EVALUATION OF CAULIFLOWER (*Brassica oleracea* L. var. *botrytis*) FOR SOUTHERN KERALA

by

SHRUTHY. O. N.

(2011-12-102)

THESIS

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DECLARATION

I hereby declare that this thesis entitled **"Evaluation of cauliflower (*Brassica oleracea* L. var. *botrytis*) for southern Kerala"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

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Dedicated to

My

Beloved Parents and Guide

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LIST OF ABREVIATIONS

%	-	per cent
µg	-	microgram
$µm^2$	-	micro square metre
CD	-	Critical difference
cm	-	centimeter
DAT	-	Days After Transplanting
et al	-	And others
Fig.	-	Figure
g	-	gram
GA	-	Genetic Advance
GCV	-	Genotypic Coefficient of Variation
h	-	hour
H^2	-	Heritability
ha	-	hectare
I.U	-	International Unit
KAU	-	Kerala Agricultural University
kg	-	Kilogram
m	-	metre

mg	-	milligram
min	-	minutes
ml	-	millilitre
mm	-	millimeter
nm	-	nanometer
°C	-	Degree Celcius
PCV	-	Phenotypic Coefficient of Variation
s	-	seconds
SE	-	Standard error
t	-	tons
Var.	-	variety

Introduction

1. INTRODUCTION

Cauliflower (*Brassica oleracea* L. var. *botrytis*) a member of Brassicaceae, is one of the most important vegetables in the world. It occupies the pride of place among the cole crops due to its delicious taste, flavour and nutritive value.

Cauliflower is grown for its white tender compact curd formed by the shortened flower parts. Curd is a hypertrophied pre floral meristamatic growth, which terminates main stem of the plant.

Cauliflower was introduced to India, from England in 1822 by the British (Nath *et al.,* 1994). The initial introduction was Cornish types followed by European types. Since then it has undergone acclimatisation and selection as a result of which the Indian cauliflower or tropical type has attained characteristically different form as a result of intercrossing between Cornish and other European types (Swarup and Chatterjee, 1972). The Indian cauliflowers are earlier in maturity and are adapted to warm humid conditions.

Temperature plays crucial role in curd formation of cauliflower. Indian cauliflower varieties were classified into three categories *viz.*, early, mid and late on the basis of temperature requirement for curd formation (Seshadri and Chatterjee, 1996). Varieties for different categories have been evolved in India: Early- Pusa Ketki, Early Kunwari, Pusa Deepali, Pusa Early Synthetic, Pant Shubhra; Mid season- Pusa Synthetic, Pusa Shubhra, Improved Japanese and late- Pusa Snowball, Pusa Snowball K1 (Peter, 1998).

Cauliflower is comparatively a new crop in Kerala particularly in the plains. Though it has great demand in Kerala, we largely depend on the neighbouring states for this highly esteemed vegetable. The high ranges of Kerala offers ample scope for the cultivation of cole crops, which in turn would reduce the dependence on neighbouring states. Until recently, cultivation of cauliflower was possible only in the hill tracts of Idukki and Wynad districts. Of late, with the advent of tropical cauliflower varieties, cultivation is made possible in plains of

Kerala also. So identification of suitable cauliflower varieties for the plains would in turn increase internal production and reduce the consumer dependence on supply from neighbouring states.

The research on this crop in Kerala is rather negligible except for the evaluation trials conducted at College of Horticulture, Vellanikkara, Thrissur and Agricultural Research Station, Mannuthy. They had identified Pusa Deepali, Pusa Early Synthetic, Greeshma, Atisheeghra and Basant as potential cauliflower varieties/ hybrids suitable for plains of Kerala.

Apart from varieties, time of planting is another key factor which determines the productivity. In general, the cooler months of October - January is ideal for cauliflower cultivation in Kerala. Since the varieties are very specific in its temperature requirement for curding, identification of the most suitable time of sowing for a particular variety will definitely help in increasing productivity.

Under these circumstances, the present study was carried out with the following objectives:

- To identify superior varieties with high yield, quality and with less incidence of pests, diseases and physiological disorders.
- To identify the most suitable time of sowing of these varieties
- To study the interaction effect of sowing dates and varieties
- To assess the genetic variability present in tropical genotypes.

Review of literature

2. REVIEW OF LITERATURE

Cauliflower (*Brassica oleracea* L. var. *botrytis*), one of the most popular and commonly grown winter vegetable of India is a thermo sensitive crop which differs in its temperature requirements for curd initiation and development. Indian cauliflower has undergone fast diversification within a short period of two centuries of its introduction (Seshadri and Chatterjee, 1996). With the development of tropical cauliflower varieties at IARI, New Delhi, the cultivation has spread to the non-traditional areas in South India including Karnataka and Tamil Nadu.

In this chapter, effort has been made to review of the available literature pertaining to the effect of date of sowing and varieties on the yield of cauliflower. The review is presented under the following subheads:

2.1 Influence of varieties on yield and quality

2.2 Influence of date of sowing and climate on yield and quality

2.3 Interaction between varieties and sowing dates

2.4 Incidence of physiological disorders

2.5 Incidence of pests and diseases

2.6 Genetic parameters

2.1 Influence of varieties on yield and quality

Swarup and Chatterjee (1972) classified cauliflower as Italian, Cornish, Northern, Roscoff, Angers, Erfurt and Indian. Two separate groups of cauliflowers grown in India are the Indian cauliflowers, which have mainly developed within India during the last 165 years and the annual temperate types commonly known as Snowballs.

Ghanti and Mallick (1994) evaluated early cauliflower cultivars Pusa Katki, Hot Season, Early Kunwari, Kartika, Early Patna No. 1 and Early Market and found that highest stem weight and curd area were obtained for Early Market Early Patna No. 1. Rooster and Callens (1999) conducted an experiment to compare fifteen cauliflower cultivars and best results were obtained for the early cultivars Vinson and Barcelona, and late cultivars Thalassa and Cortes.

Kumar (2002) evaluated twenty two diverse genotypes of cauliflower for various horticultural traits and net curd weight of Cauliflower-12, KJ-47 and KT-25 was found to be higher with good performance for number of leaves, curd depth, curd compactness, curd colour and riceyness. Hamid *et al.* (2005) conducted an experiment to evaluate the performance of the cauliflower cultivars Express, Reagent, Shehzadi and Indus Holland in Jammu and Kashmir. The maximum plant height, leaf length, fresh root weight and fresh weight of plant were attained by Indus Holland.

In an experiment conducted at Solan using 10 cultivars of different maturity groups, it was found that cultivars Main Crop Superior, Punjab Giant 26 and Shalimar Moti, formed curds on all seasons, while the other cultivars formed buttons (Yadav *et al.* 1995). In another experiment, eight cauliflower cultivars were evaluated and found that Sel 311 showed good performance with respect to all parameters making it suitable to favourable environments and Pusa Sharad showed average performance with respect to all parameters making it adapted to less favourable environments (Sharma *et al.*, 2001)

Pradeepkumar *et al.* (2002) conducted a study and revealed that synthetic cultivars belonging to the early maturing type of tropical cauliflower performed better under high range conditions of Kerala. They also found that the performance of early variety (PES-1) was superior and the performance of mid season (Pusa Sharad) and late types (Super Snowball) was poor. Gopalakrishnan (2004) reported that at RARS, Ambalawayal the late variety Punjab Giant produced maximum yield (8.6 t/ha) followed by Pusa Synthetic (5.92 t/ha).

Average curd weight was maximum in Punjab Giant (0.9kg) whereas early varieties produced buttons. Pusa Sharad also performed well. Narayanankutty (2012) identified NS 60N, Basant, Atisheeghra as suitable varieties for cultivation in the warm humid tropics of Kerala.

Rashid *et al.* (1990) evaluated 15 cauliflower cultivars and found that cultivars F_1 Win, Supreme, Line 78-882 and Poushali Main Grop gave reasonable yields. In a field trial, the cauliflower cultivars Kuwari, Aghani, Patna Mid Season and Pusa Deepali were evaluated and found that Kuwari produced the highest curd yield (65.82 q/ha) and average curd weight (Patil *et al.*, 1995).

In a study at Assam, Gautam *et al.* (1998) observed that cultivar, 'Heavy Silver Plate' exhibited the highest curd yield of 81.15 q/ha of marketable curd. In a study conducted to select a suitable early cauliflower cultivar (among Pusa Early Synthetic, Pusa Deepali, Bharat Mukut, White Queen, Hemantika-Kartika and Bharat Jyoti) Pusa Deepali recorded the highest yield, while Bharat Jyoti recorded the lowest yield (Thapa *et al.*, 2002).

In an experiment conducted by Jana and Mukhopadhyay (2006) to evaluate different cauliflower cultivars (Early Kunwari, First Crop, Kartika, Aghani and Improved Japanese) it was found that Aghani gave the highest curd yield of 15.76 t/ha. Sharma *et al.* (2006) conducted a study to evaluate three cultivars of cauliflower and found that Pusa Snowball K1 (20.7 tonnes/ha) significantly outyielded the Palam Uphar (17.8 tonnes/ha) and Pusa Himjyoti (16.6 tonnes/ha) along with its better performance for curd and plant attributes.

Mahesh *et al.* (2011) studied 32 genotypes of heat tolerant cauliflower and found genotypes DC-98-4, DC-98-10 and DC-124 superior to other genotypes with respect to curd characteristics. In a varietal evaluation, Srivastava *et al.* (2011) the per curd weight was maximum (472.5 g) in early Himlata followed by Pusa Deepali (439.0g) and Pusa Meghna (426.5g). The maturity was earliest (78.15 days) in Pusa Meghna followed by Early Kunwari (83.10 days).

In a trial using fourteen cauliflower cultivars Rooster, (1998) identified cv. Mayflower with best crop quality over a longer period. Pathania (2003) evaluated twenty diverse genotypes of cauliflower and observed high net weight for EC-103576, Holland Special, Autumn Giant and ACC-328 with good horticultural and quality characters. Kumar *et al.* (2009) evaluated fifteen exotic lines of temperate cauliflower and found that CGN 13966, CGN 14020, CGN 11074 and CGN 13961 were high yielding among the lot besides having good quality traits.

Callens *et al.* (2000) carried out studies at Belgium to compare 20 cauliflower cultivars and found that Fremont and Somerset were most susceptible to vein disease (*Verticillium dahliae*) but were found tolerant to high temperature. Kopecky and Dusek (2012) screened 50 cauliflower and 30 kohlrabi for resistance to clubroot disease under controlled conditions in the plant growth chamber and highest resistance were seen in Brilant and Agora genotypes of cauliflower and Adriana, and Indigo genotypes of kohlrabi.

Chaubey *et al.* (2000) evaluated 23 genotypes of cabbage and best results for gross weight, polar diameter, head shape index and ascorbic acid content were obtained for Green Challenger, Hari Rani Gol , Mitra, Red Ruby respectively. Sharma (2001) evaluated thirty genotypes of cabbage for horticultural characters and found Hansens Progress as best for highest significant yield and other horticultural traits.

Significant differences were obtained for head width and head length of three cabbage varieties and the variety 'Paradox' produced the longest head length, largest head width, highest head weight and best yield potential (37.7 tonnes/hectare) (Kenneth, 2012). In a varietal evaluation in cabbage Hasan and Solaiman (2012) found that "Atlas 70" achieved the highest results of plant height, leaf length with petiole, stem length, diameter of head, weight of whole plant, gross yield; marketable yield.

Kumar (2013) evaluated fourteen diverse genotypes of cabbage and revealed significant differences among all genotypes and Pusa Ageti was found best for early in maturity whereas, gross head weight, net head weight, yield per plot and per hectare was found maximum in the genotype AC-16.

The performances of different hybrid varieties of broccoli were evaluated and Nokguk was found superior, with high yield (14.55q/ha) in combination with best head formation (Thapa and Rai, 2012).

2.2 Influence of date of sowing and climate on yield and quality

Environmental factors like air and soil temperature, quality, intensity and duration of radiation and humidity affects physiological functioning of cauliflower. Since, the effects of weather on curd yield are complex, deeper and clear understanding of how the climatic factors affect the growth and yield of cauliflower are needed.

Indian cauliflower varieties were classified into three categories *viz.*, early, mid and late on the basis of temperature requirement for curd formation (Seshadri and Chatterjee, 1996). Varieties have been evolved for different seasons in India: Early- Pusa Ketki, Early Kunwari, Pusa Deepali, Pusa Early Synthetic, Pant Shubhra; Mid season- Pusa Synthetic, Pusa Shubhra, Improved Japanese and late- Pusa Snowball, Pusa Snowball K1 (Peter, 1998).

2.2.1 Influence of date of sowing

Time of sowing is a major factor which determines the curd initiation, development and quality. The influence of time of planting on cauliflower varieties were studied by different workers (Pandey *et al.,* 1981; Yadav, 1989; Islam *et al.*, 1990; Yadav *et al.,* 1995; Bjorn, 1995; Kanwar, 1996; Ara *et al.* 2009).

Rashid *et al.* (1990) evaluated cauliflower cultivars on 3 dates of sowing (1 September, 1 October and 1 November) and found that curd weight and number of days from sowing to harvest were highest in 1 September sowing. Buttoning and small curds occurred in most cultivars when sown on 1 October or 1

November In a trial, cauliflower cultivar Pionier was sown in the greenhouse on 15 September, 15 October, 15 November and 15 December and it was found that highest seed yield of 419 kg/ha was obtained with the earliest sowing and transplanting dates, and the lowest yield (207 kg/ha) with sowing on 15 December (Orłowski *et al.* 1991).

Late planting resulted in low yield, which may be due to the unfavourable temperature conditions as reported by Sharma and Choudhary (1996). By transplanting three cultivars of cauliflower with different transplant age Lewandowska (1992) realised that as the transplant age decreases the period from sowing to 50% harvest also decreases. He also found that earliest cultivar (SKW-1) showed the greatest reaction to transplanting age.

Castillo *et al.* (1992) observed long vegetative period and short curd formation period for snowball-type cauliflower cultivars with later sowing dates. Results showed that greater curd yields were obtained with the Jan. and March sowing dates. In a field trial to identify the best sowing season, the cauliflower cultivars were sown on 1 July, 1 August or 1 September and it was found that sowing on 1 August gave the best results (average curd weight of 211.40 g, yield of 69.37 q/ha) (Patil *et al.* 1995).

Cauliflower plants produced large-sized leaves, more days to curd maturity, compact white curds, high curd weight for early plantings (31 March) in Solan (Yadav *et al.,* 1995). In a study conducted by Baghel and Singh (1995), cauliflower cv. Pusa Katki transplanted on 15 September gave a yield of 23.04 t/ha.

Kanwar (1996) found that in cauliflower cv. Early Kunwari, curd and seed yields were highest from sowing on 15th July and lowest from sowing on 1st September. In an experiment to investigate the yield potential of green cauliflower cv. Alverda in 3 consecutive plantings (10 October and 24 November 1992 and 12

January 1993), it was found that marketable yields were highest in the January planting (Csizinszky, 1996).

In trials conducted at Port Blair, Singh *et al.* (1997) observed that transplanting between 25 November and 5 December achieved the earliest curding and produced curds of maximum weight and diameter and ultimately yield. In a planting date trial with four varieties of cauliflower from June to December at Réduit, significant differences among the varieties and the planting dates were found (Nathoo *et al.*, 1999).

Spehia (1997) studied the performance of different cauliflower genotypes and found that the performance was better for first transplanting (5th October) over other transplantings (20th October and 5th November). Fellows *et al.* (1999) evaluated early summer cauliflower cultivars under different planting dates and observed that juvenility varies considerably with growing conditions.

Jaya *et al.* (2002) carried out field experiments during January-May and September-December using tropical cauliflower cv. Milky and reported poor curd quality at high temperature and irradiance during the curd growth phase. In an experiment conducted at Himachal Pradesh, cauliflower cv. Pusa Snowball K-1 plants were transplanted on 12 or 26 October, or 10 November it was noticed that dry matter content, nitrogen and boron content in the leaves and curd, and N and B uptake decreased with delay in transplanting (Gupta *et al.* 2002).

In a study conducted to determine the optimum transplanting time (20 August, 5 and 20 September and 5 October) in West Bengal, Thapa *et al.* (2002) found that delay in transplanting markedly decreased the curd quality. Srivastava *et al.* (2002) reported maximum plants survival, plant height and maximum yield (378.72 q/ha) in 10th August planting in cauliflower cv. Pant Gobhi-4.

Pradeepkumar *et al.* (2002) reported significant difference between dates of planting on days to maturity, gross curd weight, net curd weight and per hectare yield. Early planting in the first week of October is ideal for realizing potential yields in cauliflower under high range situations of Kerala. In an experiment conducted in Pantnagar, to determine the optimum planting date (26 September and 3, 10, and 17 October) for mid-season cauliflower cv: Pant Shubhra, it was found that planting on 26th September resulted in highest curd diameter (23.28 cm) and days to 25% curd maturity (Mohanty and Srivastava, 2002).

Ajithkumar (2005) reported that D_1 planted crop produced significantly higher curd yield as well as biomass. Sharma *et al.* (2006) conducted a study in cauliflower with 3 planting dates (18 May, 2 June and 17 June) and found that transplanting on 2 June gave the maximum plant survival and highest marketable curd yield.

Jana and Mukhopadhyay (2006) studied the effect of sowing date (15 August, 31 August and 15 September) on the growth and curd yield of different cauliflower cultivars and found that sowing on 15 August gave the highest curd yield (13.07 t/ha). In a study conducted in Iran using cauliflower cv. Snow Crown, highest yield (40 t/ha) was produced in treatment with planting date of 5 September (Amoli *et al.*, 2007). In a study to evaluate transplanting dates of cauliflower (November 5, November 25 and December 5) it was found that number of leaves per plant, leaf area index, curd weight, curd size of cauliflower and yield were significantly higher when crop was transplanted 15th November followed by 25th November (Kaur *et al.*, 2007).

In an experiment conducted at Northern Areas of Pakistan to study the effect of sowing date on the growth and yield of cauliflower (Cv.Snow Ball) with five sowing dates, significant variations were observed in different growth and yield parameters among the sowing dates (Din *et al.* 2007). Second sowing date (16th June) showed maximum fresh plant weight (2.6 kg plant^{-1}), head weight (1.4 kg plant^{-1}), number of marketable heads (27.00 plot^{-1}) and head yield (37.83 t ha^{-1}).

Karthika *et al.* (2013) reported significant difference between different planting dates for curd weight of cauliflower in the central region of Kerala.

Among the different planting dates November 1st was found to be ideal (532.2g per plant) for getting higher economic yield.

Yields of marketable cabbage heads were the highest when planted in November and the yields decreased from December and the lowest yield was recovered in crops planted in March (Chavan *et al.*, 2004). An evaluation trial with different cabbage cultivars identified Gloria F1 and Victoria F1 as best for head yield and Summer Summit as best for taste, head shape and firmness. Tropical Delight was preferred for head size, firmness and low incidence of loose heads (Adeniji *et al.*, 2009)

The effects of planting dates on the performance of broccoli were studied and found that planting on 15th October resulted in greater plant and net head weight. It was also noticed that longest shelf life was obtained with planting on 14 November (Singhal *et al.,* 2009). Kałuzewicz *et al.* (2012) studied variation in length of the period from planting to head initiation in broccoli and shortest period from planting to initiation was when the plants were planted in April and June (17-18 days). The length of the period from planting to head initiation depended on mean daily air temperature.

The effects of planting date (18 July and 3 August) on characteristics and yield components of brussels sprouts (cv. De La Halle) were studied and found that planting date had a significant effect on plant weight and height, number of leaves, fresh and dry weight of leaves and stems, number of bud and bud weight, time from planting to bud initiation and bud initiation to harvest (Kurtar, 2006).

2.2.2 Influence of climate

In an investigation on curd morphology and development of cauliflower cv. Nozaki-wase and broccoli cv. Wase-midory grown at different temperatures, the effect of diurnal variation in temperature on curd formation were found significant (Fujime, 1983). The effect of temperature on cauliflower varieties Revito and a local cultivar from Mauritius were reported by Nowbuth and Pearson (1998) and found that curd initiation for both varieties was delayed by cooler and warmer temperatures.

Olesen and Grevsen (2000) reported cauliflower development and leaf area expansion as a function of temperature and curd diameter as a function of both temperature and available carbohydrates. Ajithkumar (2005) reported that weather had played a significant role in deciding the yield of cauliflower. The LAI values revealed that the development of the leaf area remained slow during the early vegetative growth period (juvenile phase) up to 30-45 days after planting and thereafter, increased sharply with the advancement of the crop age.

A study was conducted to determine relationship between yield and seasonal weather patterns of five cruciferous vegetables (broccoli, cabbage, cauliflower, radish and rutabaga) and their yields showed roughly a 10% yield loss for every 1°C increase, when the temperature reached 30°C or above during the growing season (Warland *et al.,* 2006).

In the experiments conducted by Rahman *et al.* (2007) to assess the response of cauliflower cv. "Nautilus" to different constant temperatures after curd initiation, it was found that many of the growth parameters increased with increasing mean growing temperature up to an optimum temperature *ie*., between 19° and 23°C. He also reported that cauliflower growth and development declined with increasing shade levels after curd initiation and total above ground dry matter increased linearly with accumulated incident radiation integral after curd initiation. Rahman (2002) and Rahman *et al.* (2007) have reported that cauliflower had a higher optimum temperature for curd growth components than vegetative growth components (leaf and stem) after curd initiation.

Rahman *et al.* (2013) reported greater rates of curd growth (curd length, diameter, fresh and dry weights) were achieved at warmer night temperatures than day temperatures, whilst greater leaf and stem growth (leaf area, stem length, fresh and dry weights) were achieved when day temperatures were warmer than night temperatures, even with the same mean temperatures. Cauliflower stem length was linearly related to the effective mean temperature with optimum day temperature of 24°C and optimum night temperature of 12°C.

According to Miller *et al.* (1985) and Wurr *et al.* (1995), the main factor for the transition from the vegetative to the generative phase of broccoli plants is the temperature. According to Mourao and Brito (2000), at 21.5°C initiation occurred in broccoli after 32 days, and at 9°C initiation occurred only 88 days after planting. Fellows (1997) reported that at temperatures of 5, 10, 15, 20°C initiation occurred successively after 96, 51, 36 and 64 days. Fujime *et al.* (1988) found that the vernalisation effect of temperature also depends on the length of the day for broccoli.

2.3 Interaction between varieties and planting dates

The performance of cauliflower cultivars under four dates of planting was assessed for curd yield and various growth characters by Yadav (1989)and reported that Pusa Deepali planted on 29th September gave highest yields. Rashid *et al.* (1990) evaluated 15 cauliflower cultivars on 3 dates of sowing and found 1 Sep as the most suitable season. They obtained reasonable yields at all sowing dates for cultivars F_1 Win, Supreme, Line 78-882 and Poushali Main Crop.

Lewandowska (1992) evaluated 3 cultivars of cauliflower and found that cv. SKW-1 showed the greatest reaction to transplanting age. Ghanti and Mallick, (1994) found that cauliflower cv. Early Market planted in August had highest stem weight (148.5 g/plant) and curd area (288.38 cm²). Pearson *et al.* (1994) also found different optimum temperatures of 16°C, 21°C, and 25°C for cauliflowers' cultivars "Jubro", "Revito", and "White Fox" respectively, whereas, the optimum temperature for cultivar "Nautilus" after curd initiation was found to be in the range of 19 to 23°C (Rahman, 2002; Rahman *et al.*, 2007).

Six early cauliflower cultivars transplanted during different summer months in the plains of West Bengal were evaluated by Ghanti and Mallik (1995) and found that Early Patna No. 1 and Pusa Katki transplanted in September produced most compact curds. In an experiment to determine their suitability for early sowing on 26 cauliflower cultivars at Belgium, sowing was done under glass on 3 March and got best results from the cultivars Asterix, Aviso, Cadet, Fremont and Nautilus (Vanparys, 1995).

Effect of transplanting dates on cauliflower cultivars were studied by Yadav *et al.* (1995) and found that cultivars Main Crop Superior, Punjab Giant 26 and Shalimar Moti, formed curds on all planting dates, while the other cultivars formed buttons. They also recorded large-sized leaves, more days to curd maturity, compact white curds, curd size and weight during early plantings. Patil *et al.* (1995) studied the interaction between 4 cauliflower cultivars and 3 sowing dates and best results were obtained for Kunwari sown on 1 August.

Effect of transplanting on performance of cauliflower cultivars were investigated by Vlaswinkel (1996). He observed improved curd size and quality in early transplanted (July/August) cv. Sernio. Spehia (1997) evaluated fifteen genotypes of cauliflower under 3 transplanting dates and observed significantly better performance of genotypes in the first transplanting and among the genotypes KJF4-4-11 yielded high.

In a study at Assam, Gautam *et al.* (1998) evaluated cauliflower cultivars (Pusa Katki, Pusa Deepali, Selected Early Dawn, Early Chinese Prince and Heavy Silver Plate) at different dates of sowing (15 and 30 July and 14 August). . They found that cultivar 'Heavy Silver Plate' sown on 15th July and gave the maximum curd yield (81.15 q/ha). Dutta (1999) reported that the early cultivar Pusa Katki planted on 21st September, mid-season cultivar Sabnam planted on 31st October and late cultivar Snowball-16 planted on 25th November recorded highest yield.

Rooster and Callens (1999) compared fifteen cauliflower cultivars at two planting dates i.e., 29 March and 19 April and found that different harvesting dates allowed prolonged harvest and best results were obtained for the early cultivars Vinson and Barcelona, and late cultivars Thalassa and Cortes. In a trial, Callens *et al.* (2000) compared 20 cauliflower cultivars under 4 planting dates and found that early planting of cultivars Fremont and Somerset gave good results.

Pradeepkumar *et al.* (2002) reported significant difference between the varieties and dates of planting on days to maturity, gross curd weight, and net curd weight and per hectare yield of cauliflower and realized early planting in the first week of October with Pusa Early Synthetic is ideal under high range situations of Kerala. Thapa *et al.* (2002) conducted an experiment at West Bengal and found that Pusa Deepali transplanted on 5 September recorded high curd and seed yield.

The interaction effects between cauliflower cultivars and time of transplanting indicated that Pusa Snowball K1 transplanting on 2nd June gave the maximum marketable curd yield (24.7 tonnes/ha) combined with better performance for average curd weight, gross and net curd weight, curd diameter and curd size index (Sharma *et. al*, 2006).

Jana and Mukhopadhyay (2006) conducted an experiment at West Bengal, to evaluate the effect of sowing date (15th August, 31st August and 15th September) on the growth and curd yield of different cauliflower cultivars (Early Kunwari, First Crop, Kartika, Aghani and Improved Japanese) and found that Aghani sown on 31st August produced the highest marketable curd yield of 16.67 t/ha. Ara *et al.* (2009) reported that weight of marketable curd per plant and yield t/ha differed significantly among the planting dates. Highest yield (17.56 t/ha) was obtained from the line CL0134 when planted on 1st August.

2.4 Incidence of physiological disorders

Physiological disorders of cole crops are abnormalities in leaf and stem morphology, colour, or both which are not caused by infectious diseases or insects. The abnormalities occur as a result of environmental stress, nutritional deficiencies or excesses on the plant. Various physiological disorders in cauliflower includes premature bolting, failure of or multiple head formation called blindness, riceyness , internal tip burn, bracting and buttoning (Fujime, 1983; Norman, 1992; Verma, 2009; Masarirambi, 2011).

Riceyness is an important physiological disorder in cauliflower and in this condition there is elongation of peduncles of individual flower buds that result in a granular appearance of the curd (Norman, 1992). The condition may be caused by the development of small white flower buds, attributed to high temperature during curd development (Norman, 1992; Frits *et al.*, 2009).

Leafy curds or leafiness or bracting is characterized by green leaves found between sections of the curd and is thought to be caused by relatively high temperatures and delayed harvesting (Norman, 1992; Loughton, 2009). Wiebe (1973) observed positive correlation between bracting and riceyness with average temperature. Incidence of both bracting and riceyness in snowball cauliflower was reported by Grevsen *et al.* (2003) and in early varieties of Indian cauliflower by Gopalakrishnan (2004).

Singh *et al.* (1987) observed Pusa Shubhra as resistant to riceyness. Sharma *et al.* (2001) evaluated 8 cauliflower cultivars and found significant genotype environment interactions for days to maturity and riceyness.

Sharma and Behera (2003) evaluated seven cultivars and 12 hybrids of cauliflower and found that Sel. 820 was superior with regard to number of days to maturity, harvest index, riceyness and curd compactness. Kumar *et al.* (2009) evaluated fifteen exotic lines of temperate cauliflower and were screened for quality traits viz. riceyness, leafiness, curd color and blanching habit. It was found that six lines showed riceyness and none of the lines showed leafiness.

Buttoning disorder is characterized by production of small unmarketable curds called buttons. Plants that develop buttons are small and have small leaves that do not cover the developing head (Norman, 1992; Fritz *et al.*, 2009). The cause of this disorder is a limited nitrogen supply and the delay in transplanting. According to Norman (1992) and Fritz *et al.* (2009), any check in growth due to dry soil or delay in planting may cause small curds to be formed. Too little or too much hardening, cold weather for 10 days or more at 4 to 10°C, diseases, insects and micronutrient deficiencies have been reported to cause cauliflower buttoning (Fritz *et al.*, 2009). Rashid *et al.* (1990) evaluated 15 cauliflower cultivars sown on three dates and observed occurrence of small curds and buttoning in most cultivars sown on 1st October or 1st November.

Blindness is another disorder in cauliflower which results in no curd formulation and the plants remain vegetative. Several causes of blindness have been reported which includes poor fertility, insect damage, disease, genetic irregularities or cold temperature. High temperatures (days over 30°C and nights of 26°C) delay and prevent proper curd development and affect subsequent quality (Fritz *et al.*, 2009; Verma, 2009). Mounsey-wood (1957) studied the effects of different planting dates on blindness, yield and quality of early summer cauliflower and noticed subsequent amount of blindness in late sowing, which coincides with frost periods.

Hartman (1938) reported internal brown spotting with or without surface discoloration of the head, and hollow stem as the chief symptom of boron deficiency in cauliflowers.

2.5 Incidence of pests and diseases

2.5.1 Incidence of Pests

The major pests in cruciferous vegetables include diamond back moth (*Plutella xylostella),* tobacco caterpillar (*Spodoptera litura),* cabbage aphid (*Brevicoryne brassicae, Myzus persicae*), cabbage butterfly (*Pieris brassicae)* and cabbage head caterpillar *(Crocidolomia pavonana)* (Loganathan, 2002).

2.5.1.1 Diamond back moth

Kumar (2002) evaluated twenty two diverse genotypes of cauliflower and found that cultivars cauliflower-12, KJ-47 and KT-25 were less preferred by

P.xylostella and *P.brassicae*. Pathania (2003) reported cauliflower genotypes KT-25, Lawyna, RS-199, KT-38 and ACC-331 were resistant to diamondback moth. Kanwar *et al.* (2010) tested the susceptibility reaction of different genotypes of cauliflower against diamond back moth and found that C-8 was less susceptible to it.

Devjani and Singh (1999) correlated the number of diamond back moth larvae with ambient temperature, relative humidity and rainfall and the results indicated their maximum abundance during March. In a field trial to correlate weather parameters with insect pest incidence in cauliflower, it was found that larval populations of *Spodoptera litura* and *Plutella xylostella* were negatively correlated with the maximum and minimum temperatures, while those of *Crocidolomia binotalis* and *Brevicoryne brassicae* were positively correlated with the evening relative humidity and minimum temperature, respectively (Rao *et al.*, 2003).

2.5.1.2 Leaf caterpillar

Seasonal flight activity in *Spodoptera litura* in cauliflower fields indicated a peak of activity in November-December and February-March, which shows the survival of adults in cold winter temperatures (Ali, 1989). In an experiment conducted to determine the seasonal incidence of *Spodoptera litura* on cauliflower, it was found that the larvae could be seen from 36^{th} standard week onwards in a fluctuating manner and the population attained its peak during the 43^{rd} standard week (T_{max}= 39.5°C and T_{min}= 20.7°C) and declined gradually after the 46^{th} standard week (Monobrullah *et al.*, 2007).

An evaluation of feeding pattern of polyphagous pest, *Spodoptera litura* revealed that the larvae prefers mostly to feed on cauliflower and least preference for castor (Chand and Tripathi, 2008).

2.5.1.3 Aphid

Date of planting highly influences the incidence of pests in cruciferous vegetables. In a trial, aphid population was significantly lower in early planting cauliflower trial (late September) while in case of late planting cauliflower trial (late October) it was significantly higher (Saleha *et al.,* 2009). Studies revealed that increase in temperature had a pronounced effect on the aphid (*Brevicoryne brassicae* L) and painted bug (*Bagrada cruciferarum*) population in cauliflower (Abrol and Gupta, 2010).

Ozder and Saglam (2011) evaluated the development, survival and reproduction of the cabbage aphid, *Brevicoryne brassicae* (L.) at three constant temperatures (20, 25 and 30°C) on cabbage, cauliflower, red cabbage, turnip and radish and found significant difference in their incidence at different temperatures. Population dynamics of cabbage aphid (*Brevicoryne brassicae* L.) was studied in cabbage, cauliflower, knolkhol and broccoli and the correlation study between weather parameters and aphid population showed negative influence of temperature, relative humidity and rainfall on population growth of aphid (Patra *et al.*, 2012).

In an experiment to study the effects of *Brevicoryne brassicae*, on growth parameters of cauliflower, significant differences were observed for net curd weight in the aphid infested cauliflowers (Chowfla and Baruah, 1990).

2.5.1.4 Cabbage butterfly

Pathania (2003) evaluated twenty diverse genotypes of cauliflower and found that genotypes ACC-328, Grodan, KJ-38, Holland Special, ACC-330, RS-199 and All the Year Round were resistant to cabbage white butterfly. Yadav and Barwal (2008) screened eighteen cultivars of cauliflower and concluded that 3-5-1-1, Pusa Shubhra, BR- 2 were superior in field resistance against cabbage butterfly. Kanwar *et al.* (2010) tested the susceptibility reaction of different genotypes of cauliflower against cabbage white butterfly C-4 were less susceptible to it.

2.5.2 Incidence of diseases

Clubroot caused by *Plasmodiophora brassicae* is a major disease of cruciferous crops and one of the limiting factors for its successful cultivation. No significant difference in susceptibility between cauliflower cultivars against clubroot were reported by Dixon and Robinson (1986). Grandclement (1996) incorporated resistance against clubroot by diallel mating using resistant kale [*B. oleracea* var. *viridis*] lines and susceptible cauliflower [*B. oleracea* var. *botrytis*] lines.

Singh *et al.* (1987) screened several varieties against black rot (*Xanthomonas campestris* pv. *campestris*), downy mildew (*Peronospora parasitica*) and curd blight (*Alternaria brassicae*) and found as Pusa Shubhra resistant to all these diseases and riceyness. Inheritance of downy mildew (*Peronospora parasitica*) resistance was studied in Indian cauliflower (Group III) and no significant difference was observed between cultivars and incidence of disease (Mahajan *et al.* 1995).

A large number of genotypes of cauliflower were evaluated by Baswana (1990) against stalk rot (*Sclerotinia sclerotiorum* (Lib.) de Bary) and found that two lines Janavon and Early White Adams White were resistant and moderately resistant respectively. Leaf and blossom rot of cauliflower caused by *Choanephora cucurbitarum* was reported by Pavgi (1970) and Siddiqui *et al.* (1974).

Incidence of leaf blight caused by *Alternaria brassicae* in Pusa Deepali, Pusa Meghna and Pusa Sharad was reported by Deep and Sharma (2012). A relative humidity of 95% and a diurnal temperature between 20° and 25°C were conducive for incidence of *Alternaria* leaf spot (Weimer, 1924 and Pandey *et al.*, 2002).

Sixteen landraces of cauliflower were evaluated for resistance against black rot and three landraces showing moderate resistance to the bacterium were selected (Branca *et al.,* 2006). Abdelzaher (2003) reported a severe root rot disease occurred in cauliflower caused by *Pythium ultimum* var. *ultimum*. *P. aphanidermatum* was established as the cause of a curd rot occurring at Solan (Shyam *et al.*, 1987 and Sharma and Sain, 2005).

2.6 Genetic parameters

2.6.1 Variability

The efficiency of selection in crop improvement programmes largely depends on the extent of genetic variability present in the population. Genetic variability for yield and yield contributing traits in the base population is essential for successful crop improvement. Larger the variability better are the chances of identifying superior genotypes.

The variation present in the plant population is of three types viz., phenotypic, genotypic and environmental. Of these the genetic variance can be further partitioned to additive, dominance and epistatic variance components. The phenotypic, genotypic and environmental coefficient of variation (PCV, GCV and ECV respectively) gives an idea about the magnitude of variability present in the population.

Genetic variability among cauliflower genotypes in India was studied by Singh *et al.* (1976), Radhakrishna and Korla (1994), Nathoo *et al.* (1999) and Batra and Singh (2000) , Sharma and Verma (2001), Singh *et al.* (2006) and Mahesh *et al.* (2011).

Jamwal (1992) reported phenotypic coefficient of variation (PCV) predominant over the genotypic coefficient of variation (GCV) for curd yield/plant, gross weight/plant, leaf size and curd size index of cauliflower. In an experiment involving 13 genotypes of cauliflower, the PCV and GCV were high for stalk length, while moderate for net curd weight and gross curd weight (Kumar, 1999).

Sharma *et al.* (2000) evaluated 11 varieties and 21 hybrids of early Indian cauliflower and the analysis of variance indicated high significant differences among varieties for yield per plot, maturity days, harvest index and riceyness. Kumar and Korla (2001) evaluated thirteen genotypes of cauliflower and recorded high estimates of phenotypic and genotypic coefficients of variability for curd weight, stalk length and leaf size.

Kanwar and Korla (2002) observed that phenotypic and genotypic coefficient of variance in late maturing cauliflower was moderate for stalk length and net curd weight and high heritability with moderate genetic gain for stalk length and leaves per plant. Sharma and Behera (2003) evaluated seven cultivars and 12 hybrids of early Indian cauliflower and the analysis of variance revealed substantial variation among the hybrids for all the characters.

Pathania (2003) evaluated twenty diverse genotypes of cauliflower and observed phenotypic and genotypic coefficients of variability were high for stalk rot incidence, gross curd weight and net curd weight, while moderate for black rot severity and curd compactness.

The results of a study with 36 genotypes of November-maturity cauliflower revealed the existence of wide genotypic differences for plant height, plant spread, whole plant weight, net curd weight, days to curd maturity, harvest index, dry matter content, total mineral matter and ascorbic acid content, except number of leaves per plant, curd diameter and curd depth Jindal and Thakur (2004).

Genetic variability in tropical cauliflower was studied by Sharma *et al.* (2005) and reported a wide range of variability for characters like curd weight, color, compactness, harvest index and days to marketable maturity. Singh *et al* (2006) observed highest variability in leaf size, curd weight without guard leaves and curd weight with guard leaves in early Indian cauliflower.

In a study with thirteen cauliflower varieties, it was seen that phenotypic and genetic coefficients of variation were highest for net curd weight, stalk length, marketable curd yield per plant, gross plant weight, and harvest index (Sharma *et al.* 2006). Kumar *et al.* (2006) observed moderate phenotypic (PCV) and genotypic coefficients of variation (GCV) for leaf size index, gross curd weight and net curd weight in cauliflower.

Singh *et al.* (2006) reported phenotypic coefficient of variance was invariably higher than corresponding genotypic coefficient of variance for all the morphological traits in cauliflower. Dhatt and Garg (2008) evaluated 21 genotypes of December maturing cauliflower and found that marketable curd weight, gross curd weight, net curd weight and stalk length exhibited considerable genetic variability, while days to curd maturity was the least variable character.

Singh *et al.* (2010) evaluated 45 cauliflower genotypes of November maturity and found that phenotypic coefficient of variation was higher than the genotypic coefficient of variation for all characters which indicates the role of environment on expression of characters. Varalakshmi *et al.* (2010) reported significant difference among 77 germplasm lines of early cauliflower. Based on D^2 values, the 77 breeding lines were grouped into 13 clusters. The characters responsible for maximum divergence were curd weight, curd diameter, total plant weight and leaf weight.

Santhosha *et al.* (2011) reported significant difference among 51 germplasm lines of early cauliflower. The characters responsible for maximum divergence were plant weight, leaf number, curd diameter, curd size, net curd-weight, net plot yield, yield per hectare and marketable curd-weight. Mahesh *et al.* (2011) studied the genetic variability of 32 genotypes and found that overall values of PCV were higher than those of GCV. The highest estimate of GCV was observed for vitamin C contents (54.58) followed by duration of curd availability (49.04).

Bhardwaj (1996) evaluated twenty divergent genotypes of cabbage obtained from different sources and found significant differences among the genotypes.

Kumar (1998) evaluated twenty five diverse genotypes of cabbage and the analysis of variance showed highly significant differences among genotypes for all the traits.

Highest estimates of PCV and GCV in cabbage were obtained for marketable yield (Atter *et al.* 2009) and for stalk length (Meena, 2009). Kumar (2013) observed moderate PCV, GCV for gross weight of head, net weight of head, yield per plot and per hectare in cabbage.

2.6.2 Heritability (H^2) and Genetic advance (GA)

Heritability and genetic advance are important selection parameters. The ratio of genetic variance to phenotypic variance is known as heritability. Heritability (%) was categorized into low (0-30%), moderate (30-60%) and high (above 60%) as suggested by Robinson *et al.* (1949) and Johnson *et al.* (1955). Higher H^2 indicates the least environmental influence on the characters. The difference between the mean phenotypic value of the progeny of selected plants and the base or parental population is called as the genetic advance. The genetic advance was categorized into low (<20%) and high (>20%) as suggested by Robinson *et al.* (1949) and Johnson *et al.,* (1955). High GA indicates that additive genes govern the character and low GA shows that non-additive gene action is involved. Heritability along with GA helps us in predicting the gene action and the method of breeding to be practiced.

Net curd yield per plant exhibited high heritability and genetic advance whereas gross weight per plant, curd size index and leaves per plant exhibited moderate values in late cauliflower as reported by Khar *et al.* (1997), Kumar and Korla (2001) and Kanwar and Korla (2003).

Jamwal (1992) reported high heritability and genetic advance for leaf size and curd yield/plant respectively in cauliflower. Radhakrishna and Korla, (1994) observed 6 yield components in 17 F_4 progenies derived from the cross of commercial cauliflower cv. Pusa Snowball 1 with the heading broccoli Janavon and found that heritability and genetic advance were high for plant weight, net curd weight, harvest index and stalk length.

Spehia (1997) evaluated fifteen genotypes of cauliflower and the estimates of heritability and genetic advance were high for curd depth, curd solidity, gross weight and net curd weight. Kumar and Korla (2001) observed high heritability (82.79%) and genetic advance for number of leaves per plant and stalk length in cauliflower.

Pathania (2003) evaluated twenty diverse genotypes of cauliflower and observed highest heritability and genetic gain for net curd weight. In a study on biparental and F_3 progenies of heterotic cross PSB-1 x KT-9, heritability and genetic advance as percentage of mean was maximum in net curd weight, gross weight and harvest index (Aggarwal, 2004).

In a study with 36 genotypes of November-maturity cauliflower, high heritability with high genetic advance were recorded for harvest index and whole plant weight, indicating the occurrence of additive gene effects. High heritability with low genetic advance was recorded for plant spread and days to curd maturity, indicating the occurrence of non-additive gene effects (Jindal and Thakur, 2004). Thirteen cauliflower varieties were evaluated and high levels of heritability and genetic advance were recorded for marketable curd yield per plant, net curd weight, and stalk length, indicating the predominance of the additive genetic variance for these traits (Sharma *et al.* 2006).

Kumar *et al.* (2006) observed high heritability with high genetic advance for net curd weight. Singh *et al* (2006) recorded 80% heritability for curd weight with guard leaves, curd weight without guard leaves and leaf size of cauliflower. Leaf size, curd weight with guard leaves and curd weight without guard leaves exhibited high genetic advance along with high heritability.

Dhatt and Garg (2008) evaluated 21 genotypes of December maturing cauliflower and observed high heritability coupled with high genetic advance for gross curd weight, marketable curd weight and stalk length. Singh *et al.* (2010) evaluated 45 cauliflower genotypes of November maturity and observed high heritability along with high genetic advance for plant height and whole plant weight. Plant spread and curd diameter exhibited high heritability along with low genetic advance indicated non additive gene effects.

Mahesh *et al.* (2011) evaluated 32 genotypes of heat tolerant cauliflower highest heritability was recorded for days to 50% curd formation (0.992). High heritability along with high genetic advance as per cent of mean was estimated for curd compactness, net curd weight and vitamin C content.

Heritability and genetic advance of yield contributing characters in cabbage were studied by Rai and Singh (2000) and found that gross and net head weight, number of non-wrapper leaves and stalk length mainly contributed to its yield. Sharma (2001) evaluated thirty genotypes of cabbage observed highest broad sense heritability for gross head weight followed by days to marketable maturity, while genetic gain was highest for net head weight.

Atter *et al.* (2009) noticed high heritability for shape of head, compactness of head, marketable yield and gross weight per plant and showed low heritability for days to marketable maturity of cabbage. High genetic advance was observed for marketable yield, whereas it was low for days to marketable maturity, marketable head, length of stalk and harvest index.

Meena (2009) noticed high estimates of heritability for yield (98.90%) and low heritability estimates for gross weight (78.60%). High % of genetic gain was observed for yield (75.54%) whereas it was low for days to maturity (21.10%) and polar length (33.16%) of cabbage. Kumar (2013) observed high heritability estimates coupled with moderate genetic gain for gross weight of head, net weight of head, yield per plot and per hectare in cabbage.

2.6.3 Correlation

Yield is a complex character determined by several component characters (Singh, 2005). Improvement in yield is possible only through selection for the desired component characters. Hence knowledge of association between yield and its component characters and between component characters is essential for yield improvement through selection programme. Correlation coefficients were carried out according to the method suggested by Panse and Sukhatme (1967).

Aditya *et al.* (1989) reported that gross weight was positively and significantly correlated with stalk length, leaves per plants, curd diameter and curd depth. In an evaluation of 13 genotypes of cauliflower, net curd weight was positively and significantly associated with plant frame, leaf size index and curd depth (Kumar, 1999).

In a correlation analysis for yield components of cauliflower, Jana and Mukhopadhyay (2003) reported that leaf width was significantly correlated with number of leaves while leaf length with plant height. HouCheng *et al.* (2004) studied the relationship between plant growth parameters and curd yield of cauliflower (cv. Baiyang) and found a significant correlation among leaf mass, leaf area, plant mass, diameter of curd stem, and curd mass.

Kumar and Thakur (2003) reported significant and positive correlations between net curd weight and plant height, plant spread, whole plant weight, harvest index and curd diameter both at phenotypic as well as genotypic level.

Negative association of days to curd initiation and maturity with net curd weight and yield was reported by Aditya *et al.* (1989) and Mahesh *et al.* (2011). Booij (1990) positively correlated the length of the harvest period with the length of the curd initiation period. Significant negative correlation between days to curd initiation and maturity with mean temperatures and yield was observed by Ajithkumar (2005).

Jamwal *et al.* (1992) observed that curd yield/plant was strongly associated with curd size index and hence considered as a promising character for use in selection programmes. Spehia (1997) evaluated fifteen genotypes of cauliflower and found that the net curd weight was positively and significantly correlated with curd depth, curd solidity and gross weight along with stalk length and total number of leaves.

Kanwar and Korla (2002) observed that net curd weight was significantly and positively correlated with stalk length, gross plant weight and harvest index in late cauliflower. Kumar (2002) evaluated twenty two diverse genotypes of cauliflower and found that net curd weight had positive and significant correlation with gross curd weight, curd depth and curd compactness.

Pathania (2003) evaluated twenty diverse genotypes of cauliflower and found that net curd weight had positive and significant correlation with days taken to marketable curds, number of leaves, gross curd weight, curd depth, curd width and curd compactness. Garg and Lal (2004) found that net curd weight had positive and significant correlations with equatorial diameter of curd, curd size index, polar diameter of curd and curd compactness index.

Thirteen cauliflower varieties were evaluated and found that genotypic correlation was more pronounced than the phenotypic correlation and marketable curd yield per plant exhibited a positive correlation with net curd weight, curd size index, curd length, curd breadth and gross plant weight (Sharma *et al.* 2006). In a study conducted in Iran using cauliflower cv. Snow Crown significant positive correlation was observed between curd diameter and fresh leaves weight and also between yield and curd diameter (Amoli, 2007).

Kanwar *et al.* (2010) evaluated different genotypes of cauliflower and found that net curd weight was positively and significantly associated with days to marketable maturity, gross curd weight, number of leaves, curd depth and curd compactness. Mahesh *et al.* (2011) reported that total yield had significant positive correlation with net curd weight and harvest index.

In a study conducted to determine the seasonal incidence of *Spodoptera litura* on cauliflower (cv. Selection-4), the number of moths per trap per week exhibited significant positive correlation with maximum and minimum temperature, whereas the larval population on cauliflower showed positive correlation with mean minimum temperature (Monobrullah *et al.*, 2007).

2.6.4 Path coefficient analysis

Certain characters might indirectly influence yield, but their correlation with yield may not be statistically significant. In such cases, path coefficient analysis explained by Dewey and Lu (1959), is an efficient technique which permits the separation of coefficients into components of direct and indirect effects.

Path coefficient analysis by Kumar (1999) revealed high positive direct effect of gross curd weight and harvest index on net curd weight of cauliflower. Kanwar and Korla (2003) reported that the number of leaves per plant had the greatest direct and positive effect on net curd weight in cauliflower.

Kumar and Thakur (2003) reported positive direct effects of plant height, number of leaves per plant, whole plant weight, curd diameter and harvest index on net curd weight at genotypic as well as phenotypic level.

Significant direct effects of plant weight and curd diameter on curd weight were observed by Lui *et al.* (2004). Similarly in another study, path analysis revealed significant direct effects of plant weight and curd diameter on curd weight (HouCheng *et al.* 2004).

Results on path analysis for yield components suggested the importance in the order of curd compactness index, curd size index and equatorial diameter of curd (Garg and Lal, 2004). In a study highest positive direct effect was exerted by curd weight with guard leaves and curd width whereas negative effect observed for leaf size (Singh *et al*, 2006).

Path coefficient analysis showed that gross plant weight had the greatest direct effect on marketable curd yield per plant (Sharma *et al.*, 2006). Dhatt and Garg (2008) observed negative direct effect of considerable magnitude for days to curd maturity on net curd weight. Mahesh *et al.* (2011) studied direct positive contribution of that net curd weight and curd compactness towards the total yield.

Meena *et al.* (2001) found that among the yield contributing characters gross weight, leaf length, stalk length, head weight, number of non-wrapper leaves and equatorial length had direct effect on yield

2.6.5 Selection Index

Selection index helps in selecting plants for crop improvement based on several characters of economic importance. This method aims at simultaneous improvement of several or multiple characters.

In a correlation analysis for seed yield and yield components of five cauliflower cultivars, net curd weight, number of pods per plant, pod length, number of seeds per pod, and 1000-seed weight were used as selection indices for higher seed yield (Jana and Mukhopadhyay, 2003).

Kumar and Thakur (2003) reported whole plant weight, curd diameter and harvest index as the most effective selection indices in increasing the net curd weight in cauliflower.

In a study with thirteen cauliflower varieties, curd breadth, curd size index, net curd weight and harvest index, were given emphasis and taken as selection index for high curd yield in cauliflower (Sharma *et al.* 2006).

In a field evaluation of 36 genetically diverse genotypes of cabbage gross plant weight was taken as direct selection index for genetic improvement (Singh *et al.* 2010).

Materials and methods

3. MATERIALS AND METHODS

The experiment entitled "Evaluation of cauliflower (*Brassica oleracea* L. var. *botrytis*) for southern Kerala" was conducted at the Department of Olericulture, College of Agriculture, Vellayani, during the period October 2012 to March 2013. The study was conducted for the purpose to identify tropical cauliflower varieties suitable for plains of southern Kerala and to study the influence of date of sowing and their interaction effects on yield and quality.

3.1 Experimental site

The experimental site was located at $8^{\circ}\ 5'$ N latitude and $77^{\circ}\ 1'$ E longitude at an altitude of 29 m above mean sea level. Predominant soil type of the experimental site was red loam belonging to Vellayani series, texturally classified as sandy clay loam with a pH of 5.2. The area enjoys a warm humid tropical climate.

3.2 Season

The four crops were raised as winter crop from October 2012 to March 2013.

3.3 Materials

The experimental material comprised of 12 early/ mid season cauliflower varieties/ hybrids released by public/ private sector. The details of varieties used for the experiment are given in Table 1.

3.4 Method

3.4.1 Design and layout

Split plot design was adopted for the layout of the experiment with sowing dates as main plot treatments and varieties as sub plot treatments. Field view of this experiment was given in Plate 1. The details of the layout were as follows:

Main plot : 4 sowing dates

Sub plots : 12 varieties/ hybrids

Plate 1. Field view of the expiriment

Replications : 5

Spacing : 60 x 60 cm

Plants/ plot : 25

Plot size : 3 x 3 m

One month old seedlings were transplanted into the main field at a spacing of 60 x 60 cm. The crop received timely management practices as per package of practices recommendations of Kerala Agricultural University (KAU, 2011).

3.4.2 Treatments

3.4.2.1 Main plot treatments

In the main plot four sowing dates were evaluated. They are:

D1 – 1st October Sowing

D2 – 15th October Sowing

D3 – 1st November Sowing

D4 – 15th November Sowing

3.4.2.2 Sub plot treatments

In the sub plots 12 cauliflower varieties were evaluated.

Table 1. Cauliflower varieties used for evaluation

Sl. No.	Number	Variety name	Variety/ Hybrid	Source
1	T1	Pusa Meghna	Variety	IARI, New Delhi
2	T 2	Pusa Sharad	Variety	IARI, New Delhi
3	T 3	Pusa Paushja	Variety	IARI, New Delhi
4	T 4	Pusa Hybrid 2	Hybrid	IARI, New Delhi
5	T 5	Pusa Shukti	Variety	IARI, New Delhi
6	T 6	NS 60 N	Hybrid	Namdhari Seeds, Banglore

7	T 7	Himshort	Hybrid	Century Seeds, New Delhi
8	T 8	Himlatha	Hybrid	Century Seeds, New Delhi
9	T 9	Himpriya- 60	Hybrid	Century Seeds, New Delhi
10	T 10	Indam 2435	Hybrid	Indo-American Hybrid Seeds, Bangalore
11	T11	G 45	Hybrid	Green Co. Ltd, Vietnam .
12	T 12	White Snow	Hybrid	Green Co. Ltd, Vietnam

3.4.3 Observations

Three plants were selected randomly from each replication and tagged for recording the observations.

3.4.3.1 Vegetative characters

3.4.3.1.1 Plant height – 30 DAT (cm)

Plant height was recorded from the ground level to the topmost leaf apex of the plants at 30 days after transplanting and presented in centimeters.

3.4.3.1.2 Plant height – at harvest (cm)

Plant height was recorded from the ground level to the topmost leaf apex of the plants at curd harvest stage and presented in centimeters.

3.4.3.1.3 Leaves per plant

Number of leaves per plant was recorded from all the sample plants at the harvest stage and average was worked out.

3.4.3.1.4 Gross plant weight (kg)

Whole plant weight including curd was taken and recorded for all the sample plants and average was worked out.

3.4.3.1.5 Leaf length – 30 DAT (cm)

The seventh leaf from top of the selected plants was used for making this observation. The length was measured as the distance from the base of the leaf lamina to the top of the leaf and expressed in centimeters at 30 days after transplanting.

3.4.3.1.6 Leaf breadth – 30 DAT (cm)

The width of same leaf, used for recording the length was taken at the region of maximum width at 30 days after transplanting and expressed in centimeters.

3.4.3.1.7 Leaf size – 30 DAT (cm^2)

The product of leaf length and breadth at 30 days after transplanting was calculated and expressed in cm^2.

3.4.3.1.8 Leaf length - at harvest (cm)

The seventh leaf from top of the selected plants was used for making the above observation. The length was measured as the distance from the base of the leaf lamina to the top of the leaf and expressed in centimeters at harvest stage.

3.4.3.1.9 Leaf breadth – at harvest (cm)

The width of same leaf, used for recording the length was taken at the region of maximum width at harvest stage and expressed in centimeters.

3.4.3.1.10 Leaf size at curd harvest (cm^2)

The product of leaf length and breadth at harvest stage was calculated and expressed in cm^2.

3.4.3.1.11 Position of leaves

Position of leaves is determined in relation to curd at maturity (Appendix-I). It is categorized as:-

Type No. 1 - Flat

Type No. 2 - Semi- erect

Type No. 3 - Erect

Type No. 4 - Very erect

3.4.3.2 Curd characters

3.4.3.2.1 Days to curd initiation

Number of days from the date of transplanting to curd initiation of observation plants was recorded and the average obtained.

3.4.3.2.2 Days to curd harvest

Number of days from the date of transplanting to date of curd harvest of observation plants was recorded and the average obtained

3.4.3.2.3 Days to curd maturity from curd initiation

Number of days from the date of curd initiation to date of curd harvest of observation plants was recorded and the average obtained

3.4.3.2.4 Days to curd maturity from transplanting

Number of days from the date of transplanting to 50% of the population formed marketable curds was recorded.

3.4.3.2.5 Curd depth (cm)

The vertical distance in cm from the top end of the curd to the lowest point of the basal button of the half cut curd.

3.4.3.2.6 Curd diameter (cm)

The maximum distance in cm between the outermost buttons on both sides of the half cut curd.

3.4.3.2.7 Curd size index (cm^2)

It is the product of curd depth and curd diameter of observation plants.

3.4.3.2.8 Curd compactness (g/cm^3)

The compactness index of the curd was worked out by the formula given by Pearson (1931) as given below:

$$Z = \frac{C}{W3} \times 100$$

where, Z is an index of compactness, C is the net weight of the curd and W is the average of depth and diameters of the curd. A higher value of z indicates a more compact curd.

3.4.3.2.9 Stalk length (cm)

It is taken as stem length up to insertion of first leaf from curd and expressed in cm.

3.4.3.2.10 Curd colour

Based on visual observation curd colour is recorded (Appendix- I). It is categorized as:-

(1) White

(2) Creamy White

(3) Yellow

3.4.3.3 Yield characters

3.4.3.3.1 Net curd weight (kg)

The weight of curd without leaves and stalk of observation plants were taken and average was worked out.

3.4.3.3.2 Gross curd weight (kg)

The weight of curd along with leaves and stalk of observation plants were taken and average was worked out.

3.4.3.3.3 Yield per plot (kg)

It is the net weight of marketable curds per plot (3 x 3 m)

3.4.3.3.4 Yield per hectare (t. ha^{-1})

It is the net weight of marketable curds per hectare.

3.4.3.3.5 Harvest index

It is the ratio of economic yield (net curd weight) to biological yield (gross plant weight).

$$\text{Harvest index} = \frac{\text{Economic Yield}}{\text{Biological Yield}}$$

3.4.3.3.6 Percentage curding

Number of plants producing curds was counted from each plot and their average was worked out.

3.4.3.4 Quality characters

3.4.3.4.1 Protein

Protein was estimated by Bradford method (Sadasivam and Manickam, 1996).

Reagents:

1. Dye concentrate: 100mg of coomasie brilliant blue G 250 was dissolved in 50 ml of 95 per cent ethanol. 100ml of concentrated orthophosphoric acid was added and final volume was made up to 200 ml with distilled water. It was stored under refrigerated conditions in amber bottles. One volume of concentrated dye solution was mixed with four volumes distilled water for use. This was filtered with Whatman No.1 filter paper if any precipitate occurred.
2. Phosphate-buffer saline (PBS)
3. Protein solution (Stock standard): 50 mg of bovine serum albumin was accurately weighed and dissolved in distilled water and made up to 50 ml in a standard flask.
4. Working standard: 10 ml of the stock solution was diluted to 50 ml with distilled water in a standard flask. One ml of this solution contains 200 μg protein.

Procedure:

500 mg of the sample was weighed and ground well with a pestle and mortar in 5-10 ml of the buffer. This was centrifuged and the supernatant was used for protein estimation.

0.2, 0.4, 0.6, 0.8, and 1 ml of the working standard was pipette out into a series of test tubes. 0.1 ml of the sample extract was pipetted out into 2 other test tubes. The volume was made up to 1 ml in all the test tubes. A tube with 1 ml of water is used as blank and 5 ml of diluted dye solution was added to each tube. This was mixed well and the colour was allowed to develop for five minutes, but not longer than 30 minutes. The absorbance was read at 595 nm. A standard curve was plotted using standard absorbance *vs* concentration. The protein in the sample was calculated using the standard curve.

3.4.3.4.2 Vitamin A

Carotene content of fresh leaves at harvest (30 DAT) was estimated according to the method proposed by Srivastava and Kumar (1998).

Reagents

1. Acetone
2. Anhydrous sodium sulphate
3. Petroleum ether

Procedure

5g of fresh sample was taken and crushed in 10-15 ml acetone, adding a few crystals of anhydrous sodium sulphate, with the help of pestle and mortar. The supernatant was decanted into a beaker. Repeated the process twice and transferred the combined supernatant to a seperatory funnel. 10-15 ml of petroleum ether was added and mixed thoroughly. The two layers separated out on standing. The lower layer discarded and the upper layer was collected in a 100ml volumetric flask. The volume was made upto 100ml with petroleum ether and recorded the optical density at 452 nm using petroleum ether as blank.

$$\beta \text{ carotene } (\mu g\ 100\ g^{-1} \text{ sample}) = \frac{\text{Optical density X } 13.9 \times 10^{4} \text{ X } 100}{\text{Weight of sample X } 560 \text{ X } 1000}$$

$$\text{Vitamin A (IU)} = \frac{\beta \text{ carotene } (\mu g\ 100\ g^{-1} \text{ sample})}{0.6}$$

3.4.3.4.3 Vitamin C

Vitamin C content of fruit was estimated by 2, 6-dichlorophenol indophenols dye method (Sadasivam and Manickam, 1996).

Reagents

1. Oxalic acid (4%)

2. Ascorbic acid standard: Stock solution was prepared by dissolving 100 mg of ascorbic acid in 100 ml of four per cent oxalic acid. 10 ml of this stock solution was diluted to 100 ml with four per cent oxalic acid to get working standard solution.

3. 2, 6-dichlorophenol indophenols dye: 42 mg sodium bicarbonate was dissolved in a small volume of distilled water. 52 mg 2, 6-dichlorophenol indophenols was added into this and made up to 200 ml with distilled water..

Procedure

5 ml of the working standard solution was pipette out into a 100 ml conical flask and 10 ml four per cent oxalic acid was added. It was titrated against the dye (V_1 ml). End point was the appearance of pink colour of which persisted for atleast five seconds. One gram of fresh leaf was extracted in an acid medium (4 % oxalic acid) and made upto a known volume (20 ml) and centrifuged. 5ml of the supernant was taken and titrated against was calculated the dye until pink colour appeared (V_2 ml). Ascorbic acid content was calculated using the formula.

$$\text{Amount of ascorbic acid (mg 100 g}^{-1}\text{ sample)} = \frac{0.5 \times V_2 \times \text{Vol. made up}}{V_1 \times 5 \text{ ml} \times \text{weight of sample}}$$

3.4.3.5 Physiological Disorders

Number of plants showing physiological disorders were recorded and percentage worked out using the formula.

$$\text{Percentage incidence of disorders} = \frac{\text{Number of plants showing disorder}}{\text{Total number of plants}} \times 100$$

The physiological disorders observed during the crop period were as follows:

1. Riceyness
2. Hairiness
3. Leafiness
4. Buttoning

3.4.3.6 Incidence of pests and diseases

Number of plants affected was recorded and from this percentage of plants affected was calculated.

$$\text{Percentage of plants affected} = \frac{\text{Number of plants affected}}{\text{Total number of plants}} \quad 00$$

The pest and diseases observed during the crop period were as follows:

1. Leaf caterpillar (*Spodoptera litura*)
2. *Alternaria* blight (*Alternaria brassicae*)
3. Soft rot (*Pythium* sp.)
4. *Choanephora* rot (*Choanephora* sp.)
5. Curd rot (*Alternaria brassicae*)

3.4.3.7 Weather parameters

Following weather parameters during the course of investigation were recorded and furnished in Appendix II.

1 Maximum temperature (^{o}C)

2 Minimum temperature (^{o}C)

3 Rainfall (mm)

4 Relative humidity (%)

3.4.3.8 Statistical Analysis

The technique of analysis of variance for split plot design (Gomez and Gomez, 1984) was used for analyzing the experimental data and results obtained.

Critical differences (5% and 1% levels) were worked out for multiple comparisons among the means, whenever the effects turned significant. Main plot effects, sub plot effects and their interaction effects were compared using the multiple comparisons of their respective means. The breakup of the degrees of freedom (df) in the analysis of variance with reference to the present study is furnished.

Table 2. Analysis of variance

Source of variation	Degrees of freedom	Sum of Squares	Mean Sum of Squares	F Ratio
Main plot analysis				
Replication	r-1	SSR		
Main plot treatment (A)	a-1	SSA	MSA	MSA/MSE1
Main plot error (E1)	(r-1) (a-1)	SSE1	MSE1	
Sub plot analysis				
Sub plot treatment (B)	b-1	SSB	MSB	MSB/MSE2
Interaction (AxB)	(a-1) (b-1)	SS(AB)	MS(AB)	MS(AB)/MSE2
Sub plot error (E2)	a(r-1)(b-1)	SSE2		
Total	rab-1	SST		

The best sowing date based on the analysis of variance was selected and again the data were statistically analyzed. It was done to estimate genetic parameters like variability, heritability, genetic advance, correlation coefficients, etc.

The other genetic parameters were estimated as follows: (Table 3)

3.4.3.8.1 Variance:

	X	Y
Environmental variance ($\sigma^2 e$)	$\sigma^2_{ex} = E_{xx}$	$\sigma^2_{ey} = E_{yy}$
Genotypic variance (σ^2_g)	$\sigma^2_{gx} = \frac{G_{xx} - E_{xx}}{r}$	$\sigma^2_{gy} = \frac{G_{yy} - E_{yy}}{r}$
Phenotypic variance ($\sigma^2 p$)	$\sigma^2_{px} = \sigma^2_{gx} + \sigma^2_{ex}$	$\sigma^2_{py} = \sigma^2_{py} + \sigma^2_{ey}$

3.4.3.8.2 Coefficient of variation

Phenotypic and genotypic coefficients of variation (PCV and GCV) were estimated as:

$$GCV = \frac{\sigma_{px}}{\overline{x}} \times 100$$

$$PCV = \frac{\sigma_{px}}{\overline{x}} \times 100$$

Where,

σ_{gx} - genotypic standard deviation

σ_{px} - phenotypic standard deviation

$\overline{x}_x$ - Mean of the character under study

3.4.3.8.3 Heritability

$$H^2 = \frac{\sigma^2_{gx}}{\sigma^2_{px}} \times 100$$

Where, H^2 is the heritability expressed in percentage (Jain, 1982). Heritability estimates were categorized as suggested by Jhonson *et al.* (1995).

0 – 30 per cent → Low

31 – 60 per cent → Moderate

>60 per cent → High

Table 3. Analysis of variance / covariance

Source	Df	Observed mean square XX	Expected mean square XX	Observed mean sum of products XY	Expected mean sum of products XY	Observed mean square YY	Expected mean square YY
Block	(r-1)	B_{xx}		B_{xy}		B_{yy}	
Genotype	(v-1)	G_{xx}	$\sigma^2_{ex}+$ σ^2_{gx}	G_{xy}	$\sigma^2_{exy}+$ $r\sigma^2_{gxy}$	G_{yy}	Σ^2_{ex} $+r\sigma^2_{gx}$
Error	(v-1) (r-1)	E_{xx}	σ^2_{ex}	E_{xy}	$\sigma2_{exy}$	E_{xy}	σ^2_{xy}
Total	T_{xx}		T_{xx}			T_{yy}	

3.4.3.8.4 Genetic Advance as percentage mean

$$GA = \frac{k\,H^2}{\sigma_p}$$

Where, k is the standard selection differential.

K = 2.06 at 5% selection intensity (Miller *et al.*, 1958)

The range of genetic advance as per cent of mean was classified according to Jhonson *et al.* (1995).

0- 10 per cent → Low

11- 20 per cent → Moderate

> 20 per cent → High

3.3.5 Correlation

Genotypic correlation coefficient (r_{gxy}) $= \frac{\sigma gx}{\sigma gx \times \sigma gy}$ $\frac{\sigma_{gxy}}{\sigma_{gx} \times \sigma_{gy}}$

Phenotypic correlation coefficient (r_{pxy}) $= \frac{\sigma pxy}{\sigma px \times \sigma py}$ $\frac{\sigma_{pxy}}{\sigma_{px} \times \sigma_{py}}$

Environmental correlation coefficient (r_{exy}) $= \frac{\sigma egx}{\sigma ex \times \sigma ey}$ $\frac{\sigma_{exy}}{\sigma_{ex} \times \sigma_{ey}}$

3.3.6 Path analysis

The direct and indirect effects of yield contributing factors were estimated through path analysis technique (Wright, 1954; Dewey and Lu, 1959)

3.3.8 Selection Index

The selection index .developed by Smith (1937) using discriminate function of Fisher (1936) was used to discriminate the genotypes based on all the characters.

The selection index is described by the function, $I = b_1 x_1 + b_2 x_2 + \ldots\ldots\ldots + b_k x_k$ and the merit of a plant is described by the function, $H = a_1 G_1 + a_2 G_2 + \ldots\ldots\ldots + b_k G_k$ where $x_1, x_2 \ldots\ldots\ldots\ldots x_k$ are the phenotypic values and $G_1, G_2 \ldots\ldots\ldots\ldots G_k$ are the genotypic values of the plants with respect to characters, $x_1, x_2 \ldots\ldots\ldots\ldots x_k$ and H is the genetic worth of the plant. It is assumed that the economic weight assigned to each character is equal to unity i. e., $a_1, a_2 \ldots\ldots\ldots\ldots a_k = 1$

The regression coefficients (b) are determined such that the correlation between H and I is maximum. The procedure will reduce to an equation of the form, $b = P^{-1}Ga$ where, P is the phenotypic variance-covariance matrix and G is the genotypic variance-covariance matrix x.

Results

4. RESULTS

The experiment entitled 'Evaluation of cauliflower (*Brassica oleracea* L. var. *botrytis*) for southern Kerala' was carried out in the Department of Olericulture, College of Agriculture, Vellayani during the period from October 2012 to March 2013.

The experiment was laid out in split plot design with four dates of sowing in main plot and 12 varieties in subplots. The experimental data collected on vegetative characters, curd characters, yield and yield attributes, quality characters and physiological disorders, pest and disease incidence were statistically analyzed and the results obtained are presented below.

4.1 Analysis of variance

Analysis of variance revealed significant difference between four dates of sowing, 12 varieties and their interactions for almost all the characters studied. The mean performance of the varieties for various vegetative, curd and yield characters are furnished in Table 4 to 13.

4.1.1 Vegetative characters

4.1.1.1 Plant height- 30 DAT (cm)

At 30 days after transplanting, plant height was significantly influenced by different sowing dates, varieties and their interaction (Table 4).

Plant height at 30 days after transplanting was highest (42.48 cm) for November 1st (D3) followed by October15th (D2- 41.70 cm) and lowest for (31.25 cm) October1st (D1) sowing. Among varieties, it was maximum (44.47 cm) for Himpriya 60 (T9) which was on par with Pusa Sharad (T2- 44.39 cm) and minimum (34.59 cm) for Pusa Shukti (T5) which was on par with Himshort (T7- 34.85 cm).

Table 4. Effect of sowing dates, varieties and their interactions on plant height and leaves per plant of cauliflower

Varieties	Plant height- 30 DAT (cm)					Plant height- at harvest (cm)					Leaves per plant				
	D1	D2	D3	D4	Mean	D1	D2	D3	D4	Mean	D1	D2	D3	D4	Mean
T1	29.80	39.25	39.51	38.17	36.68	39.25	60.50	67.52	58.72	56.50	21.61	23.78	27.95	22.05	23.85
T2	34.09	47.49	50.13	45.82	44.39	45.24	68.22	69.98	68.00	62.86	21.63	19.73	22.92	26.21	22.62
T3	32.32	42.48	40.87	37.24	38.23	42.48	66.56	70.86	60.34	60.06	19.83	24.81	23.30	19.18	21.78
T4	29.97	43.61	38.61	35.83	37.00	65.44	65.60	69.02	60.04	65.03	24.42	29.73	23.30	32.79	27.56
T5	27.58	39.02	35.94	35.83	34.59	59.04	55.92	61.68	57.70	58.59	21.43	20.93	21.52	27.02	22.73
T6	30.44	44.41	44.01	45.32	41.09	64.13	64.53	66.76	60.36	63.94	28.20	27.50	26.52	24.37	26.65
T7	31.57	34.80	39.84	33.20	34.85	49.56	47.06	57.78	62.02	54.11	19.41	19.76	29.18	23.65	23.00
T8	27.45	37.89	44.51	35.29	36.28	44.41	60.12	63.90	59.14	56.89	23.00	27.33	27.15	22.10	24.89
T9	38.10	45.24	46.59	47.96	44.47	67.67	66.26	70.04	64.16	67.03	26.82	32.84	29.91	23.75	28.33
T10	30.58	38.55	42.60	41.17	38.22	62.00	62.42	65.78	61.20	62.85	21.41	25.87	26.20	24.15	24.41
T11	34.17	43.09	45.43	45.37	42.01	63.55	63.72	70.16	64.80	65.56	22.08	24.48	26.23	23.47	24.07
T12	28.95	44.61	41.74	39.67	38.69	58.03	61.42	64.54	57.78	60.44	22.52	22.23	25.96	21.91	23.15
Mean	31.25	41.70	42.48	40.07		55.07	61.86	66.50	61.19		22.69	24.92	25.85	24.22	
CD (5%)	D				0. 563					0.828					0.385
	V				0 .993					1.134					0.708
	DxV				1.986					2.268					1.415

Pusa Sharad sown on October15th (D3T2) had the maximum (50.13 cm) plant height and Himlatha sown on October1st (D1T8) had the minimum (27.45 cm).

4.1.1.2 Plant height- at harvest (cm)

Plant height at harvest was significantly different for sowing dates and varieties (Table 4). It was highest (66.50 cm) for November 1st sowing (D3) and lowest (55.07 cm) for October 1st (D1). Maximum plant height (67.03 cm) was recorded for Himpriya 60 (T9) and minimum (54.11 cm) for Himshort (T7).

The interaction between sowing dates and varieties was significant for plant height at harvest stage. Highest plant height (70.86 cm) was recorded for Pusa Paushja sown on November 1st (D3T3) and lowest (39.25 cm) for Pusa Meghna sown on October 1st (D1T1).

4.1.1.3 Leaves per Plant

Leaves per plant differed significantly for sowing dates and varieties. It was highest (25.85) for D3 sowing followed by D2 (24.92) and lowest (22.69) for D1. T9 recorded maximum leaves per plant (28.33) followed by T4 (27.56) and minimum (21.78) for T3 (Table 4).

The interactions among various treatment combinations were also significant. The results showed that among the treatment combinations, D2T9 (32.84) which was on par with D4T4 (32.79) had maximum number of leaves and D4T3 (19.18) had minimum (Fig. 1).

4.1.1.4 Gross plant weight (kg)

Gross plant weight varied significantly for sowing dates and D3 resulted in maximum gross plant weight (1.37 kg) followed by D1 (1.26 kg) while lowest (1.17 kg) was noticed in D4.

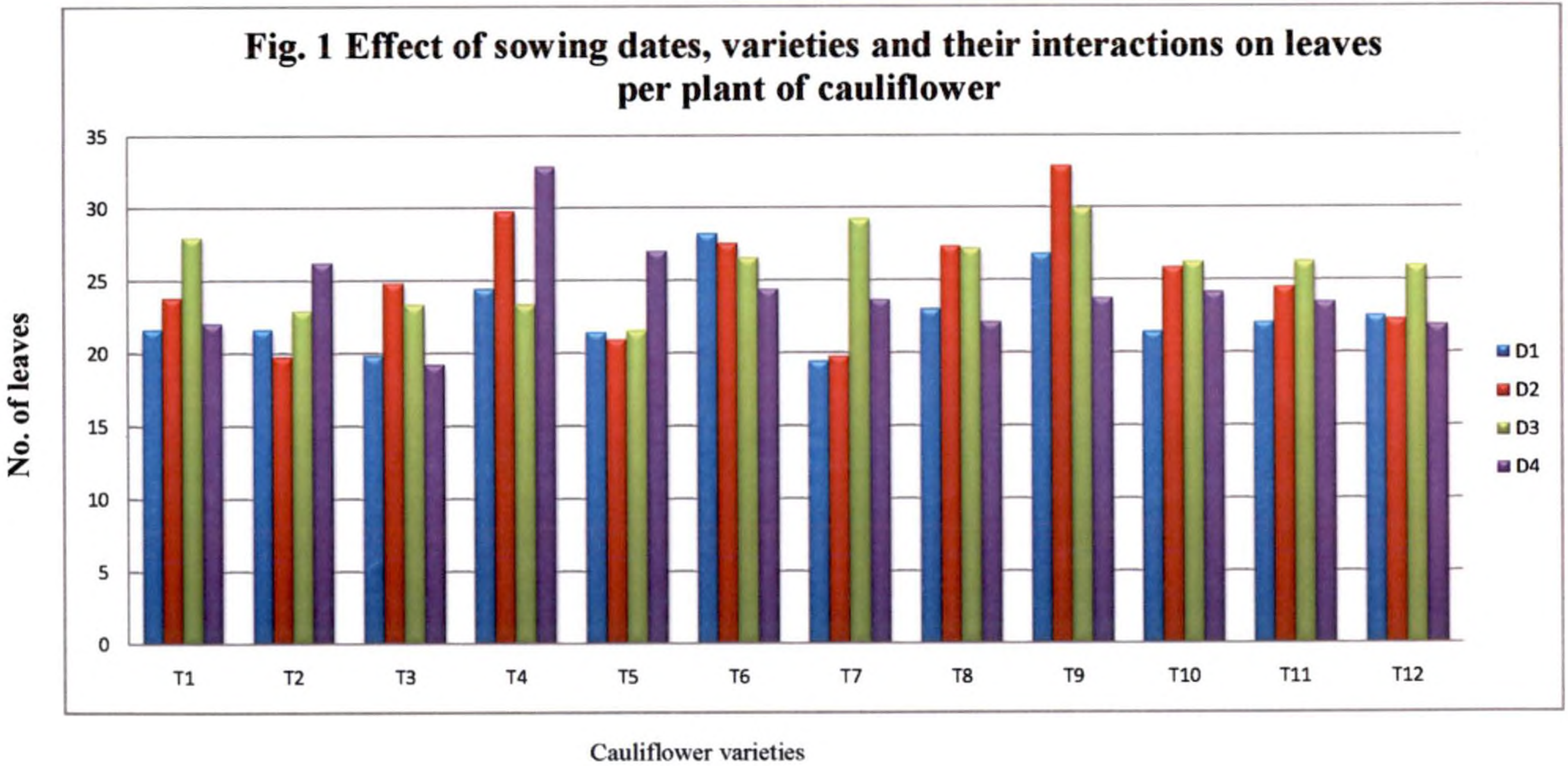


Fig. 1 Effect of sowing dates, varieties and their interactions on leaves per plant of cauliflower
No. of leaves
35
30
25
20
15
10
5
0
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12
D1
D2
D3
D4
Cauliflower varieties

Significant difference was obtained for varieties also (Table 5). T9, T4 and T11 were superior and on par for gross plant weight (1.64, 1.47 and 1.31 kg). T7 and T3 recorded lower gross plant weight (0.99 and 1.07 kg).

Interaction effect was also significant. Maximum gross plant weight (2.29 kg) was observed for Himpriya-60 sown on November1st (D3T9) which was on par with D3T4 (1.71 kg) i.e., Pusa Hybrid-2 sown on the same time. Pusa Paushja sown on 15th October resulted in least value (0.84 kg) (Fig. 2).

4.1.1.5 Leaf length- 30 DAT (cm)

Leaf length taken at 30 days after transplanting was significantly influenced by different sowing dates and varieties. Highest leaf length (32.60 cm) was obtained for D3 and lowest (24.61 cm) for D1. Leaf length was highest (32.69 cm) for T9 followed by T11 (31.59 cm) which was on par with T6 (31.55 cm) and T4 (31.46 cm) and lowest (25.48 cm) for T7 (Table 5).

D x T interaction also significantly influenced leaf length of plants. Maximum leaf length was recorded for D3T11 (35.38 cm), D2T11 (35.10 cm), D4T9 (34.79 cm), D3T5 (34.51 cm), D3T6 (34.37 cm) and D2T4 (34.32 cm) and minimum for D1T7 (21.43 cm), D1T2 (22.36 cm), D1T10 (22.98 cm), D1T5 (23.27 cm), D1T1 (23.35 cm) and D1T8 (23.36 cm) at 30 days after transplanting.

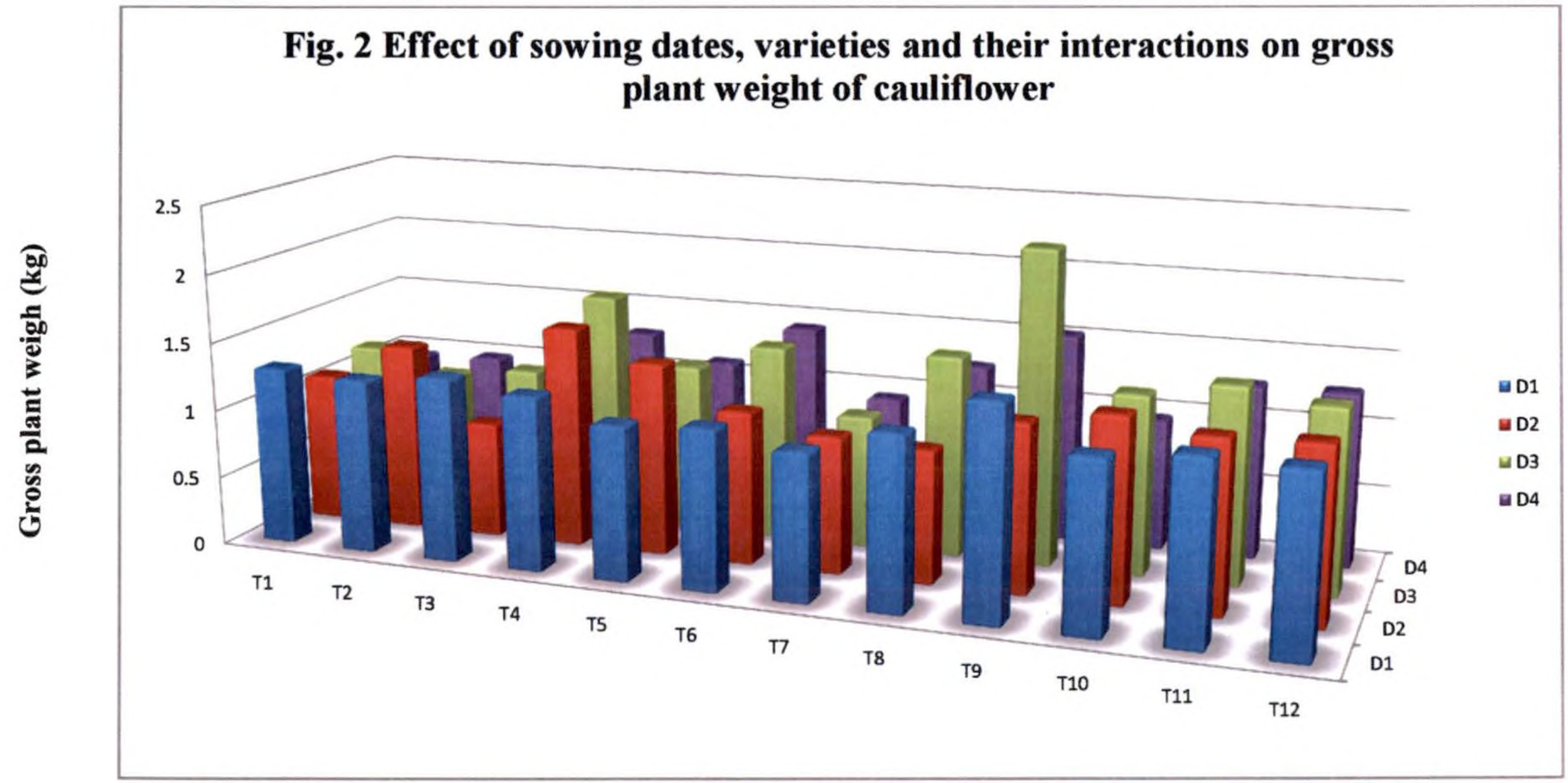
4.1.1.6 Leaf length- at harvest (cm)

Leaf length at harvest stage was significantly influenced by different sowing dates and varieties. D3 recorded maximum leaf length (44.61 cm) whereas D1 recorded the minimum (39.99 cm). T9 recorded the maximum leaf length (48.43 cm) followed by T11 (44.87 cm) which was on par with T4 (44.58 cm) and lowest (38.14 cm) for T2 (Table 5).

Interaction effects were also significant. Among all the combinations maximum leaf length (50.08 cm) was obtained for D3T9 and minimum (37.23 cm) for D4T2.

Table 5. Effect of sowing dates, varieties and their interactions on gross plant weight and leaf length of cauliflower

Varieties	Gross plant weight (kg)					Leaf length- 30 DAT (cm)					Leaf length- at harvest (cm)				
	D1	D2	D3	D4	Mean	D1	D2	D3	D4	Mean	D1	D2	D3	D4	Mean
T1	1.30	1.09	1.17	0.96	1.13	23.35	28.93	30.26	25.95	27.12	38.83	38.11	40.49	38.74	39.04
T2	1.27	1.37	1.01	0.99	1.16	22.36	27.11	30.45	26.43	26.59	37.35	38.07	39.89	37.23	38.14
T3	1.34	0.84	1.09	1.00	1.07	29.58	30.89	31.78	32.10	31.09	40.31	44.29	45.88	42.38	43.22
T4	1.27	1.61	1.71	1.29	1.47	25.67	34.32	33.03	32.82	31.46	43.25	44.20	47.27	43.61	44.58
T5	1.12	1.40	1.23	1.11	1.22	23.27	30.72	34.51	33.92	30.60	38.40	44.06	46.61	41.05	42.53
T6	1.16	1.11	1.43	1.43	1.28	24.77	33.88	34.37	33.17	31.55	40.97	44.45	46.89	41.42	43.43
T7	1.06	0.99	0.97	0.94	0.99	21.43	24.51	31.72	24.27	25.48	37.58	39.31	42.13	37.98	39.25
T8	1.25	0.96	1.47	1.24	1.23	23.36	32.96	31.45	31.03	29.70	38.32	43.47	41.25	43.13	41.55
T9	1.53	1.22	2.29	1.53	1.64	28.31	33.96	33.72	34.79	32.69	47.30	48.94	50.08	47.39	48.43
T10	1.22	1.33	1.31	0.96	1.21	22.98	29.57	31.67	29.11	28.33	37.69	40.02	42.19	38.86	39.69
T11	1.29	1.24	1.43	1.27	1.31	24.13	35.10	35.38	31.74	31.59	40.83	46.12	48.33	44.18	44.87
T12	1.27	1.26	1.34	1.27	1.29	26.06	30.18	32.89	32.53	30.42	39.17	43.64	44.33	43.75	42.73
Mean	1.26	1.20	1.37	1.17		24.61	31.01	32.60	30.65		39.99	42.89	44.61	41.64	
CD (5%)	D				0.020					0.504					0.772
	V				0.340					0.696					0.917
	DxV				0.680					1.391					1.834



Cauliflower varieties

4.1.1.7 Leaf breadth- 30 DAT (cm)

Leaf breadth at 30 days after transplanting was significantly influenced by different sowing dates. Highest leaf length (20.22 cm) was obtained for November1st sowing and lowest (15.67 cm) for October 1st (Table 6).

Significant variation was obtained among different varieties also. Leaf breadth was highest for T9 (19.99 cm) which was on par with T4 (19.59 cm) and lowest for T7 (15.43 cm).

Interaction between varieties and sowing dates influenced the leaf breadth of plants significantly. Maximum leaf breadth (23.03 cm) was recorded for D3T4 and minimum (13.69 cm) for D4T7 which was on par with D1T2 (14.22cm), D4T8 (14.51 cm) and D2T7 (14.55 cm) at 30 days after transplanting.

4.1.1.8 Leaf breadth- at harvest (cm)

Leaf breadth recorded at harvest was also significantly influenced by different sowing dates and varieties. D3 recorded maximum leaf breadth (25.95 cm).while D1 recorded the minimum (21.46 cm). Among varieties, it was highest (25.73 cm) for T9 followed by T5 (24.38 cm) and lowest (21.20 cm) for T7 (Table 6).

Interaction effect was significant for leaf breadth. Maximum breadth (28.36 cm) was observed for Pusa Hybrid-2 sown on November 1st (D3T4) which was on par with D4T4 (27.35 cm) i.e., Pusa Hybrid-2 planted on November 15th. Least value (19.64 cm) was obtained for D4T7 which was on par with D1T2 (19.85 cm), D4T8 (20.27 cm) and D2T7 (20.29 cm).

4.1.1.9 Leaf size- 30 DAT (cm^2)

Leaf size of plants taken 30 days after transplanting varied significantly for different sowing dates and it was observed that D3 resulted in maximum leaf size

Table 6. Effect of sowing dates, varieties and their interactions on leaf breadth of cauliflower

Varieties	Leaf breadth- 30 DAT (cm)					Leaf breadth- at harvest (cm)				
	D1	D2	D3	D4	Mean	D1	D2	D3	D4	Mean
T1	15.77	17.26	20.06	16.30	17.35	21.60	23.01	25.75	22.05	23.10
T2	14.22	18.51	19.30	17.67	17.43	19.85	24.27	25.05	23.43	23.15
T3	16.39	17.19	19.41	16.03	17.26	22.03	22.92	25.24	21.18	22.84
T4	15.38	18.32	23.03	21.63	19.59	20.98	24.05	28.36	27.35	25.18
T5	15.52	19.49	20.44	18.49	18.49	21.99	25.26	26.19	24.07	24.38
T6	16.09	18.17	20.24	17.73	18.06	21.99	23.92	25.89	23.48	23.82
T7	15.17	14.55	18.30	13.69	15.43	20.77	20.29	24.09	19.64	21.20
T8	15.08	17.80	19.99	14.51	16.84	20.84	23.56	25.76	20.27	22.61
T9	17.58	21.10	21.11	20.15	19.99	23.32	26.89	26.85	25.88	25.73
T10	15.18	15.64	19.35	16.30	16.62	20.94	21.39	24.99	22.06	22.35
T11	15.82	19.35	21.23	16.48	18.22	21.55	25.10	26.97	22.16	23.95
T12	15.81	19.39	20.17	16.34	17.93	21.65	25.15	26.22	22.13	23.79
Mean	15.67	18.06	20.22	17.11		21.46	23.82	25.95	22.81	
CD (5%)	D				0.574					0.353
	V				0.655					0.598
	DxV				1.310					1.196

(660.90 cm^2) followed by D2 (557.95 cm^2). Lowest leaf size (387.38 cm^2) was noticed in D1 sowing (Table 7).

Significant differences were obtained for varieties also. Himpriya-60 (T9) was superior (656.94 cm^2) for leaf size which was on par with T4 (631.76 cm^2). Smallest leaf size (398.75 cm^2) was recorded for T7 (Fig. 3).

Interaction effect was also significant for leaf size taken at 30 days after transplanting. Maximum leaf size (815.18 cm^2) was obtained for Pusa Hybrid-2 sown on November 1st (D3T4) and smallest leaf size was obtained for D1T2 (318.25 cm^2) which was on par with D1T7 (324.61 cm^2), D4T7 (336.54 cm^2), D1T10 (349.07 cm^2), D2T7 (352.42 cm^2), D1T8 (353.71 cm^2) and D1T5 (361.11 cm^2).

4.1.1.10 Leaf size- at harvest (cm^2)

Leaf size of plants taken at harvest varied significantly for sowing dates and varieties and D3 resulted in maximum leaf size (1159.77 cm^2) followed by D4 (1025.66 cm^2). Lowest leaf size (860.18 cm^2) was noticed in D1 (Table 7).

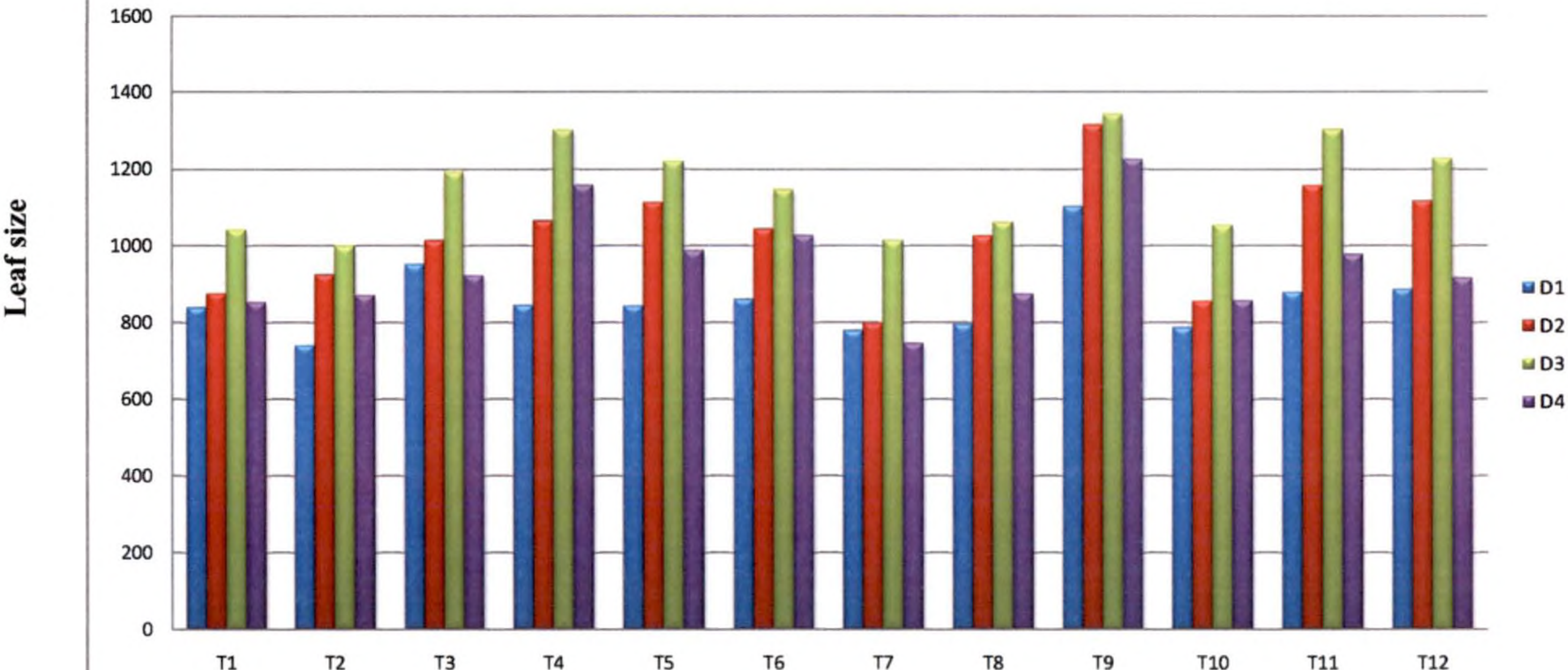
T9 was superior (1247.29 $cm^{2)}$ followed by T4, T11, T5, T12, T3 and T6 which were on par for leaf size at harvest stage i.e., 1093.06 cm^2, 1079.82 cm^2, 1041.86 cm^2, 1037.95 cm^2, 1021.10 cm^2 and 1020.10 cm^2 respectively. Smallest leaf size (835.01 cm^2) was recorded for T7 which was on par with T2 (884.82 cm^2) and T10 (889.22 cm^2).

Interaction effect was also significant. Maximum leaf size (1344.65 cm^2) was obtained for D3T9 which was on par with D2T9 (1315.068 cm^2), D3T11 (1302.96 cm^2) and D3T4 (1301.83 cm^2). Smallest leaf size (740.96 cm^2) was obtained for D1T2 which was on par with D4T7 (746.42 cm^2), D1T7 (780.24 cm^2), D1T10 (788.03 cm^2), D1T8 (797.00 cm^2) and D2T7 (797.72 cm^2).

Table 7. Effect of sowing dates, varieties and their interactions on leaf size of cauliflower

Varieties	Leaf size- 30 DAT (cm^2)					Leaf size- at harvest (cm^2)				
	D1	D2	D3	D4	Mean	D1	D2	D3	D4	Mean
T1	369.41	447.86	607.07	471.85	474.05	839.59	876.94	1042.50	854.45	903.37
T2	318.25	489.41	588.92	479.24	468.954	740.96	924.52	1001.00	872.81	884.82
T3	484.59	552.00	617.12	495.43	537.26	953.28	1013.67	1193.06	924.39	1021.10
T4	371.60	581.29	815.18	758.97	631.76	845.72	1065.12	1301.83	1159.55	1093.06
T5	361.11	661.20	705.56	568.71	574.14	844.04	1114.14	1220.84	988.41	1041.86
T6	398.92	602.49	696.02	601.78	574.80	861.41	1043.69	1147.38	1027.91	1020.10
T7	324.61	352.42	581.43	336.54	398.75	780.24	797.72	1015.64	746.42	835.01
T8	353.71	552.48	628.84	478.28	503.33	797.00	1025.09	1063.18	874.33	939.90
T9	498.04	733.89	711.80	684.02	656.94	1103.18	1315.07	1344.65	1226.25	1247.29
T10	349.07	455.81	612.98	482.24	475.02	788.03	856.36	1054.80	857.71	889.22
T11	406.86	635.55	700.78	565.73	577.23	880.62	1157.84	1302.96	977.85	1079.82
T12	412.45	631.05	665.08	493.12	550.43	888.06	1117.73	1229.39	916.63	1037.95
Mean	387.38	557.95	660.90	534.66		860.18	1025.66	1159.77	952.23	
CD (5%)	D				23.540					27.227
	V				25.573					35.223
	DxV				51.147					70.445

Fig. 3 Effect of sowing dates, varieties and their interactions on leaf size of cauliflower



Cauliflower varieties

4.1.2 Curd characters

4.1.2.1 Days to curd initiation

Different sowing dates exerted significant influence on days to curd initiation in cauliflower (Table 8). Sowing on November 15th resulted in earliest curd initiation (47.14 days) while on October 15th resulted in latest (55.52 days).

Varietal differences also influenced days to curd initiation in cauliflower. Himshort (38.72 days) followed by NS 60N (44.42 days) was earliest. Maximum number of days taken for curd initiation was observed in T2, Pusa Sharad (66.57 days).

Significant difference was observed between D x T interactions for this character. D4T5 (37.04 days) which was on par with D1T7 (37.22 days), D3T7 (38.16 days) and D2T7 (39.23 days) recorded least number of days for curd initiation. Maximum number of days for curd initiation (79.50 days) was taken by D1T2 which was on par with D2T4 (78.97 days).

4.1.2.2 Days to curd harvest

Days to curd harvest were influenced by different sowing dates and varieties. Sowing on October 1st (61.61days) resulted in minimum days to harvest and that on October 15th (69.13 days) resulted in maximum days for harvest (Table 8).

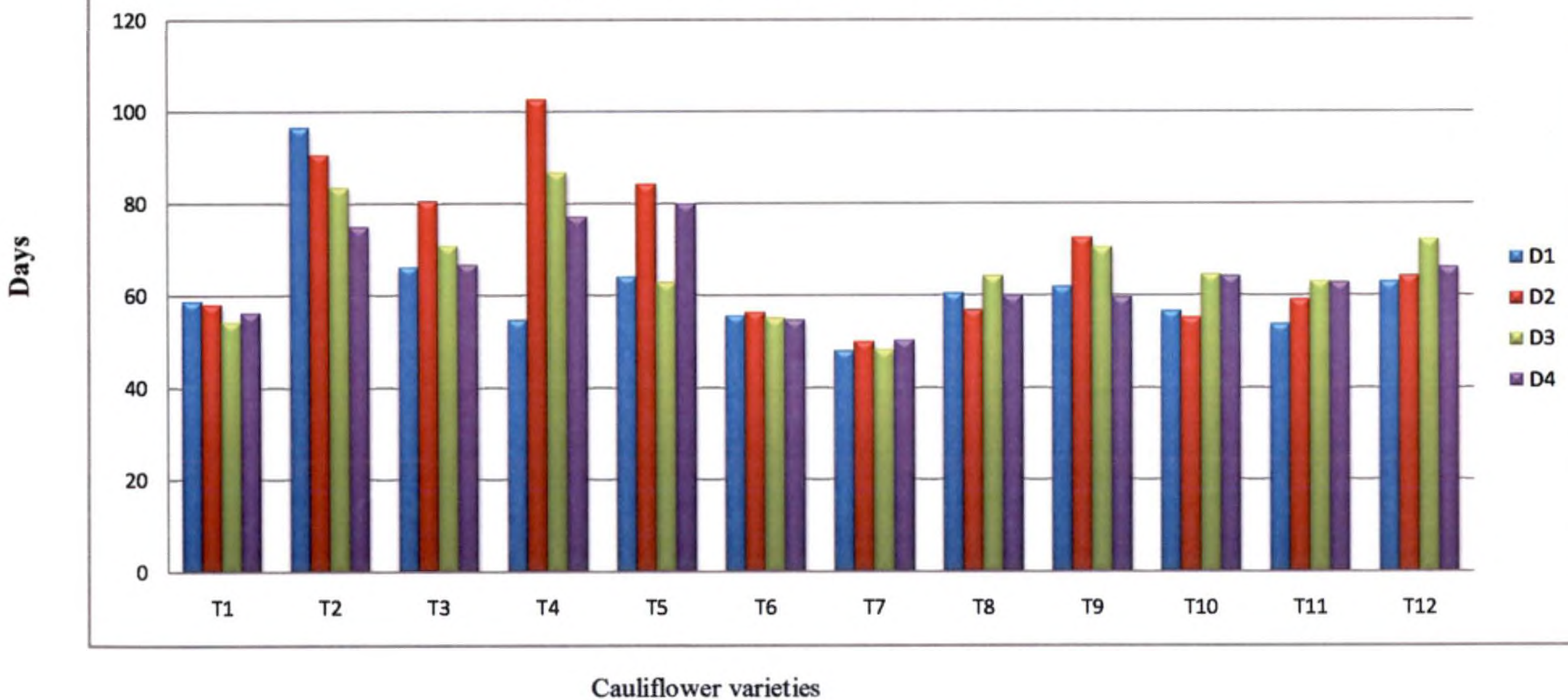
Among the varieties, Himshort (T7- 49.04 days) followed by NS 60N (T6- 55.44 days) which was on par with Pusa Meghna (T1- 56.76 days) was earliest whereas Pusa Sharad (T2- 86.39 days) was late for harvest (Fig. 4).

Significant difference was observed between D x T interactions also. Minimum days for curd harvest (47.91 days) were observed in D1T7 which was on par with D3T7 (48.18 days), D2T7 (49.80 days) and D4T7 (50.27 days).

Table 8. Effect of sowing dates, varieties and their interactions on days to curd initiation and harvest of cauliflower

Varieties	Days to curd initiation					Days to curd harvest				
	D1	D2	D3	D4	Mean	D1	D2	D3	D4	Mean
T1	46.140	46.83	42.97	46.31	45.56	58.66	57.93	54.19	56.27	56.76
T2	79.50	73.39	63.70	49.70	66.57	96.50	90.67	83.46	74.92	86.39
T3	52.94	66.20	58.10	45.61	55.71	66.23	80.52	70.79	66.68	71.06
T4	43.34	78.97	64.44	47.05	58.44	54.66	102.52	86.76	77.21	80.29
T5	48.80	65.60	48.60	37.04	50.00	64.13	84.16	62.78	80.04	72.78
T6	43.56	45.81	44.47	43.84	44.42	55.67	56.33	55.08	54.69	55.44
T7	37.22	39.23	38.16	40.27	38.72	47.91	49.80	48.18	50.27	49.04
T8	48.90	45.48	52.42	49.07	48.97	60.48	56.78	64.29	60.02	60.39
T9	49.44	60.85	59.20	48.20	54.42	61.83	72.46	70.49	59.61	66.10
T10	44.48	43.95	53.77	53.39	48.90	56.56	55.10	64.62	64.18	60.12
T11	41.03	47.23	51.53	51.43	47.80	53.70	59.07	63.11	62.81	59.67
T12	50.29	52.72	60.39	53.82	54.31	62.93	64.27	72.26	66.10	66.39
Mean	48.80	55.52	53.15	47.14		61.61	69.13	66.33	64.40	
CD (5%)	D				0.968					0.885
	V				1.374					1.444
	DxV				2.747					2.889

Fig. 4 Effect of sowing dates, varieties and their interactions on days to curd harvest in cauliflower



Maximum number of days for harvest (102.52 days) was taken by D2T4 followed by D1T2 (96.50 days).

4.1.2.3 Days to curd maturity from curd initiation

Number of days to curd maturity from curd initiation was influenced by different sowing dates and varieties (Table 9). D1 resulted in minimum days to curd maturity (12.80 days) while D4 resulted in maximum days (17.25 days).

Least number of days taken for curd maturity (10.32 days) was observed in T7, Himshort followed by NS 60N (T6- 11.02 days). Maximum number of days taken for curd maturity (22.75 days) was observed in Pusa Shukti (T5).

Significant difference was observed between D x T interactions for days to curd maturity from curd initiation. Minimum days for curd maturity was recorded in D4T1(9.96 days) which was on par with D4T7, D3T7, D2T6, D2T7, D3T6, D1T7, D4T10, D4T6, D3T10 and D4T8.

4.1.2.3 Days to curd maturity from transplanting

Number of days from transplanting to curd maturity was influenced by different sowing dates and varieties. October 1st sowing resulted in minimum days to curd maturity (64.47 days) which was on par with that on November 15th (64.53 days). Sowing on October 15th resulted in maximum days for curd maturity (69.68 days).

Least number of days for curd maturity (49.20 days) was observed in Himshort (T7) followed by NS 60N (T6- 55.55 days). Maximum number of days for curd maturity (87.10 days) was observed in Pusa Sharad (Table 9).

Significant difference was observed between D x T interactions also. Minimum days for curd maturity (48.20 days) were observed in D3T7 which was on par with D1T7 (48.80 days), D2T7 (49.40 days), and D4T7 (50.40 days).

Table 9. Effect of sowing dates, varieties and their interactions on days to maturity from curd initiation and transplanting of cauliflower

Varieties	Days to curd maturity from curd initiation					Days to curd maturity from transplanting				
	D1	D2	D3	D4	Mean	D1	D2	D3	D4	Mean
T1	12.52	11.11	11.22	9.96	11.20	54.60	58.60	59.80	57.60	57.65
T2	17.00	17.28	19.76	25.22	19.81	97.00	93.20	83.80	74.40	87.10
T3	13.29	14.32	12.69	21.07	15.34	71.60	82.00	66.00	66.60	71.55
T4	11.32	23.56	22.32	30.16	21.84	55.60	103.80	87.80	77.00	81.05
T5	15.33	18.56	14.18	42.92	22.75	90.40	84.00	64.00	80.00	79.60
T6	12.12	10.52	10.61	10.85	11.02	56.00	56.60	55.40	54.20	55.55
T7	10.69	10.57	10.02	9.99	10.32	48.80	49.40	48.20	50.40	49.20
T8	11.59	11.31	11.88	10.95	11.43	60.80	56.60	66.00	59.60	60.75
T9	12.40	11.61	11.29	11.41	11.68	62.80	72.60	71.20	59.40	66.50
T10	12.09	11.15	10.85	10.79	11.22	57.80	55.80	66.20	65.00	61.20
T11	12.68	11.84	11.58	11.38	11.87	54.40	59.40	65.60	63.20	60.65
T12	12.64	11.55	11.86	12.28	12.08	63.80	64.20	72.20	67.00	66.80
Mean	12.80	13.61	13.19	17.25		64.47	69.68	67.18	64.53	
CD (5%)	D				0.310					0.695
	V				0.511					1.307
	DxV				1.023					2.613

D2T4 (103.80 days) followed by D1T2 (97.00 days) had taken maximum days for curd maturity.

4.1.2.4 Curd depth (cm)

Curd depth was significantly influenced by different sowing dates and varieties. D3 recorded maximum curd depth (8.31 cm) while D4 recorded the minimum (6.25 cm). Among varieties, it was highest (9.82 cm) for T6 followed by T11 (8.67 cm) and lowest (3.72 cm) for T2 (Table 10).

Interaction effect was significant for curd depth. Maximum depth (11.93 cm) was observed for D1T4 which was on par with D3T6 (10.78 cm), D1T6 (10.53 cm), D2T10 (10.36 cm) and D3T8 (10.30 cm). Least value (2.24 cm) was obtained for D2T4 followed by D4T2 (2.96 cm).

4.1.2.4 Curd diameter (cm)

Curd diameter for different sowing dates varied significantly and was highest (12.57 cm) for D3 which was on par with D1 (12.56 cm). Lowest curd diameter (9.51 cm) was noticed in D4 which was on par with D2 (9.53 cm).

It was influenced significantly by different cauliflower varieties. Maximum curd diameter (14.54 cm) was obtained for NS 60N (T6) and lowest (5.61 cm) for Pusa Sharad (T2).

Interaction effect was also significant for curd diameter (Table 10). Maximum curd diameter was obtained for D3T6 (16.54 cm) and minimum for D2T4 (2.71 cm) followed by D3T4 (3.91 cm).

4.1.2.5 Curd compactness (g/cm^3)

Curd compactness varied significantly for sowing dates and varieties. It was observed that D4 (47.53 g/cm^3) which was on par with D2 (38.90 g/cm^3) produced highly compact curds and D1 (30.38 g/cm^3) on par with D3 (31.80 g/cm^3) and D2 (38.90 g/cm^3) produced least compact curds.

Table 10. Effect of sowing dates, varieties and their interactions on curd depth and diameter of cauliflower

Varieties	Curd depth (cm)					Curd diameter (cm)				
	D1	D2	D3	D4	Mean	D1	D2	D3	D4	Mean
T1	7.53	7.77	8.89	7.04	7.81	12.96	11.35	14.95	11.84	12.77
T2	3.47	4.24	4.20	2.96	3.72	5.90	6.26	5.84	4.42	5.61
T3	8.31	4.91	8.34	3.17	6.18	13.16	6.53	13.05	4.79	9.38
T4	11.93	2.24	3.13	4.35	5.41	16.01	2.71	3.91	4.59	6.80
T5	8.38	5.00	8.38	4.22	6.50	12.38	6.86	12.38	4.14	8.94
T6	10.53	9.25	10.78	8.71	9.82	14.69	12.97	16.54	13.95	14.54
T7	6.44	8.46	10.30	6.96	8.04	9.55	11.35	14.17	11.40	11.62
T8	7.76	8.15	9.11	8.14	8.29	14.17	11.54	13.85	12.99	13.14
T9	8.77	6.07	9.75	7.85	8.11	13.97	9.03	14.47	12.05	12.38
T10	7.46	10.36	8.61	6.61	8.26	11.99	12.93	13.14	9.94	12.00
T11	8.44	8.73	9.18	8.33	8.67	12.34	12.63	13.67	13.30	12.99
T12	8.65	6.67	9.02	6.69	7.76	13.56	10.23	14.89	10.67	12.34
Mean	8.14	6.82	8.31	6.25		12.56	9.53	12.57	9.51	
CD (5%)	D				0.266					0.279
	V				0.329					0.582
	DxV				0.658					1.164

Pusa Sharad (T2- 84.22 g/cm^3) on par with Pusa Hybrid-2 (T4- 72.31 g/cm^3) produced highly compact curds and NS 60 N (T6- 25.15 g/cm^3) which was on par with Pusa Meghna produced least compact curds (29.81 g/cm^3).

Interaction effect was also highly significant (Table 11). Highly compact curds (356.18 g/cm^3) were obtained for D2T4 followed by D4T2 (206.99 g/cm^3) and least compact curds (17.21 g/cm^3) were obtained for D1T4 followed by D1T6 (22.06 g/cm^3).

4.1.2.6 Curd size index (cm^2)

Different sowing dates and varieties exerted significant influence on curd size index of cauliflower (Fig. 5). Highest curd size index (104.42 cm^2) was associated with D3 which was on par with D1 (102.18 cm^2). Least curd size index (59.45 cm^2) was obtained for D4 (Table 11).

It was maximum (142.68 cm^2) for NS 60N (T6) followed by G 45 (T11- 112.61cm^2) and minimum (20.84 cm^2) for Pusa Sharad (T2).

Significant difference was observed between D x T interactions also. Maximum curd size index (190.93 cm^2) was observed in D1T4 which was on par with D3T6 (178.21 cm^2) and minimum (6.07 cm^2) was observed in D2T4 which was on par with D3T4 (12.24 cm^2), D4T2 (13.08 cm^2), D4T5 (17.47 cm^2) and D4T4 (19.97 cm^2).

4.1.2.7 Stalk length (cm)

Stalk length varied significantly for different sowing dates and D3 recorded minimum stalk length (3.83 cm) whereas, maximum (4.98 cm) recorded for D2 (Fig. 6)

Stalk length was influenced significantly by different cauliflower varieties (Table 11). Least stalk length (3.50 cm) was observed for T6 while it was

Table 11. Effect of sowing dates, varieties and their interactions on curd compactness, curd size index and stalk length of cauliflower

Varieties	Curd compactness (g/cm^3)					Curd size index (cm^2)					Stalk length (cm)				
	D1	D2	D3	D4	Mean	D1	D2	D3	D4	Mean	D1	D2	D3	D4	Mean
T1	37.52	27.15	25.18	27.66	29.82	97.59	88.13	132.91	83.35	99.73	3.35	4.54	2.97	3.70	3.64
T2	58.41	57.70	74.03	206.99	84.22	20.45	26.56	24.53	13.08	20.84	5.64	6.39	5.20	4.98	5.55
T3	28.52	69.52	28.96	103.89	47.88	109.34	32.10	108.91	15.16	58.02	3.91	5.29	4.08	5.08	4.59
T4	17.21	356.18	118.46	94.61	72.31	190.93	6.07	12.24	19.97	36.82	5.36	5.32	4.54	4.79	5.00
T5	27.54	65.22	27.54	142.40	46.56	103.74	34.30	103.74	17.47	58.06	4.94	6.06	4.70	5.31	5.25
T6	22.06	23.58	24.71	28.97	25.15	154.60	120.05	178.21	121.43	142.68	3.49	3.77	3.11	3.63	3.50
T7	41.72	24.44	23.47	34.73	30.26	61.52	95.99	145.90	79.34	93.40	3.95	4.61	3.66	4.15	4.09
T8	30.04	28.14	27.92	28.08	28.83	109.93	94.09	126.10	105.77	108.91	3.55	5.68	4.43	4.15	4.45
T9	27.07	43.47	23.26	37.97	31.89	122.50	54.86	141.10	94.58	100.42	3.46	4.60	3.37	3.91	3.84
T10	29.85	23.37	25.268	31.16	27.54	89.47	133.95	113.09	65.74	99.13	4.24	4.88	3.59	4.95	4.41
T11	31.89	23.89	28.85	29.24	28.53	104.15	110.33	125.46	110.83	112.61	3.85	4.39	3.17	4.11	3.88
T12	26.60	38.90	26.77	39.51	32.40	117.25	68.29	134.23	71.44	95.72	3.51	4.17	3.15	3.96	3.70
Mean	30.38	38.90	31.80	47.53		102.18	65.04	104.42	59.45		4.10	4.98	3.83	4.39	
CD (5%)	D				14.635					4.323					0.118
	V				18.703					7.077					0.135
	DxV				37.417					14.153					0.269

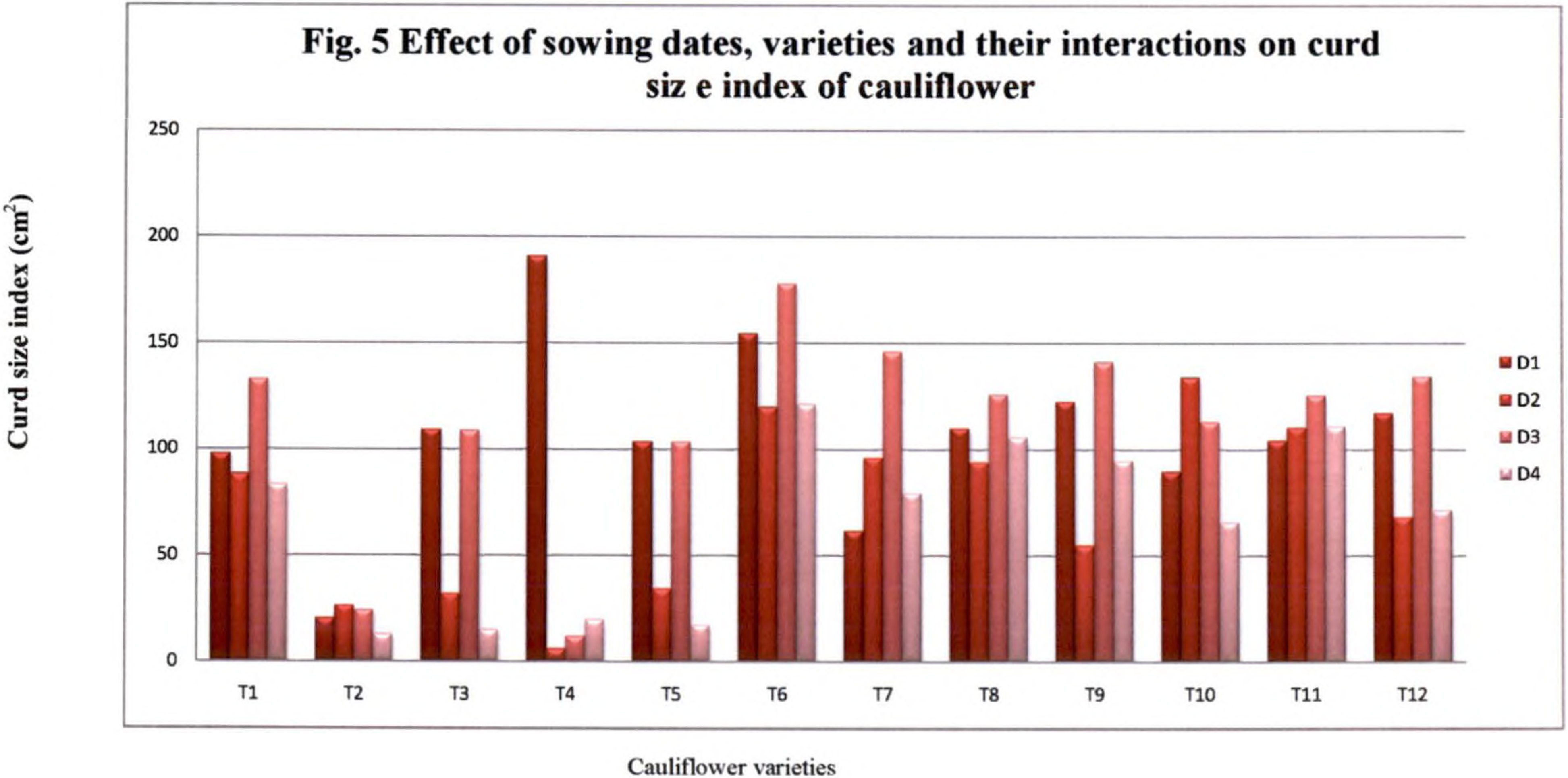
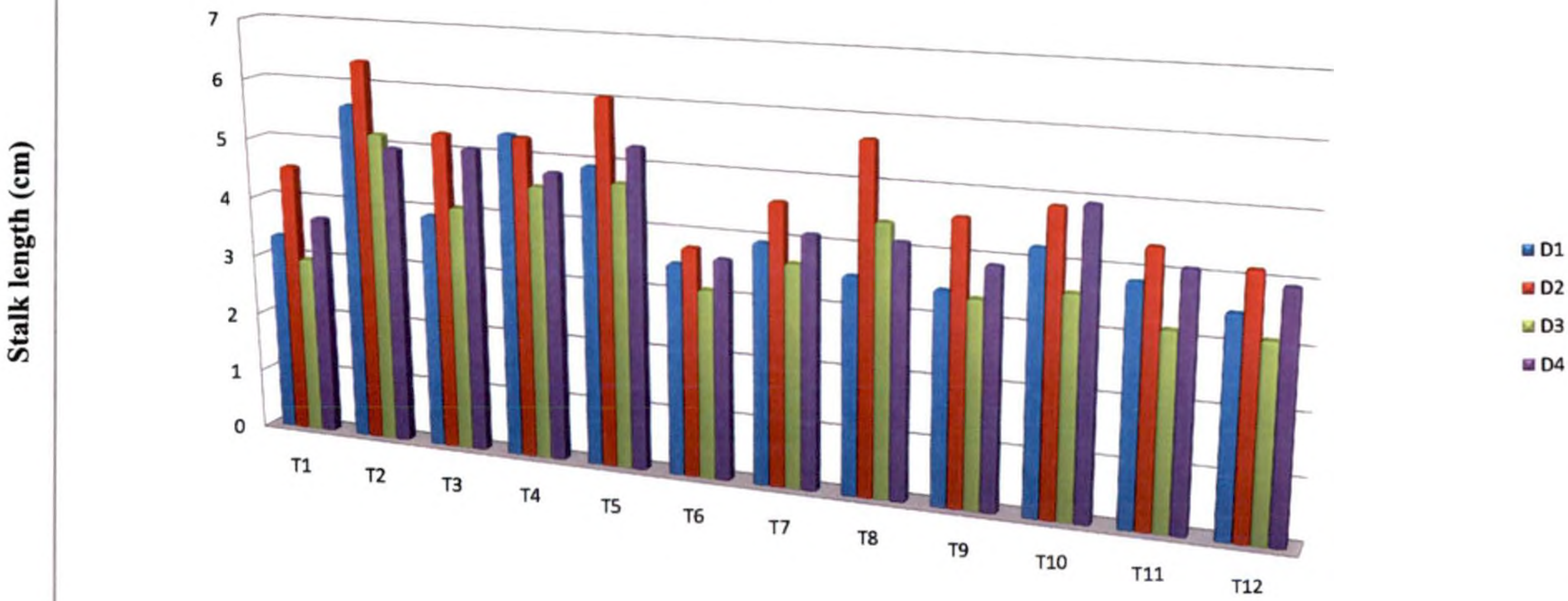


Fig. 5 Effect of sowing dates, varieties and their interactions on curd siz e index of cauliflower
Curd size index (cm^2)
250
200
150
100
50
0
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12
D1
D2
D3
D4
Cauliflower varieties

Fig. 6 Effect of sowing dates, varieties and their interactions on stalk length of cauliflower



Cauliflower varieties

maximum (5.55 cm) for T2 followed by T5 (5.25 cm), T4 (5.00 cm) and T3 (4.59 cm).

Interaction effect was highly significant for stalk length. Least stalk length (2.99 cm) was obtained for D3T1 which was on par with D3T6 (3.11 cm), D3T12 (3.15 cm) and D3T11 (3.17 cm) and maximum stalk lengths were obtained for D2T2 (6.39 cm) followed by D2T5 (6.06 cm), D2T8 (5.68 cm) and D1T2 (5.64 cm).

4.1.3 Yield characters

4.1.3.1 Net curd weight (g)

Net curd weight was influenced by different sowing dates and varieties. It was maximum (361.69 g) for D3 followed by D1 (336.57 g). Lowest net curd weight (212.77 g) was observed for D2 (Table 12).

Among varieties, highest curd weight (454.02 g) was obtained for NS 60 N (T6) followed by G 45 (T11- 362.27 g) and lowest (85.31 g) for Pusa Sharad (T2) followed by Pusa Hybrid 2 (T4- 164.78 g), Pusa Shukthi (T5- 214.00 g) and Pusa Paushja (T3- 225.78 g) (Fig. 7).

Significant difference was observed between D x T interactions also. Highest net curd weight (629.33 g) was obtained for D3T6 followed by D1T4 (468.93 g) which was on par with D3T12 (457.00 g), D1T6 (442.07g), D3T11 (430.00 g) and D3T7 (429.70 g). It was minimum for D3T4 (51.67 g), D2T4 (54.00 g), D1T2 (60.00 g), D4T3 (65.33 g), D2T2 (83.57 g) and D4T4 (84.50 g).

4.1.3.2 Gross curd weight (g)

Gross curd weight was influenced by different sowing dates and varieties (Table 12). It was maximum for (408.68 g) D3 followed by D1 (391.91 g). Lowest gross curd weight (263.81 g) was observed for D2 which was on par with D4 (278.67 g).

Table 12. Effect of sowing dates, varieties and their interactions on net curd weight, gross curd weight and harvest index of cauliflower

Varieties	Net curd weight (g)					Gross curd weight (g)					Harvest index				
	D1	D2	D3	D4	Mean	D1	D2	D3	D4	Mean	D1	D2	D3	D4	Mean
T1	403.50	237.00	426.43	232.67	324.90	452.33	294.67	474.70	288.33	377.51	0.31	0.22	0.37	0.24	0.28
T2	60.00	83.57	93.66	104.00	85.31	110.00	141.80	136.83	142.00	132.66	0.05	0.06	0.09	0.10	0.08
T3	352.77	130.33	354.67	65.33	225.78	408.67	171.33	408.67	107.00	273.92	0.26	0.16	0.33	0.06	0.20
T4	468.93	54.00	51.67	84.50	164.78	533.40	91.50	80.67	125.00	207.64	0.37	0.03	0.03	0.07	0.12
T5	308.00	136.00	308.00	104.00	214.00	344.20	190.60	344.20	144.00	255.75	0.28	0.10	0.25	0.09	0.18
T6	442.07	323.67	629.33	421.00	454.02	516.67	368.33	670.00	465.33	505.08	0.38	0.29	0.45	0.29	0.35
T7	213.3	237.33	429.70	268.67	287.26	259.67	295.33	469.00	317.33	335.33	0.20	0.24	0.44	0.29	0.29
T8	395.87	268.67	422.00	331.33	354.47	444.67	322.00	470.33	372.67	402.37	0.32	0.28	0.29	0.27	0.29
T9	397.87	187.33	413.00	374.00	343.05	460.67	239.67	484.67	433.67	404.67	0.26	0.15	0.18	0.24	0.21
T10	274.67	369.00	324.80	176.67	286.28	325.00	417.50	349.27	221.33	328.27	0.22	0.28	0.25	0.18	0.23
T11	357.73	291.34	430.00	370.00	362.27	401.00	341.67	496.00	423.67	415.58	0.28	0.23	0.30	0.29	0.28
T12	364.07	235.00	457.00	258.67	328.68	446.80	291.33	519.83	303.67	390.4	0.29	0.19	0.34	0.20	0.25
Mean	336.57	212.77	361.69	232.57		391.91	263.81	408.68	278.67		0.27	0.19	0.28	0.19	
CD (5%)	D				15.212					16.883					0.014
	V				19.570					22.498					0.018
	DxV				39.140					44.995					0.035

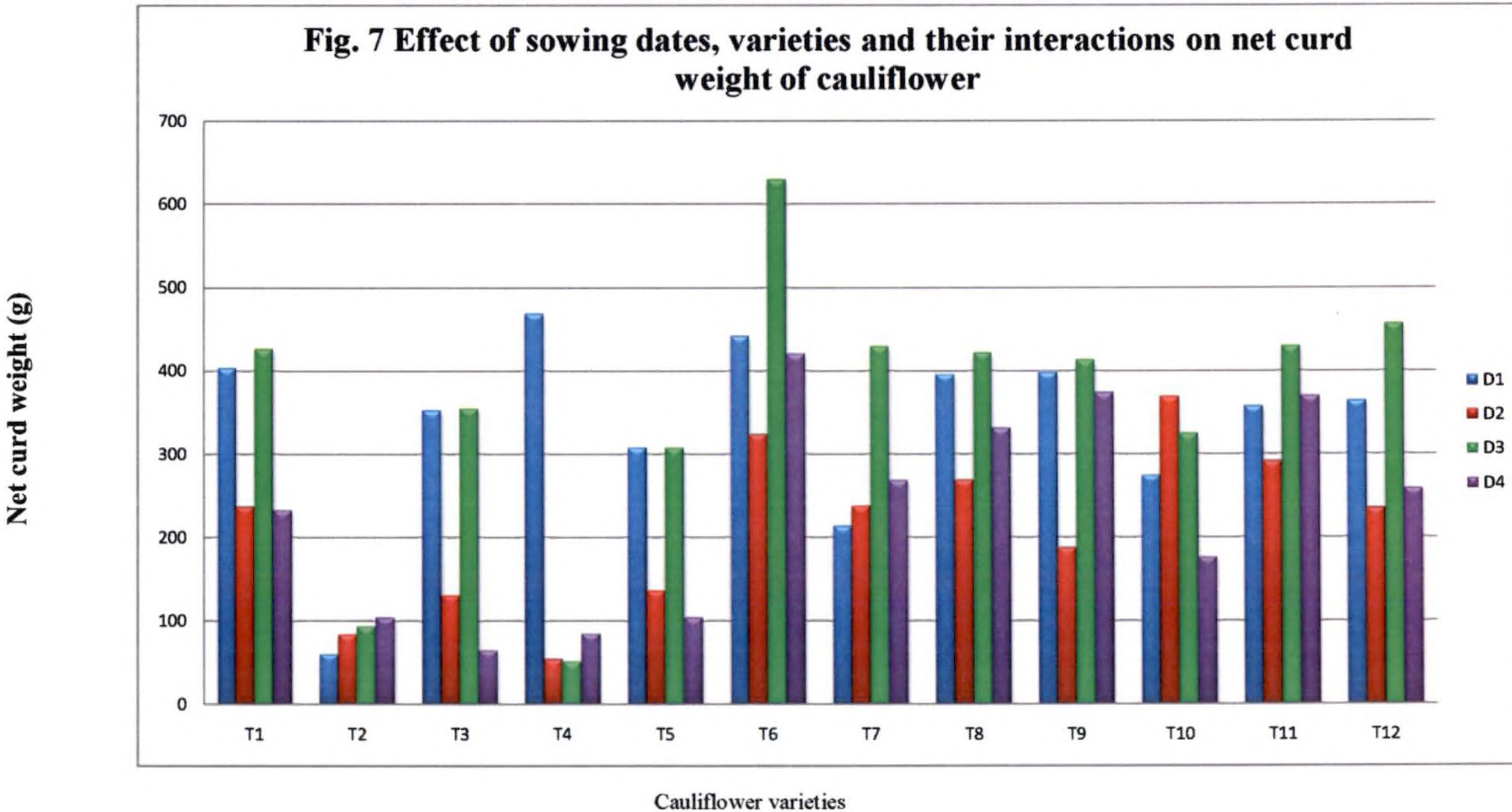


Fig. 7 Effect of sowing dates, varieties and their interactions on net curd weight of cauliflower
Net curd weight (g)
700
600
500
400
300
200
100
0
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12
D1
D2
D3
D4
Cauliflower varieties

Maximum curd weight (505.08 g) was obtained for NS 60 N (T6) followed by G 45 (T11- 415.58 g) which was on par with Himpriya 60 (T9- 404.67 g) and Himlatha (T8- 402.37 g). Lowest gross curd weight (132.66 g) was recorded for Pusa Sharad (T2) followed by Pusa Hybrid 2 (T4- 207.64 g), Pusa Shukthi (T5- 273.92 g), Pusa Paushja (T3- 255.75 g).

Interaction effects also varied significantly. Maximum gross curd weight (670.00 g) was obtained for D3T6 followed by D1T4 (533.4 g) which was on par with D3T12 (519.83 g), D1T6 (516.67 g) and D3T11 (496.00 g). Gross curd weight was minimum (80.67 g) for D3T4, D2T4 (91.50 g), D1T2 (110.00 g), D4T3 (107.00 g), D2T2 (141.80 g) and D4T4 (125.00 g).

4.1.3.3 Harvest index

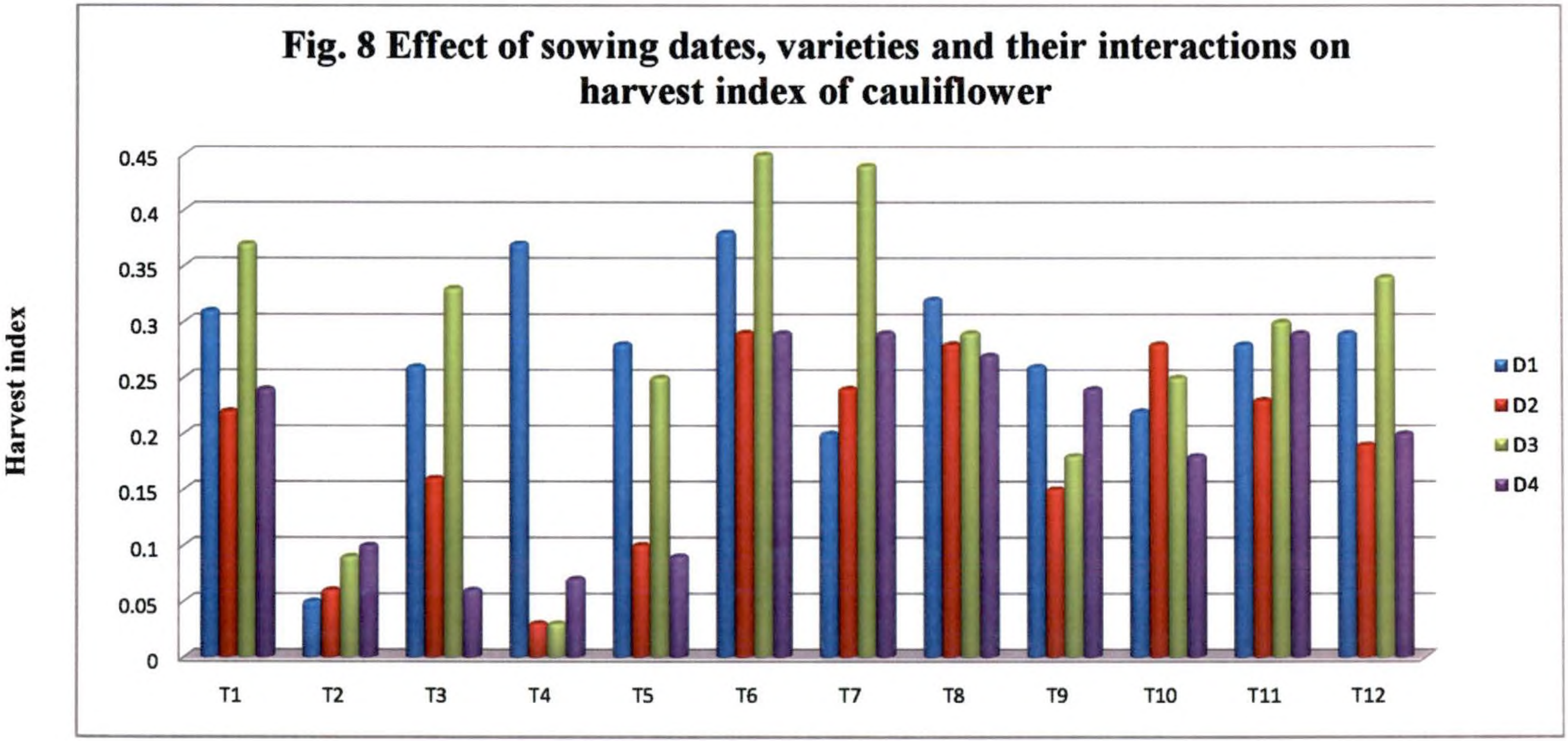
Harvest Index was influenced by different sowing dates and varieties (Table 12). Harvest index was maximum (0.28) for D3 followed by D1 (0.27). Lowest harvest index (0.19) was observed for D2 which was on par with D4 (0.19).

Among varieties, highest harvest index (0.35) was obtained for NS 60 N (T6) followed by Himshort (T7- 0.29) and Himlatha (T8- 0.29) and lowest (0.08) for Pusa Sharad followed by Pusa Hybrid 2 (T4- 0.12).

Interaction effects were highly significant for harvest index. D3T6 (0.45) and D3T7 (0.44) recorded high harvest index whereas D3T4 (0.03), D2T4 (0.03) and D1T2 (0.05) recorded low (Fig. 8).

4.1.3.4 Yield. plot^{-1} (kg)

Yield per plot was significantly influenced by different sowing dates and varieties. It was highest (9.04 kg) for D3 followed by D1 (8.41 kg) and lowest (5.32 kg) for D2.



Cauliflower varieties

Highest yield (11.35 kg) was recorded for T6 followed by T11 (9.06 kg), T8 (8.86 kg), T9 (8.58 kg), T12 (8.22 kg) and T1 (8.12 kg) and lowest for T2 (2.13 kg) followed by T4 (4.12 kg) (Table 13).

Significant difference was observed between D x T interactions also. Highest yield was obtained for D3T6 (15.73 kg) followed by D1T4 (11.72 kg) which was on par with D3T12 (11.43 kg), D1T6 (11.05 kg), D3T11 (10.75 kg) and D3T7 (10.74 kg). Yield per plot was minimum for D3T4 (1.29 kg), D2T4 (1.35 kg), D1T2 (1.50 kg), D4T3 (1.63 kg), D2T2 (2.09 kg) and D4T4 (2.11 kg).

4.1.3.5 Yield (t. ha^{-1})

Yield per hectare was significantly influenced by different sowing dates and varieties. It was maximum (10.05 t. ha^{-1}) for D3 followed by (9.35 t. ha^{-1}). Lowest yield (5.91 t. ha^{-1}) was observed for D2 (Table 13).

The top yielder was NS 60N (12.61 t. ha^{-1}) followed by G 45 (10.06 t. ha^{-1}), Himlatha (9.85 t. ha^{-1}), Himpriya-60 (9.53 t. ha^{-1}), White snow (9.13 t. ha^{-1}) and Pusa Meghna (9.03 t. ha^{-1}) and lowest for Pusa Sharad (2.37 t. ha^{-1}) followed by Pusa Hybrid 2 (4.58 t. ha^{-1}).

Significant difference was observed between D x T interactions for yield per hectare. Highest yield (17.48 t. ha^{-1}) was obtained for D3T6 followed by D1T4 (13.02 t. ha^{-1}) which was on par with D3T12 (12.69 t. ha^{-1}), D1T6 (12.28 t. ha^{-1}). It was lowest for D3T4 (1.44 t. ha^{-1}), D2T4 (1.50 t. ha^{-1}), D1T2 (1.67 t. ha^{-1}), D4T3 (1.81 t. ha^{-1}), D2T2 (2.32 t. ha^{-1}) and D4T4 (2.35 t. ha^{-1}).

4.1.3.6 Percentage of curding

Percentage of curding varied significantly among different sowing dates, varieties and their interactions (Table 13). D3 recorded highest curding percentage (82.66 %) followed by D1 (79.00 %) and lowest (76.00 %) for D2. Among varieties T6, T9 and T11 recorded complete curding, whereas T5 (23.00 %), T4 (30.00 %) and T2 (33.00 %) exhibited least curding percentage (Fig. 9).

Table 13. Effect of sowing dates, varieties and their interactions on yield and curding percentage of cauliflower

Varieties	Yield. Plot^{-1} (kg)					Yield (t. ha^{-1})					Percentage of curding (%)				
	D1	D2	D3	D4	Mean	D1	D2	D3	D4	Mean	D1	D2	D3	D4	Mean
T1	10.09	5.93	10.66	5.82	8.12	11.21	6.58	11.84	6.46	9.03	96.00	84.00	100.00	100.00	95.00
T2	1.50	2.09	2.34	2.60	2.13	1.67	2.32	2.60	2.89	2.37	12.00	40.00	56.00	24.00	33.00
T3	8.82	3.26	8.87	1.63	5.64	9.80	3.62	9.85	1.81	6.27	96.00	64.00	80.00	72.00	78.00
T4	11.72	1.35	1.29	2.11	4.12	13.03	1.50	1.43	2.35	4.58	32.00	28.00	28.00	32.00	30.00
T5	7.70	3.40	7.70	2.60	5.35	8.56	3.78	8.56	2.89	5.94	12.00	20.00	32.00	28.00	23.00
T6	11.05	8.09	15.73	10.52	11.35	12.28	8.99	17.48	11.69	12.61	100.00	100.00	100.00	100.00	100.00
T7	5.33	5.93	10.74	6.72	7.18	5.93	6.59	11.94	7.463	7.98	100.00	92.00	100.00	96.00	97.00
T8	9.90	6.72	10.55	8.28	8.86	10.99	7.46	11.72	9.20	9.85	100.00	88.00	100.0	92.00	95.00
T9	9.96	4.68	10.33	9.35	8.58	11.05	5.20	11.47	10.39	9.53	100.00	100.00	100.0	100.00	100.00
T10	6.87	9.22	8.120	4.42	7.16	7.63	10.25	9.02	4.91	7.95	100.00	100.00	96.00	88.00	96.00
T11	8.94	7.28	10.75	9.25	9.06	9.94	8.09	11.94	10.28	10.06	100.00	100.00	100.00	100.00	100.00
T12	9.10	5.88	11.43	6.47	8.22	10.11	6.53	12.69	7.18	9.13	100.00	96.00	100.0	96.00	98.00
Mean	8.41	5.32	9.04	5.81		9.35	5.91	10.05	6.46		79.00	76.00	82.66	77.33	
CD (5%)	D				0.380					0.422					1.941
	V				0.489					0.545					5.399
	DxV				0.978										

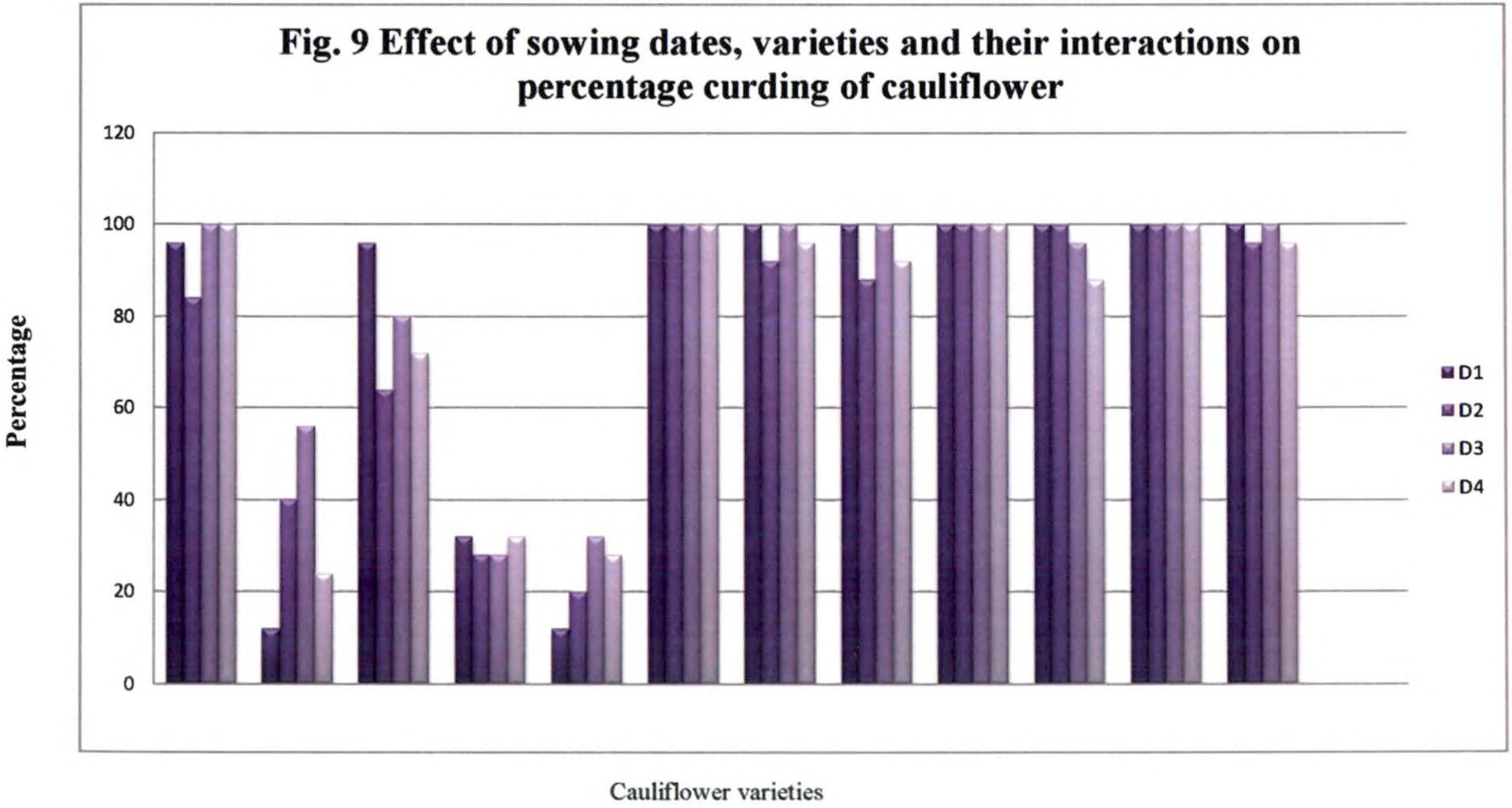


Fig. 9 Effect of sowing dates, varieties and their interactions on percentage curding of cauliflower
120
100
80
60
40
20
0
Percentage
D1
D2
D3
D4
Cauliflower varieties

Complete curding was observed for D1T1, D1T7, D1T8, D1T9, D1T11, D1T10, D1T12, D2T6, D2T9, D2T10, D2T11, D3T1, D3T6, D3T7, D3T8, D3T9, D3T11, D3T12, D4T6, D4T9 and D4T11. Least curding was observed in D1T2 (12.00 %) which was on par with D1T5 (12.00 %) and D2T5 (20.00 %).

4.1.4 Quality parameters

4.1.4.1 Protein (%)

Sowing dates did not exert any significant influence on protein content. Among varieties it was significantly different and highest content (2.44 %) was recorded in T4 and least (2.06%) in T10 (Table 14).

The interaction effect between the sowing dates and varieties was significant for protein content. It was high for D4T4 (2.49 %) followed by D2T4 (2.44 %) and low for D1T8 (2.03 %) and D3T10 (2.03 %).

4.1.4.2 Vitamin A (IU)

There was no significant difference among the sowing dates for Vitamin A content (Table 14). But it differed significantly for varieties and was highest in T1 (298.96 IU) followed by T2 (211.25 IU) and least in T11 (59.02 IU) followed by T6 (76.66 IU).

Significant difference was observed between D x T interactions also. High Vitamin A content was recorded for D4T1 (302.89 IU) which was on par with D3T1 (298.96 IU). It was low for D4T11 (57.91 IU).

4.1.4.3 Vitamin C (mg/100g)

There was no significant difference between sowing dates, varieties and their interactions for vitamin C content. It varied between 51.16 mg/100g and 72.04 mg/100g (Table 14).

Table 14. Effect of sowing dates, varieties and their interactions on quality characters in cauliflower

Varieties	Protein (%)					Vitamin A (IU)					Vitamin C (mg/ 100g)				
	D1	D2	D3	D4	Mean	D1	D2	D3	D4	Mean	D1	D2	D3	D4	Mean
1	2.12	2.18	2.15	2.10	2.14	291.34	289.39	298.96	302.89	295.65	52.34	54.23	51.16	57.45	53.79
2	2.09	2.04	2.09	2.11	2.08	215.86	221.45	211.25	219.78	217.09	67.45	74.76	72.04	69.98	71.065
3	2.23	2.19	2.12	2.06	2.15	90.45	87.56	92.11	99.78	92.48	53.67	52.87	56.28	60.61	55.86
4	2.39	2.44	2.42	**2.49**	2.44	187.37	182.09	190.29	198.58	189.58	56.83	63.47	58.33	60.63	59.815
5	2.39	2.31	2.37	2.40	2.37	163.89	171.58	164.92	173.46	168.46	59.78	65.34	58.55	63.85	61.8
6	2.05	2.15	2.12	2.06	2.10	70.81	83.54	76.66	78.85	77.47	53.78	51.43	54.45	57.67	54.33
7	2.25	2.19	2.21	2.24	2.22	175.68	191.69	182.57	188.68	184.66	54.39	56.89	53.66	52.17	54.28
8	2.03	2.12	2.08	2.07	2.08	149.76	161.32	155.00	156.74	155.70	56.56	58.63	54.67	53.28	55.78
9	2.17	2.10	2.13	2.14	2.14	91.65	104.67	99.83	97.62	98.44	66.73	60.83	64.69	65.58	64.46
10	2.09	2.07	2.03	2.04	2.06	128.59	127.96	119.69	123.86	125.05	50.89	56.73	52.18	53.55	53.34
11	2.22	2.17	2.18	2.16	2.18	58.65	63.63	59.02	57.91	59.80	52.46	55.63	53.03	54.95	54.02
12	2.08	2.09	2.06	2.05	2.07	197.85	198.46	195.26	201.47	198.26	69.73	63.74	66.59	68.56	67.15
Mean	2.18	2.17	2.16	2.16		151.83	156.95	153.80	158.30		57.88	59.54	57.97	59.85	
CD (5%)	D				0.073					7.353					14.613
	V				0.105					9.564					19.751
	DxV				0.197					13.342					23.874

4.1.5 Morphological characters

Morphological characters like leaf orientation, curd colour, leaf shape, leaf waxiness, curd doming etc. were also recorded (Plate 2 and 3). It was found that, all the varieties possess erect leaf orientation, except for Pusa Shukti which has flat and for Pusa Sharad which has very erect orientation (Table 15). For curd colour, Himpriya 60 (T9) and G 45 (T11) produced white curds. The curd colour of almost all the varieties was creamy white except Pusa Sharad, which produced yellow curds.

4.1.6 Incidence of physiological disorders

4.1.6.1 Riceyness

Dates of sowing and varieties influenced riceyness significantly (Plate 4a). November 1st sowing exerted least influence on percentage of curds affected by riceyness (4.67 %), whereas greater influence was noticed for D2 (24.33 %), D1 (22.00 %) and D4 (17.75 %) sowing (Table16).

Riceyness was low (3.00 %) for T4 which was on par with T9 (10.00 %), T6 (13.00 %) and was high (41.00 %) for T3 followed by T10 (28.00 %), T3 (24.00 %) and T5 (20.00 %).

Interaction effects varied significantly and no incidence of riceyness was observed in D4T4, D2T4, D3T11 and D4T11. It was high for D1T3 (68.00 %), D2T3 (56.00 %), D1T2 (52.00 %), D4T10 (44.00 %), D4T3 (40.00 %), D2T5 (40.00 %) and D1T10 (40.00 %)

4.1.6.2 Hairiness

Hairiness was significantly influenced by different sowing dates and varieties (Table 16). D3 exerted least influence on percentage of hairiness (7.00 %), whereas greater influence for D2 (52.33 %), D4 (34.67 %) and D1 (30.67 %) sowing was noticed. Incidence of hairiness was low for T6 (15.00 %) which was

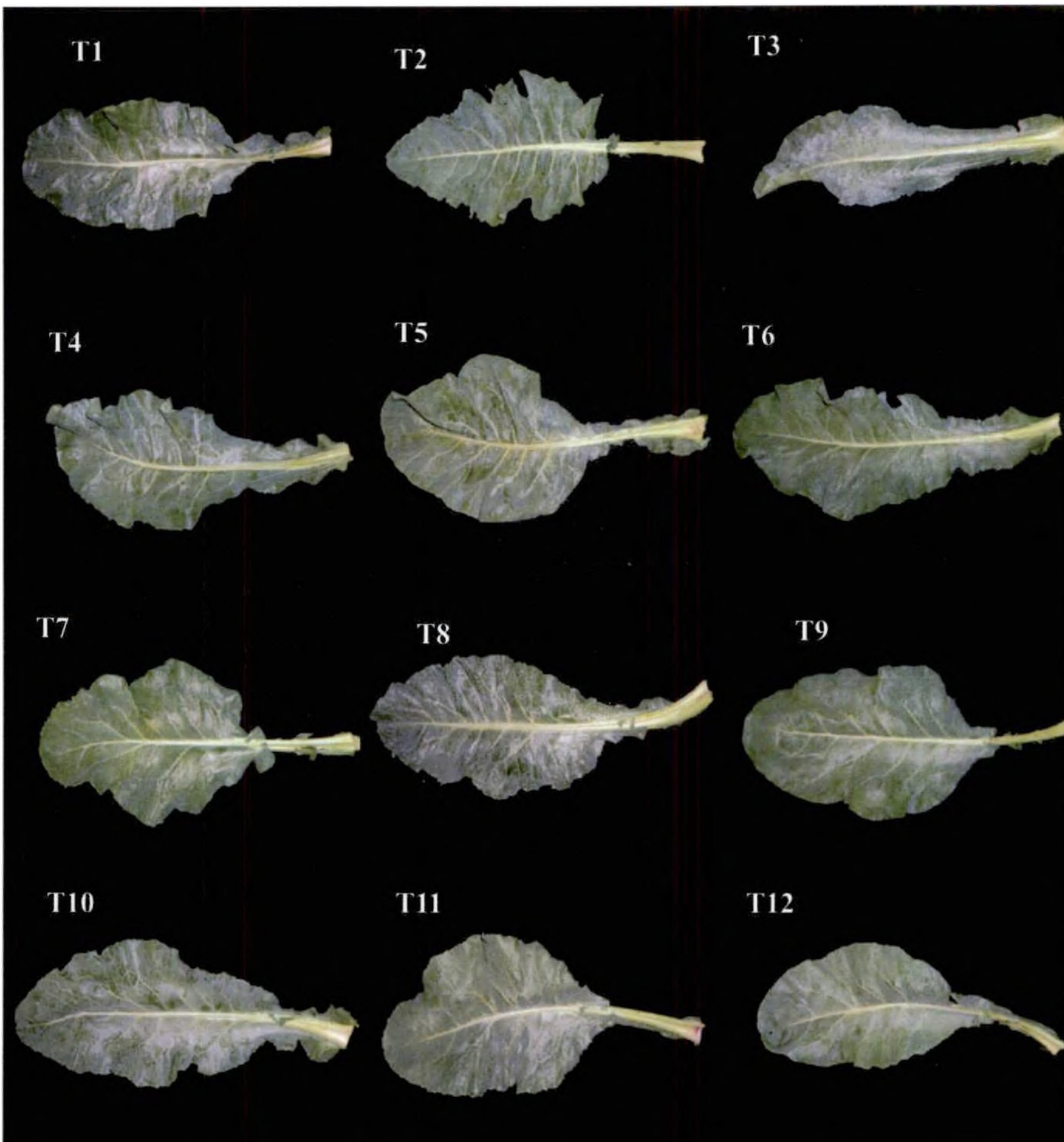
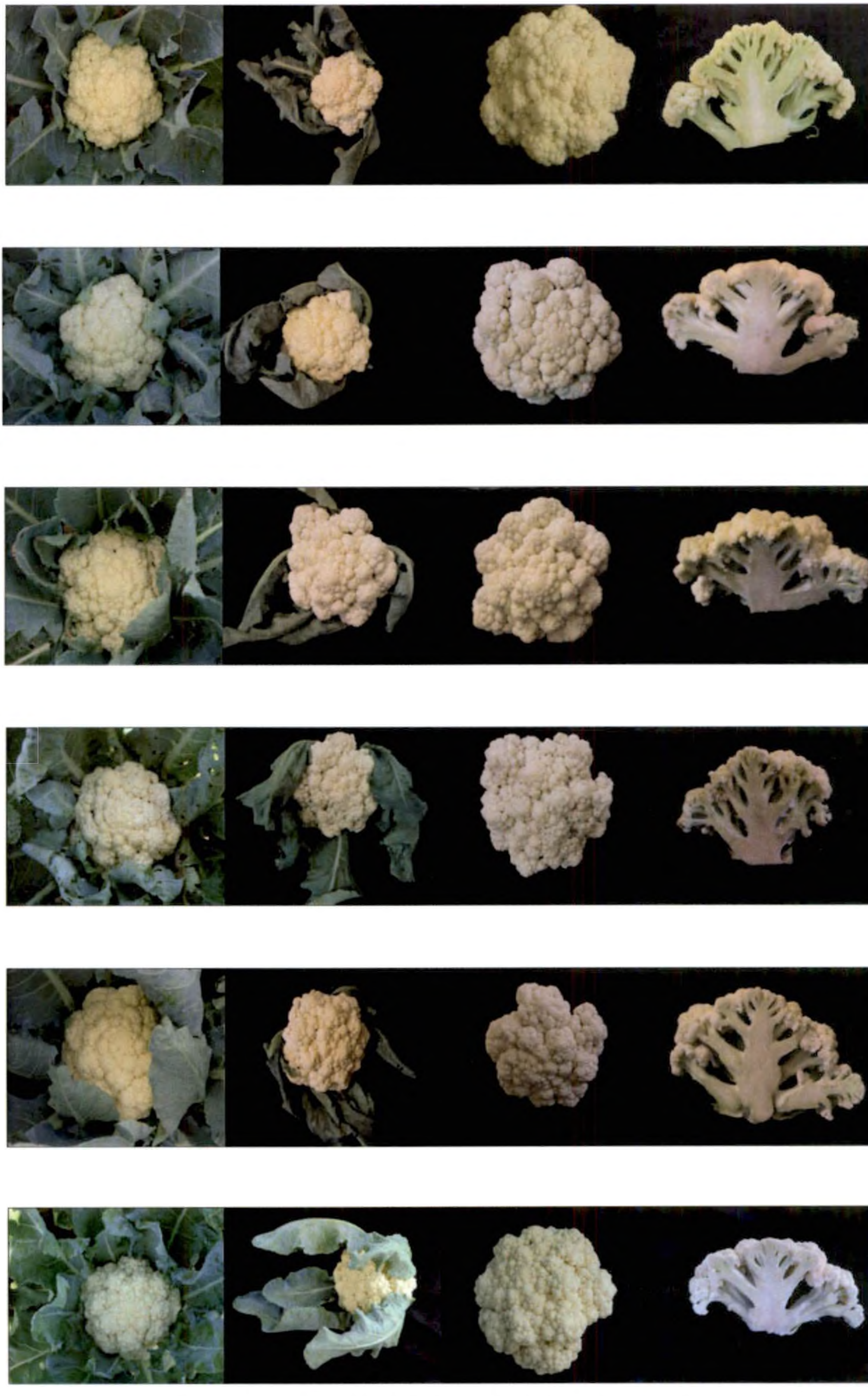


Plate 2. Variation in leaf shape and colour in different varieties of cauliflower

Plate 3. Curd characters of different varieties of cauliflower



T7

T8

T9

T10

T11

T12

Plate 3. Curd characters of different varieties of cauliflower

Table 15. Morphological characterisation of 12 varieties of cauliflower

Varieties	Seedling pigmentation	Seedling leaf colour	Seedling leaf margin serration	Seedling pubescence	Leaf orientation	Leaf shape	Leaf colour	Leaf waxiness	Leaf torsion of tip	Leaf puckering
Pusa Meghna	Absent	White green	Dentate	Glabrous	Semi erect	Elliptic	Dark green	Medium	Absent	Medium
Pusa Sharad	Absent	White green	Dentate	Glabrous	Very erect	Elliptic	Light green	Strong	Medium	Weak
Pusa Paushja	Absent	Dark green	Crenate	Glabrous	Erect	Narrow elliptic	Bluish green	Strong	Medium	Absent
Pusa Hybrid 2	Absent	White green	Dentate	Glabrous	Erect	Elliptic	Dark green	Medium	Medium	Strong
Pusa Shukti	Absent	White green	Dentate	Glabrous	Flat	Broad elliptic	Dark green	Medium	Absent	Strong
NS 60 N	Absent	White green	Dentate	Glabrous	Erect	Elliptic	Bluish green	Medium	Weak	Weak
Himshort	Absent	White green	Dentate	Glabrous	Erect	Broad elliptic	Dark green	Medium	Absent	Weak
Himlatha	Absent	White green	Crenate	Glabrous	Erect	Elliptic	Dark green	Medium	Medium	Weak
Himpriya- 60	Absent	White green	Dentate	Glabrous	Erect	Broad elliptic	Dark green	Medium	Absent	Weak
Indam 2435	Absent	Yellow green	Dentate	Glabrous	Erect	Elliptic	Dark green	Medium	Medium	Weak
G- 45	Absent	Light green	Dentate	Glabrous	Erect	Broad elliptic	Bluish green	Medium	Medium	Weak
White Snow	Absent	Light green	Dentate	Glabrous	Erect	Elliptic	Bluish green	Medium	Medium	Weak

Table 15. Continued….

Varieties	Leaf crimping near vein	Undulation of leaf margin	Curd covering by inner leaves	Curd doming	Curd shape in longitudinal section	Curd colour	Curd knobbing	Curd texture	Curd compactness	Curd anthocyanin colouration
Pusa Meghna	Weak	Medium	Not covered	Weak	Circular	Creamy white	Medium	Fine	Medium	Absent
Pusa Sharad	Medium	Strong	Not covered	Medium	Broad elliptic	Yellow	Medium	Coarse	Compact	Absent
Pusa Paushja	Medium	Medium	Partly covered	Strong	Narrow elliptic	Creamy white	Medium	Fine	Compact	Absent
Pusa Hybrid 2	Strong	Strong	Not covered	Medium	Broad elliptic	Creamy white	Medium	Coarse	Compact	Present
Pusa Shukti	Strong	Medium	Not covered	Medium	Broad elliptic	Creamy white	Medium	Fine	Compact	Present
NS 60 N	Weak	Medium	Partly covered	Weak	Broad elliptic	Creamy white	Coarse	Coarse	Medium	Absent
Himshort	Weak	Medium	Not covered	Medium	Circular	Creamy white	Coarse	Coarse	Medium	Absent
Himlatha	Weak	Medium	Partly covered	Strong	Circular	Creamy white	Medium	Fine	Medium	Absent
Himpriya- 60	Weak	Medium	Partly covered	Strong	Circular	White	Medium	Fine	Medium	Absent
Indam 2435	Weak	Medium	Partly covered	Medium	Circular	Creamy white	Coarse	Fine	Medium	Present
G- 45	Weak	Medium	Partly covered	Strong	Circular	White	Fine	Fine	Medium	Absent
White Snow	Weak	Weak	Partly covered	Strong	Circular	Creamy white	Fine	Fine	Medium	Absent

Plate 4a. Physiological Disorders

Riceyness

Hairiness

Leafness

Buttoning

Plate 4b Pest and Diseases

Leaf caterpillar

Alternaria blight

Soft rot

Choanephora rot

Curd rot

Table 16. Effect of sowing dates, varieties and their interactions on incidence of riceyness and hairiness in cauliflower

Varieties	Riceyness (%)					Hairiness (%)				
	D1	D2	D3	D4	Mean	D1	D2	D3	D4	Mean
T1	16.00	8.00	8.00	32.00	16.00	24.00	20.00	0.00	24.00	17.00
T2	52.00	20.00	8.00	16.00	24.00	68.00	84.00	40.00	80.00	68.00
T3	68.00	56.00	0.00	40.00	41.00	60.00	52.00	12.00	20.00	36.00
T4	8.00	0.00	4.00	0.00	3.00	56.00	100.00	8.00	100.00	66.00
T5	36.00	40.00	0.00	4.00	20.00	60.00	60.00	0.00	36.00	39.00
T6	8.00	20.00	8.00	16.00	13.00	4.00	40.00	0.00	16.00	15.00
T7	12.00	36.00	8.00	8.00	16.00	12.00	48.0	0.00	8.00	17.00
T8	12.00	24.00	4.00	24.00	16.00	20.00	40.00	4.00	20.00	21.00
T9	8.00	20.00	4.00	8.00	10.00	20.00	48.00	0.00	28.00	24.00
T10	40.00	24.00	4.00	44.00	28.00	24.00	36.00	0.00	24.00	21.00
T11	0.00	28.00	0.00	20.00	12.00	8.00	36.00	12.00	32.00	22.00
T12	4.00	16.00	8.00	28.00	14.00	12.00	64.00	8.00	28.00	28.00
Mean	22.00	24.33	4.67	17.75		30.67	52.33	7.00	34.67	
CD (5%)	D				9.637					9.543
	V				10.320					13.903
	DxV				20.000					27.806

on par with T7 (17.00 %), T1 (17.00 %) and was high for T2 (68.00 %) and T4 (66.00 %).

Interaction effects varied significantly and hairiness was not observed in D3T1, D3T5, D3T6, D3T7, D3T9 and D3T10. Hundred percent incidence of hairiness was observed in D2T4 and D4T4.

4.1.6.3 Leafiness

Dates of sowing and varieties influenced leafiness significantly (Table 17). November 1st sowing exerted least influence on percentage of curds affected by leafiness (1.00%), whereas it was highest for D2 (26.00 %), D1 (15.33 %) and D4 (15.17 %). Incidence of leafiness was low for T11 (1.00 %) which was on par with T6 (3.00 %), T1 (3.00 %), T9 (4.00 %), T7 (7.00 %) and was high for T4 (65.00%).

Interaction effects varied significantly and no incidence of leafiness was observed in D1T10, D1T11, D1T12, D3T1, D3T2, D3T3, D3T6, D3T9, D3T11, D3T12, D4T6, D4T9, D4T11 and D4T12. It was high for D4T4 (92.00%), D2T4 (88.00 %) and D1T4 (80.00 %).

4.1.6.4. Buttoning

Buttoning was significantly influenced by different sowing dates and varieties. It was least in D1 (8.00 %) and D3 (13.00 %) sowing whereas high for D4 (23.33 %) and D2 (22.67 %) sowing. There was no incidence of buttoning in T1, T6, T7, T9, T10 and T11. Its incidence was high for T4 (75.00 %), T2 (69.00 %) and T5 (35.00 %).

Interaction effects varied significantly. No or negligible buttoning was noticed in the D x T interactions except D2T4, D3T4, D4T4, D1T2, D2T2, D4T5, and D2T5 (Table 17).

Table 17. Effect of sowing dates, varieties and their interactions on incidence of leafiness and buttoning in cauliflower

Varieties	Leafiness (%)					Buttoning (%)				
	D1	D2	D3	D4	Mean	D1	D2	D3	D4	Mean
T1	4.00	4.00	0.00	4.00	3.00	0.00	0.00	0.00	0.00	0.00
T2	12.00	32.00	0.00	16.00	15.00	92.00	88.00	56.00	40.00	69.00
T3	8.00	20.00	0.00	28.00	14.00	0.00	24.00	0.00	56.00	20.00
T4	80.00	88.00	0.00	92.00	65.00	0.00	100.00	100.00	100.00	75.00
T5	52.00	48.00	0.00	20.00	30.00	0.00	60.00	0.00	80.00	35.00
T6	4.00	8.00	0.00	0.00	3.00	0.00	0.00	0.00	0.00	0.00
T7	8.00	12.00	4.00	4.00	7.00	0.00	0.00	0.00	0.00	0.00
T8	12.00	20.00	4.00	4.00	10.00	0.00	0.00	0.00	4.00	1.00
T9	4.00	12.00	0.00	0.00	4.00	0.00	0.00	0.00	0.00	0.00
T10	0.00	24.00	4.00	16.00	11.00	0.00	0.00	0.00	0.00	0.00
T11	0.00	4.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
T12	0.00	40.00	0.00	0.00	10.00	4.00	0.00	0.00	0.00	1.00
Mean	15.33	26.00	1.00	15.17		8.00	22.67	13.00	23.33	
CD (5%)	D				7.728					6.061
	V				11.216					10.888
	DxV				22.432					21.777

4.1.7 Incidence of pest and diseases

4.1.7.1 Leaf caterpillar (*Spodoptera litura*)

Caterpillar incidence varied significantly among different sowing dates, varieties and their interactions (Plate 4b). November 1st sowing resulted in least incidence (11.67 %) whereas October 15th in maximum (50.33 %). Incidence of caterpillar was low for T2 (5.00 %) followed by T6 (17.00 %) and high for T12 (91.00 %) followed by T8 (55.00 %).

Least incidence of caterpillar was observed in D3T11, D3T2, D3T6 and D3T9 whereas, hundred percent incidence was noticed in D1T12, D2T8, D2T11 and D2T12 (Table 18).

4.1.6.2 *Alternaria* blight (*Alternaria brassicae*)

Incidence of *Alternaria* blight varied significantly among different sowing dates, varieties and their interactions (Table 18). It was lowest (27.33 %) in D1 followed by D3 (31.33 %) and was highest in D2 (56.00 %). Incidence of leaf blight was low (28.00%) for T6 which is on par with T9 (31.00 %) and T5 (35.00%) and high for T3 (53.00%).

Least incidence of leaf blight was observed in D1T12 (4.00 %), D2T2 (8.00 %), D2T11 (8.00 %), D3T2 (8.00 %) and D4T9 (8.00 %). Highest incidence was observed in D2T4 (100 %), D2T12 (92.00 %) and D2T8 (84.00 %).

4.1.6.3 Soft rot (*Pythium sp.*)

Percentage incidence of soft rot varied significantly among different sowing dates, varieties and their interactions (Table 18). There was no soft rot incidence in November 1st sowing while it was highest on October 1st sowing (7.67 %). T4 and T5 had no incidence of soft rot and was highest for T12 (11.00 %).

Table 18. Effect of sowing dates, varieties and their interactions on incidence of leaf caterpillar, *Alternaria* blight and soft rot in cauliflower

Varieties	Leaf caterpillar (%)					*Alternaria* blight (%)					Soft Rot (%)				
	D1	D2	D3	D4	Mean	D1	D2	D3	D4	Mean	D1	D2	D3	D4	Mean
T1	32.00	56.00	4.00	20.00	28.00	12.00	68.00	48.00	68.00	49.00	8.00	0.00	0.00	0.00	2.00
T2	4.00	8.00	0.00	8.00	5.00	8.00	8.00	8.00	12.00	9.00	0.00	8.00	0.00	0.00	2.00
T3	20.00	24.00	8.00	72.00	31.00	36.00	80.00	48.00	48.00	53.00	4.00	8.00	0.00	0.00	3.00
T4	36.00	48.00	8.00	20.00	28.00	32.00	100.00	40.00	24.00	49.00	0.00	0.00	0.00	0.00	0.00
T5	4.00	8.00	16.00	64.00	23.00	24.00	56.00	8.00	52.00	35.00	0.00	0.00	0.00	0.00	0.00
T6	8.00	32.00	0.00	28.00	17.00	32.00	24.00	16.00	40.00	28.00	4.00	0.00	0.00	0.00	1.00
T7	12.00	52.00	4.00	28.00	24.00	28.00	68.00	24.00	28.00	37.00	8.00	0.00	0.00	0.00	2.00
T8	64.00	100.00	16.00	40.00	55.00	40.00	84.00	24.00	36.00	46.00	16.00	4.00	0.00	0.00	5.00
T9	72.00	56.00	0.00	8.00	33.76	28.00	68.00	20.00	8.00	31.00	0.00	12.00	0.00	0.00	3.00
T10	24.00	20.00	8.00	44.00	24.00	32.00	16.00	44.00	76.00	42.00	24.00	0.00	0.00	0.00	6.00
T11	8.00	100.00	0.00	16.00	31.00	52.00	8.00	52.00	80.00	46.00	8.00	0.00	0.00	0.00	2.00
T12	100.00	100.00	76.00	88.00	91.00	4.00	92.00	44.00	44.00	46.00	20.00	20.00	0.00	4.00	11.00
Mean	32.00	50.33	11.67	36.33		27.33	56.00	31.33	43.00		7.67	4.33	0.00	0.33	
CD (5%)	D				5.328					6.574					3.557
	V				10.054					9.852					4.451
	DxV				20.108					19.705					8.902

Interaction effects were significant and no or negligible soft rot incidence were observed in almost all combinations except D1T10 (24.00 %), D2T12 (20.00 %), and D1T12 (20.00 %).

4.1.6.4 *Choanephora* rot (*Choanephora sp.*)

Incidence of *Choanephora* rot varied significantly among different sowing dates, varieties and their interactions (Table 19). D3 exerted least incidence of *Choanephora* rot (23.67 %) and D2 has high incidence (65.67 %).

Choanephora rot was low for T6 (15.00 %) which is on par with T1 (22.00 %) and T7 (23.00 %) whereas high incidence was noticed in T12 (80.00%) followed by T4 (61.00 %), T10 (53.00 %) and T8 (52.00 %).

Among the interaction effects least incidence was observed for D1T11, D3T3, D3T6 and D3T7 whereas, hundred percent incidence was recorded for D2T4, D2T12 and D4T3.

4.1.6.5 Curd rot (*Alternaria brassicae*)

Significant differences were observed among varieties and their interactions for incidence of curd rot (Table 19). Incidence of curd rot on all the sowing dates was on par. Incidence of curd rot was low for T7 (0.00 %), T6 (1.00 %) and T9 (3.00%) and high for T4 (19.00 %).

Interaction effects were significant and no or negligible curd rot incidence were observed in almost all combinations except D4T4 (28.00 %), D2T2 (20.00 %), D1T4 (20.00 %), D1T12 (16.00 %), D4T12 (16.00 %), D3T4 (16.00 %) and D2T10 (16.00 %).

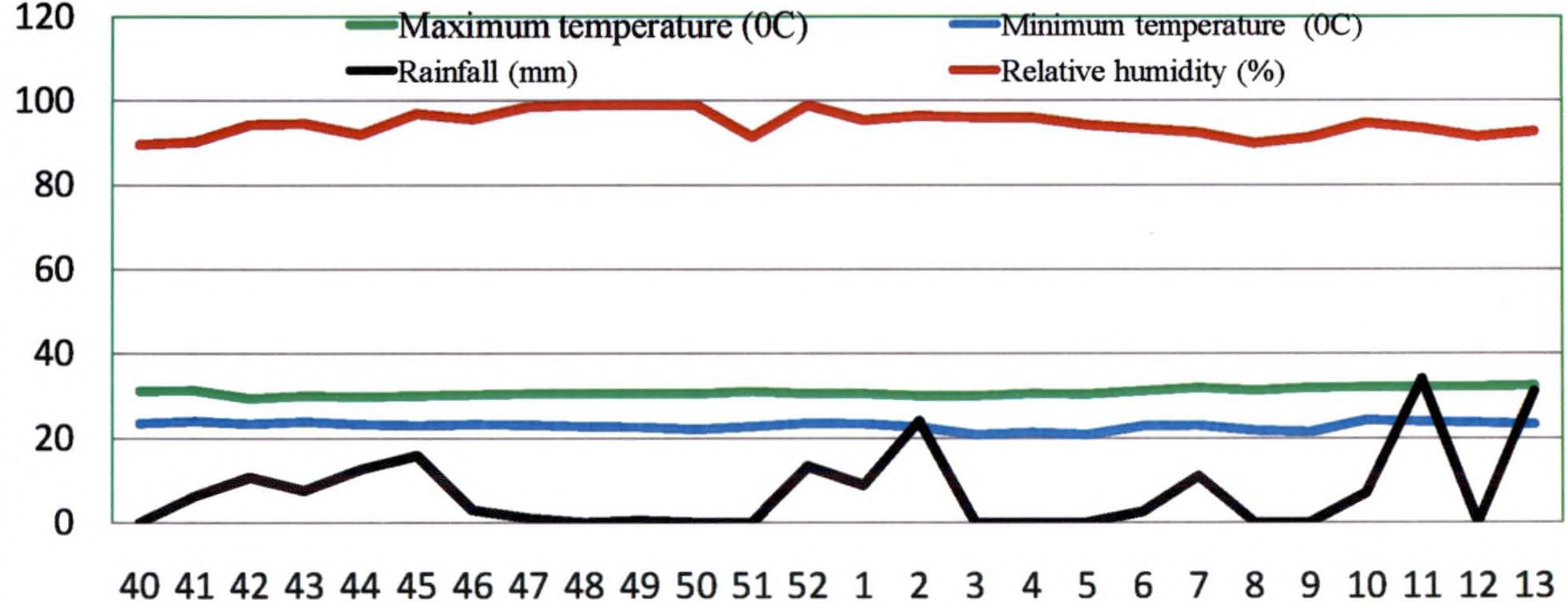
4.1.8 Weather parameters

There was not much variation in weather parameters during the cropping period from October 2012 to March 2013 (Fig. 10).

Table 19. Effect of sowing dates, varieties and their interactions on incidence of *Choanephora* rot and curd rot in cauliflower

Varieties	*Choanephora* rot (%)					Curd rot (%)				
	D1	D2	D3	D4	Mean	D1	D2	D3	D4	Mean
T1	32.00	28.00	16.00	12.00	22.00	0.00	8.00	4.00	4.00	4.00
T2	24.00	40.00	12.00	28.00	26.00	4.00	20.00	4.00	4.00	8.00
T3	52.00	48.00	4.00	100.00	51.00	0.00	4.00	0.00	0.00	1.00
T4	32.00	100.00	56.00	56.00	61.00	20.00	12.00	16.00	28.00	19.00
T5	32.00	60.00	24.00	36.00	38.00	8.00	0.00	8.00	4.00	5.00
T6	16.00	12.00	4.00	28.00	15.00	0.00	4.00	0.00	0.00	1.00
T7	28.00	52.00	4.00	8.00	23.00	0.00	0.00	0.00	0.00	0.00
T8	40.00	84.00	24.00	60.00	52.00	0.00	12.00	0.00	12.00	6.00
T9	32.00	88.00	8.00	24.00	38.00	0.00	4.00	0.00	8.00	3.00
T10	32.00	88.00	36.00	56.00	53.00	4.00	16.00	12.00	12.00	11.00
T11	4.00	88.00	16.00	24.00	33.00	8.00	4.00	4.00	0.00	4.00
T12	56.00	100.00	80.00	84.00	80.00	16.00	0.00	12.00	16.00	11.00
Mean	31.67	65.67	23.67	43.00		5.00	7.00	5.00	7.33	
CD (5%)	D				7.528					3.995
	V				9.803					7.295
	DxV				19.607					14.590

Fig. 10 Weather parameters during cropping period (October 2012 to March 2013)



Standard weeks

Maximum temperature ranged from 29.4° to 32.5°C and minimum from 20.8° to 24.3°C. In the field rainfall ranging from 0.0-34.0 mm and relative humidity from 89.6-99.0 % was also experienced.

4.2 Genetic variability, heritability and genetic advance

The population means, range, genotypic coefficients of variation (GCV) and phenotypic coefficients of variation (PCV), heritability and genetic advance for 29 characters of cauliflower were studied and are presented in Table 20, Fig. 11 and Fig. 12.

4.2.1 Vegetative characters

Plant height ranged from 56.30 cm to 73.40 cm with a mean of 66.50 cm. The GCV was 5.88 and PCV was 6.44. Heritability was as high as 83.26 per cent while genetic advance was 11.05.

Leaves per plant showed a range of 19.98 - 32.00 and the mean was 25.85. GCV was 9.72 and PCV was 11.44. Heritability was 72.13 per cent while genetic advance was 17.00.

Gross plant weight ranged from 0.93- 2.36 kg and showed a mean value of 1.37 kg. The GCV and PCV were 26.02 and 26.31 respectively. Heritability was 97.78 per cent and genetic advance was 52.99.

Leaf length ranged from 36.45 - 50.80 cm and showed a mean value of 44.61 cm. The GCV and PCV were 7.43 and 7.93 respectively. Heritability was moderate as 87.73 per cent and genetic advance was moderate (14.34). Leaf breadth ranged from 19.62 - 28.58 cm with an overall mean of 25.95 cm. GCV was 7.29 and PCV was 8.26. Heritability was 77.86 per cent. Genetic advance was 12.16. Mean leaf size was 1159.77 cm2 and it ranged between 757.14 - 1364.06 cm2. GCV and PCV values were 13.94 and 15.08 respectively. Heritability was 85.48 per cent and genetic advance was 23.48.

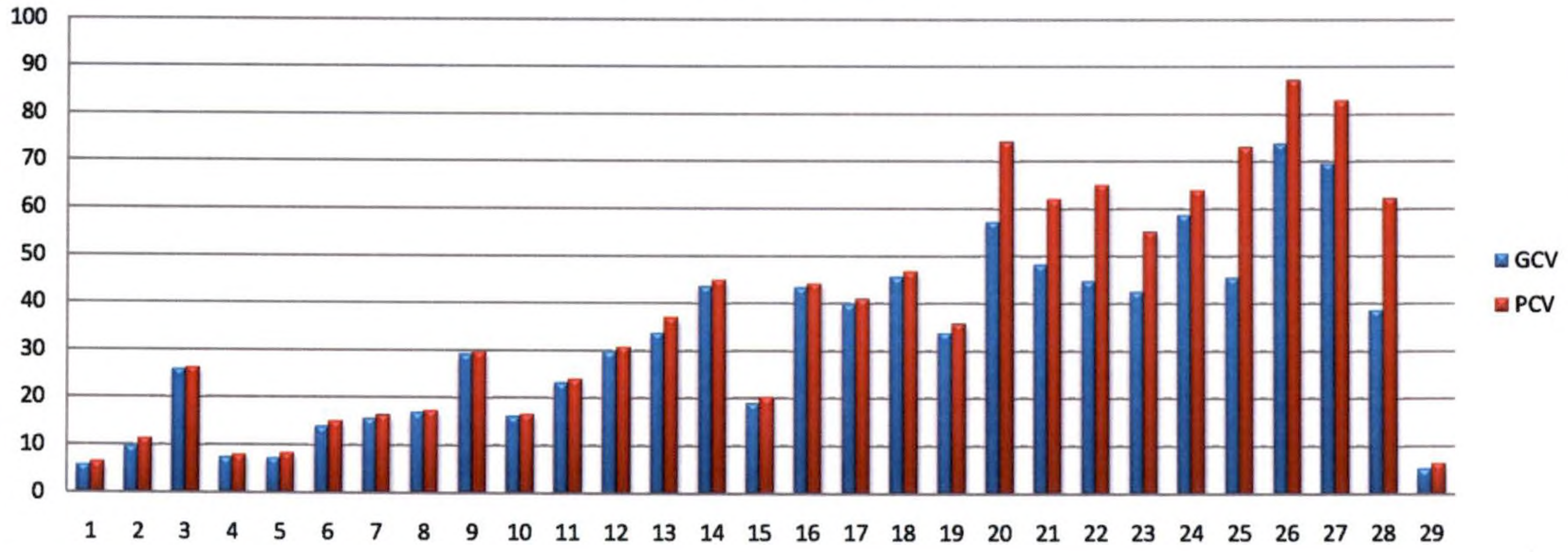
Table 20. Variability, Heritability and Genetic Advance in Cauliflower

Characters	Range	Mean	GCV	PCV	Heritability	Genetic Advance at (5%)	Genetic Advance as percentage of mean
Plant height (cm)	56.30 - 73.40	66.50	5.88	6.44	83.26	7.35	11.05
Leaves per plant	19.98 - 32.00	25.85	9.72	11.44	72.13	4.39	17.00
Gross plant weight (kg)	0.93- 2.36	1.37	26.02	26.31	97.78	0.73	52.99
Leaf length (cm)	36.45 - 50.80	44.61	7.43	7.93	87.73	6.40	14.34
Leaf breadth (cm)	19.62 - 28.58	25.95	7.29	8.26	77.86	3.16	12.16
Leaf size (cm^2)	757.14 - 1364.06	1159.77	13.94	15.08	85.48	272.32	23.48
Days to curd initation	36.67 - 66.24	53.15	15.70	16.44	91.19	16.41	30.88
Days to curd harvest	46.40 - 89.15	66.33	16.83	17.28	94.84	22.57	34.02
Days to curd maturity from curd initiation	9.38 - 22.91	13.19	29.13	29.65	96.54	7.76	58.96
Days to curd maturity	47.00 - 90.00	67.18	16.18	16.56	95.45	21.88	32.57
Curd depth (cm)	4.20 - 12.47	8.31	23.25	23.96	94.17	3.93	47.32
Curd diameter (cm)	2.60 - 17.75	12.57	29.83	30.79	93.90	7.49	59.55
Curd compactness (g/cm^3)	17.39 - 154.11	31.80	33.80	36.99	91.88	6.25	19.65
Curd size index (cm^2)	5.46 - 199.98	104.42	43.57	44.97	93.84	94.28	90.29
Stalk length (cm)	2.87 - 5.47	3.83	19.03	20.23	88.54	1.41	36.89
Net curd weight (g)	20.00 - 670.00	361.69	43.36	44.21	96.19	316.87	87.61

Table continues….

Characters	Range	Mean	GCV	PCV	Heritability	Genetic Advance at (5%)	Genetic Advance as percentage of mean
Gross curd weight (g)	40.00 - 720.00	408.68	39.83	41.03	94.24	325.53	79.65
Harvest Index	0.01 - 0.52	0.28	45.59	46.72	95.18	0.25	91.49
Percentage of curding	20.00 - 100.00	82.67	33.79	35.83	88.94	54.16	65.51
Riceyness (%)	0.00 - 30.00	4.67	57.34	74.20	56.43	0.88	18.92
Hairiness (%)	0.00 - 100.00	7.00	48.25	61.95	18.91	1.09	15.57
Leafiness (%)	0.00 - 10.00	1.00	44.69	65.10	10.48	0.51	50.83
Buttoning (%)	0.00 - 100.00	13.00	42.47	55.19	93.92	1.32	10.15
Leaf caterpillar (%)	0.00 - 100.00	14.67	58.77	64.03	67.31	0.73	4.98
Alternaria blight (%)	0.00 -100.00	31.33	45.48	73.03	38.77	18.28	58.34
Choanephora rot (%)	0.00 - 100.00	23.67	73.79	87.27	63.97	3.78	15.97
Curd rot (%)	0.00 - 40.00	5.00	69.63	82.92	10.69	2.35	46.91
Vitamin A (IU)	59.02 - 298.96	153.80	38.61	62.24	38.48	75.88	49.34
Protein (%)	1.92 - 2.63	2.16	5.32	6.54	66.00	0.19	8.90

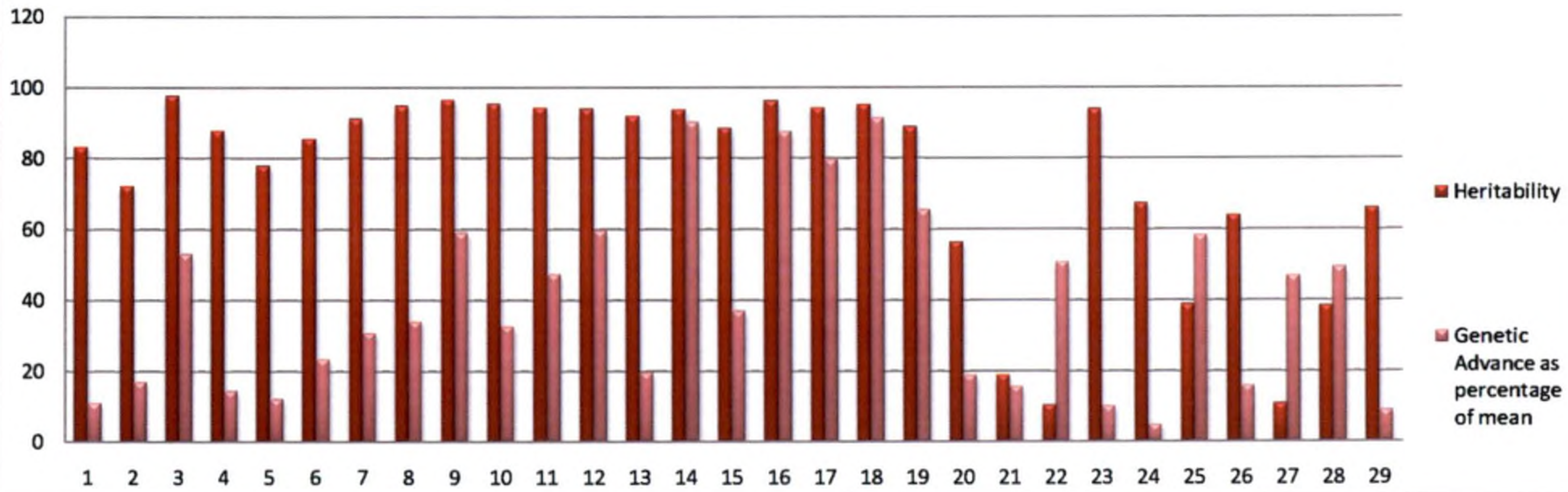
Fig.11 Genotypic and phenotypic coefficients of variation for different characters



Characters

X1 - Plant height (cm)
X2 - Leaves per plant
X3 - Gross plant weight (kg)
X4 - Leaf length (cm)
X5 - Leaf breadth (cm)
X6 - Leaf size (cm^2)
X7 - Days to curd initiation
X8 - Days to curd harvest
X9 - Days to curd maturity from curd initiation
X10 - Days to curd maturity
X11 - Curd depth (cm)
X13 - Curd compactness (g/cm^3)
X14 - Curd size index (cm^2)
X15 - Stalk length (cm)
X16 - Net curd weight (g)
X17 - Gross curd weight (g)
X18 - Harvest Index
X19 - Percentage of curding
X20 - Riceyness (%)
X21 - Hairiness (%)
X22 Leafiness (%)
X23 - Buttoning (%)
X24 - Leaf caterpillar (%)
X25 - *Alternaria* blight (%)
X26 - *Choanephora* rot (%)
X27 - Curd rot (%)
X28 - Vitamin A (IU)
X29 - Protein (%)

Fig. 12 Heritability and genetic advance as percentage of mean in cauliflower varieties for different characters



Characters

X1 - Plant height (cm)
X2 - Leaves per plant
X3 - Gross plant weight (kg)
X4 - Leaf length (cm)
X5 - Leaf breadth (cm)
X6 - Leaf size (cm^2)
X7 - Days to curd initiation
X8 - Days to curd harvest
X9 - Days to curd maturity from curd initiation
X10 - Days to curd maturity
X11 - Curd depth (cm)
X13 - Curd compactness (g/cm^3)
X14 - Curd size index (cm^2)
X15 - Stalk length (cm)
X16 - Net curd weight (g)
X17 - Gross curd weight (g)
X18 - Harvest Index
X19 - Percentage of curding
X20 - Riceyness (%)
X21 - Hairiness (%)
X22 Leafiness (%)
X23 - Buttoning (%)
X24 - Leaf caterpillar (%)
X25 - *Alternaria* blight (%)
X26 - *Choanephora* rot (%)
X27 - Curd rot (%)
X28 - Vitamin A (IU)
X29 - Protein (%)

4.2.2 Curd characters

Mean of days to curd initiation was 53.15 days and the range was 36.67 - 66.24 days. GCV and PCV values were 15.70 and 16.44 respectively. Heritability was 91.19 per cent and genetic advance was 30.88. Days to curd harvest ranged from 46.40 - 89.15 days with a mean of 66.33 days. The GCV was 16.83 and PCV was 17.28, heritability was as high as 94.84 while genetic advance was 34.02.

Days to curd maturity from curd initiation ranged from 9.38 - 22.91 days with a mean of 13.19 days. The GCV was 29.13 and PCV was 29.65, heritability was as high as 96.54 while genetic advance was moderate (58.96). Days to curd maturity showed the range of 47.00 - 90.00 and mean was 67.18 days. GCV and PCV values were 16.18 and 16.56 respectively. Heritability was high as 95.45 per cent and genetic advance was 32.57.

The range of curd depth is 4.20 cm to 12.47 cm with a mean of 8.31cm. The GCV was 23.25 and PCV was 23.96. Heritability was as high as 94.17 while genetic advance was moderate i.e. 47.32. Curd diameter ranged from 2.60 - 17.75 cm and the mean was 12.57 cm. GCV was found to be 29.83 and PCV was 30.79. Heritability was 93.90 per cent and genetic advance was 59.55.

Curd compactness showed a range of 17.39 - 154.11 g/cm^3 and showed a mean value of 31.80 g/cm^3. The GCV and PCV were 33.80 and 36.99 respectively. Heritability was high as 91.88 per cent and genetic advance was as high as 19.65.

Curd size index ranged 5.46 - 199.98 cm and showed a mean value of 104.42cm. The GCV and PCV were 43.57 and 44.97 respectively. Heritability was high as 93.84 per cent and genetic advance was 90.29.

The range of stalk length was 2.87 - 5.47 cm with an overall mean of 3.83 cm. GCV was 19.03 and PCV was 20.23. Heritability was found to be 88.54 per cent and genetic advance was 36.89.

4.2.3 Yield characters

Net curd weight ranged from 20.00 - 670.00 g with a mean of 361.69 g. The GCV was 43.36 and PCV was 44.21, heritability was 96.19 and genetic advance was 87.61.

Gross curd weight ranged from 40.00 - 720.00 g with an overall mean of 408.68 g. GCV was 39.83 and PCV was 41.03. Heritability was 94.24 per cent and genetic advance was high as 79.65.

Harvest Index ranged from 0.01 to 0.52 with an overall mean of 0.28. GCV and PCV was 45.59 and 46.72 respectively. Heritability was 95.18 per cent and genetic advance was as high as 91.49.

Yield per hectare ranged from 0.56 - 18.61 tonnes with a mean of 10.05 tonnes. The GCV was 43.36 and PCV was 44.21. Heritability was very high i.e., 96.19 and genetic advance was high as 87.61.

Yield per plot showed a range of 0.50 - 16.75 kg and the mean was 43.36 kg. GCV was found to be 9.04 and PCV was 44.21. Heritability was very high i.e., 96.19 and genetic advance was high as 87.61.

Percentage of curding ranged from 20.00 - 100.00 per cent with a mean of 33.79 percent. The GCV was 82.67 and PCV was 35.83. Heritability was 88.94 and genetic advance was 65.51.

4.2.4 Quality characters

Protein content varied from 1.92 - 2.63 mg/100g and the mean was 2.16. GCV was 5.32 and PCV was 6.54. Heritability was 66.00 and genetic advance was very low i.e. 8.90.

Vitamin A content showed a range of 59.02 - 298.96 IU and the mean was 153.80. GCV was found to be 38.61and PCV was 62.24. Heritability was 38.48 and genetic advance was 49.34.

4.2.5 Incidence of physiological disorders

Riceyness ranged from 0.00 - 30.00 per cent with a mean of 4.67. The GCV was 57.34 and PCV was 74.20. Heritability was 56.43 and genetic advance was 18.92.

Incidence of hairiness ranged from 0.00 - 100.00 percent with a mean value of 7.00 percent. The GCV and PCV were 48.25 and 61.95 respectively. Heritability was low i.e., 18.91 per cent and genetic advance was 15.57.

Leafiness ranged from 0.00 - 10.00 percent with a mean value of 1.00 per cent. The GCV and PCV were 44.69 and 65.10 respectively. Heritability was low i.e., 10.48 per cent and genetic advance was 50.83.

Incidence of buttoning ranged from 0.00 - 100.00 percent with a mean value of 13.00 per cent. The GCV and PCV were 42.47 and 55.19 respectively. Heritability and genetic advance was high i.e., 93.92 and 10.15 respectively.

4.2.6 Incidence of pests and diseases

Percentage incidence of leaf caterpillar ranged from 0.00 - 100.00 with a mean of 14.67. The GCV was 58.77 and PCV was 64.03. Heritability was 67.31 and genetic advance was as high as 4.98.

Percentage incidence of *Choanephora* rot ranged from 0.00 - 100.00 with a mean value of 23.67. The GCV and PCV were 73.79 and 87.27 respectively. Heritability was 63.97 per cent and genetic advance was 15.97.

Percentage of *Alternaria* blight infected plants also ranged from 0.00 - 100.00 with an overall mean of 31.33. GCV was 45.48 and PCV was 73.03. Heritability was found to be 38.77 per cent and genetic advance was 58.34.

Curd rot ranged from 0.00 - 40.00 per cent with a mean of 5.00. The GCV was 69.63 and PCV was 82.92. Heritability was 10.69 and genetic advance was 46.91.

4.3 Correlation studies

The phenotypic, genotypic and environmental correlation among 19 vegetative, curd and yield characters were worked out and are presented in Tables 21, 23 and 25 respectively. Incidence of physiological disorders, pests and diseases with yield characters were computed and presented in Tables 22, 24 and 26 respectively.

4.3.1 Phenotypic correlation coefficients

4.3.1.1 Correlation between yield and other characters

Net curd weight showed significant positive correlation with leaves per plant (0.5238), curd diameter (0.9369), curd size index (0.9465), gross plant weight (0.9888), harvest index (0.8780) and percentage of curding (0.7482). It exhibited significant negative correlation with plant height ((-0.3042), days to curd initiation (-0.6086), days to curd harvest (-0.7714), days to curd maturity from curd initiation (-0.8723), days to curd maturity (-0.7759), curd compactness (-0.8012) and stalk length (-0.7353) (Table 21).

4.3.1.2 Correlation among the yield component characters

Plant height had high significant positive correlation with gross plant weight (0.3054), leaf size (0.3830), days to curd initiation (0.6803), days to curd harvest (0.5777), days to curd maturity (0.6167), and curd compactness (0.3409).

Leaves per plant showed significant positive correlation with gross plant weight (0.3039), curd diameter (0.5254), curd size index (0.5190), net curd weight (0.5238), gross curd weight (0.5450) and harvest index (0.4048).

Table 21. Phenotypic correlation coefficients for vegetative, curd and yield characters

Character	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18	X19
X1	1.0000																		
X2	-0.1189	1.0000																	
X3	0.3054	0.3039	1.0000																
X4	0.3830	0.0019	0.7293	1.0000															
X5	0.6803	-0.3482	0.3419	0.4016	1.0000														
X6	0.5777	-0.5282	0.2495	0.3428	0.9433	1.0000													
X7	0.3452	-0.5773	0.0281	0.0329	0.6265	0.8242	1.0000												
X8	0.6167	-0.4221	0.3011	0.2951	0.9121	0.9563	0.8274	1.0000											
X9	0.1129	0.0402	0.6441	0.5410	0.1072	0.0982	0.0555	0.1056	1.0000										
X10	-0.3015	0.5254	0.0208	0.0647	-0.5900	-0.7638	-0.9319	-0.7843	0.0516	1.0000									
X11	0.3409	-0.3963	0.1063	-0.0230	0.5768	0.7295	0.9212	0.7787	0.1126	-0.9026	1.0000								
X12	-0.4028	0.5190	0.0087	0.0191	-0.6596	-0.8076	-0.8997	-0.8315	0.1065	0.9667	-0.8568	1.0000							
X13	0.0014	-0.5812	-0.2102	-0.0759	0.4137	0.5909	0.6642	0.5046	-0.2599	-0.6996	0.5357	-0.7264	1.0000						
X14	-0.3042	0.5238	0.0515	0.0920	-0.6086	-0.7714	-0.8723	-0.7759	0.1725	0.9369	-0.8012	0.9465	-0.7353	1.0000					
X15	-0.2602	0.5450	0.0813	0.1447	-0.5725	-0.7419	-0.8590	-0.7453	0.1761	0.9292	-0.7937	0.9265	-0.7370	0.9888	1.0000				
X16	-0.4657	0.4048	-0.3822	-0.2735	-0.7603	-0.8602	-0.8149	-0.8882	-0.0840	0.8388	-0.7663	0.8748	-0.6120	0.8780	0.8532	1.0000			
X17	-0.0525	0.6903	0.0649	-0.0750	-0.3953	-0.6436	-0.7722	-0.5600	-0.0684	0.7503	-0.6311	0.7049	-0.7145	0.7482	0.7623	0.6491	1.0000		
X18	-0.1142	-0.0129	-0.2394	-0.3579	-0.0779	0.0157	0.2020	0.1094	-0.2602	-0.1942	0.1993	-0.2244	0.1148	-0.2364	-0.2539	-0.0831	-0.1292	1.0000	
X19	-0.1327	-0.3511	0.0948	0.2046	0.0030	0.2196	0.4314	0.1631	0.3243	-0.3937	0.3754	-0.3268	0.3288	-0.3677	-0.3684	-0.2911	-0.5969	0.0624	1.0000

X1. Plant height (cm)

X2. Leaves per plant

X3. Gross plant weight (kg)

X4. Leaf size (cm^2)

X5. Days to curd formation

X6.Days to curd harvest

X7 Days to curd maturity from curd initiation

X8. Days to curd maturity

X9. Curd depth (cm)

X10. Curd diameter (cm)

X11. Curd compactness (cm^2)

X12 Curd size index (cm)

X13. Stalk length (cm)

X14. Net curd weight (g)

X15. Gross curd weight (g)

X16. Harvest index

X17. Percentage of curding

X18. Vitamin A (IU)

X19. Protein (%)

Table 22.Phenotypic correlation coefficients for yield, incidence of physiological disorders, pests and diseases

Character	X1	X2	X3	X4	X5	X6	X7	X8	X9
X1	1.000								
X2	0.2341	1.000							
X3	-0.3285**	-0.1064	1.000						
X4	-0.0056	-0.1695	-0.0991	1.000					
X5	-0.8065**	-0.1425	0.1967	-0.1150	1.000				
X6	-0.2928*	0.0371	-0.0528	-0.0328	-0.1859	1.000			
X7	-0.2228	-0.0489	-0.1333	0.0634	0.3137	0.5193	1.000		
X8	0.0588	0.2858*	-0.0265	-0.0638	-0.0669	0.0002	0.1670	1.000	
X9	-0.2963*	0.0262	-0.0613	0.0967	0.2731*	0.1363	0.2872*	0.2911*	1.000

*-Significant at 5% level

**- Significant at 1% level

X1 = Yield (t. ha^{-1})

X2 = Riceyness (%)

X3 = Hairiness (%)

X4 = Leafiness (%)

X5 = Buttoning (%)

X6 = Incidence of leaf caterpillar (%)

X7 = Incidence of *Choanephora* rot (%)

X8 = Incidence of *Alternaria* rot (%)

X9= Incidence of curd rot (%)

Gross plant weight has strong positive correlations with plant height (0.3054), leaves per plant (0.3039), leaf size (0.7293), days to curd initiation (0.3419) and curd depth (0.6441).

Leaf size had significant positive correlations with plant height (0.3830), gross plant weight (0.7293), days to curd initiation (0.4016), days to curd harvest (0.3428), days to curd maturity (0.2951) and curd depth (0.5410).

Days to curd initiation exhibited positive correlation with plant height (0.6803), gross plant weight (0.3419), leaf size (0.4016), days to curd harvest (0.9433), days to curd maturity (0.9121), curd compactness (0.5768) and stalk length (0.4137). It was negatively correlated with curd size index (-0.6596) and net curd weight (-0.6086).

Days to curd harvest showed significant positive correlation with days to curd initiation (0.9433), days to maturity from curd initiation (0.8242) and days to curd maturity (0.9563), curd compactness (0.7295), plant height (0.5777), leaf size (0.3428) and stalk length (0.5909) and was negatively correlated with leaves per plant (-0.5282), curd size index (-0.8076) and net curd weight (-0.7714).

Curd size index exhibited positive correlation with leaves per plant (0.5190), curd diameter (0.9667), net curd weight (0.9465), gross curd weight (0.9265) and harvest index (0.8748). It was negatively correlated with plant height (-0.4028), days to curd initiation (-0.6596), days to curd harvest (-0.8076), curd compactness (-0.8568) and stalk length (-0.7264)

Curd compactness showed positive correlation with plant height (0.3409), days to curd initiation (0.5768), days to curd harvest (0.7295), stalk length (0.5357) and negative correlation with net curd weight (-0.8012), gross curd weight (-0.7937) and harvest index (-0.7663).

Stalk length was positively correlated with days to curd initiation (0.4137), days to curd harvest (0.5909), curd compactness (0.5357) and negatively correlated with curd size index (-0.7264), net curd weight (-0.7353), gross curd weight (-0.7370) and harvest index (-0.6120).

Incidence of physiological disorders like hairiness (-0.0056), leafiness (-0.8065), buttoning (-0.2928), pests like leaf caterpillar (-0.2228) and diseases like *Choanephora* rot (-0.3285) and curd rot (-0.2963) showed negative correlation with net curd weight.

4.3.2 Genotypic correlation coefficients

Genotypic correlation coefficients were in general higher than phenotypic correlation for the characters under study.

4.3.2.1 Correlation between yield and other characters

Positive correlation was obtained between net curd weight and leaf length (0.1520), leaf size (0.1204) and curd depth (0.1892). Very strong significant positive correlation was obtained between net curd weight and leaves per plant (0.6152), curd diameter (0.9650), curd size index (0.9771), gross plant weight (0.9987), harvest index (0.8789) and percentage of curding (0.7896). It exhibited significant negative correlation with plant height (-0.3494), days to curd initiation (-0.6450), days to curd harvest (-0.8043), days to curd maturity from curd initiation (-0.9057), days to curd maturity (-0.8004), curd compactness (-0.8666) and stalk length (-0.7784) (Table 23).

4.3.2.2 Correlation among the yield component characters

Plant height had positive correlation with gross plant weight (0.3638), leaf size (0.4380), days to curd initiation (0.7454), days to curd harvest (0.6220), days to curd maturity (0.6862), curd depth (0.1425) and curd compactness (0.3751).

Leaves per plant showed positive correlation with gross plant weight (0.3715), curd diameter (0.6199), curd size index (0.6343), net curd weight (0.6152), gross curd weight (0.6239) and harvest index (0.4699).

Table 23. Genotypic correlation coefficients for vegetative, curd and yield characters

Character	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18	X19
X1	1.0000																		
X2	-0.2221	1.0000																	
X3	0.3638	0.3715	1.0000																
X4	0.4380	-0.0141	0.7872	1.0000															
X5	0.7454	-0.4662	0.3686	0.4378	1.0000														
X6	0.6220	-0.6637	0.2643	0.3706	0.9446	1.0000													
X7	0.3770	-0.6865	0.0303	0.0472	0.6713	0.8520	1.0000												
X8	0.6862	-0.5250	0.3213	0.3321	0.9360	0.9708	0.8513	1.0000											
X9	0.1425	0.0576	0.6759	0.5985	0.1285	0.1098	0.0484	0.1166	1.0000										
X10	-0.3461	0.6199	0.0222	0.0835	-0.6481	-0.8176	-0.9795	-0.8232	0.0675	1.0000									
X11	0.3751	-0.5181	0.1066	0.0020	0.6399	0.7886	0.9769	0.8305	0.1369	-0.9718	1.0000								
X12	-0.4466	0.6343	0.0064	0.0272	-0.7177	-0.8606	-0.9481	-0.8728	0.1222	0.9740	-0.9163	1.0000							
X13	0.0286	-0.7201	-0.2099	-0.1169	0.4439	0.6429	0.7496	0.5454	-0.2777	-0.7684	0.6398	-0.7996	1.0000						
X14	-0.3494	0.6152	0.0539	0.1204	-0.6450	-0.8043	-0.9057	-0.8004	0.1892	0.9650	-0.8666	0.9771	-0.7784	1.0000					
X15	-0.2945	0.6239	0.0865	0.1734	-0.6055	-0.7771	-0.9042	-0.7716	0.1889	0.9661	-0.8669	0.9691	-0.7874	0.9987	1.0000				
X16	-0.5524	0.4699	-0.3810	-0.2807	-0.8142	-0.9049	-0.8532	-0.9294	-0.0796	0.8682	-0.8315	0.9080	-0.6546	0.8789	0.8613	1.0000			
X17	-0.0693	0.8625	0.0660	-0.0831	-0.4086	-0.6847	-0.8495	-0.5849	-0.0866	0.7962	-0.7235	0.7576	-0.7823	0.7896	0.8018	0.6862	1.0000		
X18	-0.1639	-0.0421	-0.3964	-0.5231	-0.0753	0.0696	0.3416	0.1677	-0.4368	-0.3159	0.2962	-0.3178	0.2016	-0.3925	-0.3979	-0.1343	-0.2581	1.0000	
X19	-0.1974	-0.4313	0.1172	0.1602	-0.0323	0.2529	0.5513	0.1938	0.4349	-0.5038	0.5107	-0.3990	0.3543	-0.4575	-0.4742	-0.3667	-0.8185	0.1819	1.0000

X1. Plant height (cm)

X2. Leaves per plant

X3. Gross plant weight (kg)

X4. Leaf size (cm^2)

X5. Days to curd formation

X6.Days to curd harvest

X7 Days to curd maturity from curd initiation

X8. Days to curd maturity

X9. Curd depth (cm)

X10. Curd diameter (cm)

X11. Curd compactness (cm^2)

X12 Curd size index (cm)

X13. Stalk length (cm)

X14. Net curd weight (g)

X15. Gross curd weight (g)

X16. Harvest index

X17. Percentage of curding

X18. Vitamin A (IU)

X19. Protein (%)

Table 24. Genotypic correlation coefficients for yield, incidence of physiological disorders, pests and diseases

Character	X1	X2	X3	X4	X5	X6	X7	X8	X9
X1	1.000								
X2	0.2373	1.000							
X3	-0.7886**	-0.7801**	1.000						
X4	-0.0650	0.1563	-0.6081**	1.000					
X5	-0.8451**	-0.5558**	0.7067**	-0.3594*	1.000				
X6	-0.3818*	0.2239	-0.1526	-0.2414	-0.2306	1.000			
X7	-0.2642*	0.3460*	0.0213	0.0984	0.3148*	0.7719**	1.000		
X8	0.0933	0.3240*	-0.2679*	0.3534*	-0.0871	0.2234	0.4268**	1.000	
X9	-0.8572**	0.1333	0.1155	0.2569*	0.8604**	0.5693**	0.5430**	0.3573*	1.000

*-Significant at 5% level **- Significant at 1% level

X1 = Yield (t. ha^{-1})

X2 = Riceyness (%)

X3 = Hairiness (%)

X4 = Leafiness (%)

X5 = Buttoning (%)

X6 = Incidence of leaf caterpillar (%)

X7 = Incidence of *Choanephora* rot (%)

X8 = Incidence of *Alternaria* rot (%)

X9= Incidence of curd rot (%)

Gross plant weight has strong positive correlations with plant height (0.3638), leaves per plant (0.3715), leaf size (0.7872), days to curd initiation (0.3686) and curd depth (0.6759).

Leaf size had positive correlations with plant height (0.4380), gross plant weight (0.7872), days to curd initiation (0.4378), days to curd harvest (0.3706), days to curd maturity (0.3321) and curd depth (0.5985).

Days to curd initiation exhibited positive correlation with plant height (0.7454), gross plant weight (0.3686), leaf size (0.4378), days to curd harvest (0.9446), days to curd maturity (0.9360), curd compactness (0.6399) and stalk length (0.4439). It was negatively correlated with curd size index (-0.7177) and net curd weight (-0.6450).

Days to curd harvest showed strong significant positive correlation with days to curd initiation (0.9446), days to maturity from curd initiation (0.8520) and days to curd maturity (0.9708), curd compactness (0.7886). It was positively correlated with plant height (0.6222), gross plant weight (0.2643), leaf size (0.3706) and stalk length (0.6429). It showed significant negative correlation with leaves per plant (-0.6637), curd diameter (-0.8176), curd size index (-0.8606), net curd weight (-0.8043), gross curd weight (-0.7771) and harvest index (-0.9049).

Curd compactness showed positive correlation with plant height (0.3751), days to curd initiation (0.6399), days to curd harvest (0.7886), stalk length (0.6398) and negative correlation with net curd weight (-0.8666), gross curd weight (-0.8669) and harvest index (-0.8315).

Curd size index exhibited positive correlation with leaves per plant (0.6343), curd diameter (0.9740), net curd weight (0.9771), gross curd weight (0.9691) and harvest index (0.9080). It was negatively correlated with plant height (-0.4466), days to curd initiation (-0.7177), days to curd harvest (-0.8606), curd compactness (-0.9163) and stalk length (-0.7996)

Table 25. Error correlation coefficients for vegetative, curd and yield characters

Character	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18	X19
X1	1.0000																		
X2	0.2465	1.0000																	
X3	-0.3745	-0.1029	1.0000																
X4	0.0862	0.0643	0.1697	1.0000															
X5	0.2535	0.1911	-0.1401	0.1334	1.0000														
X6	0.2687	0.1729	-0.1492	0.1054	0.9614	1.0000													
X7	0.0943	-0.0448	-0.0485	-0.1412	-0.0598	0.2132	1.0000												
X8	0.0572	0.1199	-0.2907	-0.0593	0.6134	0.6754	0.2565	1.0000											
X9	-0.1345	-0.0570	-0.1267	0.0444	-0.1653	-0.1011	0.2083	-0.0956	1.0000										
X10	0.0441	0.1172	-0.0134	-0.1072	0.1319	0.1388	0.0133	-0.0946	-0.1996	1.0000									
X11	0.1098	0.1693	0.1240	-0.2281	-0.1062	-0.1024	0.0202	0.0161	-0.2137	0.0014	1.0000								
X12	-0.0794	-0.0215	0.0678	-0.0557	0.0601	0.0774	0.0592	-0.1040	-0.1400	0.8553	-0.0837	1.0000							
X13	-0.1674	-0.0318	-0.2963	0.1999	0.1482	0.0236	-0.4578	0.0452	-0.0781	0.0123	-0.4293	0.0287	1.0000						
X14	0.1065	0.1100	-0.0276	-0.2309	-0.0770	-0.0740	0.0134	-0.2164	-0.1611	0.4087	0.2430	0.3756	-0.2564	1.0000					
X15	0.0073	0.2413	-0.0474	-0.1205	-0.1563	-0.1329	0.0776	-0.2628	-0.0324	0.3429	0.1910	0.2544	-0.2183	0.8100	1.0000				
X16	0.2910	0.1329	-0.4474	-0.2429	-0.0266	-0.0094	0.0734	-0.0514	-0.1624	0.3324	0.1811	0.3065	-0.1483	0.8642	0.7108	1.0000			
X17	0.0527	-0.0029	0.0685	-0.0205	-0.2765	-0.1959	0.2410	-0.2972	0.1346	0.2764	0.2423	0.1542	-0.1797	0.2759	0.3537	0.2434	1.0000		
X18	-0.0667	0.0225	0.0326	-0.1937	-0.1431	-0.1475	-0.0421	0.0462	0.0143	-0.0220	0.1040	-0.1718	-0.0110	0.0158	-0.0761	-0.0109	0.0836	1.0000	
X19	0.0572	-0.1740	0.0075	0.3792	0.1622	0.1471	-0.0798	0.0745	-0.1314	0.0202	-0.1342	-0.0881	0.2935	-0.0283	0.0396	-0.0035	0.1560	-0.0641	1.0000

X1. Plant height (cm)

X2. Leaves per plant

X3. Gross plant weight (kg)

X4. Leaf size (cm^2)

X5. Days to curd formation

X6.Days to curd harvest

X7 Days to curd maturity from curd initiation

X8. Days to curd maturity

X9. Curd depth (cm)

X10. Curd diameter (cm)

X11. Curd compactness (cm^2)

X12 Curd size index (cm)

X13. Stalk length (cm)

X14. Net curd weight (g)

X15. Gross curd weight (g)

X16. Harvest index

X17. Percentage of curding

X18. Vitamin A (IU)

X19. Protein (%)

Table 26. Error correlation coefficients for yield, incidence of physiological disorders, pests and diseases

Character	X1	X2	X3	X4	X5	X6	X7	X8	X9
X1	1.000								
X2	-0.0398	1.000							
X3	0.0445	-0.0295	1.000						
X4	-0.1419	-0.1975	-0.0158	1.000					
X5	-0.0676	-0.0606	-0.4553**	-0.0094	1.000				
X6	-0.1294	-0.3627**	0.0032	0.0579	-0.0187	1.000			
X7	-0.1328	-0.1965	-0.2604*	0.0667	0.4706**	0.0373	1.000		
X8	0.0119	0.3130	0.0653	-0.1824	-0.0744	-0.2547	-0.0970	1.000	
X9	-0.1157	0.1245	-0.0914	0.0778	0.0016	-0.0304	-0.2052	0.2952*	1.000

*-Significant at 5% level

**- Significant at 1% level

X1 = Yield (t. ha^{-1})

X2 = Riceyness (%)

X3 = Hairiness (%)

X4 = Leafiness (%)

X5 = Buttoning (%)

X6 = Incidence of leaf caterpillar (%)

X7 = Incidence of *Choanephora* rot (%)

X8 = Incidence of *Alternaria* rot (%)

X9= Incidence of curd rot (%)

Stalk length was positively correlated with days to curd initiation (0.4439), days to curd harvest (0.6429), curd compactness (0.6398) and negatively correlated with curd size index (-0.7996), net curd weight (-0.7784), gross curd weight (-0.7874) and harvest index (-0.6546).

Incidence of physiological disorders like hairiness (-0.7886), leafiness (-0.0650), buttoning (-0.8451), pests like leaf caterpillar (-0.3818) and diseases like *Choanephora* rot (-0.2642) and curd rot (-0.8572) showed negative correlation with yield.

4.3.3 Error correlation coefficients

Most of the error correlation coefficients were very low.

4.4 Path coefficient analysis

Genotypic correlation between yield and its component characters were portioned into different components to find out the direct and indirect contribution of each character on yield. Plant height, number of leaves, gross plant weight, leaf size, days to curd initiation, curd depth, curd size index and stalk length were selected for path coefficient analysis.

Direct effects and correlation of these yield components are presented in Table 27 and Fig. 13.

All characters except plant height, days to curd formation and stalk length recorded positive direct effect. Highest positive direct effect was observed for curd size index (0.8829) followed by leaves per plant (0.8673).

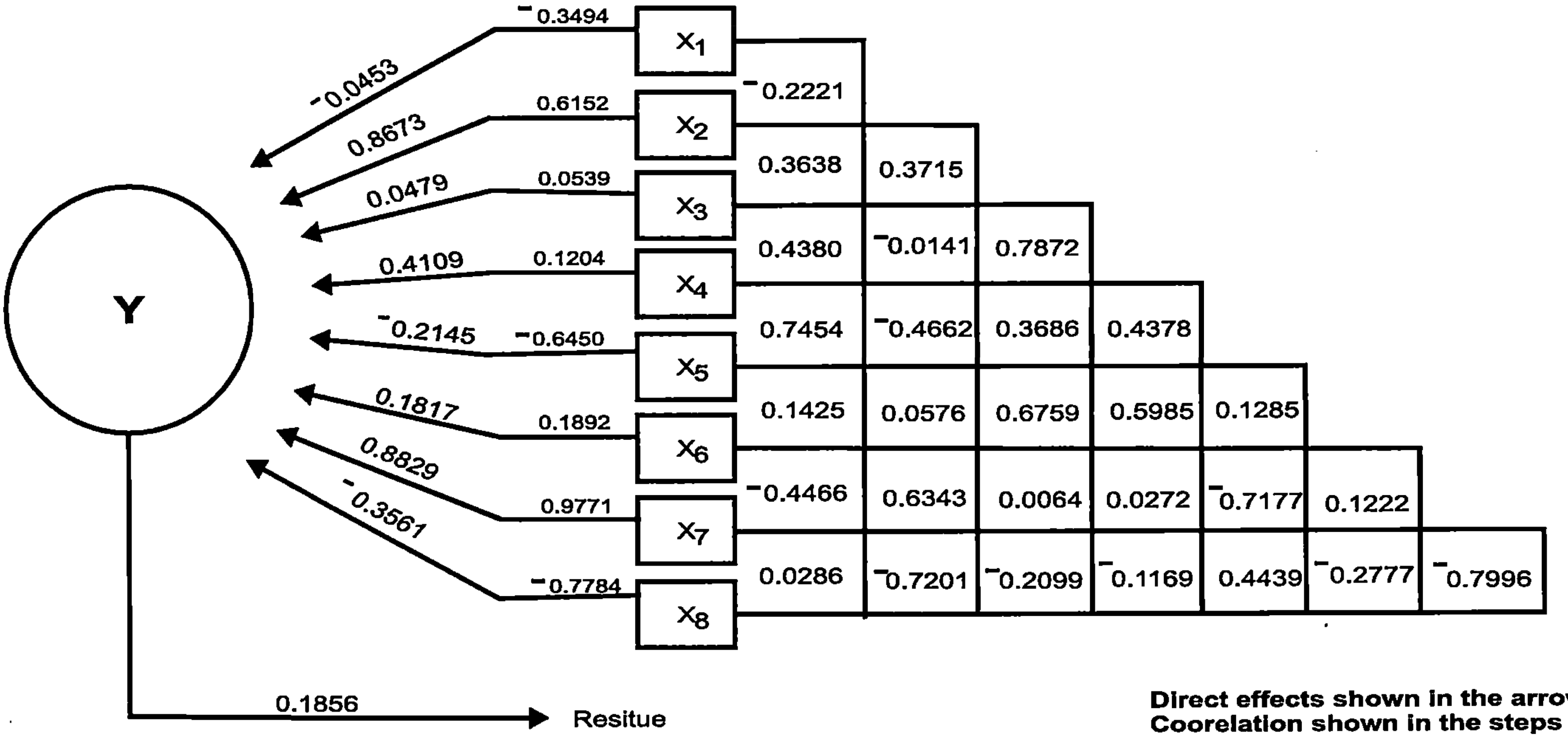
Plant height had genotypic correlation of -0.3494 with yield. In this, the direct effect was -0.0453. Major portion of indirect effects was contributed by days to curd initiation (0.4419). Other indirect effect were number of leaves per plant (-0.5799), gross plant weight (0.1556), leaf size (0.2773), curd depth (0.1492), curd size index (-0.7591) and stalk length (0.0109).

Table 27. Direct and indirect effects of yield components of cauliflower

Characters	Plant height	Leaves per plant	Gross plant weight	Leaf size	Days to curd initiation	Curd depth	Curd size index	Stalk length	Total correlation
Plant height	-0.0453	-0.5799	0.1556	0.2773	0.4419	0.1492	-0.7591	0.0109	-0.3494
Leaves per plant	-0.1926	0.8673	0.4022	-0.0122	-0.4043	0.0494	0.5301	-0.6245	0.6152
Gross plant weight	0.0357	0.0407	0.0479	0.4431	0.1088	0.2228	-0.0552	-0.7899	0.0539
Leaf size	0.2106	-0.6086	0.6809	0.4109	0.2158	0.0656	0.0166	-0.8714	0.1204
Days to curd initiation	0.5599	-0.4600	0.1091	0.0926	-0.2145	0.0276	-0.8549	0.0952	-0.6450
Curd depth	0.0971	0.0393	0.1608	0.3080	0.0886	0.1817	0.1033	-0.7893	0.1892
Curd size index	-0.3943	0.5600	0.0356	0.2240	-0.6337	0.6079	0.8829	-0.306	0.9771
Stalk length	0.3790	-0.2216	-0.1684	-0.0943	0.6023	-0.4528	-0.4665	-0.3561	-0.7784

Residue (R) =0.1856 (Underlined figures are direct effects)

Fig.13. path diagram showing direct and indirect effect of yield components on total yield of cauliflower



Direct effects shown in the arrow
Coorelation shown in the steps

Genotypic correlation of leaves per plant with yield was 0.6152. Its direct effect was high i.e., 0.8673. Major portion of indirect effect was through curd size index (0.5301). Indirect effect through gross plant weight (0.4022) and curd depth (0.0494) also contributed to yield.

The direct effect of gross plant weight on yield was 0.0479 and genotypic correlation with yield was 0.0539. Indirect effects were maximum for leaf size i.e., 0.4109. Other indirect effects through plant height, leaves per plant, days to curd formation and curd depth were 0.0357, 0.0407, 0.1088 and 0.2228 respectively.

Leaf size had a genotypic correlation of 0.1204 with yield. In this, the direct was 0.4109. The indirect effects were plant height (0.2106), leaves per plant (-0.6086), gross plant weight (0.6809), days to curd formation (0.2158), curd depth (0.0656), curd size index (0.0166) and stalk length (-0.8714).

The total genetic correlation of days to curd initiation on yield was -0.6450. The direct effect was negative i.e., -0.2145. The indirect effects were plant height (0.5599), leaves per plant (-0.4600), gross plant weight (0.1091), leaf size (0.0926), curd depth (0.0276), curd size index (-0.8549) and stalk length (0.0952).

The direct effect of curd depth on yield was 0.1817 but genotypic correlation with yield was 0.1892. Indirect effects on yield were through plant height (0.0971), leaves per plant (0.0393), gross plant weight (0.1608), leaf size (0.3080), days to curd initiation (0.0886) and curd size index (0.1033).

Curd size index had high direct effect i.e., 0.8829 whereas the genotypic correlation with yield was 0.9771. The rest of its effect on yield was contributed by indirect effect through leaves per plant (0.5600), gross plant weight (0.0356), leaf size (0.2240) and curd depth (0.6079).

The total genetic correlation of stalk length on yield was -0.7784. The direct effect was -0.3561. Indirect effects through plant height, leaves per plant, gross plant weight, leaf size, days to curd formation, curd depth and curd size index were 0.3790, -0.2216, -0.1684, -0.0943, 0.6023, -0.4528, -0.4665 respectively.

The residue was 0.1856 indicating that the selected eight characters contributing the remaining eighty one per cent.

4.5 Selection index

Discriminant function analysis was adopted for the construction of selection index (Table 28).

Selection index (I) was computed based on the six characters *viz*., Days to curd initiation (X_1), days to curd harvest (X_2), curd depth (X_3), curd diameter (X_4), net curd weight (X_5) and percentage of curding (X_6).

$$I = 10.9601\ X_1 + -9.6729\ X_2 + 4.6056\ X_3 + 2.9757\ X_4 + 0.7831\ X_5 + -1.7199\ X_6$$

Accordingly selection index values were worked out and presented in the Table. The cauliflower variety T6 (2717.20) recorded the maximum selection index value followed by T11 (2016.52) and T12 (1861.26). The lowest value was recorded by T4 (-131.96) followed by T2 (-0.18).

Table 28. Cauliflower varieties/ hybrids ranked according to selection index

(Based on discriminant function analysis)

Variety	Index	Ranks in ascending order
NS 60N	2717.20	1
G 45	2016.52	2
White Snow	1883.28	3
Himpriya 60	1861.26	4
Himlatha	1822.474	5
Himshort	1794.14	6
Pusa Meghna	1791.04	7
Pusa Paushja	1528.56	8
INDAM 2435	1452.10	9
Pusa Shukti	917.20	10
Pusa Sharad	-0.18	11
Pusa Hybrid 2	-131.96	12

Table 29. Genetic cataloguing of cauliflower varieties used for the study

Characters	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12
Seedling pigmentation	1	1	1	1	1	1	1	1	1	1	1	1
Seedling leaf colour	1	1	5	1	1	1	1	1	1	2	3	3
Seedling leaf margin serration	2	2	1	2	2	2	2	1	2	2	2	2
Seedling pubescence	0	0	0	0	0	0	0	0	0	0	0	0
Leaf orientation	2	4	3	3	1	3	3	3	3	3	3	3
Leaf shape	5	5	3	5	7	5	7	5	7	5	7	5
Leaf colour	2	1	3	2	2	3	2	2	2	2	3	3
Leaf waxiness	5	7	7	5	5	5	5	5	5	5	5	5
Leaf torsion of tip	1	5	5	5	1	3	1	5	1	5	5	5
Leaf puckering	5	3	1	7	7	3	3	3	3	3	3	3
Leaf crimping near vein	3	5	5	7	7	3	3	3	3	3	3	3
Undulation of leaf margin	5	7	5	7	5	5	5	5	5	5	5	3
Curd covering by inner leaves	3	3	5	3	3	5	3	5	5	5	5	5
Curd doming	3	5	7	5	5	3	5	7	7	5	7	7
Curd shape in longitudinal section	1	3	5	3	3	3	1	1	1	1	1	1
Curd colour	2	3	2	2	2	2	2	2	1	2	1	2
Curd knobbing	5	5	5	5	5	7	7	5	5	7	3	3
Curd texture	3	3	3	7	3	7	7	3	3	3	3	3
Curd compactness	5	7	7	7	7	5	5	5	5	5	5	5
Curd anthocyanin colouration	1	1	1	9	9	1	1	1	1	9	1	1

Discussion

5. DISCUSSION

Investigations were conducted at the Department of Olericulture, College of Agriculture, Vellayani to identify tropical cauliflower varieties suitable for plains of southern Kerala and to study the influence of date of planting on yield and quality, during the period October 2012 to March 2013. In this chapter, attempt is being made to discuss salient experimental findings and to offer possible explanations and evidences with a view to determine the cause and effect relationships with regard to different characters.

The experimental results are discussed under the following headings.

5.1 Effect of sowing dates

The study included four sowing dates *viz.* October 1st, October 15th, November 1st and November 15th and 12 varieties of cauliflower. The response of cauliflower to different sowing dates, varieties and their interaction revealed significant differences with respect to vegetative, curd and yield characters and incidence of physiological disorders, pests and diseases.

5.1.1 Vegetative characters

In the present study, November 1st sowing resulted in maximum plant height, leaves per plant, gross plant weight, leaf length, leaf breadth and leaf size. These results are in agreement with the findings of Srivastava *et al.* (2002). Similarly, influence of sowing dates on different vegetative characters like leaves per plant, leaf area index , plant weight were reported by Ajithkumar (2005), Kaur *et al.* (2007) and Din *et al.* (2007). The better plant growth of November 1st sowing might be due to conducive climatic conditions which in turn resulted in high dry matter accumulation.

Among the varieties Himpriya 60 excelled other varieties in overall performance with respect to all the vegetative characters like plant height, leaves per plant, gross plant weight, leaf length, leaf breadth and leaf size whereas, Himshort recorded the least values. Varietal variation for vegetative characters of cauliflower was reported by Jindal and Thakur (2004), Hamid *et al.* (2005), Kumar *et al.* (2006), Sharma *et al.* (2006), Singh *et al.* (2006), Devraju *et al.* (2010) and Yadav *et al.* (2013).

Interaction effects for dates of sowing and varieties were also significant for all vegetative characters. Cumulative effect of best sowing date and variety for vegetative characters were reflected in their interaction too. Maximum plant height and leaves per plant were recorded for November 1st sowing of Pusa Paushja and October 15th sowing of Himpriya 60 whereas, highest gross plant weight and leaf size were recorded for November 1st sowing of Himpriya 60. Findings of Pradeepkumar *et al.* (2002), Jana and Mukhopadhyay (2006), Sharma *et al.* (2006) were in line with the present results.

5.1.2 Earliness

Earliness in curd initiation, maturity and harvest are preferred characters in cauliflower since the duration of winter is too short in Kerala especially in the plains. According to Booij (1987) days to curd initiation was influenced by the number of days until the 19th leaf was initiated and by the mean temperature from that date until curd initiation. The plants will remain in their vegetative phase till the advent of favorable temperature for curd initiation. A temperature of 20-24°C is optimum for curding in early cultivars of cauliflower (Nieuwhof, 1969).

In the present study, the days to curd initiation, maturity and harvest were significantly altered by sowing dates, varieties and their interaction. November 15th sowing resulted in early curd initiation (47.14 days) while, sowing on October 1st and

November 15th resulted in early curd maturity and harvest, since they received high temperature during the curd maturity stage. These finding are in conformity with the findings of Pradeepkumar *et al.* (2002) who reported a similar range for days to maturity in cauliflower.

Among the varieties, Himshort was the earliest followed by NS 60N and the late ones were Pusa Sharad and Pusa Hybrid 2 which are mid season varieties. Similar variation among genotypes for earliness were reported by many workers (Thapa *et al.*, 2002; Jindal and Thakur, 2004; Sharma *et al.*, 2005 and Dhatt and Garg, 2008).

October 1st sowing of Himshort resulted in earliest curd initiation (37.22 days) and curd harvest (47.91 days) whereas November 1st sowing of the same resulted in early maturity (48.20 days). Interaction between sowing dates and varieties for days to curd initiation and maturity were earlier reported by Yadav *et al.* (1995), Callens *et al.* (2000) and Pradeepkumar *et al.* (2002).

5.1.3 Curd characters

Among the different sowing dates, November 1st sowing recorded highest curd depth (8.31 cm), curd diameter (12.57 cm) and curd size index (104.42 cm^2). Such result may be attributed to the fact that plants in November 1st sowing got better opportunity to develop vegetatively, since they received favorable weather. Adequate vegetative growth and carbohydrate accumulation contributes a lot in the development of economic part in cauliflower. Hence, vigorous plants ultimately led to larger curd size. In contrast, those sowing dates having inadequate vegetative growth resulted into small curds. Significant differences among sowing dates and curd characters were earlier reported by Yadav *et al.* (1995), Ghanti and Mallik (1995), Mohanty and Srivastava, (2002) and Kaur *et al.* (2007). However, Chatterjee and Som (1990) reported greater curd weight and diameter with later planting of medium late cauliflower cv. KPS-1.

Curd characters like curd depth, curd diameter and curd size index were highest for NS 60N and lowest for Pusa Sharad and Pusa Hybrid 2. Earlier findings for variability among genotypes for curd characters were reported by Kumar (2002), Sharma *et al.* (2005), Devraju *et al.* (2010), Mahesh *et al.* (2011) and Yadav *et al.* (2013).

Among interaction effects, maximum curd depth, curd diameter and curd size index were observed in October 1st sowing of Pusa Hybrid 2 and November 1st sowing of NS 60N. Studies by Ghanti and Mallick, (1994), Yadav *et al.* (1995), Rooster and Callens (1999), Pradeepkumar *et al.* (2002), Sharma *et al.* (2006) support the present findings. For stalk length, lowest value was recorded for November 15th sowing of NS 60N and Pusa Meghna.

Curd compactness is a preferred curd character in cauliflower and expressed as an index. Pearson (1931) had explained this index as the ratio of net curd weight and cube of mean curd depth and diameter. In the present investigation, high temperature and adverse climate during curding time of November 15th sown plants resulted in formation of buttons which in turn resulted in high compactness index. Buttons resulted in high compactness value since they had low net curd weight, curd depth and curd diameter. This is not in line with the earlier findings of Yadav *et al.* (1995).

High compactness values were observed for Pusa Sharad and Pusa Hybrid-2 which produced buttons and low for NS 60 N and Pusa Meghna which produced normal curds. This result was not in line with previous findings by Kumar (2002), Sharma *et al.* (2005) and Mahesh *et al.* (2011).

In the present study highest compactness was obtained for October 15th sowing of Pusa Hybrid 2, which showed buttoning. In other varieties and sowing dates where normal curding was observed, the curd compactness ranged between 23.26 and 43.47 which was in accordance with the findings of Yadav *et al.* (1995) and Ghanti and Mallik (1995).

Stalk length determines the stability of curds. It is generally understood that short stalks results in stable compact curds whereas long stalks results in toppling of curds which ultimately resulted in yield loss. Short stalks were attributed by low temperature whereas long stalks were attributed by high temperature. Similar trend was observed in the present study also i.e., November 1st sowing coinciding with low temperature recorded minimum stalk length (3.83 cm). This corroborates with the early findings of Choudhary and Ramphal (1961). Stalk length was influenced significantly by different cauliflower varieties also. Least stalk length was observed for NS 60, Pusa Meghna, Himpriya 60 and G 45. Interaction effect showed that least stalk length was obtained for the above varieties sown on November 1st.

5.1.4 Yield characters

Yield is the most important factor in any crop production. In cauliflower, curd is the economic part and the net curd weight was found to be influenced by different sowing dates. It was highest for November 1st sowing (361.69 g) followed by that of October 1st (336.57 g) hence curd weight was greatly influenced by temperature. It was clear from the result that in southern Kerala, a difference of 15 days in sowing resulted in remarkable reduction in curd yield. This is in accordance with the findings of Pradeepkumar *et al.* (2002) and Karthika *et al.* (2013). Similarly, gross curd weight, harvest index, yield and curding percentage were high for November 1st sowing. Similar reports were suggested Jaya *et al.* (2002), Mohanty and Srivastava, (2002), Srivastava *et al.* (2002) and Thapa *et al.* (2002), Amoli *et al.* (2007), Din *et al.* (2007), Kaur *et al.* (2007) and Karthika *et al.* (2013).

Among varieties, the best performers with respect to net curd weight, gross curd weight and yield per plot were NS 60 N followed by G 45 whereas Pusa Sharad and Pusa Hybrid 2 were poor yielders. The present result is in accordance with the finding Narayanankutty (2012) who identified NS 60N as the suitable variety for the warm humid tropics of Kerala. Variability among genotypes for yield were reported by several workers confirming the present findings (Jana and Mukhopadhyay, 2006; Kumar *et al.*, 2006; Sharma *et. al.*, 2006; Dhatt and Garg, 2008; and Yadav *et al.*, 2013).

Harvest index gives an indication about the extent of economic yield to total biological yield. In the present study it was high for NS 60 N, Himshort and Himlatha and low for Pusa Sharad and Pusa Hybrid 2. Similar findings were made by Sharma *et al.* (2000), Jindal and Thakur (2004) and Sharma *et al.* (2005) who obtained differences in harvest index while comparing different genotypes (Plate 5).

The interaction of November 1st sowing of NS 60N resulted in highest net curd weight (629.33 g), gross curd weight (670.00 g), harvest index (0.45), yield per plot (15.73 kg) and curd yield (17.48 t. ha^{-1}). Similar higher yield was reported by several workers confirming to the present findings (Callens *et al.*, 2000; Pradeepkumar *et al.* 2002; Thapa *et al.* 2002; Sharma *et al.*, 2006; Jana and Mukhopadhyay, 2006; Ara *et al.*, 2009). Complete curding was observed for Pusa Meghna, NS 60N, Himshort, Himpriya 60 and G 45 in all the four sowing dates.

5.1.5 Quality characters

Quality characters are as important as yield in food crops especially vegetables. But in most of the cases quality is negatively correlated with yield. In the present study, it was observed that protein, Vitamin A and vitamin C content were highly influenced by genotype rather than environment. Contrary to the present findings,

Plate 5a. Top Yielders


NS 60N


G 45

Plate 5b. Earliest Variety


Himshort

variation in quality characters under varying environmental conditions was earlier reported by JiaFu (2005).

Among the varieties high protein and Vitamin A content was observed in Pusa Hybrid 2 and Pusa Meghna respectively. No significant difference was observed for vitamin C content among varieties. Variation among cauliflower genotypes for protein, Vitamin A and vitamin C were reported by Hoser-Krauze, (1994), Singh *et al.* (2005), Yun Hua (2010) and Yadav *et al.* (2013).

Significant interactions between sowing dates and varieties were observed for protein and Vitamin A content. Pusa hybrid 2 and Pusa Meghna sown on November 15 had high protein and Vitamin A content respectively. For Vitamin C content no significant difference was observed between the sowing dates and varieties.

5.1.6 Physiological disorders

Weather has profound effect on the incidence of physiological disorders in cauliflower. High temperature coupled with rainfall results in high incidence of physiological disorders like riceyness, hairiness, leafiness and buttoning. So identification of suitable time with least incidence of physiological disorders helps to manipulate these adverse environmental effects. In the present study, November 1st sowing recorded least incidence of these physiological disorders. Significant environment interactions on incidence of physiological disorders were earlier reported by Rashid *et al.* (1990), Sharma *et al.* (2001) and Sharma and Behera (2003).

Cauliflower varieties also exhibit variation in their response to fluctuation in temperature especially during curd initiation and development phases leading to several physiological disorders like riceyness, buttoning, leafiness, bolting and browning (Norman, 1992 and Verma, 2009). Least incidence of riceyness, leafiness, hairiness and buttoning was observed for NS 60N, G 45, Himpriya 60 Himshort and Pusa Meghna whereas high incidence was noticed for mid season varieties like Pusa

Paushja, Pusa Sharad and Pusa Hybrid 2. Similar variation between varieties for incidence of physiological disorders at high temperature was reported by Wiebe (1973), Singh *et al.* (1987), Grevsen *et al.* (2003), Sharma and Behera (2003), Gopalakrishnan (2004), Kumar *et al.* (2009) and Susheela and Rangaswamy (2011).

Interaction effects varied significantly and incidence of riceyness, hairiness, leafiness and buttoning was lowest in November 1st sowing of NS 60N, G 45 and Pusa Meghna. Low incidence of these disorders were observed in October 1st sowing of Pusa Hybrid 2 also, but in the latter seasons it exhibited disorders like buttoning, leafiness and hairiness.

5.1.7 Pests and diseases

Temperature, rainfall and relative humidity are the critical climatic factors that have profound effect on incidence of pests and diseases. The above condition influences the activity and seasonal population dynamics of insects (Huffaker *et al.*, 1999; Huey and Berrigan, 2001; Roy *et al.* 2002) and it provides a congenial condition for fungal pathogens causing diseases. Similar situation was experienced in the present study also.

During the course of the study, the important biotic stress factors noticed were leaf caterpillar (*Spodoptera litura*), *Alternaria* blight (*Alternaria brassicae*), soft rot (*Pythium* sp.) and *Choanephora* rot (*Choanephora* sp.). Least incidence was observed in November 1st sowing, since the active vegetative period and curding time coincides with low temperature, rainfall and relative humidity. No significant difference among sowing dates was observed for the incidence of curd rot (*Alternaria brassicae*).

High incidence of pests and diseases like leaf caterpillar, *Alternaria* leaf blight, *Choanephora* rot, soft rot and curd rot were observed for certain treatments during the period. Among the varieties low incidence of these pests and diseases were noticed in NS 60N, Himpriya 60, G 45 and Himshort. Various workers have reported incidence of the above pests and diseases in cauliflower i.e., leaf caterpillar (*Spodoptera litura*) by Monobrullah *et al.* (2007) and Chand and Tripathi, (2008); leaf blight and curd rot caused by *Alternaria brassicae* by Pandey *et al.* (2002), Kohl *et al.* (2010) and Deep and Sharma (2012); *Choanephora* rot caused by *Choanephora* sp. By Pavgi (1970) and Siddiqui (1974) and soft rot caused by *Pythium aphanidermatum* by Sharma and Sain (2005).

Low incidence of leaf caterpillar, *Alternaria* blight, *Choanephora* rot, soft rot and curd rot were observed in November 1st sowing of NS 60N, G 45, Himpriya 60, White snow and Pusa Sharad.

5.1.8 Morphological characters

Almost all the varieties had erect leaf orientation which contributes to self blanching character and hence mostly preferred. Pusa Sharad with very erect and Pusa Shukti with flat leaf orientation resulted in low yield and curd quality. The experimental site experienced high temperature and as a result most of the varieties had creamy white curd colour.

5.1.9 Influence of weather parameters

The transition from the vegetative to the generative phase in plants is a complex morphogenetic process. The length of the juvenile phase is specific to species and variety (Wiebe, 1994). According to Miller *et al.* (1985) and Wurr *et al.* (1995), the main factor for the transition from the vegetative to the generative phase of cauliflower is the temperature. Significant correlation coefficients between the curd yield and yield attributing characters were observed with the weather parameters.

In the present study, the crop gave better yield when the minimum and maximum temperature during curd initiation stage was 20.8°C and 30.6°C respectively which coincided with the November 1st sowing while low yield was experienced when the temperature was high as 24.3°C and 32.5°C respectively which coincided with the November 15th sowing. This result is in corroboration with the findings of Ajithkumar (2005) who reported that maximum, minimum and mean temperatures were negatively and significantly correlated with number of days during the curd induction phase and curd maturity phase.

Cauliflower varieties are very much sensitive to temperature and play an important role in vegetative, curding and reproductive phases of the plant (Premnath *et al.* 1996). In the present study, the performance of mid season varieties like Pusa Sharad, Pusa Hybrid 2, Pusa Paushja, Pusa Shukti and Indam 2435 were greatly affected by high temperature and rainfall. Susheela and Rangaswamy (2011) reported delayed curd formation of cauliflower varieties when mean maximum temperature and average temperature exceeded 33.5°C and 30.5°C respectively which was in line with the above findings.

Incidence of physiological disorders is also greatly influenced by temperature. The occurrence of leafiness or 'bracting' was positively correlated with the average temperature during the 10 days after curd initiation but there were large cultivar differences. The incidence of 'riceyness' was positively correlated with the temperature from 15 to 25 days after curd initiation (Grevsen and Olesen, 1994). The results of the present study also revealed that high temperature during curd development phase leads to physiological disorders.

In the present study profound influence of increase in temperature and rainfall on the incidence of leaf caterpillar was observed. Similar results were reported by Golizadeh *et al.* (2009) for the incidence of diamond back moth (*Plutella xylostella).*

5.2 Variability studies

The magnitude of variability present in a population is of utmost importance as it provides the basis for effective selection. Since the observed variability in a population is the sum of variation arising due to the genotypic and environmental effects, knowledge on the nature and magnitude of genetic variation contributing to gain under selection is essential. The PCV and GCV are the components used to measure the variability present in a population.

In the present investigation, the phenotypic coefficient of variation (PCV) was greater than genotypic coefficient of variation (GCV) for all the traits, which indicates that the genotypic expression was super-imposed by the environmental influence. Such environmental interference in the manifestation of these characters was earlier reported by Jamwal *et al.* (1992).

The PCV and GCV were highest for curd size index, net curd weight, gross curd weight, harvest index and percentage of curding. Range of curd size index and net curd weight was 5.46 - 199.98 cm and 20.00 - 670.00 g respectively. Similar findings were also reported by Kumar *et al.* (2006), Sharma *et al.* (2006) and Singh *et al.* (2006). For selection of such characters, therefore, more vigorous testing of progenies over different environments may be required.

High and closer estimates of phenotypic and genotypic coefficients of variability were observed for gross plant weight, curd and yield characters suggesting greater contribution of genotype rather than environment. These results were in line with Kumar and Korla (2001), Kanwar and Korla (2002) and Singh (2010).

Protein content recorded lowest GCV indicating limited scope for improvement of this trait through selection due to low magnitude of variability. Wide estimates of PCV and GCV for Vitamin A content revealed the influence of environment on this character.

High magnitude of PCV, GCV and their difference for incidence of physiological disorders like riceyness, hairiness, leafiness, buttoning and incidence of pests and diseases like leaf caterpillar, *Alternaria* blight, *Choanephora* rot and curd rot were observed.

From the foregoing discussions, it is clear that the characters *viz.*, curd size index, net curd weight, gross curd weight, harvest index offer good scope for improvement through selection in cauliflower.

5.3 Heritability and genetic advance

The variability existing in a population is the sum total of heritable and non heritable components. A high value of heritability indicates that the phenotype of that trait strongly reflects its genotype. The magnitude of heritability indicates the effectiveness with which selection of the genotypes can be made based on the phenotype.

In the present investigation, the heritability estimates were high for all characters studied except for Vitamin A content and incidence of riceyness, hairiness, leafiness, *Alternaria* blight and curd rot which have least heritability. High heritability can be attributed to the greater role of additive gene and additive x additive gene action, which can be exploited by following simple selection. Similar reports have also been put forward by Singh *et al.* (1995), and Reddy and Varalakshmi (1995). High heritability for yield and yield attributes in cauliflower was reported by many workers earlier (Aggarwal, 2004; Jindal and Thakur, 2004; Sharma *et al.* 2006; Kumar *et al.* 2006; Singh *et al.* 2006; Dhatt and Garg, 2008; Singh *et al.*, 2010; Mahesh *et al.* 2011).

Kumar and Korla (2001) observed high heritability (82.79%) for number of leaves per plant and stalk length in cauliflower. High heritability for days to curd maturity was reported by Jindal and Thakur, (2004) and for curd depth and curd solidity by Spehia (1997).

High heritability estimates indicate the effectiveness of selection based on good phenotypic performance but does not necessarily mean high genetic gain for the particular character. Johnson *et al.* (1955) pointed out that high heritability along with high genetic advance would be useful than heritability values alone in predicting the resultant effect of selecting the genotype.

High values of genetic advance as percentage of mean (> 20 %) were obtained in the present study for gross plant weight, leaf size, days to curd formation, days to curd harvest, days to curd maturity from curd initiation, days to curd maturity, curd depth, curd diameter, curd size index, stalk length, net curd weight, gross curd weight, harvest index and percentage of curding. The results are in line with the findings of Kumar and Korla (2001), Kumar *et al.* (2001), Kanwar and Korla (2003) Pathania (2003) and Aggarwal (2004). On the other hand, Mahesh *et al.* (2011) reported high genetic advance for curd compactness which is contradictory to the present findings wherein compactness exhibited low genetic advance. Biochemical characters like Vitamin A content showed high genetic advance whereas, protein content had low genetic advance. Incidence of physiological disorders like riceyness, hairiness, buttoning and pests and diseases like leaf caterpillar and *Choanephora* rot had least genetic advance.

In present study net curd weight, gross curd weight, harvest index, gross plant weight, leaf size, days to curd formation, days to curd harvest, days to curd maturity from curd initiation, days to curd maturity, curd depth, curd diameter, curd size index, stalk length and percentage of curding recorded high heritability coupled with high genetic advance indicates the presence of flexible additive gene effects and will be a useful criterion for selection for these characters. This result confirms the findings of Kumar and Korla (2001), Pathania (2003), Kumar *et al.* (2006), Sharma *et al.* 2006) and Dhatt and Garg (2008) who reported high heritability coupled with high genetic advance for whole plant weight, leaves per plant, gross curd weight, net curd weight and stalk length. High heritability and low genetic advance observed for plant height and curd compactness in the present study is in accordance with the findings of Singh *et al.* (2010).

High heritability coupled with low genetic advance was observed for protein content whereas low heritability coupled with high genetic advance was observed for Vitamin A content.

5.4 Correlation Studies

Correlation coefficient analysis measures the mutual relationship between various plant characters and determines the component characters on which selection can be based for improvement in yield. Correlation provides information on the nature and extent of relationship between all pairs of characters. So when the breeder applies selection for a particular character, not only it improves that trait, but also provides a reliable measure of genetic association between them, which is useful in the breeding programmes.

In the present study, high and positive phenotypic and genotypic correlation was obtained between net curd weight and leaves per plant, leaf size, gross plant weight, curd depth, curd diameter, curd size index, harvest index and percentage of curding. It exhibited significant negative correlation with plant height, days to curd initiation, days to curd harvest, days to curd maturity from curd initiation, days to curd maturity, curd compactness and stalk length.

Positive genotypic correlation of net curd weight with leaves per plant, leaf size, gross plant weight, curd diameter, curd depth, curd size index, gross curd weight, harvest index was in line with the results reported by Kanwar and Korla

(2003), Kumar and Thakur (2003), Pathania (2003), Garg and Lal (2004), Sharma *et al.* (2006), Kanwar *et al.* (2010) and Mahesh *et al.* (2011).

Singh *et al.* (2006) reported that net curd weight was negatively correlated with curd compactness which was in line with the findings of present study. On the other hand, Aditya *et al.* (1989), Spehia (1997), Kanwar and Korla (2002), Kumar (2002), Pathania (2003), Garg and Lal (2004) and Kanwar *et al.* (2010) reported that curd compactness was positively correlated with net curd weight which was contrary to the present findings.

Positive correlations between net curd weight and curd depth, curd diameter and curd size index was reported by Kumar and Thakur (2003), Pathania (2003), Garg and Lal (2004), Lui *et al.* (2004), Sharma *et al.*, (2006) and Kanwar *et al.* (2010) which was in accordance with the present findings.

Positive correlations between net curd weight and stalk length was reported by Aditya *et al.* (1989) and Kanwar and Korla (2002) which contradicts the present findings.

Booij (1990), Dhatt and Garg (2008) and Mahesh *et al.* (2011) observed negative correlation of days to curd maturity on net curd weight which was in conformity with the present findings while the findings of Pathania (2003) and Kanwar *et al.* (2010) were against the above result.

Positive and high phenotypic and genotypic correlation of net curd weight with other characters implies that these characters can be taken into consideration for indirect selection for yield improvement in cauliflower.

In general magnitude of genotypic correlation coefficients was higher than the corresponding phenotypic correlation coefficients for the characters positively correlated with yield indicating low environmental influence on these characters.

5.5 Path analysis

The path analysis unravels whether the association of the component characters with yield is due to their direct effect on yield, or is a consequence of their indirect effect via some other trait(s). Thus path analysis helps in partitioning the genotypic correlation coefficient into direct and indirect effects of the component characters on the yield on the basis of which improvement programmes can be devised effectively. If the correlation between yield and any of its components is due to the direct effect, it reflects a true relation between them and selection can be practiced for such a character in order to improve yield. But if the correlation is mainly due to indirect effect of the character another component trait, the breeder has to select the latter trait through which the indirect effect is exerted.

In the present study leaves per plant, gross plant weight, leaf size, curd depth and curd size index showed positive direct effect on net curd weight. This is in line with the findings of Kumar and Thakur (2003), Kanwar and Korla (2003), Singh *et al.* 2006) and Sharma *et al.* (2006). But, Singh *et al.* (2006) observed that leaf size was negatively correlated with net curd weight which contradicts the present findings.

Plant height, days to curd initiation and stalk length had negative direct effect on net curd weight. Contrary to the present findings, Kumar and Thakur (2003) reported that plant height had positive direct effect on yield and Mahesh *et al.* (2011) observed that days to curd initiation had positive direct effect on net curd weight.

5.6 Selection index

Discriminant function analysis developed by Fisher (1936) gives information on the proportionate weightage to be given to a yield component. Thus, selection index was formulated to increase the efficiency of selection by taking into account the important characters contributing to yield. Further Hazel (1943) suggested that selection based on suitable index was more efficient than individual selection for the characters.

The characters used for constructing selection index were days to curd initiation, days to curd harvest, curd depth, curd diameter, net curd weight and percentage of curding. Based on the selection index values, top ranking varieties were NS 60N (2717.20), G 45 (2016.52), Himpriya 60 (1883.28), White Snow (1861.26), Himlatha (1822.47), Himshort (1794.14) and Pusa Meghna (1791.04) They were identified as superior ones in terms of curd and yield characters.

The results of the present study identified two hybrids namely NS 60 N and G 45 and a variety Pusa Meghna as promising for cultivation in the southern parts of Kerala. The most ideal time of sowing was November 1st for better quality and yield.

Summary

6. SUMMARY

The study entitled "Evaluation of cauliflower (*Brassica oleracea* L. var. *botrytis*) for southern Kerala" was conducted at the Department of Olericulture, College of Agriculture, Vellayani, during the period October 2012 to March 2013. The main objective of the experiment was the identification of tropical cauliflower varieties suitable for plains of southern Kerala and to study the influence of date of sowing and their interactions on yield and quality.

The experiment was laid out in split plot design with four sowing dates as main plot treatment and 12 varieties of cauliflower as the subplot treatments constituting forty eight treatments with five replications. The sowing dates were 1st October, 15th October, 1st November and 15th November. The 12 varieties were Pusa Meghna, Pusa Sharad, Pusa Paushja, Pusa Hybrid 2, Pusa Shukti, NS 60 N, Himshort, Himlatha, Himpriya- 60, Indam 2435, G 45 and White Snow.

Observations were recorded on important vegetative, curd and yield characters. The data generated were analysed, presented in tables and discussed in previous chapters. Genetic analysis was also carried out. The findings of the study are summarised below.

- The direct effect of the treatments showed that highest plant height was for November 1st sowing and the variety, Himpriya 60. The interaction effect revealed that highest plant height was for Pusa Paushja sown on November 1st.

- Highest leaf number per plant was recorded by November 1st sowing and Himpriya 60. D x T interaction showed that Himpriya 60 sown on October 15th had maximum number of leaves.

- November 1st sowing recorded highest gross plant weight and among varieties it was for Himpriya 60. Interaction effect showed that maximum gross plant weight was for Himpriya-60 sown on November1st.

- Leaf length, breadth and size were significantly influenced by different sowing dates and varieties. November 1st recorded maximum values for these characters and among varieties, Himpriya 60 was the best. Interaction effect revealed that November 1st sowing of Himpriya 60 was superior for leaf length and size whereas, for leaf breadth Pusa Hybrid-2 sown on November 1st was the best.

- Sowing on November 15th resulted in earliest curd initiation. Among varieties, Himshort followed by NS 60N was the earliest. D x T interactions showed that October 15th sowing of Pusa Shukti and October 1st sowing of Himshort were earlier.

- Earliest curd harvest was for October 1st sowing and among varieties Himshort (49.04 days). Interaction effect was significant and October 1st sowing of Himshort resulted in early curd harvest.

- Minimum days from transplanting to curd maturity was observed in October 1st sowing. Among varieties Himshort followed by NS 60N was the earliest. Interaction effects showed that November 1st sowing of Himshort resulted in early maturity.

- November 1st sowing resulted in maximum curd depth, curd diameter and curd size index. Among varieties, NS 60N and G 45 were superior for these characters. For curd depth and curd size index interaction effect was high in October 1st sowing of Pusa Hybrid 2 whereas, for curd diameter November 1st sowing of NS 60N was the best.

- Curd compactness was high for November 15th sowing and Pusa Sharad. D x T interaction was highest for October 15th sowing of Pusa Hybrid 2.

- November 1st sowing resulted in minimum stalk length. Among varieties NS 60N was superior. D x T interaction showed that November 1st sowing of Pusa Meghna resulted in least stalk length.

- The most important character, the net curd weight was influenced by different sowing dates and varieties. November 1st sowing resulted in maximum (361.69 g) net curd weight. It was highest for NS 60 N (454.02 g) followed by G 45 (362.27 g). Among the interaction effects November 1st sowing of NS 60N recorded highest net curd weight (629.33 g).

- Gross curd weight was also influenced by different sowing dates and varieties. November 1st sowing resulted in maximum gross curd weight. It was highest for NS 60 N followed by G 45. Interaction effects showed that highest gross curd weight was obtained for November 1st sowing of NS 60N.

- Highest harvest index and curding percentage were recorded by November 1st sowing and NS 60 N. Interaction effects showed that November 1st sowing of NS 60N was the best for these characters.

- Yield per plot and per hectare revealed that November 1st sowing was the best and NS 60N was the top yielder. The interaction effects showed that NS 60N sown on November 1st resulted in highest yield.

- There was no significant difference between sowing dates for protein and vitamin A content whereas, varietal influence was significant. Among varieties Pusa Hybrid 2 recorded highest protein and Pusa Meghna had highest Vitamin A content. The interaction effects showed that November 15th sowing of Pusa Hybrid 2 was superior for protein content while, November 15th sowing of Pusa Meghna for Vitamin A content.

- There was no significant difference between sowing dates, varieties and their interactions for vitamin C content and it varied between 51.16 mg/100g and 72.04 mg/100g.

- November 1st sowing recorded lowest incidence of all physiological disorders like riceyness, hairiness and leafiness except buttoning. Varietal difference and interaction effects were also significant.

- Incidence of pest like leaf caterpillar (*Spodoptera litura*) and diseases like *Alternaria* blight, soft rot, *Choanephora* rot and curd rot differs significantly among sowing dates, varieties and their interactions.

- Phenotypic and genotypic coefficients of variation were high for curd compactness, curd size index, net curd weight, gross curd weight, harvest index, incidence of physiological disorders, pests and diseases.

- Heritability along with genetic advance were high for gross plant weight, leaf size, days to curd initiation, days to curd harvest, days to curd maturity, curd depth, curd diameter, curd size index, net curd weight, gross curd weight and percentage of curding.

- At genotypic level net curd weight showed high positive correlation with leaves per plant, curd depth, curd diameter and curd size index.

- Path coefficient analysis revealed that leaves per plant, leaf size, gross plant weight, curd depth and curd size index had high positive direct effect on yield.

- In the present study selection index was worked out and the top ranking varieties were NS 60N, G 45, White Snow, Himpriya 60 and Pusa Meghna.

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Appendices

APPENDIX - I

Descriptor for cauliflower

1. Seedling pigmentation

    1 Absent

    9 Present

2. Seedling leaf colour

    1 White green
    2 Yellow green
    3 Light green
    4 Green
    5 Dark green
    6 Purple green
    7 Purple
    8 Other

3. Seedling leaf margin serration

    0 No serration
    1 Crenate
    2 Dentate
    3 Doubly dentate
    4 Other

4. Seedling pubescence

    0 Glabrous
    1 Very sparse (leaf margin only)
    3 Sparse
    5 Intermediate
    7 Abundant

5. Leaf orientation

    1 Flat
    2 Semi- erect
    3 Erect
    4 Very erect

6. Leaf shape

    3 Narrow elliptic

    5 Elliptic

    7 Broad elliptic

7. Leaf colour

    1 Light green

    2 Dark green

    3 Bluish green

8. Leaf waxiness

    1 Absent

    3 Light

    5 Medium

    7 Strong

9. Leaf torsion of tip

    1 Absent

    3 Weak

APPENDIX – I Continued

5 Medium

7 Strong

8. Leaf puckering

1 Absent

3 Weak

5 Medium

7 Strong

10. Leaf: crimping near vein

1 Absent

3 Weak

5 Medium

7 Strong

11. Undulation of leaf margin

1 Absent

3 weak

5 Medium

7 Strong

12. Curd covering by inner leaves

3 Not covered

5 Partly coverd

7 Covered

13. Curd doming

3 Weak

5 Medium

7 Strong

14. Curd shape in longitudinal section

1 Circular

2 Broad elliptic

3 Narrow elliptic

14. Curd colour

1 White

2 Creamy white

3 Yellow

15. Curd knobbing

3 Fine

5 Medium

7 Coarse

16. Curd texture

3 Fine

7 Coarse

17. Curd compactness

3 Loose

APPENDIX – I Continued

5 Medium

7 Compact

18. Curd anthocyanin colouration

1 Absent

9 Present

APPENDIX - II

Weather data for the cropping period

(Oct 2012 to March 2013)

Standard week	Temperature (°C) (maximum)	Temperature (°C) (minimum)	Rainfall (mm)	Relative Humidity (%)
40	31.2	23.5	0.0	89.6
41	31.4	24.1	6.3	90.3
42	29.4	23.4	10.7	94.4
43	30.1	23.9	7.5	94.6
44	29.8	23.3	12.5	91.9
45	30.1	23.0	15.8	96.9
46	30.3	23.2	3.0	95.6
47	30.5	23.1	1.0	98.6
48	30.6	22.7	0.0	99.0
49	30.5	22.6	0.5	99.0
50	30.6	22.1	0.0	99.0
51	31.1	22.8	0.0	91.4
52	30.5	23.5	13.3	99.0
1	30.6	23.4	8.8	95.4
2	30.0	22.6	24.0	96.4
3	30.1	20.8	0.0	96.0
4	30.5	21.3	0.0	96.1
5	30.4	20.8	0.0	94.3
6	31.2	22.9	2.5	93.3
7	32.0	23.0	11.0	92.4
8	31.4	21.8	0.0	89.9
9	32.0	21.4	0.0	91.3
10	32.1	24.3	7.0	94.7
11	32.3	23.9	34.0	93.4
12	32.3	23.7	0.0	91.4
13	32.5	23.3	31.0	92.7

EVALUATION OF CAULIFLOWER (*Brassica oleracea* L. var. *botrytis*) FOR SOUTHERN KERALA

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Abstract of the

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ABSTRACT

The present investigation on "Evaluation of cauliflower (*Brassica oleracea* L. var. *botrytis*) for southern Kerala" was conducted at the Department of Olericulture, College of Agriculture, Vellayani, during the period October 2012 to March 2013. The objectives were to identify tropical cauliflower varieties suitable for plains of southern Kerala and to study the influence of date of planting on yield and quality.

The experiment was laid out in the field in split plot design with four dates of sowing as main plot and 12 varieties of cauliflower as sub plot treatments with five replications.

Analysis of variance revealed significant difference among sowing dates, varieties and their interactions for all the characters studied.

Among the sowing dates, November 1st sowing recorded highest curd and yield characters. Highest net curd weight was recorded for November 1st sowing (361.69 g) followed by October 1st sowing (336.57 g). Sowing on November 15 resulted in early curd initiation whereas that on October 1 resulted in early curd harvest. Better plant height, leaves per plant, gross plant weight, leaf length, leaf breadth and leaf size were also exhibited by November 1st sowing. No significant differences were observed between different sowing dates for quality characters like protein, vitamin A and vitamin C. Least incidence of physiological disorders, pest and diseases were observed on November 1st sowing.

Among the varieties, NS 60N was the highest yielder (454.02 g) based on yield characters. Curd depth, curd diameter and curd size index were also highest for NS 60N followed by G 45. Earliest among the varieties was Himshort followed by NS 60N and the late varieties were Pusa Sharad and Pusa Hybrid-2. Himpriya-60 exhibited highest plant height, leaves per plant, gross plant weight, leaf length, leaf breadth and leaf size. Significant differences were observed among treatments for all quality characters except vitamin C.

The interaction effects were significant for all the characters studied. Yield characters were best for NS 60N (629.33 g) sown on November 1st. Best curd characters were exhibited by October 1st sowing of Pusa Hybrid 2 followed by November 1st sowing of NS 60N. Himpriya-60 sown on November 1st recorded highest plant height, leaves per

plant, gross plant weight and leaf size. Himshort sown on October 1st was the earliest. Least incidence of physiological disorders, pest and diseases were observed on November 1st sowing. No significant differences were observed between different sowing dates for quality characters like protein, vitamin A and vitamin C.

Variability among genotypes for all the characters was studied using phenotypic and genotypic coefficient of variation, heritability and genetic advance. Correlation and path analysis studies revealed high positive correlation of plant height, number of leaves, leaf size, days to curd initiation, curd depth, curd size index and stalk length to yield. Selection index values were worked out based on discriminant function analysis and found that NS 60N was the best.

The study identified two high yielding varieties namely NS 60N and G 45 as promising and November 1st sowing as the best sowing time for cultivation in southern Kerala.

സംഗ്രഹം

"ദക്ഷിണ കേരളത്തിനു അനുയോജ്യമായ കോളിഫ്ലവറിന്റെ (ബ്രാസ്സിക്ക ഒളറേസ്യ ഇനം ബോട്രൈറ്റിസ്) മൂല്യനിർണയം"എന്ന നിരീക്ഷണം വെള്ളായണി കാർഷിക കോളേജിലെ ഒളരിക്കൾച്ചർ വിഭാഗത്തിൽ ഒക്ടോബർ 2012 മുതൽ മാർച്ച് വരെയുള്ള കാലഘട്ടത്തിൽ നടത്തി .

ദക്ഷിണ കേരളത്തിലെ സമതല പ്രദേശങ്ങൾക്കനുയോജ്യമായ കോളിഫ്ലവർ ഇനങ്ങൾ തിരിച്ചറിയുക എന്നതും നടീൽ സമയത്തിനു ആദായത്തിലും ഗുണത്തിലുമുള്ള സ്വാധീനം മനസ്സിലാക്കുക എന്നതുമായിരുന്നു ഈ പഠനത്തിൻറെ ഉദ്ദേശ്യം.

നാല് നടീൽ സമയം മുഖ്യ കണ്ടത്തിലും 12 കോളിഫ്ലവർ ഇനങ്ങൾ കീഴ് കണ്ടത്തിലും എന്ന രീതിയിൽ അഞ്ചു ആവർത്തനങ്ങളായി സ്പ്ലിററ് പ്ലോട്ട് രൂപരേഖയിലാണ് ഈ പരീക്ഷണം നടത്തിയത്.

നടീൽ സമയവും കോളിഫ്ലവർ ഇനങ്ങളും അവയുടെ പരസ്പര പ്രവർത്തനങ്ങളും തമ്മിലുള്ള വ്യത്യസ്തതയുടെ അപഗ്രഥനം ഇവയിലുള്ള പ്രബലമായ വ്യത്യാസത്തെ സൂചിപ്പിച്ചു.

നവംബർ ഒന്നാം തീയതി വിത്ത് പാകിയ ചെടികളിൽ നിന്നും നല്ല വിളവു ലഭിച്ചതായി നിരീക്ഷണത്തിലൂടെ കണ്ടെത്തി. ഏറ്റവും വലിയ കോളിഫ്ലവർ കർഡുകൾ നവംബർ ഒന്നാം തീയതി പാകിയ ചെടികളിലും (361.69 ഗ്രാം) തുടർന്ന് ഒക്ടോബർ ഒന്നാം തീയതി പാകിയ ചെടികളിലും (336.59 ഗ്രാം) നിന്നു ലഭിച്ചു. ഒക്ടോബർ ഒന്നാം തീയതി പാകിയ ചെടികളിൽ വേഗത്തിൽ കർഡുകൾ പാകമായതായി കണ്ടു. നവംബർ ഒന്നാം തീയതി പാകിയ ചെടികളുടെ ഉയരം, ഭാരം, ഇലകളുടെ എണ്ണം, വിസ്തീർണ്ണം എന്നിവ കൂടുതലായി കണ്ടു. മാംസ്യം, ജീവകം എ, സി എന്നിവയുടെ അളവിൽ വിത്ത് പാകുന്ന സമയമനുസരിച്ച് പ്രബലമായ യാതൊരു വ്യത്യാസവും കണ്ടെത്താനായില്ല. എന്നാൽ നവംബർ ഒന്നാം തീയതി പാകിയ ചെടികളിൽ കീടരോഗങ്ങൾ നന്നേ കുറവായതായി കാണപ്പെട്ടു.

കർഡിന്റെ തൂക്കം, നീളം, വീതി, വലുപ്പം എന്നിവയിൽ NS 60N, G 45 എന്നീ ഇനങ്ങൾ മുന്നിലായി കണ്ടു. ഹിംഷോർട്ട്, NS 60N എന്നിവ വേഗത്തിൽ കർഡ് ഉണ്ടാകുന്നവയാണെന്നു നിരീക്ഷിച്ചു. ചെടികളുടെ ഉയരത്തിലും, ഇലകളുടെ എണ്ണത്തിലും വലുപ്പത്തിലും, മൊത്തം ചെടിയുടെ ഭാരത്തിലും ഹിംപ്രിയ-60 എന്ന ഇനം മികച്ചു നിൽക്കുന്നതായി കണ്ടു. മാംസ്യം, ജീവകം

എ എന്നിവയുടെ അളവിൽ ഇനങ്ങൾ തമ്മിൽ പ്രബലമായ വ്യത്യാസം ഉള്ളതായി കണ്ടെത്തി.

വിത്ത് പാകുന്ന സമയവും കോളിഫ്ലവർ ഇനങ്ങളും തമ്മിലുള്ള പാരസ്പര്യബന്ധത്തിലും പ്രബലമായ വ്യത്യാസങ്ങൾ കണ്ടെത്താനായി. നവംബർ ഒന്നാം തീയതി വിത്ത് പാകിയ NS 60N (629.33 ഗ്രാം) എന്ന ഇനം ആദായത്തിലും ഗുണത്തിലും മികച്ചു നിന്നു. ഒക്ടോബർ ഒന്നാം തീയതി പാകിയ പുസ ഹൈബ്രിഡ് 2 ഉം തുടർന്ന് നവംബർ ഒന്നാം തീയതി പാകിയ NS 60N ഉം മികച്ച ഗുണങ്ങൾ രേഖപ്പെടുത്തി. ചെടികളുടെ ഉയരം, ഭാരം. ഇലകളുടെ എണ്ണം വലുപ്പം എന്നിവയിൽ നവംബർ 1 നു പാകിയ ഹിംപ്രിയ-60 എന്ന ഇനം മികവ് പുലർത്തി. മാത്രമല്ല ഒക്ടോബർ ഒന്നാം തീയതി പാകിയ ഹിംഷോർട്ട് എന്ന ഇനത്തിൽ വേഗത്തിൽ കർഡ് ഉണ്ടായതായും നിരീക്ഷിച്ചു.

കോളിഫ്ലവർ ഇനങ്ങളുടെ വ്യത്യസ്തതാ പഠനത്തിനായി കോഎഫിഷ്യന്റ് ഓഫ് വേരിയേഷൻ, ഹെറിറ്റബിലിറ്റി, ജെനറ്റിക്ക് അഡ്വാൻസ്, കോറിലേഷൻ, പാത്ത് അനാലിസിസ്, സെലക്ഷൻ ഇൻഡക്സ് തുടങ്ങിയ രിതികൾ അവലംബിച്ചു. ഇതിലൂടെ ഇലകളുടെ എണ്ണം, വിസ്തീർണ്ണം, കർഡിന്റെ വീതി, വലുപ്പം എന്നിവ ആദായവുമായി അനുബന്ധപ്പെട്ടിരിക്കുന്നതായി കണ്ടെത്തി.

ഈ നിരിഷണത്തിലുടെ NS 60N, G 45 എന്നീ ഇനങ്ങൾ ദക്ഷിണ കേരളത്തിലെ സമതലങ്ങളിൽ കോളിഫ്ലവർ കൃഷിക്ക് അനുയോജ്യമാണെന്നും നവംബർ ഒന്നാം തീയതി വിത്ത് പാകാൻ യോജിച്ച സമയമാണെന്നും കണ്ടെത്തി.