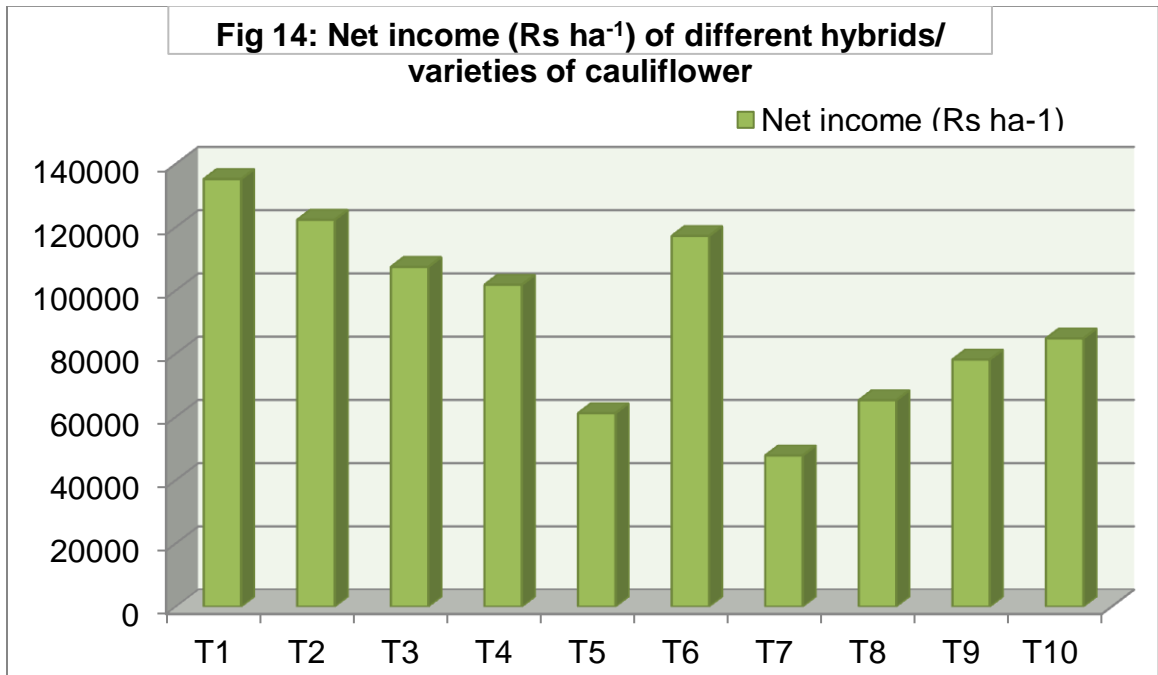
Higher money value and less cost of cultivation are desirable characters for getting higher returns. Hence, economics of the treatment was worked out. The date pertaining to economics of different treatments is depicted in Table 4.12, Fig. 14 & 15 and cost of cultivation incurred in various treatments is presented in Appendix - IV.

It is revealed form the date obtained that a significantly maximum marketable curd yield of 167.11q ha⁻¹ was obtained in cauliflower Hybrid Barkha. The net return of ₹ 1,35,226 ha⁻¹ and benefit cost ratio 5.24 was obtained under Hybrid Barkha followed by Hy Girija gave curd yield (154.25 q ha⁻¹) and net return of ₹ (1,22,366 ha⁻¹) with B:C ratio of ₹ 4.84, while, lowest marketable curd yield 79.70 q ha⁻¹ and net return of ₹ 47816 ha⁻¹ along with benefit cost ratio 2.50 was observed in variety Sitara – 70.

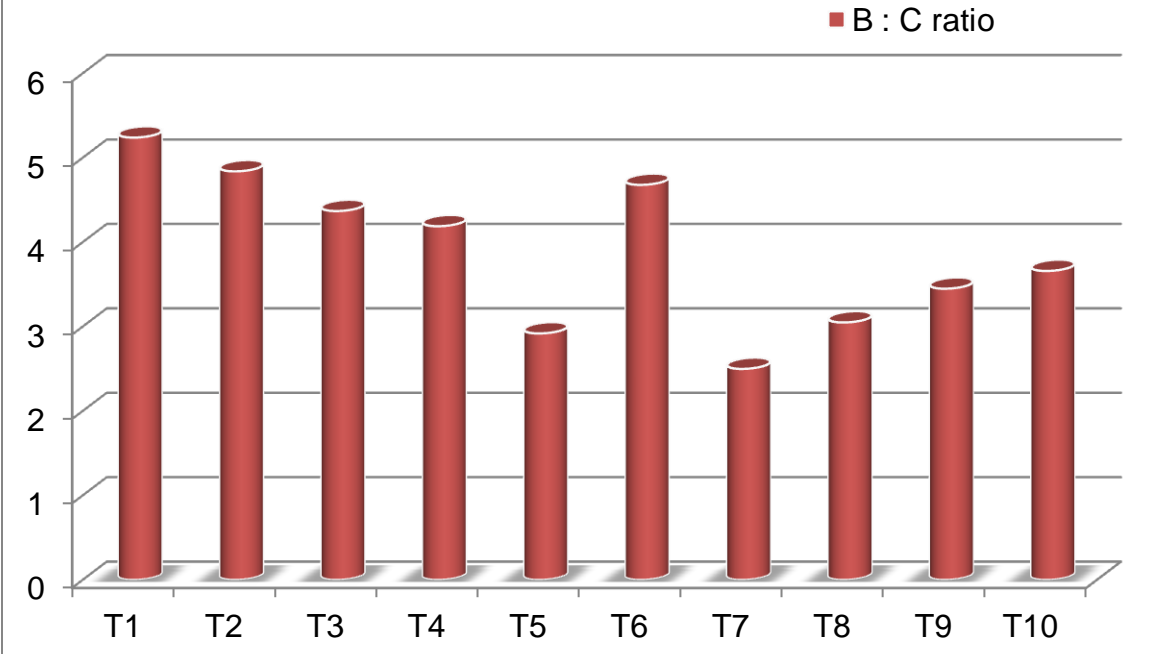
Table 4.12: Economics of different hybrids/ varieties of cauliflower.

Treat. Symb.	Treatments	Curd yield (q ha ⁻¹)	Gross income (₹ ha ⁻¹)	Expenditure (₹ ha ⁻¹)	Net income (₹ ha ⁻¹)	B : C ratio
T ₁	Barkha (Hy)	167.11	167110	31884	135226	5.24
T ₂	Girija (Hy)	154.25	154250	31884	122366	4.84
T ₃	Suhasini (Hy)	139.34	139340	31884	107456	4.37
T ₄	White excel (Hy)	133.69	133690	31884	101806	4.19
T ₅	PS -666 (Hy)	93.07	93070	31884	61186	2.92
T ₆	Versha	149.11	149110	31884	117226	4.68
T ₇	Sitara – 70	79.70	79700	31884	47816	2.50
T ₈	Early special	97.18	97180	31884	65296	3.05
T ₉	Ganga-60	110.03	110030	31884	78146	3.45
T ₁₀	Nandani	116.72	116720	31884	84836	3.66

Sale rate of produce was Rs. 1000.00 /q



**Fig 15: B : C ratio of different hybrids/
varieties of cauliflower**



CHAPTER V

DISCUSSION

The present investigation comprised 10 hybrids / varieties selected based on their genetic diversity with a view to estimate the genetics of yield and its components through the studies of growth, yield and quality parameter and economics. Such studies are helpful in the identification of suitable hybrids / varieties for cultivation in Vindhyan plateau.

The experimental results of the present investigation entitled **“Performance of different cauliflower (*Brassica oleracea* var. botrytis) hybrids / varieties under the Vindhyan plateau of Madhya Pradesh”** on the following aspects have been discussed in the light of the literature available for different characters under study in India and abroad.

5.1 Response of hybrids/ varieties on growth parameters of cauliflower

Among growth parameters, the stalk length, number of leaves plant-1, leaf length, fresh weight of plant and curd maturity duration were studied in cauliflower.

The highest stalk length was recorded in hybrid Barkha, Girija, variety Versha and Hy Suhasini and which were at par with each other. However, the lowest stalk length was found in Sitara – 70. Similar experimental conditions were provided in all the hybrids and varieties. Variation in stalk length was due to the inherent genetic makeup of the genotypes, which is some way influenced this morphological expression expressed through the activity of endogenous growth regulators. The variation for stalk length was also observed by Singh *et al.* (2011), Singh *et al.* (2013a), Singh *et al.* (2013b), Santhosha *et al.* (2014), Kumar *et al.* (2017), Sharma *et al.* (2017) and Sharma *et al.* (2018).

Hybrid Barkha was found significantly superior and recorded maximum number of leaves plant-1 and which was at par with Girija as compare to rest of the treatments. However, Sitara – 70 was observed minimum leaves plant-1. Probable reason for increased number of leaves due to the increased rates of photosynthesis and photosynthates supply for maximum growth or change in

endogenous auxin in turn in apical dominance. These findings are in agreement with the findings of Singh *et al.* (2011), Singh *et al.* (2013b), Thakur (2014), Santhosha *et al.* (2014), Kumar *et al.* (2017), Sharma *et al.* (2017) and Sharma *et al.* (2018).

The hybrid Barkha was found significantly superior and recorded maximum leaf length and which was at par with hybrid Girija (26.97 cm) as compare to rest of the treatments. However, Sitara – 70 was observed minimum leaf length. Leaf length was significantly increased by nitrogen, possibly because nitrogen helps in greater assimilation of food material by the plant which resulted in greater meristematic activities of cells and consequently the increase length of leaf. Another reason for this may be due to the inherent genetic makeup of the genotypes, which is some way influenced leaf length. Similar results have been reported by Singh *et al.* (2011), Singh *et al.* (2013a), Singh *et al.* (2013b), Santhosha *et al.* (2014), Kibar *et al.* (2014), Meena *et al.* (2014) and Kumar *et al.* (2017).

Hybrid Barkha was found significantly superior and which was recorded fresh weight of plant at par with hybrid Girija (1.58 kg) as compare to other treatments. However, Sitara – 70 was observed minimum fresh weight of plant. Similar experimental conditions were provided in all the hybrids and varieties. Variation in fresh weight of plant was due to the inherent genetic makeup of the genotypes, which is some way influenced this morphological expression expressed through the activity of endogenous growth regulators which resulted in the increased fresh weight of plant. These findings are in agreement with the findings of Singh *et al.* (2011), Singh *et al.* (2013b), Santhosha *et al.* (2014), Manaware *et al.* (2017), Kumar *et al.* (2017), Sharma *et al.* (2017) and Sharma *et al.* (2018).

Significantly maximum curd maturity duration was observed in the hybrid Barkha, followed by Hy Girija, and Hy Suhasini and which were at par with each other. Whereas, the minimum curd maturity duration was observed in Sitara – 70. Temperature plays a major role in curd maturity duration of cauliflower, some way low temperature prolongs the maturity duration and vice versa. Another reason for

this may be due to the inherent genetic makeup of the genotypes, which is some way influenced curd maturity duration. Similar results have been reported by Dhatt and Garg (2008), Singh *et al.* (2013b), Elavarasan *et al.* (2013), Elavarasan *et al.* (2014), Santhosha *et al.* (2014), Meena *et al.* (2014), Thakur (2015), Kumar *et al.* (2017), Sharma *et al.* (2018) and Kumar *et al.* (2018).

5.2 Response of hybrids/ varieties on yield parameters of cauliflower

Among yield parameters, the curd length, curd width, average curd weight, marketable curd yield plot-1, total curd yield plot-1, marketable curd yield hectare-1, total curd yield hectare-1 and harvest index per cent were studied in cauliflower.

Significantly maximum curd length were recorded in the hybrid Barkha, Girija, variety Versha, Hy Suhasini, Hy White excel and variety Nandani and which were at par with each other. While, the minimum curd length was noted in Sitara – 70. This may be due to inherent genetic makeup of the genotypes and increased supply of major plant nutrients and are required in larger quantities for growth and development of plants. Nitrogen accelerates the development of growth and reproductive phases and protein synthesis, thus promoting curd length. These findings are in agreement with the findings of Sharma *et al.* (2006), Kodithuwakku and Kirthisinghe (2009), Singh *et al.* (2011), Singh *et al.* (2013a), Elavarasan *et al.* (2013), Elavarasan *et al.* (2014), Thakur (2014), Santhosha *et al.* (2014), Kibar *et al.* (2014), Manaware *et al.* (2017), Kumar *et al.* (2017) and Sharma *et al.* (2018).

Hybrid Barkha was found significantly superior and which was recorded maximum curd width at par with hybrid Girija as compare to other treatments. However, Sitara – 70 was observed minimum curd width. This may be due to inherent genetic makeup of the genotypes and increased supply of major plant nutrients and are required in larger quantities for growth and development of plants. Nitrogen accelerates the development of growth and reproductive phases and protein synthesis, thus promoting curd width. Similar results have been reported by Sharma *et al.* (2006), Rahman *et al.* (2007), Kodithuwakku and Kirthisinghe (2009), Singh *et al.* (2011), Singh *et al.* (2013a), Singh *et al.* (2013b),

Thakur (2014), Santhosha *et al.* (2014), Kibar *et al.* (2014), Manaware *et al.* (2017), Kumar *et al.* (2017), Sharma *et al.* (2017) and Sharma *et al.* (2018).

Significantly maximum average curd weight was observed in Hybrid Barkha which was at par with hybrid Girija and variety Versha. While, the minimum average curd weight was recorded in Sitara – 70. This may be due to inherent genetic makeup of the genotypes and increased supply of major plant nutrients and are required in larger quantities for growth and development of plants. Nitrogen accelerates the development of growth and reproductive phases and protein synthesis, thus promoting average curd weight. These findings are in agreement with the findings of Sharma *et al.* (2006), Rahman *et al.* (2007), Kodithuwakku and Kirthisinghe (2009), Singh *et al.* (2011), Singh *et al.* (2013b), Elavarasan *et al.* (2013), Elavarasan *et al.* (2014), Thakur (2014), Santhosha *et al.* (2014), Kibar *et al.* (2014), Manaware *et al.* (2017), Kumar *et al.* (2017) and Kumar *et al.* (2018).

The data clearly indicate that there is significant difference under various treatments. Hybrid Barkha was observed to be significantly superior and which was recorded maximum marketable curd yield plot-1 among all the treatments followed by hybrid Girija and variety Versha as compare to other treatments. The minimum marketable curd yield plot-1 was recorded in Sitara – 70. These findings are in agreement with the results reported by Dhatt and Garg (2008), Kodithuwakku and Kirthisinghe (2009), Kumar *et al.* (2010), Meena *et al.* (2010), Singh *et al.* (2013b), Elavarasan *et al.* (2013), Elavarasan *et al.* (2014), Nimkar and Korla (2014), Santhosha *et al.* (2014), Kibar *et al.* (2014), Meena *et al.* (2014), Manaware *et al.* (2017), Kumar *et al.* (2017), Sharma *et al.* (2017) and Sharma *et al.* (2018).

Hybrid Barkha was found significantly superior and which was noted significantly maximum total curd yield followed by hybrid Girija and variety Versha as compare to other treatments. However, Sitara – 70 was observed minimum total curd yield. The probable reason for enhanced marketable curd yield may be due to inherent genetic makeup of the genotypes and promotive effects of nutrient (macro and micro) on vegetative growth which ultimately lead

to more photosynthetic activities enhance carbohydrate and nitrogen metabolism of peptic substances, as well as improve the water metabolism and water relation in the plants. These findings are in agreement with the findings of Dhatt and Garg (2008), Kodithuwakku and Kirthisinghe (2009), Kumar *et al.* (2010), Meena *et al.* (2010), Elavarasan *et al.* (2013), Elavarasan *et al.* (2014), Nimkar and Korla (2014) and Kibar *et al.* (2014).

The yield of any crop is the final index of the experiment which indicates the success or failure of any treatment with this view the curd yield of cauliflower was recorded. Among the different treatments the significantly maximum marketable curd yield hectare⁻¹ was recorded in hybrid Barkha (167.11 q ha⁻¹) followed by hybrid Girija (154.25 q ha⁻¹), variety Versha (149.11q ha⁻¹) and Hy Suhasini (139.34 q ha⁻¹) and which were at par with each other. However, the minimum (79.70 q ha⁻¹) marketable curd yield was recorded in variety Sitara – 70. These findings are in agreement with the results reported by Rahman *et al.* (2007), Kodithuwakku and Kirthisinghe (2009), Kumar *et al.* (2010), Singh *et al.* (2013b), Elavarasan *et al.* (2013), Nimkar and Korla (2014), Kibar *et al.* (2014), Meena *et al.* (2014), Chittora and Singh (2015), Manaware *et al.* (2017) and Kumar *et al.* (2017).

Significantly maximum total curd yield hectare⁻¹ was recorded in hybrid Barkha (191.25 q ha⁻¹) followed by hybrid Girija (177.86 q ha⁻¹), variety Versha (170.71 q ha⁻¹) and Hy Suhasini (160.19 q ha⁻¹) and which were at par with each other. However, the minimum (93.80 q ha⁻¹) total curd yield was recorded in variety Sitara – 70. Higher curd yield may be attributed in cumulative effect of plant height, leaves per plant, leaf area, curd circumference, curd width, length and weight. These findings are in agreement with the findings of Rahman *et al.* (2007), Kodithuwakku and Kirthisinghe (2009), Kumar *et al.* (2010), Elavarasan *et al.* (2013), Nimkar and Korla (2014), Kibar *et al.* (2014), Chittora and Singh (2015) and Kumar *et al.* (2017).

Significantly maximum harvest index per cent was recorded in hybrid Barkha followed by hybrid Girija, variety Versha, Hy Suhasini and Hy White excel and which were at par with each other. However, the minimum harvest index was

recorded in variety Sitara – 70. These findings are in agreement with the results reported by Sharma *et al.* (2006), Singh *et al.* (2011), Santhosha *et al.* (2014), Kumar *et al.* (2017), Sharma *et al.* (2017) and Sharma *et al.* (2018).

5.3 Response of hybrids/ varieties on quality parameters of cauliflower

Among quality parameters, the TSS and shelf life were studied in cauliflower.

It is obvious from data that the TSS was significantly influenced by the different treatments. Hybrid Barkha was observed to have the highest TSS which was statistically at par with hybrid Girija, variety Versha, Hy Suhasini and Hy White excel. Whereas, the lowest TSS was found in Sitara – 70. This may be due to the inherent genetic makeup of the genotypes. These findings are in agreement with the findings of Sharma *et al.* (2018).

It is obvious from results revealed that the average shelf life was significantly influenced by the different treatments. Hybrid Barkha and Girija were observed highest shelf life and which were statistically at par with each other. Whereas, the lowest shelf life was found in the Sitara – 70. These findings are in agreement with the results reported by Kodithuwakku and Kirthisinghe (2009).

5.3 Response of hybrids/ varieties on economics of cauliflower

Higher money value and less cost of cultivation are desirable characters for getting higher returns. Hence, economics of the treatment was worked out. It is revealed from the data obtained that a significantly maximum marketable curd yield of 167.11q ha⁻¹ was obtained in cauliflower Hybrid Barkha. The net return of Rs 1,35,226 ha⁻¹ and benefit cost ratio 5.24 was obtained under Hybrid Barkha. While, lowest marketable curd yield 79.70 q ha⁻¹ and net return of Rs 47816 ha⁻¹ along with benefit cost ratio 2.50 was observed in variety Sitara – 70. Similar results have been reported by Chaurasia *et al.* (2009), Bala *et al.* (2011) and Kumar *et al.* (2011).

CHAPTER VI

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FUTURE WORK

6.1 Summary

The present investigation entitled “**Performance of different cauliflower (*Brassica oleracea* var. *botrytis*) hybrids / varieties under the Vindhyan plateau of Madhya Pradesh**” was conducted during rabi season of 2017-2018, at the Horticulture Research Farm, Department of Horticulture, R.A.K. College of Agriculture, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Sehore,, (M.P.). The material of experiment for the present investigation was comprised of ten treatments (5 hybrids and 5 varieties of the cauliflower. These treatments were sown in Randomized Complete Block Design with three replications, to observed growth, yield, quality parameters and work out the economics and to estimate the genetic variability and adoptability in “Vindhyan plateau”. Observations were recorded on the basis of five random competitive plants selected from each treatment separately for growth, yield and quality parameters were evaluated as per standard procedure and also work out the economics of treatments. On the basis of results, the present investigation is summarized as follows:

The calculation of MSS due to treatments were most significant for all the parameters, indicating the presence of genetic diversity in the existing material.

Highest stalk length was recorded in hybrid Barkha, Girija, variety Versha and Hy Suhasini and which were at par with each other. However, the lowest stalk length was found in Sitara – 70.

Hybrid Barkha was found significantly superior and recorded maximum number of leaves plant-1 and which was at par with Girija as compare to rest of the treatments. However, Sitara – 70 was observed minimum leaves plant⁻¹.

The hybrid Barkha was found significantly superior and recorded maximum leaf length and which was at par with hybrid Girija (26.97 cm) as compare to rest of the treatments. However, Sitara – 70 was observed minimum leaf length.

Hybrid Barkha was found significantly superior and which was recorded fresh weight of plant at par with hybrid Girija (1.58 kg) as compare to other treatments. However, Sitara – 70 was observed minimum fresh weight of plant.

Significantly maximum curd maturity duration was observed in the hybrid Barkha, followed by Hy Girija, and Hy Suhasini and which were at par with each other. Whereas, the minimum curd maturity duration was observed in Sitara – 70.

Significantly maximum curd length were recorded in the hybrid Barkha, Girija, variety Versha, Hy Suhasini, Hy White excel and variety Nandani and which were at par with each other. While, the minimum curd length was noted in Sitara – 70.

Hybrid Barkha was found significantly superior and which was recorded maximum curd width at par with hybrid Girija as compare to other treatments. However, Sitara – 70 was observed minimum curd width.

Significantly maximum average curd weight was observed in Hybrid Barkha at par with hybrid Girija and variety Versha. While, the minimum average curd weight was recorded in Sitara – 70.

Hybrid Barkha was observed to be significantly superior and which was recorded maximum marketable curd yield plot-1 among all the treatments followed by hybrid Girija and variety Versha as compare to other treatments. The minimum marketable curd yield plot-1 was recorded in Sitara – 70.

Hybrid Barkha was found significantly superior and which was noted significantly maximum total curd yield followed by hybrid Girija and variety Versha as compare to other treatments. However, Sitara – 70 was observed minimum total curd yield.

Among the different treatments the significantly maximum marketable curd yield hectare-1 was recorded in hybrid Barkha (167.11 q ha⁻¹) followed by hybrid Girija (154.25 q ha⁻¹), variety Versha (149.11q ha⁻¹) and Hy Suhasini (139.34 q ha⁻¹) and which were at par with each other. The minimum (79.70 q ha⁻¹) marketable curd yield was recorded in variety Sitara – 70.

Significantly maximum total curd yield hectare-1 was recorded in hybrid Barkha (191.25 q ha⁻¹) followed by hybrid Girija (177.86 q ha⁻¹), variety Versha

(170.71 q ha⁻¹) and Hy Suhasini (160.19 q ha⁻¹) and which were at par with each other. The minimum (93.80 q ha⁻¹) total curd yield was recorded in variety Sitara – 70.

Significantly maximum harvest index per cent was recorded in hybrid Barkha followed by hybrid Girija, variety Versha, Hy Suhasini and Hy White excel and which were at par with each other. However, the minimum harvest index was recorded in variety Sitara – 70.

Hybrid Barkha was observed to have highest TSS which was statistically at par with hybrid Girija, variety Versha, Hy Suhasini and Hy White excel. Whereas, the lowest TSS was found in Sitara – 70.

Hybrid Barkha and Girija were observed highest shelf life and which were statistically at par with each other. Whereas, the lowest shelf life was found in the Sitara – 70.

Higher money value and less cost of cultivation are desirable characters for getting higher returns. Hence, economics of the treatment was worked out. It is revealed from the data obtained that a significantly maximum marketable curd yield of 167.11q ha⁻¹ was obtained in cauliflower Hybrid Barkha. The net return of Rs 1,35,226 ha⁻¹ and benefit cost ratio 5.24 was obtained under Hybrid Barkha.

6.2 Conclusion

Analysis of variance revealed highly significant variance for all the traits depicting greater variability in the existing material.

On the basis of current experiment, it is concluded that the cauliflower hybrid Barkha and variety Versha responded well in terms of growth (such as plant stalk length, no. of leaves plant⁻¹, green leaf length, plant fresh weight, and curd maturity duration), yield and its attributing (curd length, curd width, average curd weight, marketable curd yield plot⁻¹, total curd yield plot⁻¹, marketable curd yield hectare⁻¹, total curd yield hectare⁻¹ and harvest index per cent) and quality (viz., TSS and self life) parameters.

It is revealed from the data obtained that the significantly maximum marketable curd yield hectare⁻¹ was recorded in hybrid Barkha (167.11 q ha⁻¹)

followed by hybrid Girija (154.25 q ha^{-1}) and variety Versha (149.11 q ha^{-1}). These were identified as best hybrid and variety for cultivation in Vindhyan Plateau agro-climatic region of M.P.

Higher money value and less cost of cultivation are desirable characters for getting higher returns. It is revealed from the data obtained that a significantly maximum marketable curd yield of 167.11 q ha^{-1} was obtained in cauliflower Hybrid Barkha. The net return of Rs 1,35,226 ha^{-1} and benefit cost ratio 5.24 was obtained under Hybrid Barkha.

6.3 Suggestions for further work

1. Stability of distinct traits of cauliflower should be established over the years.
2. Desirable characters having good curd yield should be given due consideration for genetic improvement in cauliflower.
3. The genotypes showing greater yield potential with other desirable qualities may be tested under different agro climatic conditions and those found suitable could be recommended for general cultivation.

REFERENCES

- A.O.A.C. (1970). Official Methods of Analysis 15th Ed, Virginia, 838-841.
- Ahmad, Waqar; Ashraf, Muhammad Irfan; Chaudhary Muhammad Ayyub, and Noor, Munawar Ahmad (2018). Effect of curd size on seed yield and quality of Cauliflower (*Brassica oleraceae* var. botrytis L.). *Int. J. Biosci.* **12** (1): 143-148.
- Anonymous (2017a). Horticulture statistics at a glance 2017. Published by Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Govt. of India. pp. 16.
- Anonymous (2017b). Horticulture statistics at a glance 2017. Published by Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Govt. of India. pp. 202.
- Ara N., Kaiser, M. O., Khalequzzman, K. M., Kohinoor, H. and Ahamed, K. U. (2009). Effect of different dates of planting and lines on the growth, yield and yield contributing characteristics of Cauliflower. *J Soil Nat* **3** (1): 16-19.
- Bala, Brij; Sharma, Nikhil and Sharma, R.K. (2011). Cost and return structure for the promising enterprise of off-season vegetables in Himachal Pradesh. *Agricultural Economics Research Review.* **24**:141-148.
- Black, C. A. (1965). Method of plant and soil analysis part II. Pub. *Amer. Sco. Agron.* Madison, Wiscorsin, USA, pp. 1367 – 1373.
- Chaurasia, S. N. S. Rakesh Singh and Mathura Rai (2009). Effect of integrated nutrient management and spacing on yield, quality and economics of Broccoli (*Brassica oleracea* var. italica Plenck). *Veg.Sci.* **36** (1): 51-54.
- Chittora, Akshay and Singh, D. K. (2015). Genetic variability studies in early cauliflower (*Brassica oleracea* var. botrytis L.). *Electronic Journal of Plant Breeding.* **6** (3): 842-847.
- Dhatt, A. S. and Garg, Naveen (2008). Genetic variability, correlation and path analysis in November maturing cauliflower. *Haryana Journal of Horticultural Sciences.* **37** (3/4): 342-344.

- Elavarasan, K.; Pushpalatha, P. B.; John, P. Jacob; Sheela, K. B. and Narayanankutty, C. (2013). Studies on the performance of different genotypes of cabbage grown in plains and higher altitude of Kerala. *Global Journal of Bio-science and Biotechnology*. 2 (3): 317-320.
- Elavarasan, K.; Pushpalatha, P. B.; John, P. Jacob; Sheela, K. B. and Narayanankutty, C. (2014). Studies on the performance of different genotypes of cauliflower grown in plains and higher altitude of Kerala. *International Letters of Natural Sciences*. 6: 25-32.
- Jackson, M. L. (1967). Soil Chemical Analysis, Prentice Hall of India, Pvt. Ltd., New Delhi, pp. 183-192.
- Jood, S. and Neelam, K. (2011). Importance of vegetables in human nutrition and health. In: Rana, M.K. (ed.) *Fundamentals of Vegetable Production*, New Indian Publishing Agency, New Delhi. p 70.
- Kibar, Beyhan; Onur Karaag, A. C. and Hayati Kar (2014). Correlation and path coefficient analysis of yield and yield components in cabbage (*Brassica oleracea* var. *Capitata* L.). *Acta Sci. Pol., Hortorum Cultus*. 13 (6): 87-97.
- Kodithuwakku, D. P. and Kirthisinghe, J. P. (2009). The effect of different rates of nitrogen fertilizer application on the growth, yield and postharvest life of cauliflower. *Tropical Agricultural Research*. 21(1): 110-111.
- Kumar M., Sharma S. R., Kalia P. and Saha P. (2010). Genetic variability and character association for quantitative and quality traits in early maturing Indian cauliflowers. *Indian Journal of Horticulture* 67 (Special Issue): 218-223.
- Kumar, A.; Manuja, S.; Singh, J. and Chaudhary, D. R. (2011). Integrated weed management in cauliflower (*Brassica oleracea* var. *botrytis*) under dry temperate climate of western Himalayas. *Journal Crop and Weed*, 11 (2): 168-171.
- Kumar, Amit; Roy, Chandan; Ravi Kumar, Randhir Kumar, Singh, Vijay Kumar and Verma, R. B. (2018). Study of genetic divergence for earliness and yield attributing traits in tropical cauliflower (*Brassica oleracea* var. *botrytis* L.). *Journal of Pharmacognosy and Phytochemistry*. 7 (2): 1761-1763.

- Kumar, Vivek; Dharendra Kumar Singh and Ankit Panchbhaiya (2017). Genetic variability studies in mid-season cauliflower (*Brassica oleracea* var. botrytis L.). *Bulletin of Environment, Pharmacology and Life Sciences*. **6** (9): 99-104.
- Manaware, Diksha; Naidu, A. K. and Lal, Narayan (2017). Genetic diversity assessment for growth and yield traits in cauliflower. *Int. J. Curr. Microbiol. App. Sci.* **6** (8): 3016-3027.
- Meena, M. L., Ram, R. B. and Lata, R. (2010). Studies on variability, correlation and path analysis for morphological and horticultural traits in cabbage (*Brassica oleracea* var. capitata L.) genotypes under Lucknow conditions. *Horticultural Journal*. **23** (2): 73-77.
- Meena, M. L.; Ram, R. B.; Rubee Lata and Sharma, S. R. (2014). Inter-trait association and genetic variability assessment in cabbage under Lucknow conditions. *Indian Journal of Horticulture*. **71** (2): 202-206.
- Motiramani, S. A. and Wankhede, P. K. (1964). Soil nutrients bio-variability a mechanist approach. John Willey and Sons, Bombay.
- Nimkar, S. A. and Korla, B. N. (2014). Performance of F₄ progenies developed through bud and mixed pollination in Late Cauliflower (*Brassica oleracea* var Botrytis L.). *Indian Horticulture Journal*; **4** (1): 43-48.
- Olsen, S. R.; Cole, C V. and Dean, L. A. (1954). Estimation of available phosphorus in soil by extraction with sodium carbonate. USDA Circular No.939, Washington, p.15.
- Panse, V. C. and Sukhatme, P. V. (1985). Statistical methods for agricultural workers. ICAR Publications, New Delhi. pp 155.
- Piper, C S. (1967). Soil and plant analysis. *Uni.of Adelaide*, Australia. Hans Publishers, Bombay.
- Rahman, Mujeeb Ur; Iqbal, Muhammad; Jilani, Muhammad Saleem and Waseem, Kashif (2007). Effect of different plant spacing on the production of cauliflower (*Brassica oleraceae* var. Botrytis) under the agro-climatic conditions of D.I. Khan. *Pakistan Journal of Biological Sciences*. **10** (24): 453.

- Rai N and Yadav D. S. (2005). Cauliflower: In *Advances in Vegetable Production*, Research co Book Centre, New Delhi -110005. pp 292-310.
- Santhosha, H. M.; Varalakshmi, B. and Shivashankara, K. S. (2014). Characterization of early cauliflower germplasms under tropical conditions. *The Bioscan*. **9** (2): 869-874.
- Sharma Akhilesh, Pathania N K, Sharma Susheel and Pathak Sanjeev. (2006). Effect of transplanting time on growth and marketable curd yield of different cultivars of cauliflower (*Brassica oleracea* var botrytis sub var cauliflora) under dry temperate high hill conditions. *Indian Journal of Agricultural Sciences*. **76** (6): 343-345.
- Sharma, Surbhi; Singh, Yudhvair; Sekhon, Bhallan Singh and Verma, Arti (2017). Association studies for yield and some yield contributing morpho-physiological components in cauliflower (*Brassica oleracea* L. var. botrytis L.). *Electronic Journal of Plant Breeding*. **8** (2): 718-723.
- Sharma, Surbhi; Singh, Yudhvair; Sharma, Simran; Vishalakshi and Sekhon, Bhallan Singh (2018). Variability studies in cauliflower (*Brassica oleracea* L. var. botrytis L.) for horticultural traits under mid hill conditions of North-Western Himalayas, India. *Journal of Pharmacognosy and Phytochemistry*. **7** (2): 100-103.
- Singh, B.; Chaubey, T.; Jha, Aastik; Upadhvay, D. K. and Pandey, S. D. (2013a). Morphological characterization of cauliflower varieties/cultivars using DUS characters. *SAARC Journal of Agriculture*. **11** (2): 183-191.
- Singh, Pratima; Kumar, Sanjay; Maji, Sutanu and Singh, Abhishek (2013b). Genetic variability, heritability and genetic advance in cauliflower (*Brassica oleracea* var. botrytis L.). *Internat. J. Plant Sci*. **8** (1): 179-182.
- Singh, B. K.; Sharma, S. R.; Kalia, P. and Singh, B. (2011). Genetic variability for antioxidants and horticultural traits in cabbage. *Indian Journal of Horticulture*. **68** (1): 51-55.
- Subbiah, B. V. and Asija, G. L. (1956). A rapid procedure for the determination of available N in soils. *Curr. Sc*. **25**: 256-260.

- Thakur, B. S. (2015) Year round production studies of cauliflower under mid hills of Himachal Pradesh. *Journal of Horticulture*. **2**: 155.
- Thakur, Bhupinder Singh (2014). Studies on effect of temperature on curd yield under year round production system of cauliflower (*Brassica oleracea* var. botrytis L.) under mid hills of Himachal Pradesh. *The Asian Journal of Horticulture*. **9** (2): 319-323.
- Traka M and Mithen R. (2009). Glucosinolates, isothiocyanates and human health. *Phyto Chem*. **8**: 269-282.
- Yang, W.M.; Chung, S.J. and Yang, S.Y. (1989). Abstracts of Communications Papers. *Korean Soc. Hort. Sci*. **7**: 54-55.

Appendix-I

Analysis of variance for growth parameters of cauliflower (mean square)

Source of variation	d.f.	Stalk length (cm) at		
		30 DAT	45 DAT	60 DAT
Replication	2	2.337	0.122	0.182
Treatments	9	1.814**	1.060**	1.289**
Error	18	0.390	0.202	0.146

Source of variation	d.f.	Number of leaves plant ⁻¹ at		
		30 DAT	45 DAT	60 DAT
Replication	2	0.481	7.621	21.168
Treatments	9	6.953**	5.112**	5.314**
Error	18	1.020	0.928	1.210

Source of variation	d.f.	Leaf length (cm) at		
		30 DAT	45 DAT	60 DAT
Replication	2	9.000	6.226	1.796
Treatments	9	3.903*	3.996**	4.730**
Error	18	1.411	0.898	0.887

Source of variation	d.f.	Fresh weight of plant (kg)	Curd maturity duration
Replication	2	0.002	18.823
Treatments	9	0.131**	17.549**
Error	18	0.002	1.185

Appendix-II

Analysis of variance for yield parameters and yield of cauliflower (mean square)

Source of variation	d.f.	Curd length (cm)	Curd width (cm)	Average curd weight (g)	Marketable curd yield plot ⁻¹ (kg)
Replication	2	0.150	0.549	0.002	0.356
Treatments	9	4.127**	12.083**	0.026**	16.680**
Error	18	0.742	0.965	0.002	1.973

Source of variation	d.f.	Total curd yield plot ⁻¹ (kg)	Marketable curd yield hectare ⁻¹ (q)	Total curd yield hectare ⁻¹ (q)	Harvest index (%)
Replication	2	0.509	54.257	77.619	17.887
Treatments	9	20.733**	2540.062**	3157.442**	23.458**
Error	18	2.157	300.571	328.562	3.362

Appendix-III

Analysis of variance for quality parameters of cauliflower (mean square)

Source of variation	d.f.	TSS (⁰ Brix)	Self life
Replication	2	0.853	0.199
Treatments	9	1.585*	3.050**
Error	18	0.532	0.376

Appendix-IV

Cost of cultivation for cauliflower on per hectare area basis

S . No.	Field operation	Unit used	Cost / unit Rs.	Total cost Rs.
1	Land preparation			
	▪ Deep ploughing	1	600	1500
	▪ Ploughing	1	600	1200
2	Lay out of field (mandays)	3	200	600
3	Seed requirement	0.500kg	2000	1000
4	Sowing	3	200	600
5	Transplanting	20	200	4000
6	Two – hand weeding	20+20		
	▪ Man day	40	200	8000
7	Fertilizer application			
	Urea	220	6.0	1320
	SSP	470	7.5	3525
	MOP	67	17	1139
8	Irrigation	10	300	3000
9	Plant protection			2000
10	Harvesting	20	200	4000
Total				31884

VITA

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