STANDARDIZATION OF SEED PRODUCTION TECHNIQUES OF CAULIFLOWER (*Brassica oleracea* var. *botrytis* L.) IN TERAI ZONE OF WEST BENGAL

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Dedicated to my father whose unfailing love has always inspired me

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CERTIFICATE

This is to certify that the work recorded in the thesis entitled **"Standardization of seed production techniques of cauliflower (*Brassica oleracea* var. *botrytis* L.) in terai zone of West Bengal"** submitted by Sri Jagadish Chandra Jana in partial fulfilment of the requirements for the award of the degree of Doctor of philosophy (Ph.D.) in Vegetable Crops of Bidhan Chandra Krishi Viswavidyalaya, is the faithful and bonafide research work carried out under my personal supervision and guidance.

The results of the investigation reported in the thesis have not so far been submitted for any other Degree or Diploma. The assistance and help received during the course of investigation have been duly acknowledged.

(T. P. Mukhopadhyay)

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Chapter - I

Introduction

INTRODUCTION

Cauliflower is an important cole crop widely grown in tropical to temperate regions of the world. World leaders of cauliflower production are China and India, followed by France, Italy, the United Kingdom and the U.S. (Swiader *et al.*, 1994). To meet our requirement of vegetables adequately for the rapidly increasing population, the area and production of vegetables will have to be increased manifold. Development of suitable cultivars and availability of their quality seeds are the essential pre-requisites in this respect. Vegetable seed production in the country, therefore, needs to be streamlined by establishing more and more seed farms at regional levels so as to meet the local requirement. Production and supply of quality seeds are not upto the requirements due to lack of proper agrotechniques which hampers the production of cauliflower.

The cauliflower, *Brassica oleracea* var. *botrytis* L. is considered to have been domesticated in the Mediterranean region since the greatest range of variability in wild types of *Brassica oleracea* is found there. It was originated in the island of Cyprus from where it moved to other areas like Syria, Turkey, Egypt, Italy, Spain and north western Europe . It was introduced into India from the U.K in 1822. Seeds of cauliflower used in India were mostly imported from European countries. During the World War II, there had been difficulty in the import of seeds. So attempts were made to produce seeds of temperate vegetables in India. It was started at Quetta (now in Pakistan) during 1942. Some seed production programmes were also undertaken at Katrain (H.P.) and Kashmir Valley during 1942-43. During this period, vegetable seed industry made a rapid progress in comparison with field crops (Arya, 1999).

It is comparatively easy to grow seeds of cauliflowers as it is well adopted to warm weather conditions, some seeds of which were raised in North Indian plains (Lancaster, 1943; Raula, 1949 and Singh, 1955). The regions where early cauliflower seeds are commonly produced are U.P. and Bihar. Seeds can, however, be produced in other regions like Delhi, Punjab and Rajasthan. But it is not possible to grow seeds of the mid-season and late types of cauliflower in the plains of the country. Techniques have now been developed and seed production of late varieties of cauliflower is now possible in the Kulu Valley, parts of the Kashmir Valley, Himachal Pradesh, the Darjeeling Hills and the Nilgiris (Gill *et al.*, 1975 and Choudhury, 1987).

The cauliflower plant is a low herb and cultivated for the terminal dense 'curd' which is a highly suppressed and extremely ramified hypertrophied flower stalk and presently thought as the prefloral fleshy apical meristem. Stem is stout and short, leaves are long-oblong or elliptic; flowers are typical of Cruciferae family having 4 sepals, 4 petals, 6 stamens of which 2 are short, 2 carpels with superior ovary and a special kind of pod called siliqua (Sharma, 1995). Cauliflower is a cross-pollinated crop. Pollination is mainly done by insects like honeybees, blowflies,etc. Cauliflowers have the same chromosome number (2n=18) as the other cole crops. Since the cultivated cole crops are botanical varieties of *Brassica oleracea*, all crosses freely with each other. Therefore, seed fields should be isolated from the contaminants like other varieties and all other kinds of cole crops like cabbage, wild cabbage, brussels sprouts, sprouting brocoli, etc. For foundation and certified seed production, the isolation distance shall be 1600 and 1000 metres, respectively.

Cauliflower is a sensitive crop and the varieties are very specific to seasons. Broadly these have been devided into four groups (Swarup and Chatterjee, 1974).

Maturity Group I - Early varieties

a) September maturity - Early Kunwari, Early Patna, Early Banaras.

b) October maturity - Pusa Katki, Pusa Deepali.

Maturity Group II - Mid-season varieties

November maturity-Improved Japanese, Aghani, Poosi, Synthetic-II.

Maturity Group III - Main season varieties

December maturity-Giant Snowball, Patna Snowball, Synthetic-III , Hisar - I , D-96, Early Snowball.

Maturity Group IV - Late varieties

January maturity-Snowball , Pusa Snowball, Indian Snowball, Snowball - 16 , Dania, Dania Kalimpong.

Cauliflower can be grown in all types of soils with good fertility and good water regime. However, for early crops in tropical to sub-tropical regions a light medium soil may be preferred so that the drainage is easier in the rainy season. However, medium to heavy soils rich in humus are considered the best. The sandy soils may not be ideal for the production of cauliflower because the curds formed are loose and create difficulty in the rouging of off- types.

A thorough rouging of off-types and undesirable plants is essential for quality seed production (Choudhury,1987). Four crop inspections have been prescribed *viz*., i) at vegetative stage, ii) at curd initiation stage, iii) at curd maturity stage and iv) at flowering stage. The first three inspections are done for roughing of off-types and diseased plants and the last one for checking isolation (Sharma,1995) . These plants should also be uprooted where curds are buttons, loose, ricy and fuzzy; early bolters and those bolting from centre should be removed.

In cauliflower seed production, the studies have been mainly directed towards : i) transplanting of plants with fully developed curds or in - situ growing of crops ; and ii) scooping and non-scooping of curds. Lancaster (1943) reported production of better quality seeds by transplanting of plants with ball of earth when curds developed fully which was later contradicted by Raula (1949), Singh *et al.* (1959); Tripathi and Singh (1969) and Sharma and Arya (1979). The seeds produced from the plants left in-situ were apparently bolder in size than those from transplanted ones. In-situ method produced higher yields of seed and no difference was observed in the quality of curds of the plants raised from different treatments except that the plants raised from seeds obtained in-situ method formed curds 4 to 11 days earlier than those from other treatments (Choudhury and Ramphal,1961). Singh *et al.* (1978) reported that in-situ planting accelerated flowering and resulted in more and larger flower stalks, better fruit set and higher seed yields. There was no difference in the viability of seeds.

Scooping the central portion of the curd when it was fully formed helped in the early emergence of the flower stalks (Choudhury, 1987). Macis (1955) reported the beneficial effects of scooping of curds, whereas Choudhury and Ramphal (1961) did not find any significant effect of scooping with an early cauliflower variety Pusa Katki. Chatterjee and Mukherjee (1962) reported the effect of scooping only in the case of compact varieties like Snowball and not in the case of less compact varieties like Dania. According to Choudhury and Ramphal (1961) the plants left in-situ without scooping was a better for commercial seed production of early cauliflower varieties. The yield reduced proportionately to the severity of injury to the plants at the time of transplanting or scooping out of curd. Therefore, scooping out of curd or transplanting early cauliflower plants for raising seed is of no use and is not only a waste of labour and time but also results in a loss in the yield of seed.

Therefore, in case of cole crops, especially in cauliflower, not only considerable skill is required to grow a satisfactory market crop in the first phase, but a great deal of skill is also demanded to carry the crop through the essential stages of flowering, seed development and seed processing.

To attain higher seed yield, it is imperative to adopt proper cultural practices. There is great potentiality for increasing the seed yield per unit area by rational and optimum use of nutrients coupled with better management practices. Being a heavy feeder, importance of nitrogen and phosphorus in improving the growth, yield and quality of cauliflower seed crop has been demonstrated by many scientists. Further the roles of micronutrients particularly boron, molybdenum and zinc is well established in vegetable crops, in general, and cauliflower, in particular.

Information regarding suitable varieties, sowing time and the effects of different macro and micronutrients for cauliflower seed production in terai zone of West Bengal is meagre. Therefore, the present investigations were undertaken in order to standardise the agrotechniques for quality seed production in cauliflower under this agro-climatic region.

Chapter - II

Review of Literature

REVIEW OF LITERATURE

Information on the related aspects of agrotechniques of cauliflower seed production is hereby reviewed.

2.1 Climatic Requirements

The late types are true biennials and require exposure to cold temperature for curd formation. The early types are generally annuals or sometimes biennials and do not require cold temperatures to induce curd formation (Swiader *et al.*, 1994).Seed yield of cauliflower is mainly affected by the prevailing temperature specially at flowering and seed setting. Sudden rise in temperature above 30^{0}C upsets pollination and seed setting in late cauliflower (Sharma, 1995). Padda and Singh (1981) noticed that although seed stalk development in cauliflower does not require low temperature like cabbage it has the most exacting climatic requirement. Both low and high temperatures adversely affect the seed production of cauliflower. High mean maximum and minimum temperatures of 16.43^0 to 18.93^{0}C and 4.67^0 to 6.83^{0}C, respectively during October, November, December induced good vegetative growth. Fluctuation in temperature in February when curds are formed, did great damage and reduced the seed yield by 49.17 to 100 per cent. Heavy rainfall in January and February were very harmful to seed production. The relative humidity did not have any effect (Gill and Singh, 1973).

The curd initiation date of cauliflower plant depends on the date the juvenile phase comes to an end and the temperature in the following period (Wiebe, 1972 b; Hand and Atherton, 1987). Plant to plant variation within a cauliflower crop in respect of curd initiation date is due to both differences in temperature experienced subsequently by the individual plants. Variations could be partly due to genetic variability within the crop for the end of juvenility and /or cold requirement. Salter (1969) found a positive correlation between curd initiation date, curd diameter and final number of leaves in most crops and he ascribed variation within a crop to differences in cold requirement; thus plants with a higher cold requirement initiated more leaves before curd initiation. These differences were probably mainly genetically determined. Aamlid (1952), Jensma (1957), Watts (1965), Wurr *et al.* (1981 c and 1982) found that earlier cultivars had lower leaf numbers and that later cultivars had a greater cold requirement (Wiebe, 1972 b). Also within a crop of one cultivar, Jensma (1957) found a positive correlation between earliness and the final number of leaves, probably due to variation in cold requirement (Sadik,1967). Booij (1990) noticed that the final number of leaves depended on temperature after the juvenile stage. When individual plants within a crop reach the end of the juvenile stage on different dates, they would experience different temperatures subsequently, and this will influence within the crop correlation between curd diameter and final number of leaves. Sudden temperature changes during a transition period when only some plants have reached the end of juvenility or when only some plants have completed curd induction could cause considerable variation in curd initiation over and above that associated with variation in the end of juvenility. The duration of the harvest period is determined only partly by the duration of the curd initiation period. Temperature during curd growth also modified the duration of the curd harvest period. The duration of the harvest period is determined primarily by the factors date of end of juvenility, temperature after the end of juvenility and temperature during curd growth, possibly all interacting with a genetic component that made it difficult to find techniques that can consistently reduce the duration and variability of the harvest period. Salter (1969) found a positive correlation between duration of the initiation period and duration of the harvest period (both expressed on a day-degree basis), but there was still and considerable residual variation and the relation was cultivar dependent.

2.2 Variety and Sowing Time

Sowing and transplanting times should be adjusted in such a manner that the plants put up maximum vegetative growth before the temperature goes low and plants go into dormancy (Choudhury, 1987). Mishra (1989) found that plant height and number of primary branches per plant increased significantly when seeds of cauliflower variety Early Patna were sown on 15th. and 25th June. This might be due to sufficient period available for proper plant growth. Length of pod, number of seeds per pod and 100 seed weight and seed germination were increased significantly in above two dates of sowing probably due to proper plant growth and more favourable climatic conditions available during flowering and seed setting from 22nd December to 15 th February. The seed yield of 15 th and 25th June sowing ultimately increased significantly due to increase in values of yield attributing characters in calcareous sandy loam soil of North Bihar. These results were in conformity with the findings of Padda and Singh (1981) and Gupta and Saini (1983). Chatterjee and Som (1990) reported that the medium late cauliflower cultivar

KPS-1 when sown between August to January were found to produce curds and sowings between August to October were found to produce seeds in the Darjeeling hills of West Bengal. Under western Maharastra condition, the sowing of seeds during first fortnight of March - April and August for I and II maturity groups of cauliflower, respectively gave the highest yield and the cultivars, First Crop and Summer Beauty in Group - I and Kuwari and Patna Midseason in Group - II were found to give the best yields. Cultivars New Synthetic and Nasik No. 5 of Group-III with seed sowing in September gave the heighest yield. In the late Group-IV, seed sowing from 15^{th} November to 15^{th} December with cultivar Super Snowball and Late Snowball gave the best performance (Lawande *et al.*, 1991). Patil *et al.* (1995) found that 1st August gave best results of average curd weight of 211.40 g and yield of 69.379 q/ha among different sowing dates of 1st July, 1st August or 1st September. Singh *et al.* (1997) concluded that the delayed planting reduced curd formation, which might be due to the fluctuation in the temperature during growing season. Similar results were shown by Sharma *et al.* (1994). Gautam *et al.* (1998) noticed that the significantly higher yield of curd was associated with first sowing (July, 15th) and lowest yield was recorded in the third sowing (August, 14th) out of three sowings and out of five varieties tested 'Heavey Silver Plate' gave the highest curd yield.

Halim *et al* . (1995) reported that the number of flower stalks per plant, pods per plant, seeds per pod and seed yield decreased as planting was delayed after 10th October at Jalampur in Bangladesh. The variety Agrahyani showed better performance. Averaged over planting dates, seed yield from cultivars Kartika and Agrahyani were higher than from the other cultivars. The Highest seed yield (451.67 kg/ha) was obtained from cultivar Patnai planted on 10th October, and the lowest seed yield (78.33 kg/ha) from the same cultivar planted on 10th November. Seed yield in cultivar Poushali was higher at the intermidiate planting dated than at the earliest and latest ones. Kunwar (1996) found that seed yields of cultivar Early Kunwari were highest from sowing on 15^{th} July (8.77 q/ha) and lowest from sowing on 1st September (3.38 q/ha) at Ludhiana condition. Nassar *et al.* (1972) concluded that transplanting in the month of October was most suitable for seed production of Snowball - M.

2.3 Nutrition

The informations on nutritional requirements in respect of seed yield of cauliflower are very limited. However, literatures on nutritional requirements for producing maximum curd yield in different parts of the world are available. The findings on nutritional requirements for curd yield are expected to give an idea about the nutritional requirement for seed yield also. Cauliflower needs very heavy manuring. Lack of adequate fertilizer is one of the important reasons for the low yield of early crop. The requirement of the crop for fertilizers may be different according to the season especially in view of the heavy rains received in the rainy season when the early crop is grown (Anon., 1989).

2.3.1 Nitrogen Fertilization

According to Devlin (1973), the increased supply of nitrogen accelerates synthesis of chlorophyll and amino acids. The higher nitrogen application accelerate the vegetative growth and suppress generative phase. Khurana *et al.* (1987) reported that curd yield of cultivar Pusa Synthetic increased significantly with increase in nitrogen upto 100 kg N/ha. This increase in yield due to nitrogen application may be due to effective utilization of carbohydrates and other organic factors resulting in the enlargement of head (Leonard, 1962). Sharma and Parasar (1982) reported that all the growth and yield contributing characters of cauliflower cultivar Snowball - 16 increased significantly with every increment in nitrogen dose upto 120 Kg N/ha. In the Chhotanagpur Plateau of Bihar, Singh and Naik (1990) found that increased doses of nitrogen from 50 kg to 150 kg per hectare resulted in significantly higher marketable yield of cauliflower cultivar Early Kunwari. The total yield of curd, however, showed positive response upto 200 kg N/ha. Farag *et al.* (1994) observed that fresh weight of plant, curd weight, total curd yield and leaf nitrogen content increased with increasing nitrogen application rate, but the date of curd formation was delayed. Balyan *et al.* (1994) noted that marketable yield increased with increasing rate of nitrogen (120 kg N/ha) and then decreased. The highest concentration of nitrogen in leaves (3.41%) was observed at a rate of 180 kg N/ha. Batal *et al.* (1997) obtained maximum mean curd mass and maximum yields with the highest nitrogen rates of 269 and 381 kg/ha applied to sandy loam and clay loam soils, respectively. Kotur (1997) found significant response to nitrogen levels (50-300 kg/ha) in respect of curd weight, diameter and yield of cultivar Pusa Snowball -1 at 200kg/ha over 50kg/ha in Ranchi soil condition. Any further increment in nitrogen adversely affected these parameters. The severity of stem hollow markedly reduced with increasing nitrogen levels only when supply was adequate.

Csizinszky (1996) opined that yield and curd size of green cauliflower increased with increasing nitrogen rate and potassium rate had no significant effect on yield.

Pandey *et al.* (1979) reported that nitrogen level higher than 50 kg/ha decreased the seed yield of cultivar Hissar -1, as probably the increased vegetable growth and plant height resulted in their lodging. In two year experiments, there was much higher seed yield in last year in comparison to the previous year in all the treatments and this might be firstly because the crop was grown in the fallow field and the secondly there was less attack of insects and diseases. Pandey *et al.* (1985) concluded that application of 100 Kg N/ha in a split doses, one-third before transplanting, one-third at 30 days after transplanting and one third at the curd forming stage was most suitable for obtaining highest seed yield. Mishra (1992) found that nitrogen had significant effect on plant height, number of branches, number and length of pods, number and weight of seeds and seed yield of cultivar Patna Main. Nitrogen at 150 kg/ha was found significantly superior in increasing the values of all above characters, except plant height, which was recorded, maximum at 180kgN/ha. Increase in seed yield with the application of 150kgN/ha might be due to optimum dose which helped in proper growth and maturation of the plants, impairs the quality of pods and checked undue lengthening of stem internodes and ultimately effective pods were developed (Anon., 1980) and probably due to increase in plumpness in the grain (Malik, 1973). The results also find support with the findings of Sharma and Singh (1982), Mishra and Pandey (1987) and Mishra and Mishra (1985). Higher dose of nitrogen was not effective as excess of nitrogen cause lodging by inducing an undue lengthening of the stem internodes which delays the maturation of plants and also affects the seed quality (Anon, 1980; Mishra and Pandey, 1987). Jamwal *et al.*(1995) observed increase in seed yield of Pusa Snowball -1 with application of nitrogen upto 175 kg/ha under Himachal soil condition.

2.3.2 Phosphorus Fertilization

Phosphorus is mainly responsible for improving the quality and quantity of produce by way of increasing metabolic activities in the plant system (Balyan *et al.*, 1988). Sharma and Parasar (1982) found that the leaf area index, depth and diameter of curd and dry matter production of cultivar Snowball-16 significantly increased due to application of 50kg P_2O_5 /ha. However, further increase in phosphorus level (100 kg P_2O_5/ha) had only a marginal effect. Forshly (1963) opined that the increase in the levels of phosphorus reduces days to curd maturity, because phosphorus is likely to neutralize the effects of nitrogen in the process of higher vegetative growth. Khurana *et al.* (1962) observed that phosphorus levels did not influence curd yield, curd leaf ratio and number of leaves per plant significantly. According to Singh and Naik (1990) phosphorus levels had no marked influence on the yield of cauliflower cultivar Early Kunwari, however, ancillary characters were best at 100kg P_2O_5 per hectare. This result were in conformity with those of Genkov *et al.* (1972) and Nurtika (1979) indicating the highest marketable curd yield at 100kg P_2O_5 per hectare. The curd size was not influenced by varying phosphorus levels (Singh and Naik, 1990). Thakur *et al.* (1991) reported that phosphorus had significantly affected number of leaves, leaf size index and stalk length of cauliflower cultivar Pusa Snowball -II. The increase in morphological characters by phosphorus application were affected by the activity of enzymes leading to greater synthesis of lignin and protein (Takkar and Randhawa, 1978).

Hawthorn (1952) and Gill *et al.* (1975) reported a significantly higher seed yield of cauliflower by applying higher doses of phosphorus alone. Pandey *et al.* (1985) noticed that phosphate application at 50 or 100 kg per hectare did not have an appreciable effect on seed yield. Pandey *et al.* (1979) reported that phosphorus at 100kg/ha increased the seed yield of cultivar Hissar -1 significantly over rest of its doses (0 and 50 kg/ha) during first year of experiment, but no significant effect was observed during the second year though an increasing trend in the yield was recorded with increased phosphorus doses upto 50kg/ha. Jamwal *et al.* (1995) observed increase in seed yield of cultivar Pusa Snowball-1 with application of phosphate upto 150kg/ha under Himachal soil condition.

2.3.3 Nitrogen and Phosphorus Interaction

Response of nitrogen and phosphorus to marketable yield clearly indicate the synergistic effect in the presence of each other. Application of nitrogen in the absence of applied phosphorus could increase the marketable yield of cauliflower Snowball -16 upto 120kg/ha, however, significant increase was observed upto 160kgN/ha in plots where 50 kg P_2O_5/ha was applied. Moreover, 80 and 120 kgN/ha produced more yields in the presence of phosphorus as compared to higher levels of nitrogen without phosphorus. Further phosphorus application also had better effects on marketable yield in nitrogen fertilized plots and the response of crop to phosphorus increased with the increase in nitrogen levels (Balyan *et al.*,1988). Corroborative results were obtained by Raut and Kedar (1981). It is obvious that a balance between these two nutrients is very important for boosting up the production of cauliflower. Khurana *et al.* (1990) concluded that in Punjab soil the crop should be applied with nitrogen @ 120kg/ha and phosphorus @ 40 kg/ha to have higher yield of cauliflower. These nutrients improved the curd length and diameter. Balyan *et al* . (1994b) found that nitrogen application significantly affected the uptake of nitrogen, phosphorus and zinc by cauliflowers. Phosphorus application also significantly affected the uptake of nitrogen, phosphorus and zinc. In terms of yield, the best rate was nitrogen at 120 kg/ha., phosphorus at 50 kg P_2O_5/ha and zinc at 20 kg $ZnSo_4$/ha (234.4q/ha) in cauliflower cultivar Snowball-16 grown under Hisar condition. However, Swaroop *et al.* (1999) reported that the most effective treatment was 90 kg N+80 kg P/ha which increased the average weight of curd, curd diameter and curd yield over control.

Pandey *et al.* (1979) obtained the best combination of 50 kg nitrogen and 100 kg P_20_5/ha for obtaining maximum seed yield of cauliflower cultivar Hissar-I. The findings are in line with the findings of Gill *et al.* (1975) and Cutcliffe *et al.* (1967).

2.3.4 Boron Nutrition

According to Thakur *et al.* (1991) boron application significantly increased curd yield and there was significant earliness to curd maturity. The increase in the net curd weight by boron may be due to its role in enhancing the translocation of carbohydrates from the site of its synthesis to the storage tissue in curd as boron is known to play beneficial role in the translocation of carbohydrates (Sisler *et al.*,1956). Kotur and Kumar (1989) reported that in Chhotanagpur region of Bihar under boron deficiency (control) and toxicity (6.4kg/ha) stress, only 47 and 40 per cent cauliflower cultivar Pusa Snowball-1 survived due to mortality of the transplants. Marketable curd yield increased from 0.4 t/ha in the control to 9.1 t/ha at 1.6 kg B/ha and decreased thereafter. Owing to brown rot (B deficiency or toxicity) and black rot 3.8 and 0.9 t/ha of curd at 0.1 and 6.4 kg B/ha were rendered unmarketable. Similarly, the percentage marketable curd yield increased from 26 in the control to 95-98 at 0.4 - 3.2 kg B/ha, which decreased to 75 at 6.4 kg B/ha due to boron toxicity. The maximum crop stand, marketable curd yield and percentage marketable curd yield were obtained with 0.2 - 0.4, 0.8 - 1.6 and 1.6 - 3.2 kg B/ha, respectively. Singh *et al.* (1994) recorded that the yield of cauliflower incresed with increasing boron application rate up to 0.5mg P_2O_5 per kg phosphate level within the plant tissue, but decreased at higher rates. The application of both phosphorus and boron showed a synergistic effect on the contents and uptake of the two elements by the curds. Kotur (1997) noticed that increasing levels of boron (0, 0.0125 and 0.125% boric acid; each applied thrice by foliar spray) significantly increased curd size and yield of Pusa Snowball-1 and suppressed Ca content of leaf tissue while that of boron increased. Stem hollow and curd rot of cauliflower were a direct manifestation of boron deficiency. Proper balancing of nitrogen and boron was required for high curd yield and low stem hollow and curd rot. Ghosh and Hasan (1997) reported that cauliflower cultivar Early Kunwari produced plants with the highest number of leaves /plant (27.2), the largest curds (1048g) and highest yield (524 q/ha) when supplied with borax at 15kg/ha in Nadia condition of West Bengal. Batal *et al.*, (1997) observed that on clay loam soil, increasing boron from 2.2 to 8.8 kg/ha reduced hollow stem but had no effect on yield or curd mass and on sandy loam soil, boron at 4.4 kg/ha maximized the yield and curd mass, but the hollow stem disorder continued to decrease when boron rates were increased upto 8.8 kg/ha.

Mishra (1992) found that maximum number of branches, pods and seeds, length of pod, 1000 seed weight and seed yield of cultivar Patna Main were recorded with the application of Borox at 10kg/ha. Since, boron helps to check the formation of hollowness in stem and browning or brown-rot in curd of cauliflower by which quality curds were developed and ultimately proper bolting, development in flower stalk, pods and seed setting were made (Venkataratnam, 1961). Application of 0.2% boron as a seedling root dip with 1 kg boron per hectare applied to the soil resulted in the highest seed yield (2.05 q/ha) and a 97% increase in cauliflower diameter as compared to the control (Panigrahi *et al.*, 1990). Sharma (1995) obtained highest seed yields when 20 kg borax per hectare was applied in combination with 1.5 kg ammonium molybdeate per hectare.

2.3.5 Molybdenum Nutrition

Low availability of molybdenum in acid soils has been reported by a number of workers. Muthoo (1987) noted that molybdenum treatment increased the fresh weight and dry weight of leaves. This increase in the growth might have been due to activated physiological process by stimulating factor in the metabolism and growth of the plant. Anderson and Thomas (1946), Agarwala (1951) and Singh and Rajput (1976) also found increased growth in cauliflower by the application of molybdenum. According to Sharma *et al.* (1988), low amount of molybdenum (250g sodium molybdate/ha) applied as soil or spray application resulted in substantial increase in cauliflower cultivar Snowball-16 curd yield in acid soil of Himachal Pradesh. The spectacular response to molybdenum in the increased yield of cauliflower may be attributed to the low amount of available molybdenum (0.12ppm) which is below the critical level of 0.15 ppm in the soil. In a field experiment with cauliflower cultivar Pusa Snowball on a molybdenum deficit soil to standardize foliar application of molybdenum for amelioration of molybdenum deficiency symptoms and production of high curd yield at Ranchi in Bihar, Kotur (1995) found that as molybdenum rate increased from 0 to 0.20%, there were increases in leaf width from 12.0 to 13.3 cm, curd diameter from 16.8 to 18.8 cm, curd weight from 710 to 840g. Panigrahi *et al.* (1990) noticed that liming increased seed yield of cauliflower where molybdenum had no effect in acid red soil of Orissa.

2.3.6 Zinc Nutrition

Balyan *et al.* (1988) reported that zinc application did not effect 50% curd initiation and curd harvesting but leaf number per plant, leaf size index, curd compactness and marketable yield of Snowball -16 increased significantly upto 20kg $ZnSO_4$/ha which clearly indicates the necessity of zinc application along with other nutrients in this crop as also reported by Sharma *et al.* (1914) who observed water deficit conditions in leaves, caused by zinc deficiency. High amount of available zinc in the soil, i.e., application of 30 kg $ZnSO_4$/ha had toxic effect on the plant. Balyan *et al.* (1994) noticed that marketable yield of cauliflower cultivar Snowball -16 increased with increasing rate of zinc to a maximum (198.57q/ha) at a rate of 4.2 kg Zn/ha , then decreased. Pandey *et al.*(1978) concluded that application of zinc sulphate at 25 kg per hectare increased the seed yield of cauliflower variety Hissar-1 about one and a half times over the control.

2.4 Correlation between Yield and Yield Components

The ultimate profit in cauliflower depends upon the marketable yield i.e., the weight of the curd. This character is influenced by other related characters such as number of leaves per plant, diameter of curd, plant height and weight of leaves per plant. An understanding of the interrelationship between the yield and its related components is essential to bring a rational improvement in the desired direction. Sharma *et al.* (1982) noticed that the correlation coefficient of curd yield with diameter of the curd, dry matter production, number of leaves and leaf area index were highly significant. The standardized partial regression coefficients revealed that the diameter of the curd contributed maximum to the curd yield, followed by dry matter production, whereas the contribution from the number of leaves was negative. Singh (1984) reported that number of leaves per plant, curd diameter, plant height and leaf weight per plant were positively and significantly correlated with curd yield in both cultivars, the correlation being strongest for curd diameter in Early Kunwari and leaf weight in Snowball.

Chapter - III

Materials and Methods

MATERIALS AND METHODS

The investigations were carried out during 1996-97 and 1997-98 to study the effect of different varieties, sowing dates, nitrogen and phosphate fertilizations and micronutrients like boron, molybdenum and zinc applications on growth, seed yield and yield attributes of cauliflower.

3.1 Soil and Climate

Terai zone is situated between $25^0 57'$ and 27^0 N latitude and $88^0 25'$ E and $89^0 54'$ E longitude. This northern region of West Bengal is situated along Kurseong and Kalimpong hills and Bhutan hills in the north, Bihar border on the West and Assam border on the east. It includes Siliguri Sub - divission of Darjeeling district and entire district of Jalpaiguri, Cooch Behar and Islampur Sub-division of North Dinajpur district. The total geographical area of the zone is 12025 sq. km. which is 13.5% of the state area with 9.7% of the states population. Rural population comprises more than 90% of the population of the zone.

The soil of this zone can be classified into two broad tracts (a) old Himalayan piedment plains and (b) Teesta flood plains. Old Himalayan piedment plains spread along with Northern part of the area from Kharibari, Phansidewa in the west to Kumargram in east covering of northern part of Siliguri sub-division and Jalpaiguri district. Soils are sandy loam type, formed mostly from the Himalayan Detritus. This area has a dark brown topsoil, 1-3ft. deep, medium to strong acidic in nature and fairly rich in humas content. Available N_2, available P_2O_5 and available K_2O contents are low to medium. The Teesta flood plains spread along the southern portion of Siliguri sub-Division and Jalpaiguri district and entire Cooch Behar District. Soil texture varies from sandy to silty clay loam. Most soils of the zone have high fixing capacity for phosphorus. Soils being grilty, porous and poor in secondary micronutrients.

The climate of the zone is subtropical humid climate. Average annual rainfall of this zone varies between 2100 to 3300 mm. The maximum rainfall *i.e.,* about 80% is received from southwest monsoon during the months of June to September. While the range of minimum temparature of the area is $7-8^0C$, the maximum temparature varies between $24-33.2^0C$. The relative humidity of the area at 8.30 a.m is 58% and 87%

respectively in March and July. The relative humidity in the afternoon at 17.30 hour is 48% and 84% respectively in March and November.

3.2 Experimental Soil

The soil of the experimental fields were sandy loam in texture; Composite soil samples from all the experimental plots were collected and analysed before starting the experiment. The physico-chemical properties of soil of the experimental fields are given in Table 1.

3.3 Previous Cropping History

The experimental fields were used for general production of vegetables for the last several years without fertilizers or with application of some amount of fertilizers. In the first year, recent fallow field was used for planting while in second year the crop was planted after okra crop.

3.4 Agro-climatic Conditions

The climate of Terai Zone is sub-tropical humid in nature with distinctive characteristics of high rainfall, high humidity and a prolonged winter. There are practically two dominant seasons in the year – an extended winter or dry rabi season (November to March) and a long rainy or wet or kharif season (April to September and sometimes upto middle of October). The winter season is generally characterised by very little rain and cool temperature and dry clear sunny days, with occasional heavy rainfall and high humidity. The wet or rainy seasons characterised by hot and humid weather, heavy perception by south - west monsoon with cloudy overcast days and fewer hours of bright sunshine.

3.5 Crop and Variety

Five varieties of cauliflowers collected from different sources (Table 2) was taken up for the first experiment while cv. Aghani was used for other two experiments.

Table 1 - Physico - chemical properties of experimental soil

A . Mechanical composition of soil (0-15cm):

Sl. No.	Particle size distribution	Value(Percentage)		Method Used
		Ist Year	2nd Year	
1.	Sand	62.2	61.3	International
2.	Silt	20.4	22.3	Pipette Method
3.	Clay	17.4	16.4	(Piper,1966).

B. Physical properties of Soil (0-90cm)

Sl. No.	Depth of soil	Bulk Density (g/cm^{3}at 25^{0}C)		Field capacity (%)		Method used
		Ist year	2nd year	Ist year	2nd year	
1.	0 - 15	1.43	1.44	36.53	34.29	Core Sampler
2.	15 - 30	1.42	1.41	36.42	35.63	(Piper,1966)
3.	30 - 45	1.41	1.41	30.01	29.87	Field Method.
4.	45 - 60	1.37	1.36	19.89	19.16	(Piper, 1966)
5.	60 - 90	1.37	1.35	13.17	13.05	

C. Chemical properties of soil (0 -15cm)

Sl. No.	Particulars	Value		Method used
		Ist year	2nd year	
1	pH (Soil : water : : 1:2.5)	6.1	5..9	pH meter
2	Organic Carbon (%)	1.27	0..91	Rapid Titration Method (Walkley and Black,1934)
3	Total Nitrogen (%)	0.10	0.09	Modified Macrokjeldahl Method (Jackson.1973).
4	Available Potassium (Kg/ha)	36.30	23.86	Olsen's Method (Jackson,1973)
5.	Available Potassium (kg/ha)	123.4	90.2	Flame Photometer Method (Jackson,1973)
6	Available Boron (ppm)	0.27	0.23	(Jackson 1973)
7	Available Molybdenum (ppm)	0.17	0.15	Do
8	Available Zinc (ppm)	2.4	1.9	Do

Table 2. Cauliflower varieties with seed companies.

Sl No.	Variety	Matuarity group	Company
1.	Early Kunwari	1a	Sungro Seeds Pvt. Ltd., B207 Aradhana Bhavan , Azadpur , Delhi- 110033
2.	First Crop	1a	M/S Sutton & Sons (India) Pvt. Ltd. 13 D , Russel Street, Calcutta - 700071.
3.	Kartika	1b	Sungro Seeds Pvt. Ltd.
4.	Aghani	II	Do
5.	Improved Japanese	I1	National Seed Corporation , Pradhan Building, Hakimpara, Siliguri.

3.6 Experimental Details

Experiment - 1 : Effect of sowing dates, varieties and their interactions on growth and seed production of cauliflower.

The experiment was carried out in 3x5 Factorial Randomised Block Design with three replications. The treatments comprised of three seed sowing dates viz., 15th August (S_1), 31st August(S_2) and 15th September (S_3) and five open pollinated varieties of maturity group -I and II , i.e., Early Kunwari (V_1), First Crop (V_2), Kartika (V_3) , Aghani (V_4) and Improved Japanese (V_5) during the year 1996-97 and 1997-98. A fertilizer dose comprising 100 kg N, 80 kg each of P_2O_5 and K_2O and 20 kg borax per hectare was applied in each treatment. The treatment combinations were as follows (Table 4):

Table 3. Meteorological monthly mean data for the crop seasons Latitude -$26^0 19' 86''$ N, Longitude- $89^0 23' 53''$ E and Altitude 43m

Months	Rainfall (mm)		Temperature (°C)				Relative Humidity (%)				Bright Sunshine(hr)		Rainy Days	
			Maximum		Minimum		Maximum		Minimum					
	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98
August	666.8	430.4	31.93	32.54	24.96	24.67	93.42	93.16	74.58	72.68	3.6	4.6	15	14
September	288.8	463.6	31.74	30.83	24.08	23.60	93.03	93.67	73.40	75.33	6.5	5.2	7	17
October	101.8	2.5	30.66	30.97	20.40	19.01	91.35	89.19	64.90	57.42	7.8	8.3	7	1
November	0	44.1	29.30	27.94	15.78	15.58	87.67	93.80	55.03	60.87	8.1	8.5	0	2
December	0	30.6	26.71	23.50	11.05	11.67	90.81	95.97	37.93	56.55	8.6	8.1	0	3
January	3.0	0	21.22	20.19	8.96	9.23	95.01	95.84	50.22	60.94	7.7	7.2	1	0
February	11.4	4.0	23.87	25.90	10.51	11.68	93.93	95.14	47.89	44.39	7.1	7.0	2	1
March	98.5	116.1	30.42	27.16	15.52	14.83	89.74	87.61	43.06	47.90	8.1	7.7	2	4

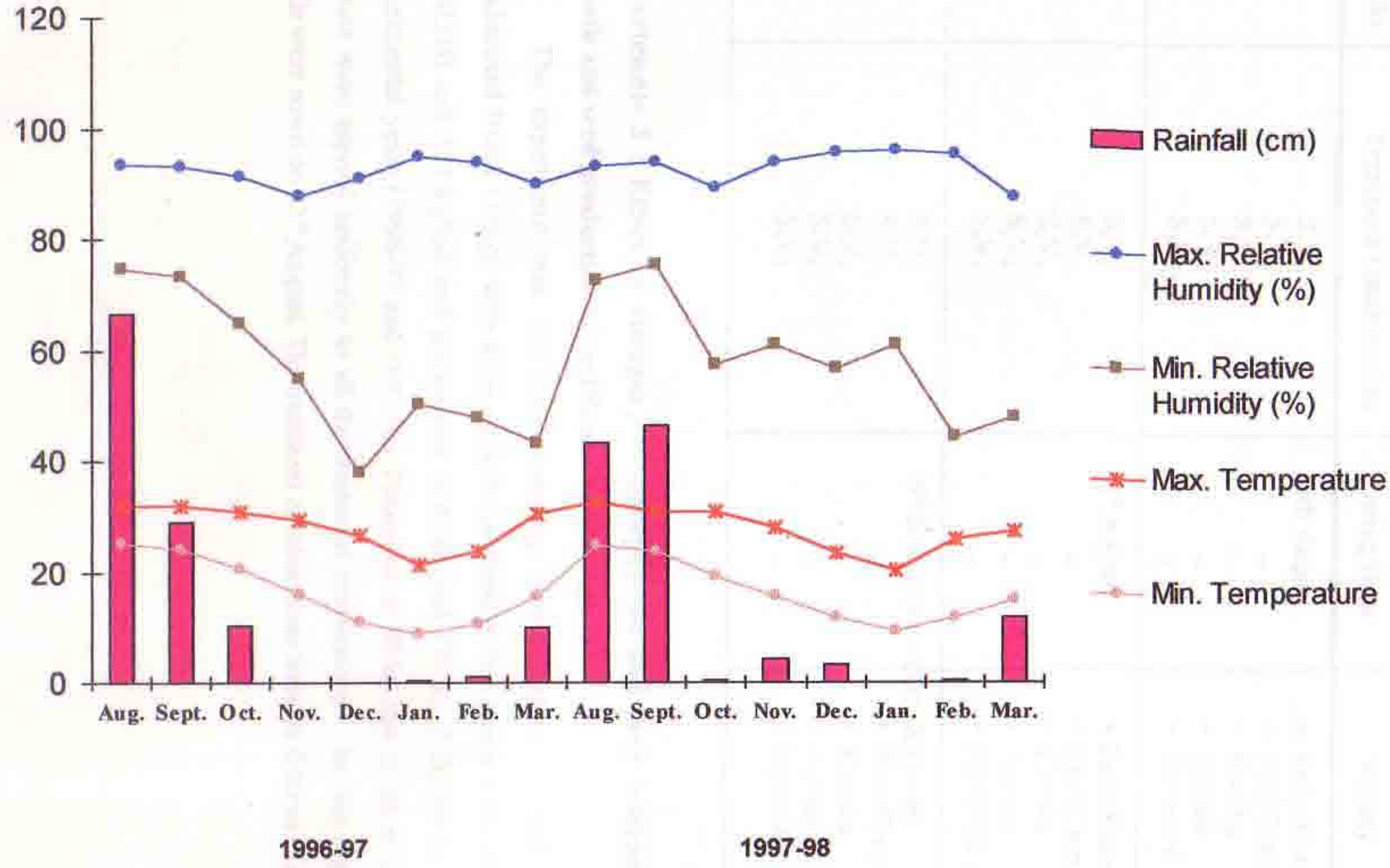


Fig. 1. Meteorological condition during the study periods

Table 4. Treatment combinations of Experiment 1.

Sl.No.	Treatment Combinations	Sowing Date	Variety
1.	S_1V_1	15th August	+ Early Kunwari
2.	S_1V_2	,,	+ First Crop
3.	S_1V_3	,,	+ Kartika
4.	S_1V_4	,,	+ Aghani
5.	S_1V_5	,,	+ Improved Japanese
6.	S_2V_1	31st August	+ Early Kunwari
7.	S_2V_2	,,	+ First Crop
8.	S_2V_3	,,	+ Kartika
9.	S_2V_4	,,	+ Aghani
10.	S_2V_5	,,	+ Improved Japanese
11.	S_3V_1	15th September	+ Early Kunwari
12.	S_3V_2	,,	+ First Crop
13.	S_3V_3	,,	+ Kartika
14.	S_3V_4	,,	+ Aghani
15.	S_3V_5	,,	+ Improved Japanese

Experiment- 2 : Effect of nitrogen , phosphorous and their interactions on growth and seed production of cauliflower variety Aghani.

The experiment was laid out employing variety Aghani in 4x4 Factorial Randomised Block Design with three replications keeping four levels each of nitrogen (0,50,100 and 150 kg/ha) and phosphorus (0,40,80 and 120 kg P_2O_5/ha) in both the experimental years (1996-97 and 1997-98). Potassium at 80 kg and borax at 20 kg per hectare were applied uniformly to all the treatment combinations. In this experiment, seeds were sown on 31st August. The treatment combinations were as follows (Table 5) :

Table 5. Treatment combinations of Experiment- 2.

Sl No.	Treatment combinations	Nitrogen (Kg/ha)	Phosphate (Kg/ha)
1.	N_1P_1	0	0
2.	N_1P_2	0	40
3.	N_1P_3	0	80
4.	N_1P_4	0	120
5.	N_2P_1	50	0
6.	N_2P_2	50	40
7.	N_2P_4	50	80
8.	N_2P_4	50	120
9.	N_3P_1	100	0
10.	N_3P_2	100	40
11.	N_3P_3	100	80
12.	N_3P_4	100	120
13.	N_4P_1	150	0
14.	N_4P_2	150	40
15.	N_4P_3	150	80
16.	N_4P_4	150	120

Experiment - 3 : Effect of boron, molybdenum and zinc and their interactions on growth and seed production of cauliflower variety Aghani.

The experiment was laid out in 2^3 Factorial Randomised Block Design with three replications in both 1996-97 and 1997-98. The treatments comprised of 0 and 20 kg/ha of borax, 0 and 1.5 kg/ha of ammonium molybdate and 0 and 25 kg/ha of zinc sulphate. Cauliflower variety Aghani was selected as test crop. In this experiment also, seeds were sown in 31st August for raising the seedlings. A general fertilizer dose of 100 kg N, 80 kg each of P_2O_5 and K_2O was applied to all treatment combinations. The treatment combinations were as follows (Table 6):

Table 6. Treatment combinations of Experiment - 3.

Sl. No.	Treatment Combinations	Borax(kg/ha)	Amm.Mohybdate(kg/ha)	ZincSulphate (kg/ha)
1.	$B_1M_1Z_1$	0	0	0
2.	$B_1M_1Z_2$	0	0	2.5
3.	$B_1M_2Z_1$	0	1.5	0
4.	$B_1M_2Z_2$	0	1.5	2.5
5.	$B_2M_1Z_1$	20	0	0
6.	$B_2M_1Z_2$	20	0	25
7.	$B_2M_2Z_1$	20	1.5	0
8.	$B_2M_2Z_2$	20	1.5	25

3.7 General Cultural Practices

3.7.1 Land preparation

The experimental field was thoroughly prepared by repeated ploughing and laddering to get a loose and friable condition of the soil upto a depth of about 30cm before starting layout of the experiment. During the final land preparation 25 tonnes of well rotten farm yard manure per hectare was applied after removing the stubbles, weeds etc. and the entire experimental field was levelled. Flat beds measuring 3.6m x 2.7m, main irrigation channel of 1m width, sub-irrigation channels of 75 cm width and ridges of 50 cm width between plots were made.

3.7.2 Seedling raising

Seeds were sown according to the scheduled dates of the first experiment and on 31st August in each year for nutritional trials. Cauliflower seeds were treated with Agrosan G.N. @ 2.5 g per kg of seeds to save the young seedlings from damping-off disease and sown in well prepared raised formaldehyde treated nursery beds. Two days after thoroughly mixing of 30kg well decomposed cowdung manure, 250g SSP and 50g MOP per 3 sq.m of seed bed, the treated seeds were sown in lines 5cm apart in optimum moist condition of soil. Only during the hottest part of the day till the seedlings were one week old and during rain the seedlings were protected with light polyethylene shade made on bamboo structure. Irrigation and spraying of plant protection chemicals were done as and when required. Micronutrient mixture Tracel-2 was sprayed @ 5g per litre of water at 15 days after sowing for one time. Seedlings were ready for transplanting in the experimental field when they were of four weeks age.

3.7.3 Transplanting of seedlings

Healthy seedlings of 4 weeks old and more or less uniform in size and growth were transplanted with a spacing of 60cm x 45cm in the afternoon and a light irrigation was provided immediately after transplanting.

3.7.4 Fertilizer application

Phosphate in the form of single super phosphate, potash in the form of muriate of potash, borax, ammonium molybdate and zinc sulphate were applied as a basal dose. While nitrogen in the form of urea was applied in three split doses : first one before transplanting , second at 30 days after transplanting and the rest the rest at curd forming stage as recommended by Pandey *et al.*(1985).

3.7.5 Irrigation

Irrigation was given in the experimental plots at an interval of 10-15 days depending on the requirements. Irrigation at pollination and seed development periods were given as per the recommendation of Sharma (1995) keeping in mind that drought at these periods may reduce the seed yield upto 50 percent.

3.7.6 Intercultural operations

The experimental plots were kept free from weeds by hand weeding and shallow hoeing. The plants were earthed up after 6 weeks of transplanting. A regular spray schedule was followed for controlling pest and diseases by applying fungicides like Blitox, Bavistin, Tetracycline, Agrimycin, Dithane M-45 and Ridomil for controlling damping off, black rot, curd rot, blight, etc. and insecticides like Thiodan, Sevin, Monocil, Dimecron, Rogor etc. for controlling sawfly, cabbage butterfly, aphids, etc. as recommended by Anon. (1989). Insecticidal spray at flowering time was for better bee activities and efficient pollination. Thorough rouging of off-types and undesirable plants were done four times at curd initiation stage, marketable stage, bolting stage and flowering stage.

3.7.7 Harvesting and threshing of seeds

The seeds of cauliflower were ready within March depending upon the variety and date of sowing. When pod colour changed to yellowish brown in about 70 percent of the crop, it was harvested completely and piled for curing on tarpauline and covered with tarpauline with occasional turning over for about a week. After complete drying of inflorescence stalks, the seeds were threshed by hand pressing and sometimes by beating with wooden sticks wherever necessary, cleaned and perfectly sun dried.

3.8 Recording of Biometric Observations

The observations on growth and seed yield of cauliflower were recorded by selecting and tagging 10 plants at random per plot for growth and seed yield parameters study separately from each replication of different treatments and their average data was recorded. The details of observations recorded are given below:

3.8.1 Plant height

The height of the plant was measured in centimetre with the help of a metre scale from ground level to the highest point of leaf at the curd initiation stage.

3.8.2 Leaf length

The length of leaf was measured in centimetre from mature green leaves of plants at curd initiation stage.

3.8.3 Leaf width

The width of leaf was measured in centimetre from mature green leaves of plants at curd initiation stage.

3.8.4 Number of leaves

Total number of leaves per plant which were more than 1cm were counted from each of the 10 tagged plants at curd initiation stage.

3.8.5 Days to curd initiation

The number of days taken from sowing to half of the plant population with curd initiation was counted.

3.8.6 Days to curd maturity

The number of days taken from sowing to half of the plant population with marketable curds was counted.

3.8.7 Curd diameter

The maximum diameter of marketable curd was measured in centimetre from each of the 10 tagged plants at the end of curding stage.

3.8.8 Curd depth

The depth of curd was measured in centimetre from the base of initiation upto the top portion of marketable curd at the end of curding stage.

3.8.9 Net curd weight

The net weight of marketable curd excluding leaves and stalk was recorded in grams at the end of curding stage.

3.8.10 Days to inflorescence initiation

The number of days taken from sowing to half of the plant population of each plot with inflorescence stalk initiation was recorded.

3.8.11 Height of inflorescence

The height of inflorescence stalk was measured in centimetre with the help of metre scale from ground level to the highest point of the inflorescence just before harvest.

3.8.12 Primary inflorescence stalks per plant

Total number of primary inflorescence stalks per plant was counted from each of the randomly selected ten tagged plants just before harvest and then averaged.

3.8.13 Days to seed harvesting

The number of days taken from sowing to 70 percent of the population with yellowish brown pods and inflorescence stalks was recorded.

3.8.14 Pods per plant

Total number of pods per plant was counted from tagged plants at harvesting stage.

3.8.15 Pod length

Ten pods per tagged plant were selected at random and harvested at ripening stage for the purpose of determination of pod length. Pod length was measured in centimetre and then an average value was recorded.

3.8.16 Seeds per pod

The randomly selected pods harvested for the purpose of determination of pod length were threshed separately and the average number of seeds per pod was counted.

3.8.17 Seed yield

The randomly selected ten plants in each plot were allowed to set seed to study the seed yield parameters. Seeds from those plants were harvested, threshed and weighted in grams. Then an average value of seed yield per plant was estimated. Seed yield per hectare was calculated on the basis of yield per plot in kilograms.

3.8.18 1000 seed weight (Test weight)

Thousand bold seeds were collected from the total seeds of each plot. The seeds were dried in sun and weighted in a electronic balance in grams.

3.8.19 Germination percentage

For the determination of germination percentage of the seeds of cauliflower for all the experiments under study, 100 seeds from each replication and treatment were placed in a most blotting paper kept in petridishes and allowed to germinate at room temperature. After about 6 days only healthy seedlings were counted to find out the germination percentage.

3.9 Methods of Statistical Analysis

The observations recorded at different stages were subjected to statistical analysis as per Panse and Sukhatme (1985) and the significance of different sources of variation was tested by Error Mean Square by Fisher Snedecor's 'F' test at probability levels of 0.05 and 0.01 . For comparison of F calculated and for computation of critical difference (C.D) at 5 percent level of significance, Fisher and Yates (1963) tables were consulted. Correlation co-efficients between growth and seed yield parameters with seed yield were worked out by the methods described by Panse and Sukhatme (1985).

3.10 Determination of Nutrient Status of Leaves

Leaves were sampled from outer whorl of ten randomly selected plants in each plot of the Experiment-2 at the time of curd initiation for the purpose of determination of N,P and K content in leaves. According to Shanmugavelu (1989), midribs of these sampled leaves were ovendried and ground to fine dust.

3.10.1 Estimation of total nitrogen

Ground leaf tissue of 100 mg was taken in Kjeldahl flask and 10ml concentrated H_2SO_4 and 3g digestion mixture of $CuSO_4$ and KCl in the ratio of 1:10 w/w was added. It was then digested until a clear greenish solution was formed. The supernatant solution was cooled, few ml. distilled water and 50ml. 40% NaOH solution were added to it. It was then steam distilled and absorbed in 4% boric acid mixed indicator and titrated it against standard H_2SO_4 solution. The percentage of total nitrogen was estimated as follows :

$$\% \text{ of total nitrogen} = \frac{(T-B) \times 14 \times \frac{N}{10} \times 100}{1000 \times W}$$

Where, T= burette reading of treatment sample
B = burette reading of blank sample
14 = constant
N/10 = Strength of H_2SO_4
and W = Weight of dry sample (g).

3.10.2 Estimation of total phosphorus and potassium

Dried and ground leaf sample of 0.5g was digested with 10ml tri-acid mixture of $HClO_4$, concentrated H_2SO_4 and concentrated HNO_3 in the ratio of 2:1:5 v/v at 180^0 to 220^0 C. The volume of the digested mixture was made upto 100cc. with distilled water, shaken thoroughly and allowed to stand overnight . The supernatant solution was divided into two halves, one for phosphorus and other for potassium estimation. Phosphorus was estimated colorimetrically by vanado-molybdo phosphoric yellow colour method with the help of Spectrophotometer and potassium was estimated with the help of flame photometer(Jackson,1973).

Chapter - IV

Results and Discussion

RESULTS AND DISCUSSION

4.1 Experiment 1. Effect of sowing date, varieties and their interactions on growth and seed production of cauliflower.

This experiment was undertaken during the year 1996-97 and repeated in the year 1997-98 to study the above objective. Results of different parameters due to different treatments have presented and discussed below.

4.1.1 Plant height

The data presented in Table 7 showed that sowing dates varieties and their interactions influenced plant height significantly both in 1996-97 and 1997-98. In pooled analysis, such effects were also found to be significant. Plants of 15th August (S_1) sowing exhibited the maximum plant height of 49.18 cm as compared to the minimum of 42.86 cm in 15th September (S_3) sown plants. Delay in sowing resulted decrease in plant height. The present trend was in agreement with the findings of Singh *et al.* (1978) and Gautam *et al.* (1998) who also reported reduced plant height in late planting. Better growth for early sowing might be due to the conducive climatic conditions. Among the varieties, Improved Japanese (V_5) showed maximum plant height of 55.40 cm as compared to the minimum of 40.73 cm in Early Kunwari (V_1). In case of interactions with different sowing dates and varieties, the plant height ranged from 37.32 to 59.20 cm during 1996-97, 36.69 to 56.86 cm during 1997-98 and 37.01 to 58.03 cm in pooled analysis with S_1V_5 and S_3V_3 treatment combinations, respectively.

4.1.2 Leaf length

Sowing dates, varieties as well as their interactions registered a marked variation on the leaf length both in 1996-97 and 1997-98. In case of pooled analysis also the variations were significantly different. Maximum leaf length of 46.71 cm was produced in plants when the seeds were sown in 15th August (S_1), while it was least in 15th September sown crop (42.72 cm). Delay in sowing resulted decrease in leaf length. Among varieties, Improved Japanese (V_5) showed maximum leaf length of 52.34 cm (Table 7) as compared to the minimum of 38.64 cm in Kartika (V_3). It was quite expected because Improved Japanese, a variety of Group II possessed comparatively longer and wider plant frame than variety Kartika of Group I. Interactions with different sowing

Table 7. Effect of sowing dates, varieties and their interactions on plant height, leaf length and leaf width of cauliflower.

Treatments	Plant height (cm)			Leaf length (cm)			Leaf width (cm)		
	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled
S_1	50.38	47.97	49.18	47.52	45.89	46.71	21.31	20.27	20.79
S_2	48.77	47.07	47.92	46.03	43.96	44.99	21.61	20.22	20.91
S_3	43.81	41.91	42.86	43.41	42.04	42.72	20.89	19.51	20.20
S.Em±	0.30	0.29	0.23	0.30	0.31	0.20	0.15	0.29	0.17
C.D.	0.87	0.84	0.67	0.87	0.90	0.58	0.43	NS	0.49
V_1	41.63	39.82	40.73	41.48	39.56	40.52	21.21	20.68	20.95
V_2	45.54	41.86	43.70	44.07	42.15	43.11	24.18	21.61	22.90
V_3	42.37	40.92	41.64	39.45	37.82	38.64	18.43	17.60	18.01
V_4	52.76	50.83	51.79	50.03	48.83	49.43	21.85	20.17	21.01
V_5	55.98	54.83	55.40	53.23	51.46	52.34	20.68	19.93	20.31
S.Em±	0.38	0.38	0.30	0.39	0.40	0.26	0.19	0.37	0.22
C.D.	1.10	1.10	0.87	1.13	1.16	0.75	0.55	1.07	0.64
S_1V_1	42.79	41.22	42.01	42.56	40.86	41.71	21.67	21.44	21.56
S_1V_2	47.33	43.57	45.45	46.37	44.58	45.47	24.85	22.60	23.73
S_1V_3	44.97	43.53	44.25	40.57	39.22	39.89	19.15	18.08	18.61
S_1V_4	57.62	54.67	56.14	53.20	51.64	52.42	21.74	19.77	20.76
S_1V_5	59.20	56.86	58.03	54.92	53.16	54.04	19.15	19.45	19.30
S_2V_1	42.12	40.63	41.38	41.33	39.16	40.25	21.03	20.67	20.85
S_2V_2	46.45	41.68	44.06	44.53	42.04	43.29	24.07	21.47	22.77
S_2V_3	44.81	42.54	43.67	39.59	36.96	38.28	18.42	17.70	18.06
S_2V_4	54.03	54.13	54.08	51.07	50.25	50.66	22.53	20.76	21.65
S_2V_5	56.45	56.38	56.41	53.61	51.37	52.49	22.01	20.48	21.24
S_3V_1	39.98	37.60	38.79	40.56	38.65	39.61	20.94	19.95	20.45
S_3V_2	42.83	40.33	41.58	41.32	39.82	40.57	23.62	20.76	22.19
S_3V_3	37.32	36.39	37.01	38.20	37.27	37.73	17.73	17.01	17.37
S_3V_4	46.63	43.69	45.16	45.81	44.60	45.21	21.28	19.98	20.63
S_3V_5	52.30	51.24	51.77	51.17	49.84	50.51	20.89	19.86	20.37
S.Em±	0.67	0.66	0.51	0.67	0.69	0.45	0.33	0.64	0.38
C.D.	1.94	1.91	1.48	1.94	2.00	1.30	0.96	NS	1.10

N.S. = Not significant

dates and varieties registered leaf length ranging from 38.20 to 54.92 cm with S_3V_3 and S_1V_5 during 1996-97, 36.96 to 53.16 cm during 1997-98 with S_2V_3 and S_1V_5 and 37.73 to 54.04 cm in pooled analysis with S_3V_3 and S_1V_5 treatment combinations, respectively.

4.1.3 Leaf width

Sowing dates, varieties as well as their interactions produced marked effect on the leaf width. Plants from 31st August (S_2) sowing exhibited the maximum leaf width of 20.91 cm while further delay in seed sowing markedly reduced the leaf width to 20.20 cm at 15th September (S_3) sowing. Among the varieties, First Crop (V_2) showed maximum leaf width of 22.90 cm as compared to the minimum of 18.01 cm in Kartika (V_3). The width of leaves due to interactions between different sowing dates and varieties, varied from 17.73 to 24.85 cm during 1996-97, 17.01 to 22.60 cm during 1997-98 and 17.37 to 23.73 cm in pooled analysis with S_3V_3 and S_1V_2 treatment combinations, respectively (Table 7).

4.1.4 Number of leaves

Sowing dates, varieties as well as their interactions showed pronounced effects on the number of leaves in both the years. The data (Table 8) revealed that sowing in 15th August (S_1) produced the maximum number of leaves (20.24). The lowest number of leaves was recorded by sowing of seeds in 15th September (S_3) in both the years. Among the varieties, Early Kunwari (V_1) showed maximum number of leaves of 22.02 as compared to the minimum of 17.90 in Improved Japanese (V_5). It was apparent that varieties of Group I produced more number of comparatively smaller leaves compared to the varieties of Group Il which had bigger leaves. In case of interactions between different sowing dates and varieties, the number of leaves ranged from 17.62 to 22.15 during 1996-97, 16.29 to 20.30 during 1997-98 and 16.95 to 21.23 in pooled analysis with S_3V_5 and S_1V_1 treatment combinations, respectively.

4.1.5 Days to curd initiation

The data in Table 8 revealed that sowing dates and varieties as well as their interactions showed marked variation on the days to curd initiation both in 1996-97 and 1997-98. In case of pooled analysis also, the effects of these factors were significant. The days to curd initiation decreased from 85.10 to 70.43 from 15th August (S_1) to 15th

Table 8. Effect of sowing dates, varieties and their interactions on number of leaves, days to crud initiation and days to curd maturity of cauliflower.

Treatments	Number of leaves			Days to curd initiation			Days to curd maturity		
	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled
S_1	21.54	18.94	20.24	88.27	81.93	85.10	96.27	90.93	93.60
S_2	19.78	17.32	18.55	81.73	76.73	79.23	88.47	84.47	86.47
S_3	18.60	16.99	17.79	71.07	69.80	70.43	76.67	76.40	76.53
S.Em±	0.21	0.15	0.14	0.20	0.19	0.32	0.28	0.21	0.35
C.D.	0.61	0.43	0.41	0.58	0.55	0.93	0.81	0.61	1.01
V_1	20.96	19.07	20.02	77.22	71.56	74.39	83.67	78.22	80.94
V_2	20.53	17.45	18.99	75.56	71.00	73.28	81.00	76.78	78.89
V_3	19.44	17.56	18.50	80.33	74.67	77.50	86.22	82.56	84.39
V_4	19.98	17.82	18.90	82.78	79.00	80.89	90.56	88.33	89.44
V_5	18.95	16.85	17.90	85.89	84.56	85.22	94.22	93.78	94.00
S.Em±	0.27	0.20	0.18	0.26	0.25	0.42	0.37	0.27	0.45
C.D.	0.78	0.58	0.52	0.75	0.72	1.22	1.07	0.78	1.30
S_1V_1	22.15	20.30	21.23	86.33	78.67	82.50	93.67	86.67	90.17
S_1V_2	22.06	18.79	20.43	85.00	78.33	81.67	91.33	85.00	88.17
S_1V_3	21.31	19.43	20.37	87.33	80.67	84.00	94.00	89.67	91.83
S_1V_4	21.17	18.63	19.90	89.33	83.33	86.33	99.33	94.00	96.67
S_1V_5	20.98	17.53	19.25	93.33	88.67	91.00	103.00	99.33	101.17
S_2V_1	21.41	18.66	20.04	78.33	70.67	74.50	84.67	77.33	81.00
S_2V_2	20.64	16.82	18.73	76.33	70.33	73.33	82.33	76.33	79.33
S_2V_3	18.50	16.53	17.52	82.67	75.67	79.17	88.00	83.67	85.83
S_2V_4	20.09	17.88	18.99	84.33	79.33	81.83	92.00	88.67	90.33
S_2V_5	18.25	16.72	17.49	87.00	87.67	87.33	95.33	96.33	95.83
S_3V_1	19.31	18.26	18.79	67.00	65.33	66.17	72.67	70.67	71.67
S_3V_2	18.89	16.74	17.81	65.33	64.33	64.83	69.33	69.00	69.17
S_3V_3	18.49	16.73	17.61	71.00	67.67	69.33	76.67	74.33	75.50
S_3V_4	18.67	16.94	17.81	74.67	74.33	74.50	80.33	82.33	81.33
S_3V_5	17.62	16.29	16.95	77.33	77.33	77.33	84.33	85.67	85.00
S.Em±	0.47	0.34	0.31	0.44	0.42	0.72	0.64	0.47	0.77
C.D.	NS	NS	NS	1.27	1.22	2.09	1.85	1.36	NS

N.S. = Not significant

September (S_3) sowing. This indicated that early sown plants had longer juvenile phase than later sown plants and the temperature in the following period played an important role in determining curd initiation date. Delay in sowing resulted decrease in days to curd initiation (Fig. 2). Among the varieties, Improved Japanese (V_5) of Group II took maximum days for curd initiation (85.22) as compared to the minimum of 73.28 days in First Crop (V_2) of Group I. Days to curd initiation ranged from 65.33 to 93.33 during 1996-97, 64.33 to 88.67 during 1997-98 and 64.83 to 91.00 in pooled analysis with S_3V_2 and S_1V_5 treatment combinations, respectively.

4.1.6 Days to curd maturity

Sowing dates and varieties as well as the interactions of sowing dates with varieties caused a remarkable variation on the days to curd maturity in both the years. Among the three sequential sowings of seeds at 15 days interval, plants from 15th August (S_1) sowing exhibited the maximum days to curd maturity of 93.60 as compared to the minimum of 76.53 in 15th September (S_3) sown plants. Days to curd maturity shortened with delayed sowing (Fig. 2). Gautam *et al.* (1998) also recorded similar results. The increase in crop duration in early sowing might be due to high temperature prevailing during the early growth stage which resulted more vegetative growth for longer duration and, thus, curd formation was delayed. Among the varieties (Fig. 3), Improved Japanese (V_5) of Group II took longer time to curd maturity of 94.00 days as compared to the minimum of 78.89 days in First Crop (V_2) of Group I. The days to curd maturity ranged from 69.33 to 103.00 days during 1996-97, 69.00 to 99.33 days during 1997-98 and 69.17 to 101.17 days in pooled analysis with S_3V_2 and S_1V_5 treatment combinations, respectively.

4.1.7 Curd weight

It is evident from the data presented in Table 9 that the average curd weight increased from 303.79 g to 373.19 g by sowing of seeds in 15th August (S_1) as compared to 15th September (S_3) sowing which was significantly different. Decrease in curd weight in the late sown crop (Fig. 8) might be due to the poor vegetative growth, minimum storage of metabolites and fall in average temperature below the requirement which resulted to the production of poor growth of the curd. Higher weight of curd in early sown crop might be due to the fact that the crop remained in the field for longer period and thereby accumulated more photosynhates for higher production. Similar results were obtained by Singh *et al.* (1997), Sharma *et al.* (1994). Lawande *et al.* (1991) and Gautam *et al.* (1998). Among the varieties, Aghani of Group II showed (Fig. 9) maximum curd weight of 499.73 g as compared to the minimum of 287.61 g in Improved Japanese (V_5). The varieties of Group I produced appreciably high curd weight in this temperature regime. The curd weight due to interactions between different sowing dates and varieties, varied from 233.89 to 560.37 g with S_3V_2 and S_2V_4 during 1996-97, 191.97 to 524.69 g with S_1V_5 and S_2V_4 during 1997-98 and 221.02 to 542.53 g in pooled analysis with S_3V_2 and S_2V_4 treatment combinations, respectively (Fig. 10).

4.1.8 Days to inflorescence initiation

Among the three sequential sowings, plants from 15th August sowing (S_1) took maximum days for inflorescence initiation of 107.63 days as compared to the minimum of 85.97 days in 15th September (S_3) sown plants in pooled analysis (Table 9). Delay in sowing resulted decrease in days to inflorescence initiation. Among the varieties, Improved Japanese (V_5) took maximum days for inflorescence initiation (108.72 days) as compared to the minimum of 88.39 in First Crop (V_2). In case of interactions between different sowing dates and varieties, the days to inflorescence initiation ranged from 78.00 to 120.67 during 1996-97, 77.33 to 115.67 during 1997-98 and 76.67 to 118.17 in pooled analysis with S_3V_2 and S_1V_5 treatment combinations, respectively (Fig. 4).

4.1.9 Height of inflorescence

A marked variation was recorded on account of the sowing dates, varieties as well as their interactions in both the years. In case of pooled analysis also the effects of these factors and interactions were highly significant. Plants from 15th August (S_1) sowing exhibited the maximum height of inflorescence of 81.64 cm as compared to the minimum of 70.31 cm in 15th September (S_3) sown plants. Delay in sowing resulted decrease in height of inflorescence. Among the varieties, Improved Japanese (V_5) showed maximum height of inflorescence of 92.08 cm as compared to the minimum of 66.10 cm in Early Kunwari (V_1). A marked variation was observed due to interactions between different sowing dates and varieties, where the height of inflorescence ranged from 61.88 to 100.37 cm with S_3V_1 and S_1V_5 during 1996-97, 59.99 to 90.95 cm with

Table 9. Effect of sowing dates, varieties and their interactions on curd weight, days to inflorescence initiation and height of inflorescence of cauliflower.

Treatments	Curd weight (g)			Days to inflorescence initiation			Height of Inflorescence (cm)		
	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled
S_1	401.69	344.68	373.19	110.67	104.60	107.63	83.88	79.40	81.64
S_2	403.67	374.40	389.04	98.80	95.53	97.17	76.88	74.02	75.45
S_3	318.68	288.90	303.79	87.00	84.93	85.97	72.02	68.60	70.31
S.Em±	5.27	3.29	4.11	0.19	0.18	0.29	0.46	0.41	0.35
C.D.	15.26	9.53	11.90	0.55	0.52	0.84	1.33	1.19	1.01
V_1	361.65	335.78	348.72	93.56	87.44	90.50	67.15	65.05	66.10
V_2	314.98	292.85	303.91	90.67	86.11	88.39	71.64	68.46	70.05
V_3	354.09	319.33	336.71	96.56	92.56	94.56	73.14	70.82	71.98
V_4	522.10	477.36	499.73	103.44	101.44	102.44	80.35	77.21	78.78
V_5	320.57	254.64	287.61	109.89	107.56	108.72	95.67	88.48	92.08
S.Em±	6.80	4.25	5.31	0.24	0.24	0.37	0.59	0.52	0.46
C.D.	19.69	12.31	15.38	0.70	0.70	1.07	1.71	1.51	1.33
S_1V_1	438.70	406.32	422.51	106.33	98.00	102.17	72.50	69.31	70.91
S_1V_2	365.55	344.02	354.79	103.33	96.67	100.00	77.21	73.53	75.37
S_1V_3	388.61	370.47	379.54	108.67	103.33	106.00	78.13	76.63	77.38
S_1V_4	498.65	410.63	454.64	114.33	109.33	111.83	91.17	86.65	88.91
S_1V_5	316.94	191.97	254.45	120.67	115.67	118.17	100.37	90.86	95.62
S_2V_1	405.73	388.62	397.17	93.67	87.00	90.33	67.06	65.84	66.45
S_2V_2	345.51	326.36	335.94	90.67	86.33	88.50	71.14	68.93	70.04
S_2V_3	363.12	330.29	346.71	96.67	92.67	94.67	73.20	70.26	71.73
S_2V_4	560.37	524.69	542.53	103.67	101.33	102.50	77.24	74.11	75.68
S_2V_5	343.63	302.02	322.83	109.33	110.33	109.83	95.73	90.95	93.34
S_3V_1	240.53	212.41	226.47	80.67	77.33	79.00	61.88	59.99	60.94
S_3V_2	233.89	208.16	221.02	78.00	75.33	76.67	66.57	62.91	64.74
S_3V_3	310.53	257.23	283.88	84.33	81.67	83.00	68.09	65.58	66.84
S_3V_4	507.29	496.75	502.02	92.33	93.67	93.00	72.66	70.88	71.77
S_3V_5	301.15	259.95	285.55	99.67	96.67	98.17	90.91	83.63	87.27
S.Em±	11.77	7.36	9.20	0.42	0.41	0.65	1.02	0.91	0.79
C.D.	34.09	21.32	26.65	1.22	1.19	1.88	2.95	2.64	2.29

S_1 = 15th August, S_2 = 31st August and S_3 = 15th September

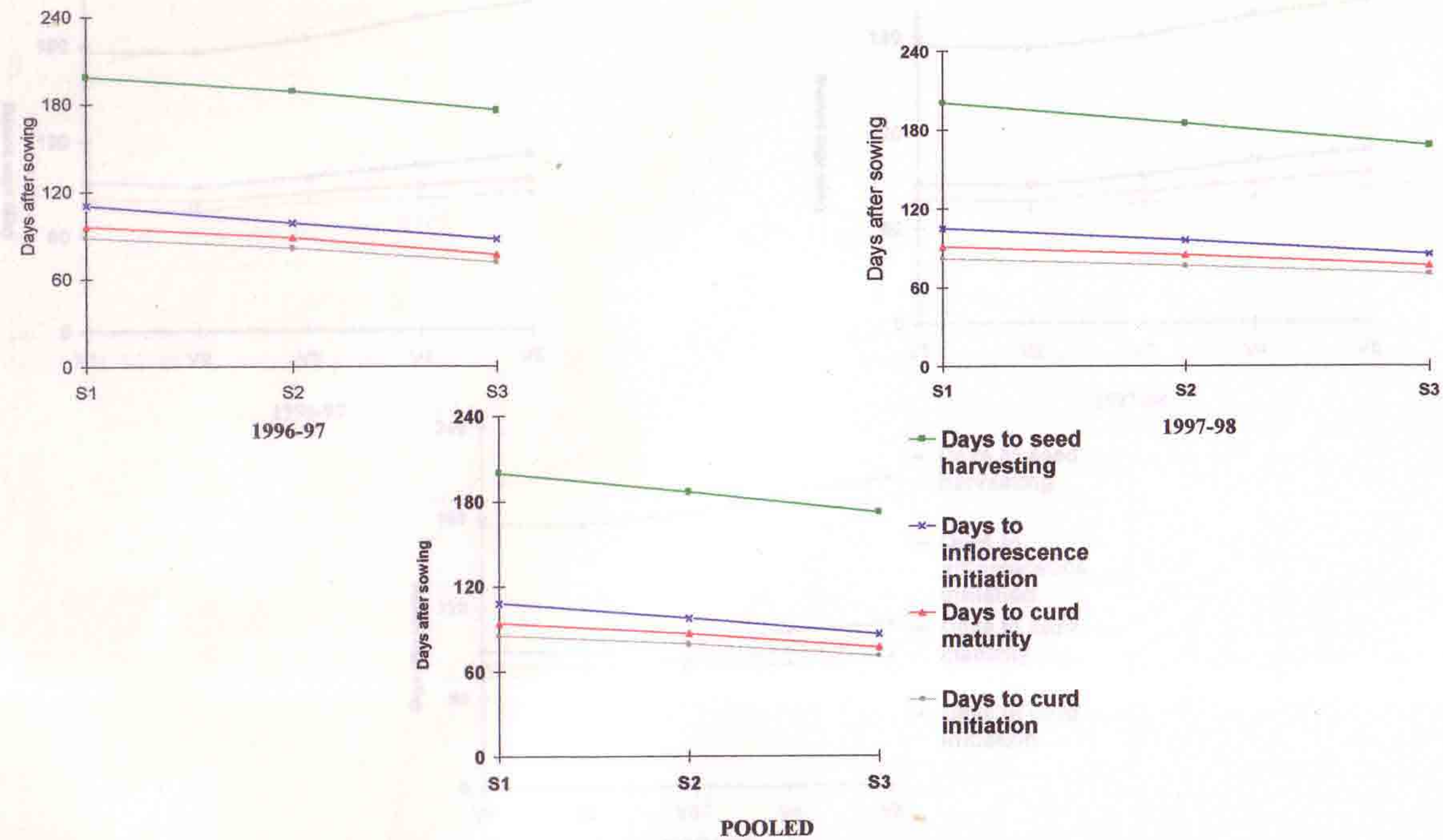
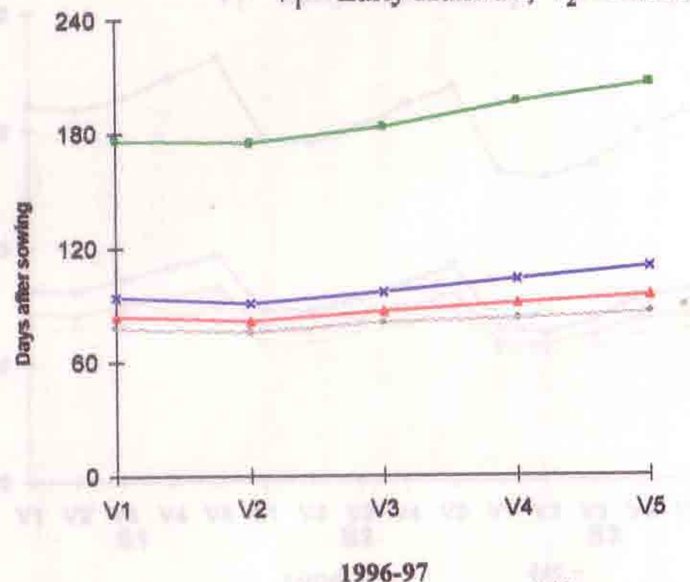
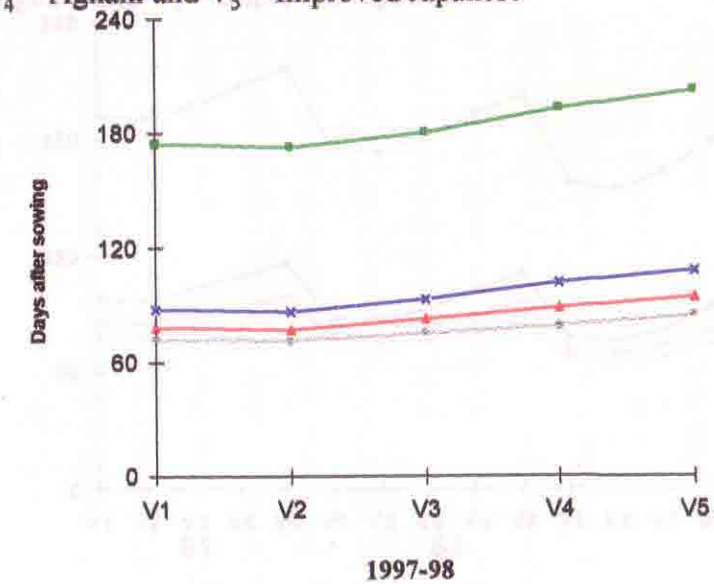


Fig. 2. Effect of sowing dates on days to curd initiation, days to curd maturity, days to inflorescence initiation and days to seed harvesting in cauliflower.

V_1 = Early Kunwari, V_2 = First Crop, V_3 = Kartika, V_4 = Aghani and V_5 = Improved Japanese





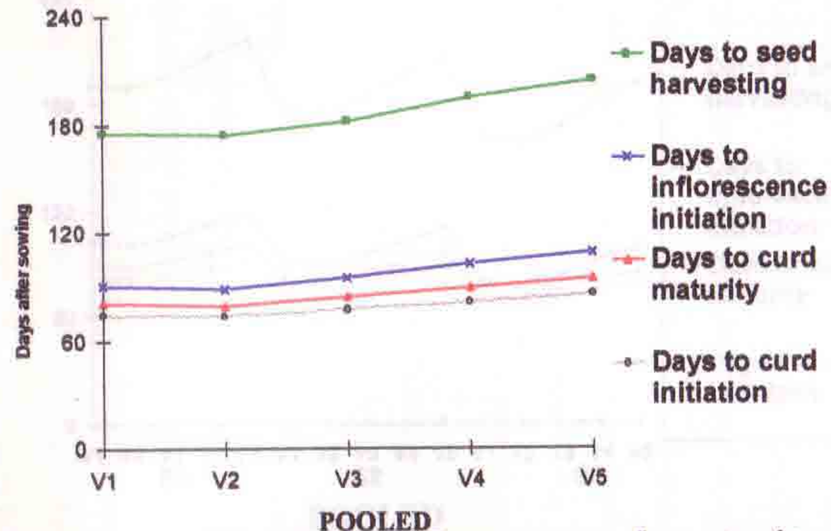


Fig. 3. Effect of varieties on days to curd initiation, days to curd maturity, days to inflorescence initiation and days to seed harvesting in cauliflower.

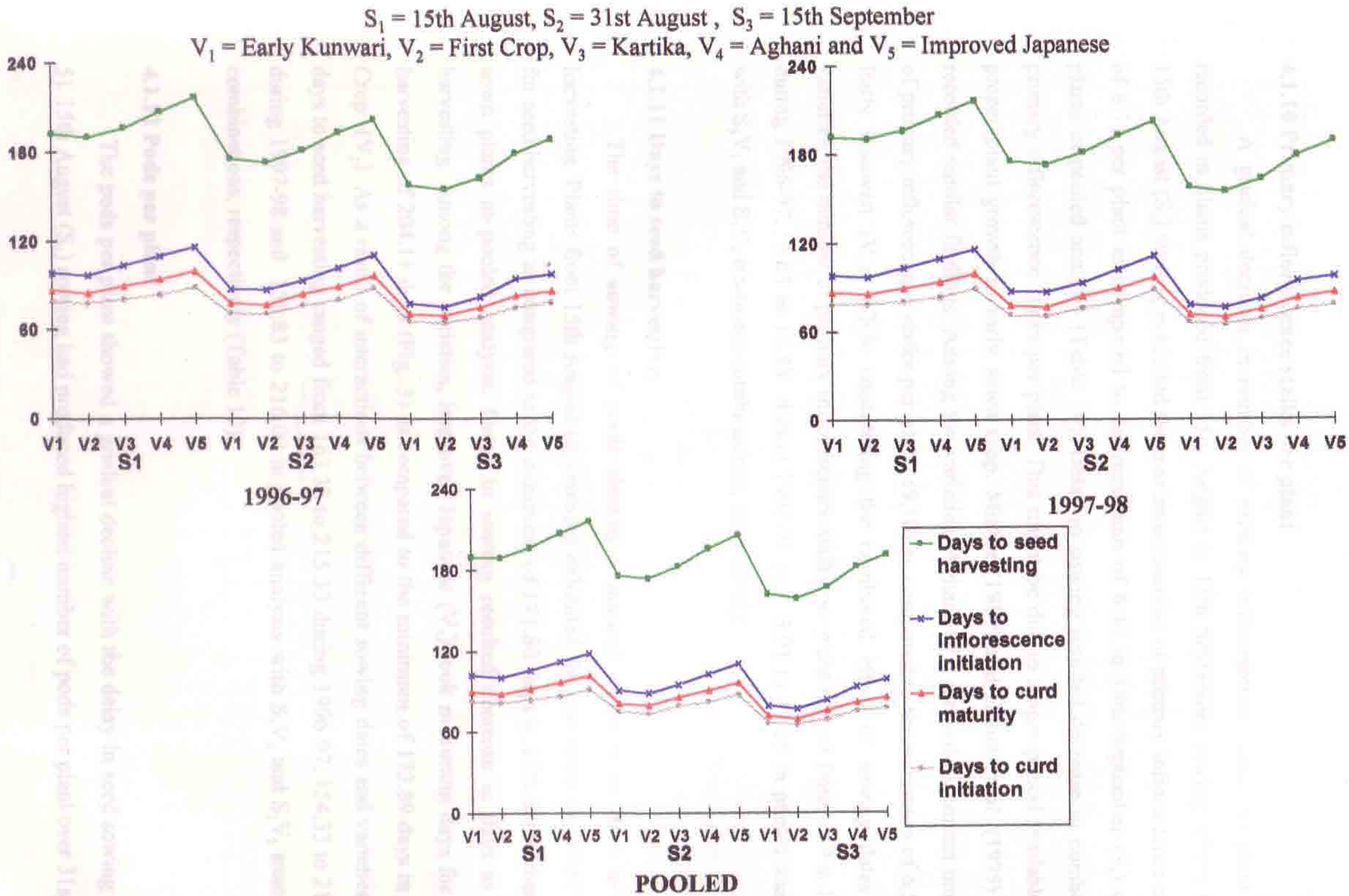


Fig. 4. Interaction effect of sowing dates and varieties on days to curd initiation, days to curd maturity, days to inflorescence initiation and days to seed harvesting in cauliflower.

S_3V_1 and S_2V_5 during 1997-98 and 60.94 to 95.62 cm in pooled analysis with S_3V_1 and S_1V_5 treatment combinations, respectively (Table 9).

4.1.10 Primary inflorescence stalks per plant

A gradual decrease in number of primary inflorescence stalks per plant was recorded in plants produced from 15th August to 15th September sowing. Plants from 15th August (S_1) sowing exhibited the maximum number of primary inflorescence stalks of 8.71 per plant as compared to the minimum of 6.40 in 15th September (S_3) sown plants in pooled analysis (Table 10). Delay in sowing resulted decrease in number of primary inflorescence stalks per plant. This might be due to longer period available for proper plant growth in early sown crop. Mishra (1989) and Halim *et al.* (1995) also recorded similar findings. Among the varieties, Aghani (V_4) showed maximum number of primary inflorescence stalks per plant (9.10) as compared to the minimum of 6.51 in Early Kunwari (V_1). While considering the combined effect of sowing dates and varieties, the number of primary inflorescence stalks per plant ranged from 6.19 to 11.81 during 1996-97, 5.63 to 10.88 during 1997-98 and 5.91 to 11.35 in pooled analysis with S_3V_1 and S_1V_4 treatment combinations, respectively.

4.1.11 Days to seed harvesting

The time of sowing of seeds showed a marked variation on days to seed harvesting. Plants from 15th August (S_1) sowing exhibited the maximum of 199.57 days for seed harvesting as compared to the minimum of 171.80 days in 15th September (S_3) sown plants in pooled analysis. Delay in sowing resulted decrease in days to seed harvesting. Among the varieties, Improved Japanese (V_5) took maximum days for seed harvesting of 204.11 days (Fig. 3) as compared to the minimum of 173.89 days in First Crop (V_2). As a result of interactions between different sowing dates and varieties, the days to seed harvesting ranged from 163.33 to 215.33 during 1996-97, 154.33 to 216.67 during 1997-98 and 158.83 to 216.00 in pooled analysis with S_3V_2 and S_1V_5 treatment combinations, respectively (Table 10).

4.1.12 Pods per plant

The pods per plant showed a gradual decline with the delay in seed sowing (Fig. 5). 15th August (S_1) sowing had produced highest number of pods per plant over 31st

Table 10. Effect of sowing dates, varieties and their interactions on number of primary inflorescence stalks per plant, days to seed harvesting and pods per plant of cauliflower.

Treatments	Primary inflorescence stalks per plant			Days to seed harvesting			Pods per plant		
	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled
S_1	9.03	8.39	8.71	198.73	200.40	199.57	775.34	806.57	790.95
S_2	7.71	7.19	7.45	188.60	184.53	186.57	743.81	779.01	761.41
S_3	6.73	6.08	6.40	175.33	168.27	171.80	628.60	674.79	651.70
S.Em±	0.13	0.13	0.09	0.19	0.17	0.44	12.01	9.76	7.17
C.D.	0.38	0.38	0.26	0.55	0.49	1.27	34.78	28.27	20.77
V_1	6.78	6.23	6.51	176.33	174.78	175.56	674.78	711.60	693.19
V_2	6.93	6.58	6.76	175.33	172.44	173.89	635.02	667.57	651.30
V_3	7.89	7.31	7.60	183.33	179.89	181.61	689.78	740.31	715.04
V_4	9.39	8.81	9.10	196.78	192.67	194.72	872.10	902.03	887.07
V_5	8.12	7.16	7.64	206.00	202.22	204.11	707.89	745.78	726.84
S.Em±	0.17	0.17	0.11	0.25	0.22	0.57	15.51	12.60	9.25
C.D.	0.49	0.49	0.32	0.72	0.64	1.65	44.92	36.49	26.79
S_1V_1	7.27	6.93	7.10	187.67	191.67	189.67	737.70	771.87	754.78
S_1V_2	7.34	7.06	7.20	187.33	190.33	188.83	730.52	753.98	742.25
S_1V_3	8.57	8.00	8.29	196.00	196.33	196.17	756.10	807.58	781.84
S_1V_4	11.81	10.88	11.35	207.33	207.00	207.17	969.86	989.91	979.89
S_1V_5	10.15	9.10	9.63	215.33	216.67	216.00	682.49	709.52	696.01
S_2V_1	6.87	6.14	6.51	175.67	175.33	175.50	713.11	739.55	726.33
S_2V_2	7.06	6.88	6.97	175.33	172.67	174.00	635.06	643.39	639.22
S_2V_3	8.15	7.82	7.98	184.00	180.67	182.33	697.88	754.42	726.15
S_2V_4	8.81	8.38	8.60	198.67	192.33	195.50	941.33	959.78	950.55
S_2V_5	7.66	6.72	7.19	209.33	201.67	205.50	731.68	797.92	764.80
S_3V_1	6.19	5.63	5.91	165.67	157.33	161.50	573.55	623.40	598.47
S_3V_2	6.40	5.79	6.10	163.33	154.33	158.83	539.50	605.33	572.42
S_3V_3	6.93	6.13	6.53	170.00	162.67	166.33	615.35	658.92	637.14
S_3V_4	7.56	7.16	7.36	184.33	178.67	181.50	705.12	756.38	730.75
S_3V_5	6.56	5.67	6.12	193.33	188.33	190.83	709.50	729.90	719.70
S.Em±	0.30	0.30	0.20	0.43	0.38	0.99	26.86	21.83	16.02
C.D.	0.87	0.87	0.58	1.25	1.10	NS	77.79	63.23	46.40

N.S. = Not significant

August and 15th September sowing in both the years of the investigation. Among the three sequential sowings of seeds at 15 days interval, plants from 15th August (S_1) showing gave the maximum number of 790.95 pods per plant as compared to the minimum number of 651.70 pods in 15th September (S_3) sown plants in pooled analysis. Halim *et al.* (1995) also noticed that delay in sowing resulted decrease in the number of pods per plant. Among varieties, Aghani (V_4) of Group II showed maximum number of pods per plant of 887.07 as compared to the minimum of 651.30 in First Crop (V_2). Due to interactions between different sowing dates and varieties, the pods per plant ranged from 539.50 to 969.86 during 1996-97, 605.33 to 989.91 during 1997-98 and 572.42 to 979.89 in pooled analysis with S_3V_2 and S_1V_4 treatment combinations, respectively (Table 10).

4.1.13 Pod length

Pod length showed considerable variations with different sowings in both the years. Plants from 15th August (S_1) sowing had produced the maximum pod length of 6.31 cm as compared to the minimum of 5.58 cm in 15th September sown (S_3) plants in pooled analysis. Mishra (1989) also observed that delay in sowing resulted decrease in pod length. Among the varieties, Aghani (V_4) showed maximum pod length of 6.33 cm as compared to the minimum of 5.49 cm in Kartika (V_3). The pod length due to interactions between different sowing dates and varieties, varied from 4.73 to 6.50 cm with S_3V_3 and S_1V_4 during 1996-97, 5.35 to 6.78 cm with S_3V_2 and S_1V_1 during 1997-98 and 5.10 to 6.61 cm in pooled analysis with S_3V_3 and S_1V_1 treatment combinations, respectively (Table 10).

4.1.14 Seeds per pod

Like number of pods per plant, seeds per pod also decreased markedly due to late sowing. Among the three sequential sowings, plants from 15th August (S_1) sowing exhibited the maximum seeds per pod of 20.18 as compared to the minimum of 15.95 in 15th September (S_3) sown plants in pooled analysis. Delay in sowing resulted decrease in number of seeds per pod (Fig. 5). These results are in conformity with the findings of Mishra (1989) and Halim *et al.* (1995). Among the varieties, Aghani (V_4) showed maximum of 19.92 number of seeds per pod as compared to the minimum of 15.70 seeds per pod in Early Kunwari (V_1). The interactions showed a significant variation in pooled

Table 11. Effect of sowing dates, varieties and their interactions on pod length, seeds per pod and seed yield per plant of cauliflower.

Treatments	Pod length (cm)			Seeds per pod			Seed yield per plant (g)		
	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled
S_1	6.20	6.43	6.31	19.76	20.59	20.18	16.88	18.11	17.49
S_2	5.87	6.06	5.97	18.33	18.96	18.64	16.02	17.05	16.53
S_3	5.40	5.76	5.58	15.39	16.52	15.95	13.21	14.04	13.63
S.Em±	0.09	0.07	0.05	0.30	0.34	0.21	0.19	0.18	0.13
C.D.	0.26	0.20	0.14	0.87	0.98	0.61	0.55	0.52	0.38
V_1	5.84	6.24	6.04	15.37	16.04	15.70	14.14	14.86	14.50
V_2	5.46	5.79	5.63	17.78	18.75	18.27	13.84	14.86	14.35
V_3	5.30	5.68	5.49	18.32	19.50	18.91	15.93	17.09	16.51
V_4	6.29	5.37	6.33	19.69	20.14	19.92	17.40	18.60	18.00
V_5	6.22	6.33	6.27	17.97	19.00	18.49	15.55	16.58	16.06
S.Em±	0.12	0.09	0.07	0.39	0.43	0.27	0.24	0.24	0.17
C.D.	0.35	0.26	0.20	1.13	1.25	0.78	0.70	0.70	0.49
S_1V_1	6.44	6.78	6.61	18.87	19.32	19.10	15.49	15.88	15.69
S_1V_2	5.84	6.27	6.06	19.10	20.70	19.90	15.76	17.26	16.51
S_1V_3	5.73	5.81	5.77	20.07	21.07	20.57	19.08	20.00	19.54
S_1V_4	6.50	6.62	6.56	21.00	21.24	21.12	19.34	21.24	20.29
S_1V_5	6.47	6.66	6.57	19.78	20.62	20.20	14.70	16.15	15.43
S_2V_1	5.95	6.29	6.12	15.02	15.64	15.33	14.71	15.82	15.26
S_2V_2	5.60	5.75	5.68	18.93	19.25	19.09	14.53	15.06	14.80
S_2V_3	5.43	5.77	5.60	19.68	20.67	20.18	15.76	18.21	16.99
S_2V_4	6.21	6.28	6.25	20.46	20.96	20.71	17.87	18.42	18.15
S_2V_5	6.17	6.22	6.19	17.55	18.25	17.90	17.24	17.72	17.48
S_3V_1	5.14	5.65	5.39	12.21	13.14	12.68	12.22	12.87	12.55
S_3V_2	4.95	5.35	5.15	15.31	16.31	15.81	11.22	12.25	11.73
S_3V_3	4.73	5.47	5.10	15.22	16.76	15.99	12.94	13.05	13.00
S_3V_4	6.16	6.21	6.19	17.62	18.22	17.92	14.98	16.14	15.56
S_3V_5	6.01	6.12	6.06	16.58	18.13	17.36	14.70	15.88	15.29
S.Em±	0.21	0.15	0.12	0.68	0.75	0.46	0.42	0.41	0.30
C.D.	NS	NS	0.35	NS	NS	1.33	1.22	1.19	0.87

N.S. = Not significant

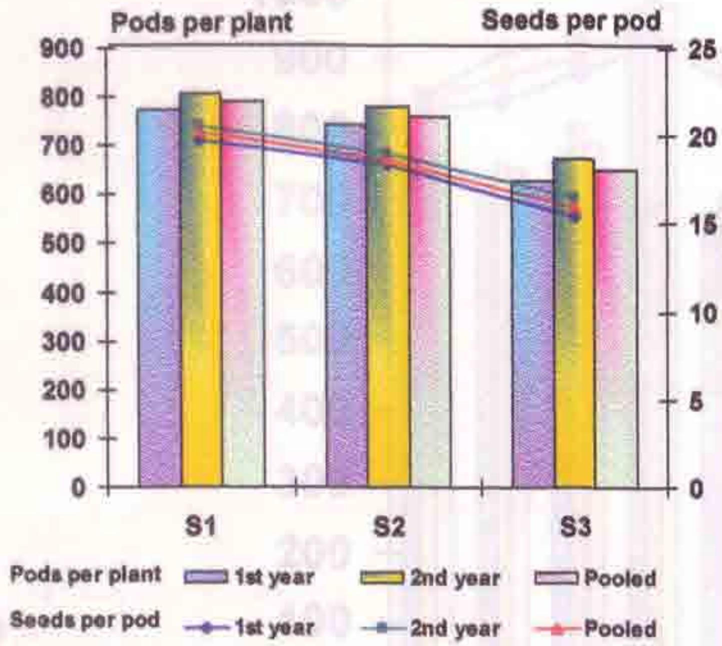


Fig. 5. Effect of sowing dates on pods per plant and seeds per pods in cauliflower.

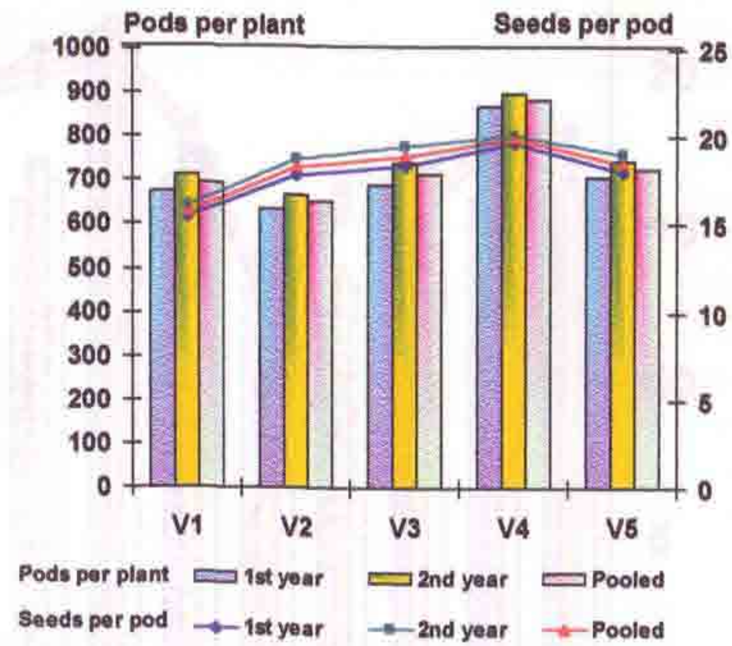


Fig. 6. Effect of varieties on pods per plant and seeds per pods in cauliflower.

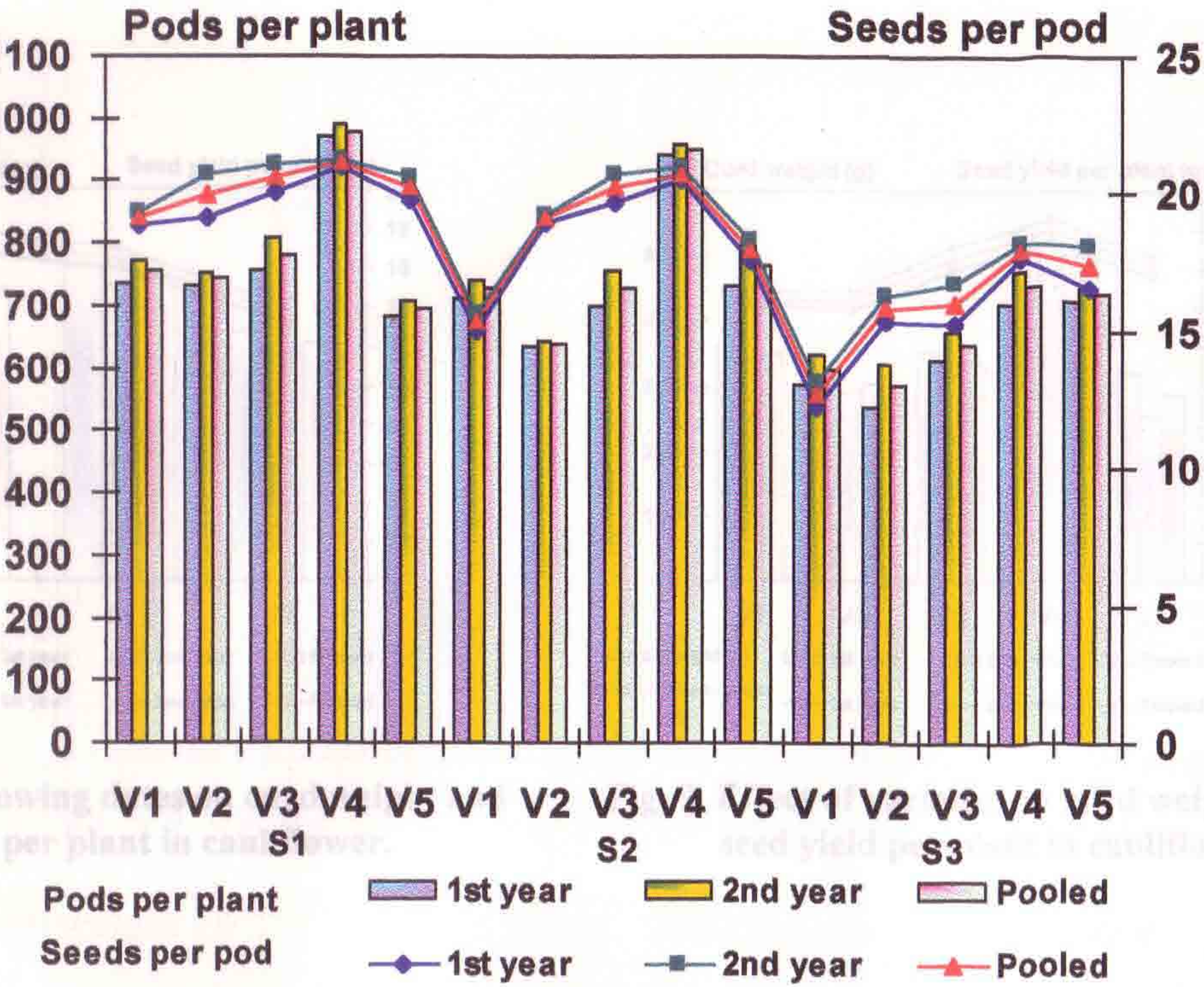


Fig. 7. Interaction effect of sowing dates and varieties on pods per plant and seeds per pod in cauliflower.

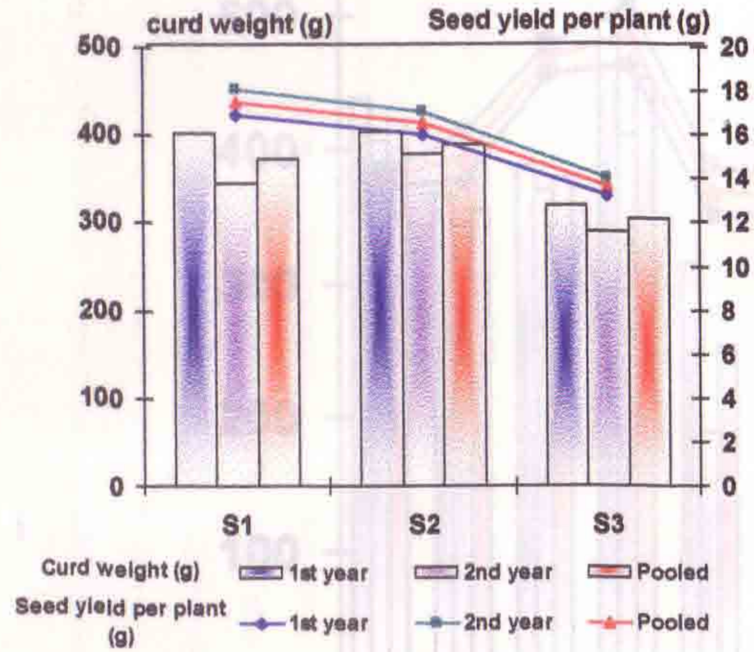


Fig. 8. Effect of sowing dates on curd weight and seed yield per plant in cauliflower.

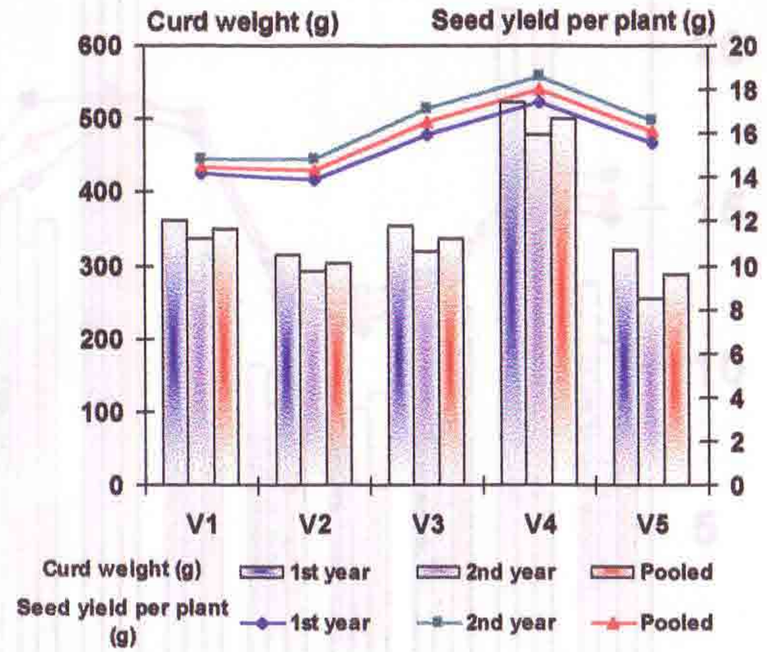


Fig. 9. Effect of varieties on curd weight and seed yield per plant in cauliflower.

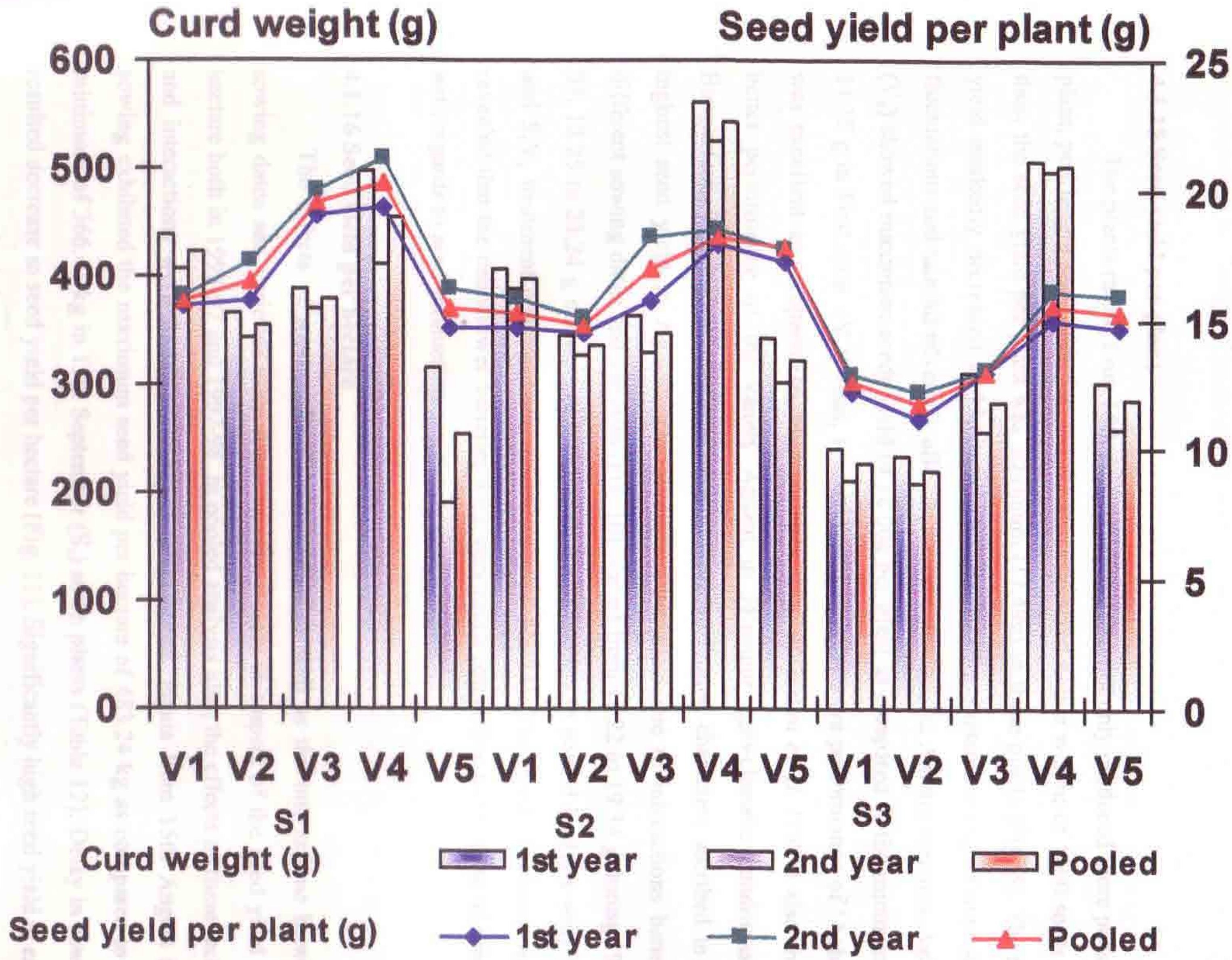


Fig. 10. Interaction effect of sowing dates and varieties on curd weight and seed yield per plant in cauliflower.

analysis only (Table 11). In the interactions between different sowing dates and varieties, the number of seeds per pod ranged from 12.21 to 21.00 during 1996-97, 13.14 to 21.24 during 1997-98 and 12.68 to 21.12 in pooled analysis with S_3V_1 and S_1V_4 treatment combinations, respectively.

4.1.15 Seed yield per plant

The plants raised from 15th August sowing (S_1) not only produced more pods per plant, pod length and seeds per pod but also registered higher weight of 1000 seeds and thus, the seed yield per plant was maximum (17.49g) in those plants (Fig. 8). The seed yield markedly decreased to 13.63g when sown in 15th September (S_3). Temperature fluctuations and rainfall adversely affected the seed production. Among varieties, Aghani (V_4) showed maximum seeds yield of 18.00g per plant as compared to the minimum of 14.35 g in First crop (V_2). Thus, it is evident that the relative performance of 'Aghani' was excellent as compared to other varieties (Fig. 9). Halim *et al.* (1995) also found better performance of the variety Aghani in Jalampur agro-climatic conditions of Bangladesh. The higher values of various yield attributing characters ascribed to the highest seed yield in Aghani. The seed yield per plant due to interactions between different sowing dates and varieties (Fig. 10), varied from 11.22 to 19.34 g during 1996-97, 12.25 to 21.24 g during 1997-98 and 11.73 to 20.29 g in pooled analysis with S_3V_2 and S_1V_4 treatment combinations, respectively (Table 11). The trend of present result revealed that the cauliflower varieties were very much responsive to the time of sowing with regards to seed production.

4.1.16 Seed yield per hectare

The effects of sowing dates and varieties as well as the interactions between sowing dates and varieties were found to vary widely in respect of the seed yield per hectare both in 1996-97 and 1997-98. In pooled analysis also, the effects of these factors and interactions were found to be highly pronounced. Plants from 15th August (S_1) sowing exhibited the maximum seed yield per hectare of 483.24 kg as compared to the minimum of 366.41 kg in 15th September (S_3) sown plants (Table 12). Delay in sowing resulted decrease in seed yield per hectare (Fig. 11). Significantly high seed yield in early sown crop resulted due to enhanced expression of yield attributing characters as early crops stayed in the field for longer period. Similar findings of lower seed yield in late sown crop was also observed by Kunwar (1996), Mishra (1989) and Halim *et al.* (1995). Gill and Singh (1973) in their experiment with cauliflower seed production concluded that temperature fluctuations and heavy rainfall adversely affected the seed production and this finding are also in agreement with the present study. Among the varieties, Aghani (V_4) of Group II produced maximum seed yield of 493.04 kg per hectare (Fig. 12) as compared to the minimum of 387.75 kg per hectare in Early Kunwari (V_1) of Group I. Among the Group I varieties, Kartika registered the highest seed yield of 454.10 kg per hectare. Better performance of the variety Aghani belonging to Group II was also noticed by Halim *et al.* (1995). Significant difference in performance of different varieties of different maturity groups for seed production was recorded earlier when planted in different times (Lawande *et al.*, 1991). The seed yield as a result of interactions between different sowing dates and varieties (Fig. 13), varied from 313.82 to 549.39 kg per hectare during 1996-97, 325.09 to 609.76 kg per hectare during 1997-98 and 319.46 to 579.57 kg per hectare in pooled analysis with S_3V_2 and S_1V_4 treatment combinations, respectively.

4.1.17 1000 seed weight (Test weight)

The 1000 seed weight was maximum (3.23g) in the plants which were raised in 15th August (S_1), while it decreased to 3.16 and 2.61 g in subsequent sowings of 31st August and 15th September (S_3), respectively (Fig. 11). This might be due to proper plant growth and more favourable climatic condition prevailed during flowering and seed setting of early sown crop. Mishra (1989) also reported that seed weight of cauliflower was more at the earliest sowing and progressively decreased with delay in sowing. Among the varieties, Aghani (V_4) showed maximum 1000 seed weight of 3.18 g (Fig. 12) as compared to the minimum of 2.80 g in First Crop (V_2). The 1000 seed weight ranged from 2.43 to 3.51 g with S_3V_1 and S_1V_4 during 1996-97, and 2.24 to 3.58 g during 1997-98 and 2.25 to 3.54 g in pooled analysis with S_3V_2 and S_1V_4 treatment combinations, respectively (Table 12) due to interactions between different sowing dates and varieties.

4.1.18 Germination percentage

The data presented in Table 12 revealed that sowing dates, varieties and their interactions affected the germination percentage of the seeds in both the years. In case of

Table 12. Effect of sowing dates, varieties and their interactions on seed yield per hectare, 1000 seed weight and germination percentage of cauliflower.

Treatments	Seed yield per hectare (kg)			1000 seed weight (g)			Germination percentage		
	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled
S_1	459.70	506.78	483.24	3.17	3.30	3.23	84.00	85.80	84.90
S_2	428.81	463.63	446.22	3.14	3.17	3.16	85.20	85.40	85.30
S_3	356.05	376.76	366.41	2.62	2.60	2.61	78.73	84.13	81.43
S.Em±	8.76	8.02	5.96	0.05	0.05	0.03	0.43	0.33	0.35
C.D.	25.37	23.23	17.26	0.14	0.14	0.09	1.25	0.96	1.01
V_1	382.15	393.34	387.75	2.84	2.93	2.89	78.11	80.78	79.44
V_2	369.09	408.97	389.03	2.76	2.83	2.80	78.33	81.00	79.67
V_3	430.69	477.50	454.10	3.05	3.07	3.06	81.22	84.22	82.72
V_4	475.81	510.26	493.04	3.18	3.17	3.18	87.33	90.22	88.78
V_5	416.51	455.20	435.86	3.04	3.10	3.07	88.22	89.33	88.78
S.Em±	11.31	10.35	7.69	0.06	0.07	0.04	0.56	0.42	0.45
C.D.	32.76	29.98	22.27	0.17	0.20	0.12	1.62	1.22	1.30
S_1V_1	406.42	423.12	414.77	3.19	3.35	3.27	79.33	82.33	80.83
S_1V_2	417.35	491.09	454.22	3.22	3.28	3.25	79.67	82.67	81.17
S_1V_3	532.35	577.01	554.68	3.33	3.44	3.38	83.00	84.67	83.83
S_1V_4	549.39	609.76	579.57	3.51	3.58	3.54	89.01	90.33	89.67
S_1V_5	392.99	432.92	412.96	2.60	2.83	2.72	89.00	89.00	89.00
S_2V_1	399.93	415.69	407.81	2.91	2.96	2.94	80.33	81.00	80.67
S_2V_2	376.11	410.73	393.42	2.81	2.97	2.89	80.67	81.00	81.00
S_2V_3	417.92	509.58	463.75	3.15	3.24	3.20	83.00	84.33	83.67
S_2V_4	487.29	487.24	487.26	3.33	3.35	3.34	90.67	90.67	90.67
S_2V_5	462.79	494.90	478.84	3.51	3.33	3.42	91.33	89.67	90.50
S_3V_1	340.10	341.22	340.66	2.43	2.47	2.45	74.67	79.00	76.83
S_3V_2	313.82	325.09	319.46	2.56	2.24	2.40	74.67	79.00	76.83
S_3V_3	341.81	345.91	343.86	2.68	2.54	2.61	77.67	83.67	80.67
S_3V_4	390.75	433.79	412.27	2.71	2.59	2.65	82.33	89.67	86.00
S_3V_5	393.77	437.79	415.78	3.00	3.14	3.07	84.33	89.33	86.83
S.Em±	19.60	17.92	13.32	0.10	0.12	0.07	0.97	0.73	0.78
C.D.	56.77	51.90	38.58	0.29	0.35	0.20	NS	NS	NS

N.S. = Not significant

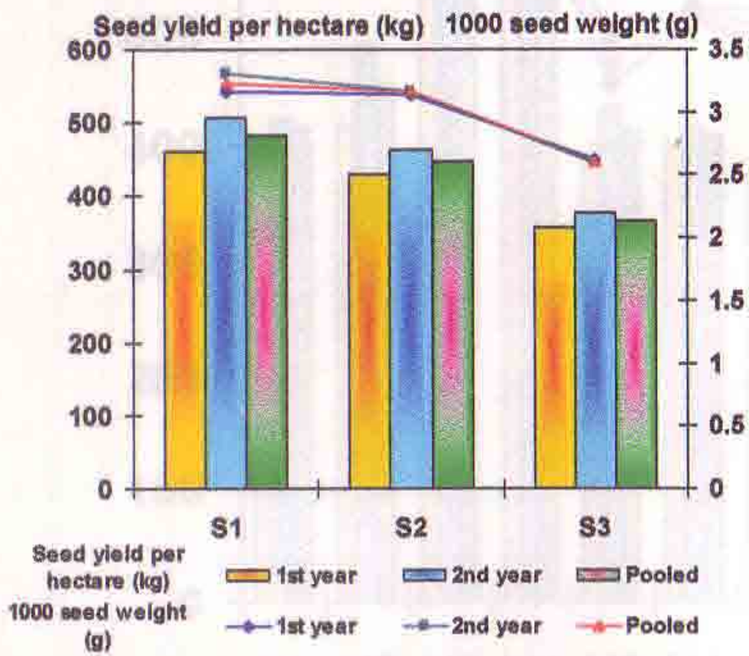


Fig. 11. Effect of sowing dates on seed yield per hectare and 1000 seed weight in cauliflower.

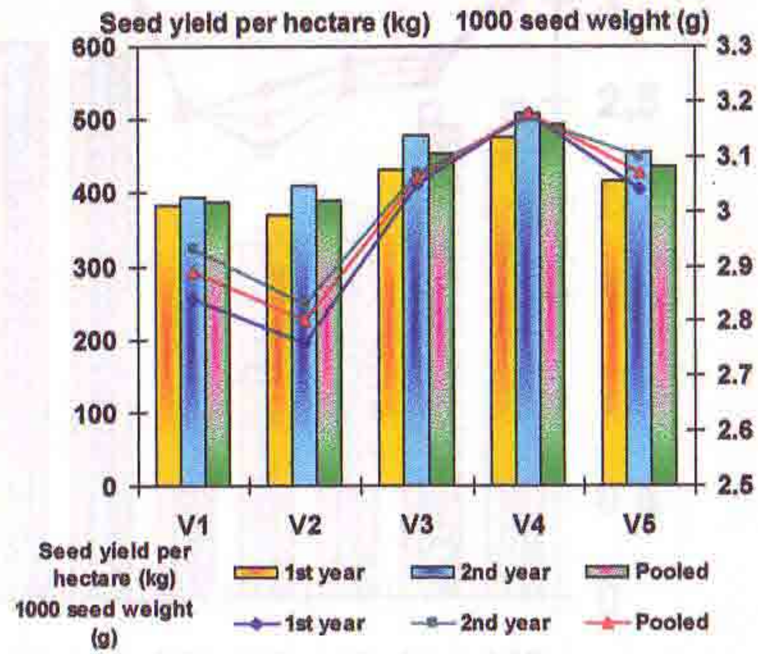


Fig. 12. Effect of varieties on seed yield per hectare and 1000 seed weight in cauliflower.

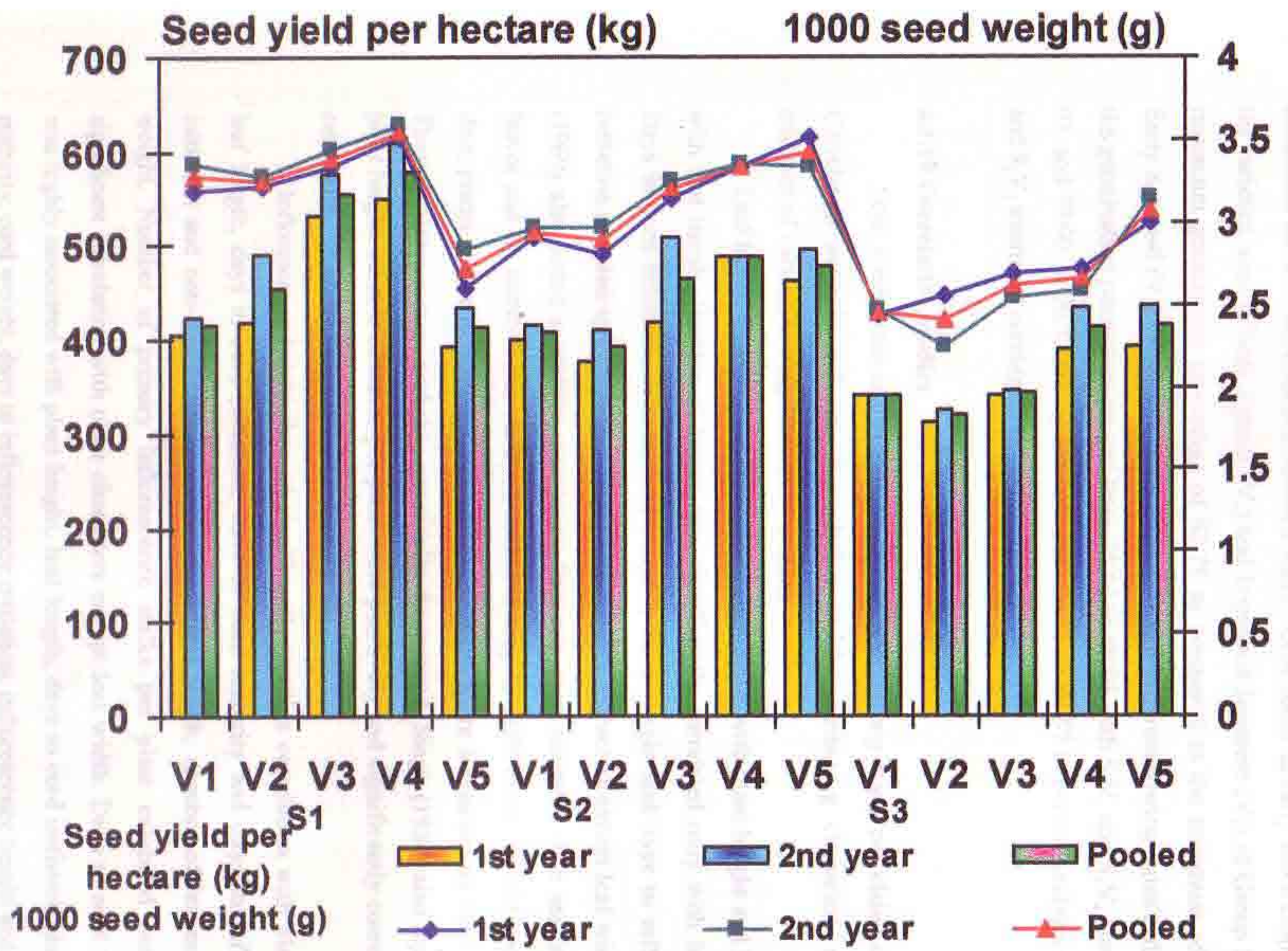


Fig. 13. Interaction effect of sowing dates and varieties on seed yield per hectare and 1000 seed weight in cauliflower.

pooled analysis also, the effects of these factors and interactions were found significant. Plants from 31st August (S_2) sowing greatly enhanced the germination percentage of 85.30 while further delay in seed sowing markedly reduced the germination percentage to 81.43 at 15th September sowing (S_3). Long duration and favourable climatic conditions for seed development resulted more viable seeds in early sown crops. Among the varieties, seed of both Aghani (V_4) and Improved Japanese (V_5) of Group II showed maximum germination percentage of 88.78 as compared to the minimum of 79.44 in Early Kunwari (V_1). In case of interactions between different sowing dates and varieties, the germination percentage ranged from 74.66 to 89.01 with S_3V_1 and S_1V_4 during 1996-97, and 79.00 to 90.33 during 1997-98 and 76.83 to 89.67 in pooled analysis with S_3V_2 and S_1V_4 treatment combinations, respectively.

4.1.19 Correlation studies

Seed yield is the end product of interactions among many correlated characters. Correlation analysis indicates the reliable yield contributing characters under the situation of varying sowing dates and varieties.

Leaf length showed a positively high correlation with plant height and leaf width with leaf length. Number of leaves was significantly correlated only with leaf width. Days to curd initiation, days to curd maturity curd weight and days to inflorescence initiation revealed significant correlations with other characters except leaf width. Salter (1969) also found a positive correlation between curd initiation date and number of leaves and he ascribed the variation within a crop to differences in cold requirement, thus, plants with a higher cold requirement initiated more leaves before curd initiation. These differences were probably genetically determined. Singh (1984) also reported that plant height, number of leaves per plant were positively and significantly correlated with curd yield.

Inflorescence height showed significantly positive correlation with plant height, leaf length, days to curd initiation, days to curd maturity and days to inflorescence initiation and non-significant correlation with leaf width, number of leaves and curd weight. Number of primary inflorescence stalks per plant exhibited positive and significant correlation with other characters except leaf width. Days to seed harvesting was highly associated with plant height, leaf length, days to curd initiation, days to curd maturity, curd weight, days to inflorescence initiation, inflorescence height and number

Table 13. Correlation co-efficients for different pairs of charceters in cauliflower seed crop.

Characters	Leaf length (cm)	Leaf width (cm)	No. of leaves	Days to curd initiation	Days to curd maturity	Curd weight (g)	Days to inf. initiation	Inf. height (cm)	Primary inflo. stalks /plant	Days to harvesting	Pods / plant	Pod length (cm)	Seeds / pod	Seed yield/ plant (g)	Seed yield/ha (kg)	1000 seed wt. (g)	Germ. p.c.
Plant height (cm)	0.932**	0.139	0.068	0.763**	0.788**	0.251*	0.815**	0.893**	0.624**	0.830**	0.585**	0.614**	0.538**	0.572**	0.548**	0.472**	0.840**
Leaf length (cm)		0.261*	0.064	0.662**	0.694**	0.228*	0.731**	0.851**	0.528**	0.753**	0.512**	0.624**	0.420**	0.438**	0.405**	0.354**	0.779**
Leaf width (cm)			0.372*	0.042	0.005	0.182	0.008	-0.006	-0.067	-0.072	0.097	0.226*	0.066	0.022	0.020	0.037	-0.010
Number of leaves				0.419**	0.368**	0.366**	0.34**	0.07**	0.325**	0.135	0.297**	0.423**	0.301**	0.379**	0.391**	0.284**	0.048
Days to curd initiation					0.985**	0.377**	0.974**	0.808**	0.684**	0.902**	0.619**	0.706**	0.704**	0.765**	0.710**	0.689**	0.712**
Days to curd maturity						0.378**	0.988**	0.829**	0.709**	0.941**	0.634**	0.719**	0.690**	0.760**	0.710**	0.688**	0.738**
Curd weight (g)							0.367**	0.096**	0.452**	0.309**	0.722**	0.502**	0.481**	0.622**	0.546**	0.515**	0.448**
Days to inf. Initiation								0.863**	0.716**	0.958**	0.638**	0.729**	0.685**	0.759**	0.703**	0.671**	0.760**
Inf. height (cm)									0.577**	0.861**	0.457**	0.562**	0.520**	0.560**	0.542**	0.479**	0.784**
Primary inf. stalks/ plant										0.670**	0.668**	0.511**	0.669**	0.700**	0.665**	0.487**	0.595**
Days to seed harvesting											0.605**	0.659**	0.636**	0.676**	0.645**	0.639**	0.737**
Pods / plant												0.567**	0.559**	0.815**	0.778**	0.701**	0.677**
Pod length (cm)													0.486**	0.534**	0.456**	0.494**	0.588**
Seeds /pod														0.699**	0.624**	0.586**	0.551**
Seed yield/plant (g)															0.902**	0.807**	0.666**
Seed yield /ha (kg)																0.742**	0.605**
1000 seed wt. (g)																	0.515**

* Significant at 5% level, ** Significant at 1% level.

of primary inflorescence stalks per plant and days to seed harvesting had negative but non-significant correlation with leaf width (Table 13).

Number of pods per plant was strongly correlated with all other characters except leaf width. Pod length exhibited significantly high positive relationship with all other characters. Number of seeds per pod, seed yield per plant, seed yield per hectare, and 1000 seed weight (test weight) showed highly significant positive correlation with all growth and seed yield parameters under varying sowing dates and varieties, and non-significant positive correlation with leaf width. Germination percentage also showed a strong positive association with all the characters except leaf width and number of leaves.

4.2 Experiment-2. Effect of nitrogen, phosphorus and their interactions on growth and seed production of cauliflower variety Aghani.

The variety Aghani of Group II was employed for this study because of its pronounced performance recorded in an earlier preliminary trial. Seed sowing for this experiment could not be done earlier than 31st August because of inconvenience in laying out of the experiment. The results are discussed below characterwise.

4.2.1 Plant height

Plant height of cauliflower was markedly increased with increasing levels of nitrogen and phosphorous. An increase in the levels of nitrogen from 0 to 150 kg per hectare increased the plant height from 42.67 to 55.56 cm, while it increased from 48.25 to 52.15cm by increasing the levels of phosphorus from 0 to 120 kg per hectare (Table 14). The combined application of both these nutrients increased the plant height of the crop and the tallest plants of 57.62cm was, however, recorded with 150 kg nitrogen and 120 kg phosphate per hectare (N_4P_4). However, the treatment variations were not significant in any years of the experimentation as well as in pooled analysis. The effect of higher doses of nitrogen in the improvement of plant growth can be explained based on the fact that nitrogen after being taken up by the plants, is converted into amino acids which are the building blocks of proteins which might have led to enhance meristematic activity resulting in better plant height.

4.2.2 Leaf length

The data presented in Table 14 showed that the levels of both nitrogen and phosphorus exercised considerable influence on the leaf length. With the rise in the levels of nitrogen from 0 to 150 kg per hectare there was an increasing trend in leaf length which ranged from 36.82 to 51.25 cm. Similarly, application of phosphorus had a significant impact on this attribute and the maximum leaf length (47.63 cm) was recorded from the application of 120 kg P_2O_5/ha. Effect of interactions between nitrogen and phosphorus on leaf length was non-significant in 1st year and in pooled analysis though it was significant in second year only. Maximum leaf length of 54.19 cm was,

Table 14. Effect of nitrogen, phosphorus and their interactions on plant height, leaf length and leaf width of cauliflower variety Aghani.

Treatments	Plant height (cm)			Leaf length (cm)			Leaf width (cm)		
	1996-97	1997-98	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled
N_1	42.60	42.75	42.67	37.16	36.55	36.82	18.09	14.98	16.53
N_2	48.24	49.28	48.76	45.66	42.60	44.13	19.58	16.66	18.12
N_3	54.48	54.40	54.44	51.64	47.42	49.53	21.49	18.60	20.05
N_4	55.77	55.36	55.56	52.90	49.60	51.25	22.70	19.79	21.24
S.Em±	0.22	0.34	0.21	0.44	0.66	0.47	0.34	0.23	0.20
C.D. at 5%	0.64	0.98	0.61	1.27	1.91	1.36	0.98	0.66	0.58
P_1	47.95	48.54	48.25	45.60	41.26	43.43	19.18	16.84	18.01
P_2	49.79	50.17	49.98	46.96	42.34	44.61	20.11	17.16	18.63
P_3	51.13	51.00	51.06	46.80	45.32	46.06	21.03	17.75	19.39
P_4	52.22	52.08	52.15	48.01	47.26	47.63	21.54	18.27	19.91
S.Em±	0.22	0.34	0.21	0.44	0.66	0.47	0.34	0.23	0.20
C.D at 5%	0.64	0.98	0.61	1.27	1.91	1.36	0.98	0.66	0.58
N_1P_1	40.26	39.61	39.94	35.46	36.66	36.06	16.59	14.46	15.53
N_1P_2	42.64	43.86	43.25	37.64	35.88	36.63	17.40	14.92	16.16
N_1P_3	43.33	43.09	43.21	37.16	36.56	36.86	19.07	15.00	17.03
N_1P_4	44.16	44.42	44.29	38.38	37.08	37.73	19.30	15.53	17.42
N_2P_1	46.05	48.44	47.25	44.55	39.97	42.26	19.12	16.23	17.68
N_2P_2	48.20	48.33	48.27	46.10	41.83	43.97	19.46	16.25	17.86
N_2P_3	49.20	49.92	49.95	45.22	44.23	44.73	19.63	16.75	18.19
N_2P_4	49.50	50.41	52.49	46.76	44.38	45.57	20.12	17.41	18.76
N_3P_1	52.07	52.90	52.49	50.90	43.36	47.13	20.18.	18.10	19.14
N_3P_2	53.43	53.71	53.57	50.92	45.42	48.17	20.75	18.34	19.55
N_3P_3	55.24	54.66	54.95	51.55	48.03	49.79	22.48	18.84	20.66
N_3P_4	57.17	56.32	56.74	53.20	52.86	53.03	22.56	19.12	20.84
N_4P_1	53.43	53.20	53.32	51.47	45.05	48.26	20.83	18.55	16.69
N_4P_2	54.88	54.76	54.82	53.16	46.23	49.70	22.83	19.12	20.98
N_4P_3	56.73	56.27	56.50	53.27	52.44	52.86	22.96	20.43	21.69
N_4P_4	58.04	57.19	57.62	53.68	54.70	54.19	24.18	21.04	22.61
S.Em±	0.45	0.68	0.41	0.87	1.33	0.95	0.68	0.46	0.39
C.D at 5%	NS	NS	NS	NS	3.84	NS	NS	NS	NS

N.S. = Not significant

however, recorded with the combination 150 kg nitrogen and 120 kg phosphate per hectare (N_4P_4).

4.2.3 Leaf width

Leaf width varied significantly with the levels of nitrogen and phosphorus. An increase in the levels of nitrogen from 0 to 150 kg per hectare remarkably increased the leaf width from 16.53 to 21.24 cm, while it increased from 18.01 to 19.91 cm with the increasing levels of phosphorus from 0 to 120 kg per hectare (Table 14). Effect of interactions between nitrogen and phosphorus was non-significant in both the years. However, maximum leaf width of 22.61 cm was recorded with 150 kg nitrogen and 80 kg phosphate per hectare (N_4P_4).

4.2.4 Number of leaves

Leaves per plant was appreciably increased with increasing levels of nitrogen and phosphorus. An increase in the levels of nitrogen from 0 to 150 kg per hectare increased the number of leaves from 17.83 to 20.06, while it increased from 18.34 to 19.52 per plant by increasing the levels of phosphorus from 0 to 120 kg per hectare (Table 15). High concentrations of nitrogen resulted a tendency to increased leaf cell number and cell size with an overall increase in leaf production. Thakur *et al.* (1991) also observed significant increase in leaf number with increase in phosphorus levels. This might be due to increase in the activity of enzymes with increase in nitrogen and phosphorus application leading greater synthesis of lignin and proteins. Interaction effect between nitrogen and phosphorus was non-significant in both the years. The highest number of leaves (20.57) per plant was, however, recorded with 150 kg nitrogen and 80 kg phosphate per hectare (N_4P_3).

4.2.5 Days to curd initiation

More days were required for curd initiation with increasing the levels of nitrogen. Levels of nitrogen from 0 to 150 kg per hectare increased the days to curd initiation upto 83.25 days, while it decreased to 80.75 days by increasing the levels of phosphorus from 0 to 120 kg per hectare (Table 15). Farag *et al.* (1994) also reported that curd initiation was delayed with increasing dose of nitrogen. Interactions between nitrogen and phosphorus the effect was non-significant in both the years. The longest period required

Table 15. Effect of nitrogen, phosphorus and their interactions on number of leaves, day to curd initiation and days to curd maturity of cauliflower variety Aghani.

Treatments	Number of leaves			Day to curd initiation			Days to curd maturity		
	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled
N_1	17.99	17.66	17.83	83.67	79.67	81.67	95.17	86.83	91.00
N_2	19.30	18.05	18.67	83.67	78.75	81.21	93.58	87.67	90.63
N_3	20.45	18.95	19.70	84.42	80.25	82.33	93.42	89.08	91.25
N_4	20.98	19.13	20.06	86.00	80.50	83.25	94.42	91.25	82.83
S.Em±	0.16	0.17	0.13	0.20	0.24	0.18	0.27	0.23	0.28
C.D. at 5%	0.46	0.49	0.38	0.58	0.69	0.52	0.78	0.66	0.81
P_1	18.97	17.72	18.34	86.00	80.83	83.42	94.42	89.50	91.96
P_2	19.29	18.57	18.93	85.17	80.08	82.63	94.33	88.67	91.50
P_3	20.19	18.73	19.46	84.00	79.33	81.67	93.83	88.58	91.21
P_4	20.27	18.78	19.52	82.58	78.92	80.75	94.00	88.08	91.04
S.Em±	0.16	0.17	0.13	0.20	0.24	0.18	0.27	0.23	0.28
C.D at 5%	0.46	0.49	0.38	0.58	0.69	0.52	NS	0.66	NS
N_1P_1	17.41	16.54	16.97	85.67	80.67	83.17	94.67	87.33	91.00
N_1P_2	17.56	17.87	17.71	84.33	80.00	82.17	95.33	86.67	91.00
N_1P_3	18.28	17.95	18.12	83.33	79.33	81.33	95.00	86.67	90.83
N_1P_4	18.71	18.30	18.51	81.33	78.67	80.00	95.67	86.67	91.17
N_2P_1	18.68	17.14	17.91	85.33	80.33	82.83	94.33	89.33	91.83
N_2P_2	18.64	17.93	18.28	84.33	78.67	81.50	94.00	87.67	90.83
N_2P_3	19.69	18.25	18.97	82.67	78.33	80.50	93.33	87.67	90.33
N_2P_4	20.18	18.89	19.54	82.33	77.67	80.00	92.67	86.33	89.50
N_3P_1	19.62	18.14	18.88	85.67	81.00	83.33	94.00	90.33	92.17
N_3P_2	20.24	19.12	19.68	85.33	80.67	83.00	93.33	88.33	90.83
N_3P_3	20.98	19.38	20.18	84.00	79.67	81.83	93.33	88.67	91.00
N_3P_4	20.95	19.15	20.05	82.67	79.67	81.17	93.00	89.00	91.00
N_4P_1	20.16	19.06	19.61	87.33	81.33	84.33	94.67	91.00	92.83
N_4P_2	20.73	19.36	20.05	86.67	81.00	83.83	94.67	92.00	93.33
N_4P_3	21.81	19.34	20.57	86.00	80.00	83.00	93.67	91.67	92.67
N_4P_4	21.23	18.78	20.00	84.00	79.67	81.83	94.67	90.33	92.50
S.Em±	0.32	0.35	0.27	0.40	0.49	0.35	0.53	0.45	0.57
C.D at 5%	0.92	1.01	0.78	1.16	1.42	1.01	NS	1.30	NS

N.S. = Not significant

for initiation of curd (84.33) was, however, recorded with 150 kg nitrogen and 0 kg phosphate per hectare (N_4P_1).

4.2.6 Days to curd maturity

Days to curd maturity was maximum (91.25 days) at 100 kg nitrogen per hectare while it was minimum of 82.83 days at 150 kg nitrogen per hectare. Days to curd maturity was not markedly affected with increasing the levels of phosphorus. It decreased from 91.96 to 91.04 by increasing the levels of phosphorus from 0 to 120 kg per hectare (Table 15). The above results are in agreement with the reports of Forshly (1963) that days to curd maturity was reduced by application of phosphorus at higher levels. This might be due to nutralization of the effects of nitrogen by phosphorus in the process of higher vegetative growth. The effect of interactions between nitrogen and phosphorus was non-significant in 1st year and pooled analysis but was significant in the 2nd year. Maximum days to curd maturity of 93.33 was, however, recorded with 150 kg nitrogen and 40 kg phosphate per hectare (N_4P_2).

4.2.7 Curd diameter

The data presented in Table 16 revealed that curd diameter was markedly increased with increasing the levels of nitrogen and phosphorus. An increase in the levels of nitrogen from 0 to 150 kg per hectare increased the curd diameter from 7.81 to 13.82 cm, while it increased from 10.62 to 11.95 cm by increasing the levels of phosphorus from 0 to 120 kg per hectare. Kotur (1997) recorded more or less similar trend where the curd diameter increased significantly with increasing nitrogen level upto 200 kg per hectare in Ranchi soil condition. Interaction effect between nitrogen and phosphorus was non-significant in 1st year but significant in 2nd year and pooled analysis. Largest curd diameter of 13.99 cm was recorded with the application of 150 kg nitrogen and 80 kg phosphate per hectare (N_4P_3).

4.2.8 Curd depth

Curd depth was also appreciably increased with influenced the levels of nitrogen and phosphorus. Application of nitrogen from 0 to 150 kg per hectare increased the curd depth from 5.01 to 8.49 cm, while it increased from 6.51 to 7.49 cm with the increase in

Table 16. Effect of nitrogen, phosphorus and their interactions on curd diameter, curd depth and curd weight of cauliflower variety Aghani.

Treatments	Curd diameter (cm)			Curd depth. (cm)			Curd weight (g)		
	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled
N_1	8.33	7.30	7.81	5.11	4.91	5.01	147.63	140.33	143.98
N_2	10.89	10.73	10.81	6.70	6.73	6.72	314.54	303.92	309.23
N_3	12.75	13.25	13.00	8.07	7.77	7.92	492.80	477.84	485.32
N_4	14.23	13.41	13.82	8.55	8.43	8.49	523.30	504.41	513.86
S.Em±	0.17	0.16	0.13	0.12	0.10	0.07	7.52	5.08	4.43
C.D. at 5%	0.49	0.46	0.38	0.35	0.29	0.20	21.72	14.67	12.79
P_1	10.90	10.62	10.76	6.60	6.41	6.51	293.10	280.08	286.59
P_2	10.91	11.13	11.02	6.89	6.71	6.80	333.33	318.82	326.08
P_3	11.69	11.74	11.72	7.42	7.26	7.34	414.20	412.43	413.32
P_4	11.75	11.95	11.85	7.53	7.46	7.49	437.64	415.18	426.41
S.Em±	0.17	0.16	0.13	0.12	0.10	0.07	7.52	5.08	4.43
C.D at 5%	0.49	0.46	0.38	0.35	0.29	0.20	21.72	14.67	12.79
N_1P_1	7.31	6.47	6.89	4.24	4.09	4.17	69.12	63.55	66.34
N_1P_2	8.55	7.01	7.78	5.24	4.95	5.10	132.89	134.18	133.53
N_1P_3	8.36	7.81	8.09	5.33	5.02	5.18	153.04	147.54	150.29
N_1P_4	9.08	7.89	8.49	5.64	5.58	5.61	235.48	216.06	225.77
N_2P_1	10.15	9.07	9.61	5.94	5.95	5.95	233.20	233.62	233.41
N_2P_2	10.29	10.06	10.17	6.41	6.33	6.37	252.58	246.92	249.75
N_2P_3	11.09	11.72	11.40	7.13	7.15	7.14	369.87	382.84	376.36
N_2P_4	12.03	12.08	12.05	7.30	7.50	7.40	402.49	352.32	377.40
N_3P_1	12.08	12.71	12.39	7.92	7.44	7.68	424.84	405.15	415.00
N_3P_2	12.35	13.22	12.79	7.62	7.61	7.62	469.88	436.76	453.32
N_3P_3	13.37	13.60	13.49	8.30	7.88	8.09	548.70	539.18	543.94
N_3P_4	13.21	13.45	13.33	8.45	8.15	8.30	527.79	530.27	529.03
N_4P_1	14.04	13.10	13.57	8.30	8.17	8.24	445.22	418.00	431.61
N_4P_2	14.26	13.32	13.79	8.27	7.96	8.11	477.98	457.43	467.71
N_4P_3	14.35	13.63	13.99	8.91	8.99	8.95	585.20	580.15	582.68
N_4P_4	14.27	13.59	13.93	8.71	8.62	8.66	584.80	562.06	573.43
S.Em±	0.34	0.33	0.27	0.25	19.00	0.15	15.04	10.15	8.86
C.D at 5%	NS	0.95	0.78	NS	0.55	0.43	43.43	29.31	25.59

N.S. = Not significant

the levels of phosphorus from 0 to 120 kg per hectare (Table 16). Interaction effect of two nutrients was non-significant in 1st year but it was significant in 2nd year and pooled analysis. Maximum curd depth of 8.95 cm was, however, recorded with the combined application of 150 kg nitrogen and 80 kg phosphate per hectare (N_4P_3).

4.2.9 Curd weight

The variations in the weight of curd due to different levels of nitrogen and phosphorus were significant. The curd weight was markedly increased with increasing the levels of nitrogen and phosphorus (Table 16). With the increasing levels of nitrogen from 0 to 150 kg per hectare markedly increased the curd weight from 143.98 to 513.86g (Fig.17) while it increased from 286.59 to 426.41g by increasing the levels of phosphorus from 0 to 120kg per hectare (Fig. 18). Such increase in curd weight due to increase in nitrogen application was supported by the findings of Sharma and Parasar (1982), Khurana *et al.* (1987), Singh and Naik (1990), Balyan *et al.* (1997) and Kotur (1997). The increased supply of nitrogen accelerates synthesis of chlorophyll and amino acids. Effective utilization of carbohydrates and other organic factors might have resulted in the enlargement of curd. The interactions between nitrogen and phosphorus also were significant in both the years. The highest level of nitrogen showed beneficial effect when combined with medium dose of phosphorus (Fig. 19). Maximum curd weight of 582.68g was recorded with 150kg nitrogen and 80 kg phosphate per hactare (N_4P_3). Similar response of interaction of these nutrients was recorded by Balyan *et al.* (1988).

4.2.10 Days to inflorescence initiation

Days to inflorescence initiation was markedly affected by the varying levels of nitrogen and phosphorus application. It decreased gradually from 104.96 to 101.96 days with the increase in the levels of nitrogen from 0 to 100 kg per hectare and then increased to 102.63 days at 150 kg nitrogen per hectare. Inflorescence initiation was delayed from 103.67 to 102.46 days with the increasing levels of phosphorus from 0 to 120 kg per hectare (Table 17). The effect of interactions between nitrogen and phosphorus was non-significant in both the years but was significant in pooled analysis. Minimum days to inflorescence initiation (101.17) was, however, recorded with 100 kg nitrogen and 120 kg phosphate per hectare (N_3P_4).

Table 17. Effect of nitrogen, phosphorus and their interactions on days to inflorescence initiation, height of inflorescence and number of primary inflorescence stalks per plant of cauliflower variety Aghani.

Treatments	Days to inflorescence initiation			Height of inflorescence (cm)			Primary inflorescence stalks per plant		
	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled
N_1	106.75	103.17	104.96	66.26	65.09	65.67	6.21	5.00	5.61
N_2	104.42	101.50	102.96	71.92	72.65	72.28	7.00	5.79	6.40
N_3	103.58	100.33	101.96	73.21	73.46	73.33	7.71	7.30	7.50
N_4	103.75	101.50	102.63	74.44	74.52	74.48	7.43	7.03	7.23
S.Em±	0.23	0.31	0.19	0.94	0.82	0.58	0.12	0.17	0.11
C.D. at 5%	0.66	0.90	0.55	2.71	2.37	1.67	0.35	0.49	0.32
P_1	105.17	102.17	103.67	68.53	66.86	67.70	6.34	5.38	5.86
P_2	104.92	102.08	103.50	70.64	71.46	71.05	6.83	6.05	6.44
P_3	104.50	101.25	102.88	72.34	72.78	72.56	7.46	6.73	7.10
P_4	103.92	101.00	102.46	74.31	74.61	74.46	7.72	6.95	7.33
S.Em±	0.23	0.31	0.19	0.94	0.82	0.58	0.12	0.17	0.11
C.D at 5%	0.66	0.90	0.55	2.71	2.37	1.67	0.35	0.49	0.32
N_1P_1	106.67	103.00	104.83	62.63	58.59	60.61	5.33	4.43	4.88
N_1P_2	106.67	103.33	105.00	64.08	65.38	64.73	5.82	4.87	5.35
N_1P_3	107.00	103.00	105.00	67.50	66.82	67.16	6.51	4.74	5.63
N_1P_4	106.67	103.33	105.00	70.83	69.59	70.20	7.18	5.96	6.57
N_2P_1	105.67	103.67	104.67	68.80	68.32	68.56	6.36	5.18	5.77
N_2P_2	104.67	102.00	103.33	72.07	73.66	72.87	6.70	5.40	6.05
N_2P_3	104.00	100.67	102.33	73.15	74.09	73.62	7.19	6.26	6.73
N_2P_4	103.33	99.67	101.50	73.65	74.52	74.09	7.75	6.33	7.04
N_3P_1	104.33	101.00	102.67	70.55	69.48	70.02	6.97	6.01	6.49
N_3P_2	104.00	101.00	102.50	72.91	72.92	72.92	7.44	7.13	7.29
N_3P_3	103.33	99.67	101.50	73.51	74.82	74.17	8.10	8.06	8.08
N_3P_4	102.67	99.67	101.17	75.86	76.60	76.23	8.32	7.98	8.15
N_4P_1	104.00	101.00	102.50	72.14	71.07	71.60	6.70	5.92	6.31
N_4P_2	104.33	102.00	103.17	73.51	73.87	73.69	7.35	6.82	7.08
N_4P_3	103.67	101.67	102.67	75.20	75.38	75.29	8.03	7.86	7.95
N_4P_4	103.00	101.33	102.17	76.90	77.75	77.33	7.63	7.52	7.58
S.Em±	0.45	0.62	0.38	1.88	1.64	1.16	0.24	0.35	0.22
C.D at 5%	NS	NS	1.10	NS	NS	NS	NS	NS	NS

N.S. = Not significant

4.2.11 Height of inflorescence

This character showed considerable variations with different levels of nitrogen and phosphorus application. The height of inflorescence was appreciably increased with the increasing levels of nitrogen and phosphorus. An increase in the levels of nitrogen from 0 to 150 kg per hectare increased the height from 65.67 to 74.48 cm, while it increased from 67.70 to 74.46 cm with increasing the levels of phosphorus from 0 to 120 kg per hectare (Table 17). Mishra (1992) recorded almost similar trend where the plant height with inflorescence increased significantly with increasing nitrogen level upto 180 kg per hectare. Thakur *et al.* (1991) also obtained increased stalk length with increased application of phosphorus which might be due to optimum doses of nitrogen and phosphorus for proper plant growth. However, effect of interactions between nitrogen and phosphorus was non-significant in both the years. Maximum height of inflorescence (77.33 cm) was, recorded with 150 kg nitrogen and 120 kg phosphate per hectare (N_4P_4).

4.2.12 Primary inflorescence stalks per plant

Nitrogen and phosphorus exerted considerable influence on number of primary inflorescence stalks per plant. An increase in the levels of nitrogen from 0 to 100 kg per hectare increased the number of primary inflorescence stalks per plant from 5.61 to 7.50 which decreased thereafter to 7.23 at 150 kg nitrogen per hectare. It increased from 5.86 to 7.33 by increasing the levels of phosphorus from 0 to 120 kg per hectare (Table 17). The increased number of inflorescence stalks per plant due to increase in the rate of nitrogen application was supported by the findings of Mishra (1992). On the other hand, interaction effect between nitrogen and phosphorus was non-significant in both the years. Maximum number of 8.15 inflorescence stalks per plant were produced in the plants received 100 kg nitrogen and 120 kg phosphate per hectare (N_3P_4).

4.2.13 Days to seed harvesting

Increase in the levels of nitrogen from 0 to 150 kg per hectare increased the days to seed harvesting from 192.42 to 195.58 days, while it increased from 193.29 to 194.46 days with increasing levels of phosphorus from 0 to 120 kg per hectare (Table 18). Delay in the maturation of plants due to increased nitrogen application was also recorded by Mishra and Pandey (1987). It might be due to lengthening of stem internodes at high nitrogen level. The effect of interactions between nitrogen and phosphorus was non-

Table 18. Effect of nitrogen, phosphorus and their interactions on days to seed harvesting, pods per plant and pod length of cauliflower variety Aghani.

Treatments	Days to seed harvesting			Pods per plant			Pod length (cm)		
	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled
N_1	189.25	195.58	192.42	358.25	390.46	374.35	5.47	5.26	5.36
N_2	190.42	196.08	193.25	517.88	586.09	551.99	5.99	5.49	5.74
N_3	191.42	197.33	194.42	731.54	762.07	746.80	6.18	5.8	5.99
N_4	192.42	198.75	195.58	713.37	737.08	725.23	6.31	6.01	6.16
S.Em±	0.20	0.20	0.14	18.25	16.86	12.10	0.43	0.06	0.04
C.D. at 5%	0.58	0.58	0.40	52.70	48.69	34.94	0.125	0.17	0.12
P_1	190.17	196.42	193.29	437.04	450.58	443.81	5.32	5.17	5.24
P_2	190.92	196.83	193.88	504.89	562.38	533.63	5.9	5.53	5.72
P_3	191.08	197.00	194.04	668.27	725.03	696.65	6.18	5.8	5.99
P_4	191.33	197.50	194.46	710.84	737.73	724.28	6.31	6.01	6.16
S.Em±	0.20	0.20	0.14	18.25	16.86	12.10	0.43	0.06	0.04
C.D at 5%	0.58	0.58	0.40	52.70	48.69	34.94	0.125	0.17	0.12
N_1P_1	188.33	195.33	191.83	296.87	295.67	296.27	5.01	5.03	5.02
N_1P_2	189.67	195.33	192.50	311.70	379.83	345.77	5.22	5.21	5.22
N_1P_3	189.33	195.67	192.50	365.77	381.33	373.55	5.64	5.21	5.42
N_1P_4	189.67	196.00	192.83	458.67	505.00	481.83	5.99	5.59	5.79
N_2P_1	189.33	195.67	192.50	392.70	448.70	420.70	5.21	5.16	5.18
N_2P_2	190.33	195.67	193.00	429.77	580.87	505.32	5.95	5.35	5.65
N_2P_3	190.67	196.33	193.50	585.50	648.73	617.12	6.29	5.54	5.92
N_2P_4	191.33	196.67	194.00	663.57	666.07	664.82	6.51	5.91	6.21
N_3P_1	191.00	196.67	193.83	534.60	522.73	528.67	5.44	5.24	5.34
N_3P_2	191.33	197.33	194.33	647.10	657.97	652.53	6.25	6.00	6.12
N_3P_3	191.67	197.67	194.67	869.63	939.47	904.55	6.45	6.25	6.35
N_3P_4	191.67	197.67	194.83	874.83	928.10	901.47	6.48	6.34	6.41
N_4P_1	192.00	198.00	195.00	524.00	535.20	529.60	5.61	5.24	5.43
N_4P_2	192.33	199.00	195.67	631.00	630.83	630.92	6.19	5.58	5.89
N_4P_3	192.67	198.33	195.50	852.17	930.57	891.37	6.35	6.2	6.27
N_4P_4	192.67	199.67	196.17	846.30	851.73	849.02	6.27	6.19	6.23
S.Em±	0.41	0.40	0.28	36.51	33.72	24.19	8.66	0.13	0.09
C.D at 5%	NS	NS	NS	105.40	97.38	69.86	0.2501	0.38	0.26

N.S. = Not significant

significant in both the years. The longest period for seed harvesting of 196.17 days was, however, recorded with the application of 150-kg nitrogen and 120 kg phosphate per hectare (N_4P_4).

4.2.14 Pods per plant

Pod number per plant was greatly increased with the increasing levels of nitrogen and phosphorus, irrespective of the year of investigation. An increase in the levels of nitrogen from 0 to 100 kg per hectare significantly increased the number of pods per plant from 374.35 to 746.80 which decreased to 725.23 at 150 kg nitrogen per hectare (Fig. 14). Levels of phosphorus had profound effect on the production of pods per plant (Fig. 15). Pods per plant increased from 443.81 to 724.28 with the increase in the levels of phosphorus from 0 to 120 kg per hectare (Table 18). Mishra (1992) also noted the similar trend. Interactions between nitrogen and phosphorus was markedly pronounced for pod production in both the years (Fig. 16). The maximum of 904.55 pods per plant was produced with 100 kg nitrogen and 80 kg phosphate per hectare (N_3P_3).

4.2.15 Pod length

From the Table 18 it is evident that the pod length markedly increased with the increase in the levels of nitrogen and phosphorus. By increasing the levels of nitrogen from 0 to 150 kg per hectare the pod length increased from 5.36 to 6.16 cm while it increased from 5.24 to 6.16 cm by increasing the levels of phosphorus from 0 to 120 kg per hectare. Similar trend in pod length due to increase in nitrogen application was also noted by Mishra (1992). The pod length due to interactions between nitrogen and phosphorus was significant in first year and pooled analysis but it was non-significant in the second year. Maximum pod length of 6.41 cm was recorded with 100 kg nitrogen and 120 kg phosphate per hectare (N_3P_4).

4.2.16 Seeds per pod

Number of seeds per pod was highly infuenced by the increase in the levels of nitrogen and phosphorus. Application of increased dose of nitrogen from 0 to 100 kg per hectare markedly increased the number of seeds per pod from 18.01 to 20.26 which, however, decreased to 19.81 at 150 kg nitrogen per hectare (Fig. 14). It increased from 17.47 to 20.70 by increasing the levels of phosphorus from 0 to 120 kg per hectare

(Table 19). The above results are in agreement with the reports of Mishra (1992). Effect of interactions between nitrogen and phosphorus were non-significant in both the years. The highest number of 21.53 seeds per pod was, however, recorded with 100 kg nitrogen and 80 kg phosphate per hectare (N_3P_3).

4.2.17 Seed yield per plant

Both nitrogen and phosphorus as well as their interactions affected the seed yield per plant significantly in both the years (Table 19). Increase in the levels of nitrogen from 0 to 100 kg per hectare markedly increased the seed yield per plant from 5.50 to 14.81g (Fig. 17), while it increased from 7.21 to 14.05g by increasing the levels of phosphorus from 0 to 120 kg per hectare (Fig. 18). Pandey *et al.* (1985) also found highest seed yield of cauliflower at 100 kg nitrogen per hectare. Similar results were also recorded by Mishra (1992). The beneficial effect of nitrogen on seed production might be due to increase in the production of green leaves which enhanced the level of photosynthates for building up of new tissues. Eventually there was an increase in the plant growth, yield of curd and ultimately the yield of seed. Phosphorus also helpes in flowering, fruiting and seed formation. Maximum of 18.55g seed yield per plant was recorded with 100 kg nitrogen and 80 kg phosphate per hectare (N_3P_3). It showed that a balance between these nutrients was important to produce the highest quantity of seed.

4.2.18 Seed yield per hectare

The data presented in Table 19 revealed that seed yield markedly increased with the increasing levels of nitrogen and phosphorus in both the years. When the levels of nitrogen increased from 0 to 100 kg per hectare, the seed yield per hectare significantly increased from 149.07 to 384.81 kg but the seed yield marginally decreased to 383.01kg per hectare when the dose of nitrogen further increased to 150 kg per hectare (Fig. 20). Seed yield per hectare increased from 208.06 to 373.79 kg by increasing the levels of phosphorus from 0 to 120 kg phosphate per hectare (Fig. 21). Increase in seed yield at higher nitrogen levels was also recorded by Mishra (1992). Jamwal *et al.* (1995) observed an increase in seed yield in cauliflower with the application of nitrogen upto 175 kg per hectare and phosphate upto 150 kg per hectare. Nitrogen level higher than 100 kg per hectare decreased the seed yield as high vegetative growth and plant height resulted in lodging of inflorescences. Application of 100-kg nitrogen per hectare might

Table 19. Effect of nitrogen, phosphorus and their interactions on seeds per pod, seed yield per plant and seed yield per hectare of cauliflower variety Aghani.

Treatments	Seeds per pod			Seed yield per plant (g)			Seed yield per hectare (kg)		
	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled
N_1	18.84	17.18	18.01	6.47	4.54	5.50	173.46	124.68	149.07
N_2	20.02	18.68	19.35	11.93	10.53	11.23	327.74	296.03	311.88
N_3	20.79	19.72	20.26	15.94	13.68	14.81	401.93	367.70	384.81
N_4	20.72	18.89	19.81	15.04	13.37	14.20	388.25	377.77	383.01
S.Em±	0.23	0.33	0.22	0.32	0.31	0.23	2.94	2.84	2.73
C.D. at 5%	0.66	0.95	0.64	0.92	0.90	0.66	8.49	8.26	7.88
P_1	19.01	15.94	17.47	7.65	6.78	7.21	220.14	195.97	208.06
P_2	19.53	18.41	18.97	11.83	9.33	10.58	291.42	255.28	273.35
P_3	20.84	19.72	20.28	15.14	12.68	13.91	388.49	358.65	373.57
P_4	20.99	20.41	20.70	14.76	13.35	14.05	391.32	356.26	373.79
S.Em±	0.23	0.33	0.22	0.32	0.31	0.23	2.94	2.86	2.73
C.D at 5%	0.66	0.95	0.64	0.92	0.90	0.66	8.49	8.26	7.88
N_1P_1	17.20	14.74	15.97	4.70	2.87	3.78	123.72	82.92	103.32
N_1P_2	17.90	17.22	17.56	6.40	3.90	5.15	167.95	117.52	136.07
N_1P_3	19.67	17.88	18.78	7.10	5.07	6.08	198.49	124.60	161.55
N_1P_4	20.59	18.89	19.74	7.67	6.33	7.00	203.67	173.66	188.67
N_2P_1	18.84	15.64	17.24	7.80	6.90	7.35	221.20	200.99	211.10
N_2P_2	19.46	17.90	18.68	11.33	9.33	10.33	306.85	264.27	285.56
N_2P_3	20.54	19.83	20.18	14.33	12.40	13.37	392.60	352.66	372.63
N_2P_4	21.24	21.36	21.30	14.23	13.50	13.87	390.29	366.18	378.24
N_3P_1	19.96	16.31	18.44	8.93	8.83	8.88	269.06	252.34	260.70
N_3P_2	20.45	19.52	19.99	14.97	12.13	13.55	352.82	319.83	336.32
N_3P_3	21.65	21.40	21.53	20.37	16.73	18.55	491.10	481.46	486.28
N_3P_4	21.10	21.04	21.07	19.50	17.03	18.27	494.72	417.16	455.94
N_4P_1	20.03	16.46	18.24	9.17	8.50	8.83	266.57	247.67	257.11
N_4P_2	20.30	19.01	19.66	14.60	11.93	13.27	338.06	319.51	328.79
N_4P_3	21.50	19.77	20.64	18.77	16.50	17.63	471.77	475.89	473.83
N_4P_4	21.04	20.33	20.69	17.63	16.53	17.08	476.59	468.01	472.30
S.Em±	0.46	0.66	0.44	0.65	0.62	0.45	5.88	5.71	5.47
C.D at 5%	NS	NS	NS	1.88	1.79	1.30	16.98	16.49	15.80

N.S. = Not significant

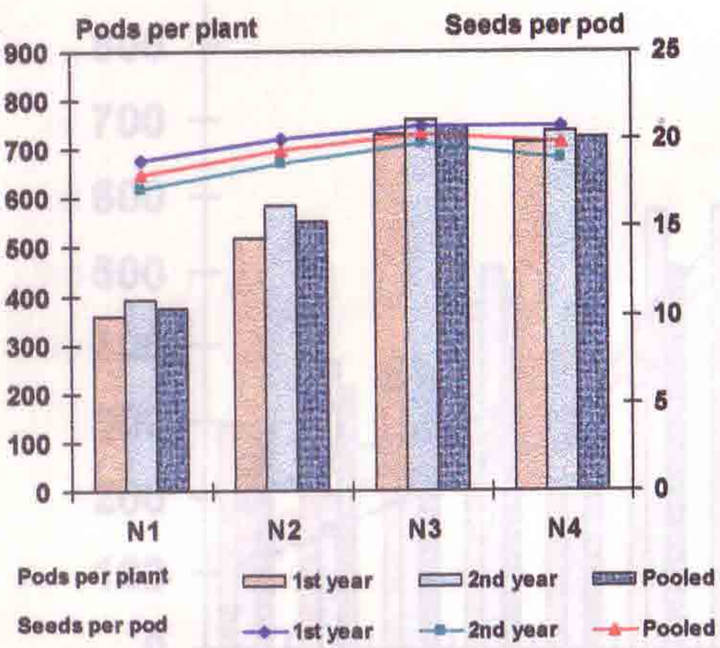


Fig. 14. Effect of levels of nitrogen on pods per plant and seeds per pod in cauliflower.

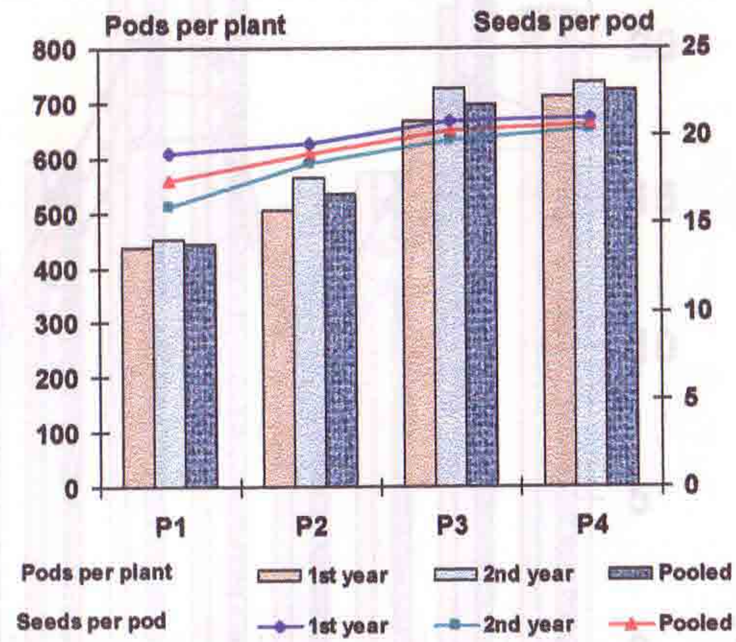


Fig. 15. Effect of levels of phosphorus on pods per plant and seeds per pod in cauliflower.

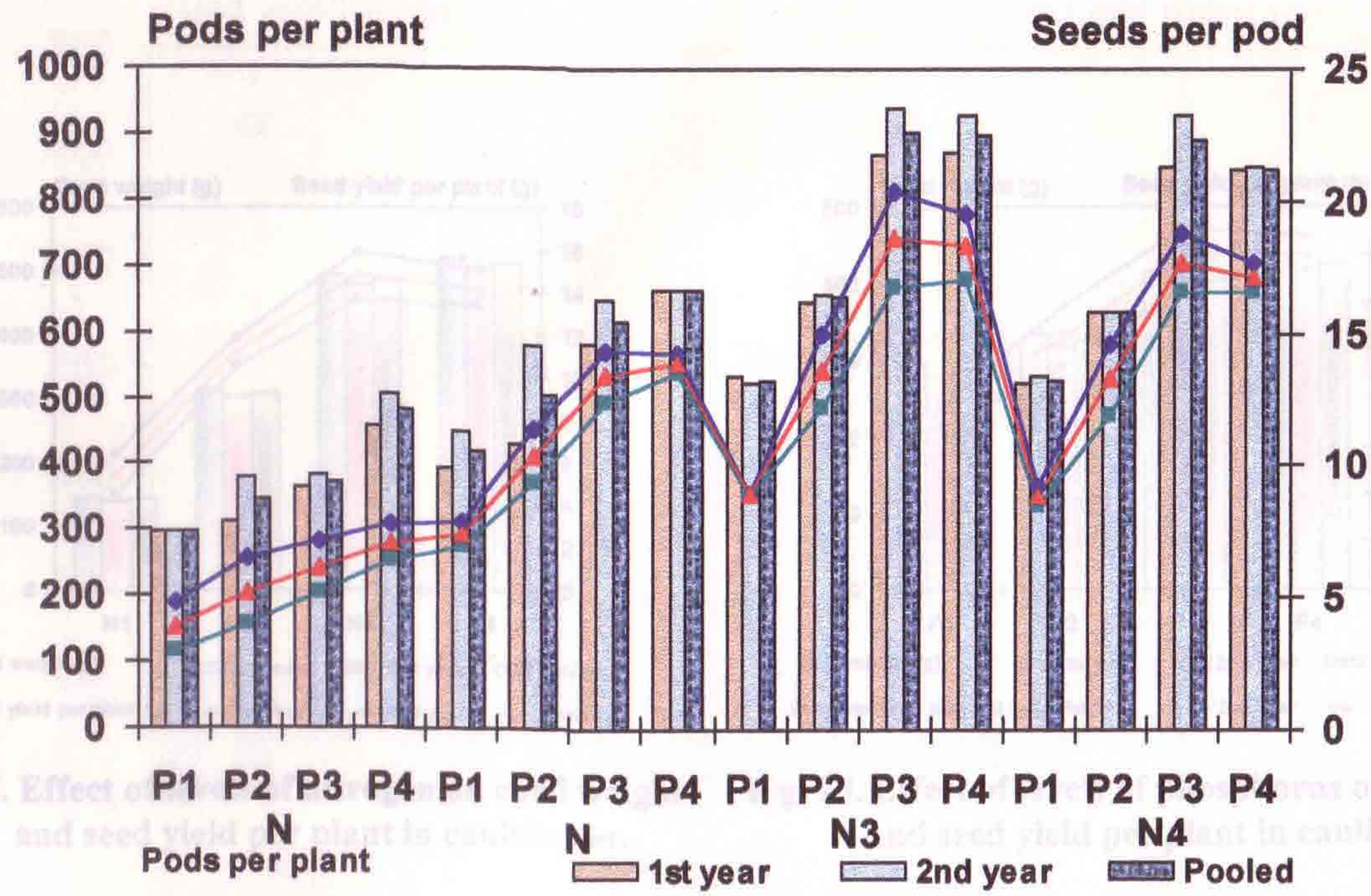


Fig. 16. Interaction effect of levels of nitrogen and phosphorus on pods per plant and seeds per pod in cauliflower.

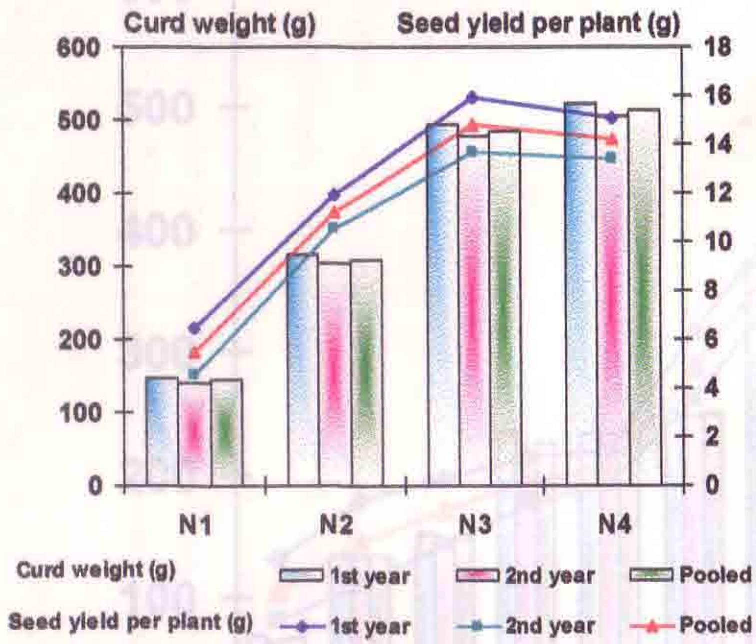


Fig. 17. Effect of levels of nitrogen on curd weight and seed yield per plant in cauliflower.

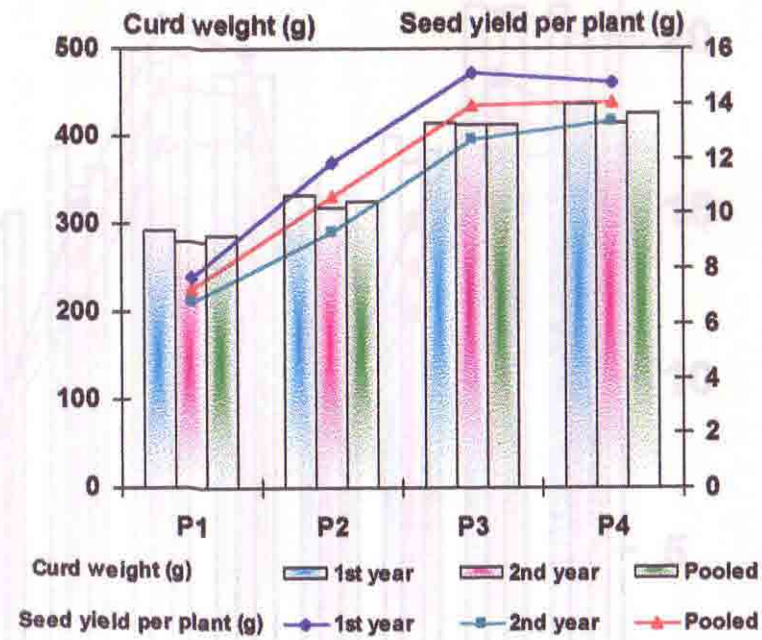


Fig. 18. Effect of levels of phosphorus on curd weight and seed yield per plant in cauliflower.

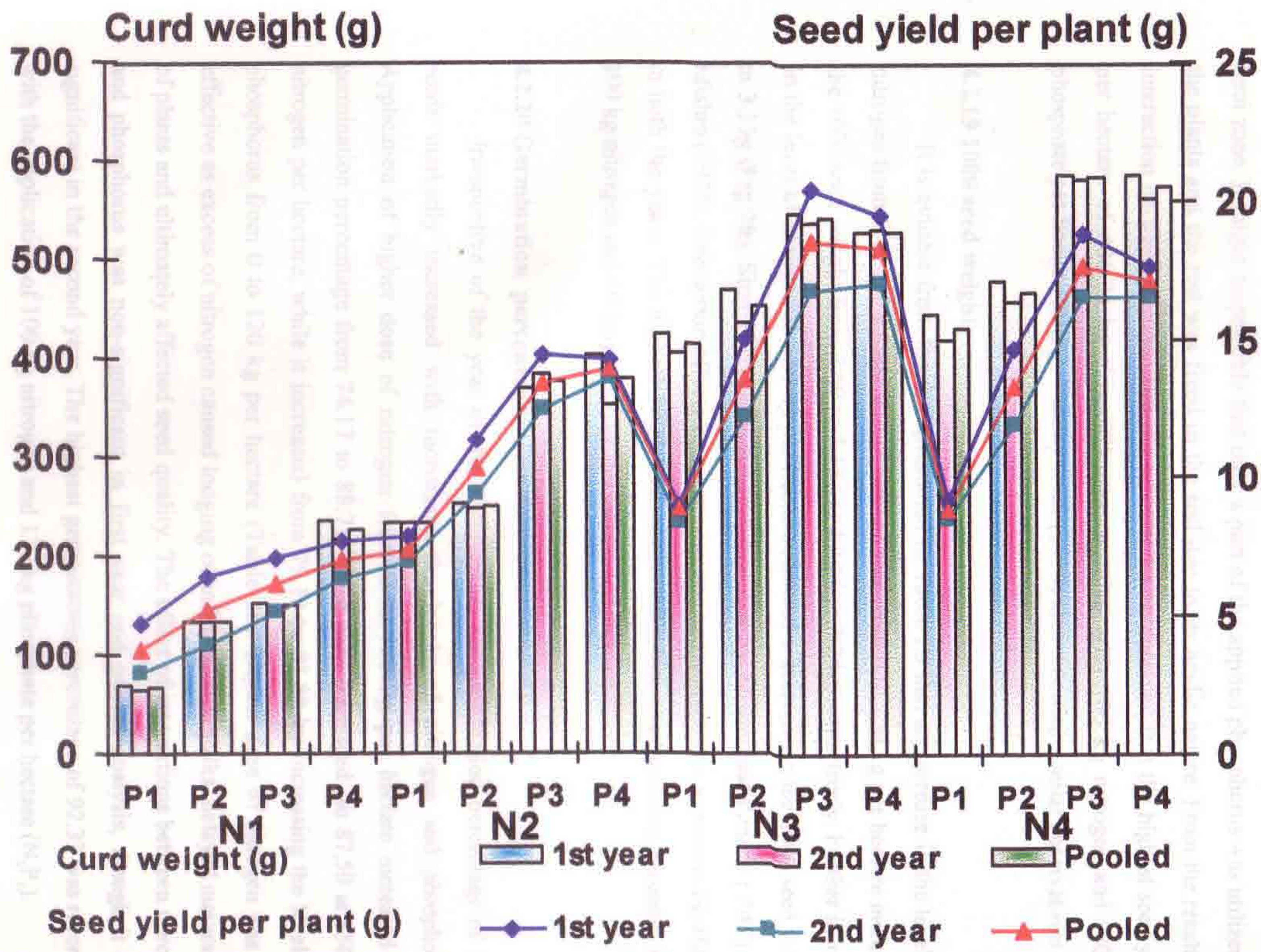


Fig. 19. Interaction effect of levels of nitrogen and phosphorus on curd weight and seed yield per plant in cauliflower.

be optimum which helped in proper growth and maturation of plants and checked undue lengthening of stem internodes and enhanced development of effective pods. This study showed a high requirement of phosphate for the production of highest amount of seed in terai zone. It might be possible that only a part of the applied phosphorus was utilized by the plants and the rest was fixed in the soil due to its acidic nature. From the results of interaction between nitrogen and phosphorus it was observed that the highest seed yield per hectare of 486.28 kg (Fig. 22) was recorded with 100 kg nitrogen and 80 kg phosphate per hectare (N_3P_3). Pandey *et al.* (1979) also recorded similar observations.

4.2.19 1000 seed weight

It is evident from the data presented in Table 20 that an increase in the levels of nitrogen from 0 to 100 kg and that of phosphorus from 0 to 120 kg per hectare increased the 1000 seed weight from 2.69 to 3.18g and 2.66 to 3.24g, respectively. Further increase in the level of nitrogen to 150 kg per hectare showed a decrease in the 1000 seed weight to 3.15g (Fig 20). Similar results were also recorded by Mishra and Pandey (1987) and Mishra (1992). Interaction effects between nitrogen and phosphorus were non-significant in both the years. The highest 1000 seed weight of 3.46g was, however, recorded with 100 kg nitrogen and 80 kg phosphate per hectare (N_3P_3).

4.2.20 Germination percentage

Irrespective of the year of the experiment, the germination percentage of the seeds markedly increased with increasing the levels of nitrogen and phosphorus. Application of higher dose of nitrogen from 0 to 100 kg per hectare increased the germination percentage from 74.17 to 88.71 which then decreased to 87.50 at 150 kg nitrogen per hectare, while it increased from 79.13 to 85.88 by increasing the levels of phosphorus from 0 to 120 kg per hectare (Table 20). Higher dose of nitrogen was not effective as excess of nitrogen caused lodging of inflorescence stalks, delayed maturation of plants and ultimately affected seed quality. The effect of interactions between nitrogen and phosphorus was non-significant in first year and pooled analysis, though it was significant in the second year. The highest germination percentage of 92.33 was recorded with the application of 100 kg nitrogen and 120 kg phosphate per hectare (N_3P_4).

Table 20. Effect of nitrogen, phosphorus and their interactions on 1000 seed weight, germination percentage of cauliflower variety Aghani.

Treatments	1000 seed weight (g)			Germination percentage		
	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled
N_1	2.80	2.57	2.69	75.83	72.50	74.17
N_2	2.99	2.82	2.90	82.58	79.75	81.17
N_3	3.20	3.17	3.18	90.33	87.08	88.71
N_4	3.15	3.14	3.15	89.17	85.83	87.50
S.Em±	0.05	0.07	0.04	0.68	0.32	0.35
C.D. at 5%	0.14	0.20	0.12	1.96	0.92	1.01
P_1	2.75	2.57	2.66	80.92	77.33	79.13
P_2	2.94	2.73	2.84	83.50	80.00	81.75
P_3	3.22	3.15	3.18	86.50	83.08	84.79
P_4	3.24	3.24	3.24	87.00	84.75	85.88
S.Em±	0.05	0.07	0.04	0.68	0.32	0.35
C.D at 5%	0.14	0.20	0.12	1.96	0.92	1.01
N_1P_1	2.60	2.28	2.44	73.33	70.33	71.83
N_1P_2	2.64	2.33	2.49	75.00	71.33	73.17
N_1P_3	2.93	2.53	2.73	77.33	77.33	75.33
N_1P_4	3.02	3.13	3.08	77.67	75.00	76.33
N_2P_1	2.65	2.45	2.55	78.33	76.00	77.17
N_2P_2	2.96	2.66	2.81	81.00	79.00	80.00
N_2P_3	3.14	3.08	3.11	84.67	80.33	82.50
N_2P_4	3.19	3.09	3.14	86.33	83.67	85.00
N_3P_1	2.85	2.69	2.77	86.33	81.67	84.00
N_3P_2	3.13	3.06	3.10	89.33	85.33	87.33
N_3P_3	3.42	3.49	3.46	92.67	89.67	91.17
N_3P_4	3.38	3.42	3.40	93.00	91.67	92.33
N_4P_1	2.88	2.87	2.87	85.67	81.33	83.50
N_4P_2	3.02	2.88	2.95	88.67	84.33	86.50
N_4P_3	3.37	3.48	3.42	91.33	89.00	90.17
N_4P_4	3.35	3.33	3.34	91.00	88.67	89.83
S.Em±	0.09	0.14	0.08	1.36	0.63	0.71
C.D at 5%	NS	NS	NS	NS	1.82	NS

N.S. = Not significant

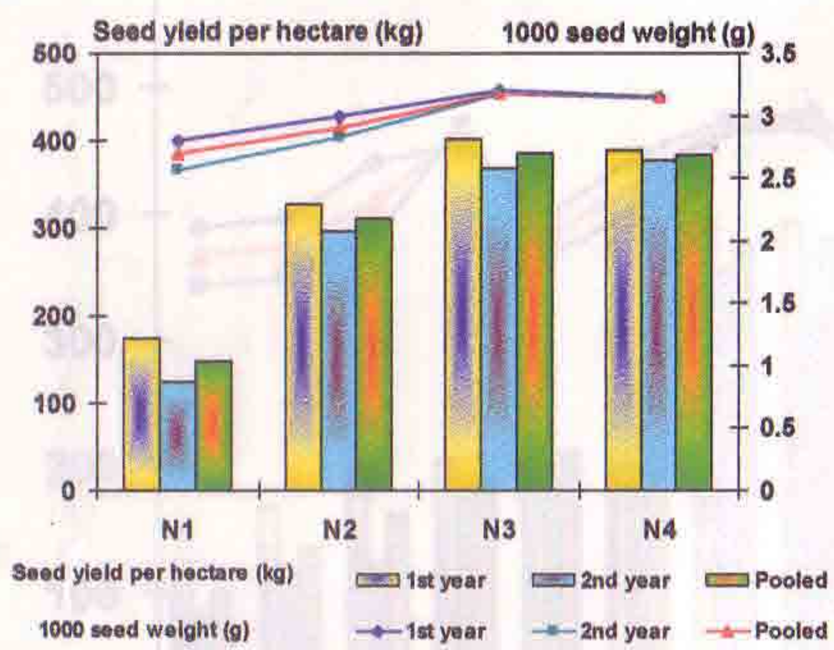


Fig. 20. Effect of levels of nitrogen on seed yield per hectare and 1000 seed weight in cauliflower.

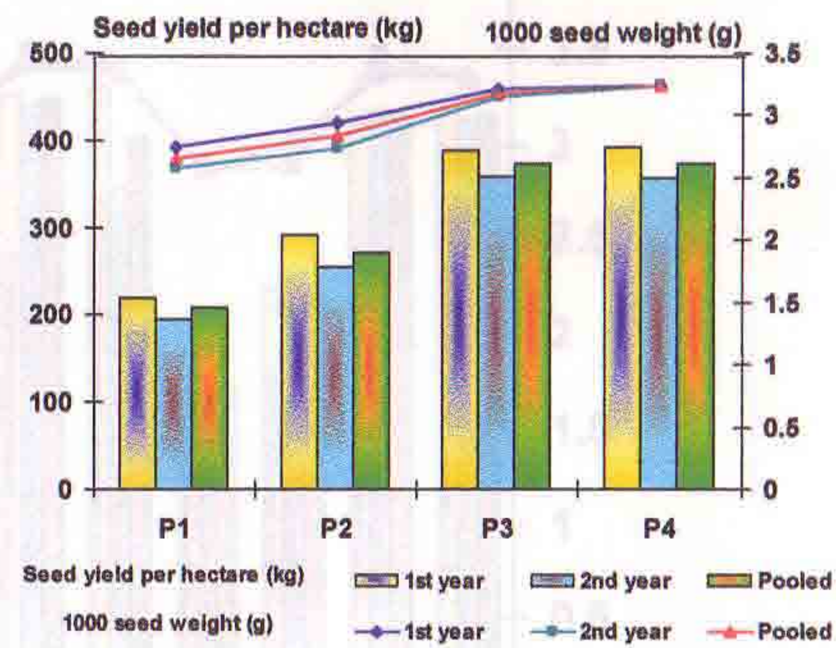


Fig. 21. Effect of levels of phosphorus on seed yield per hectare and 1000 seed weight in cauliflower.

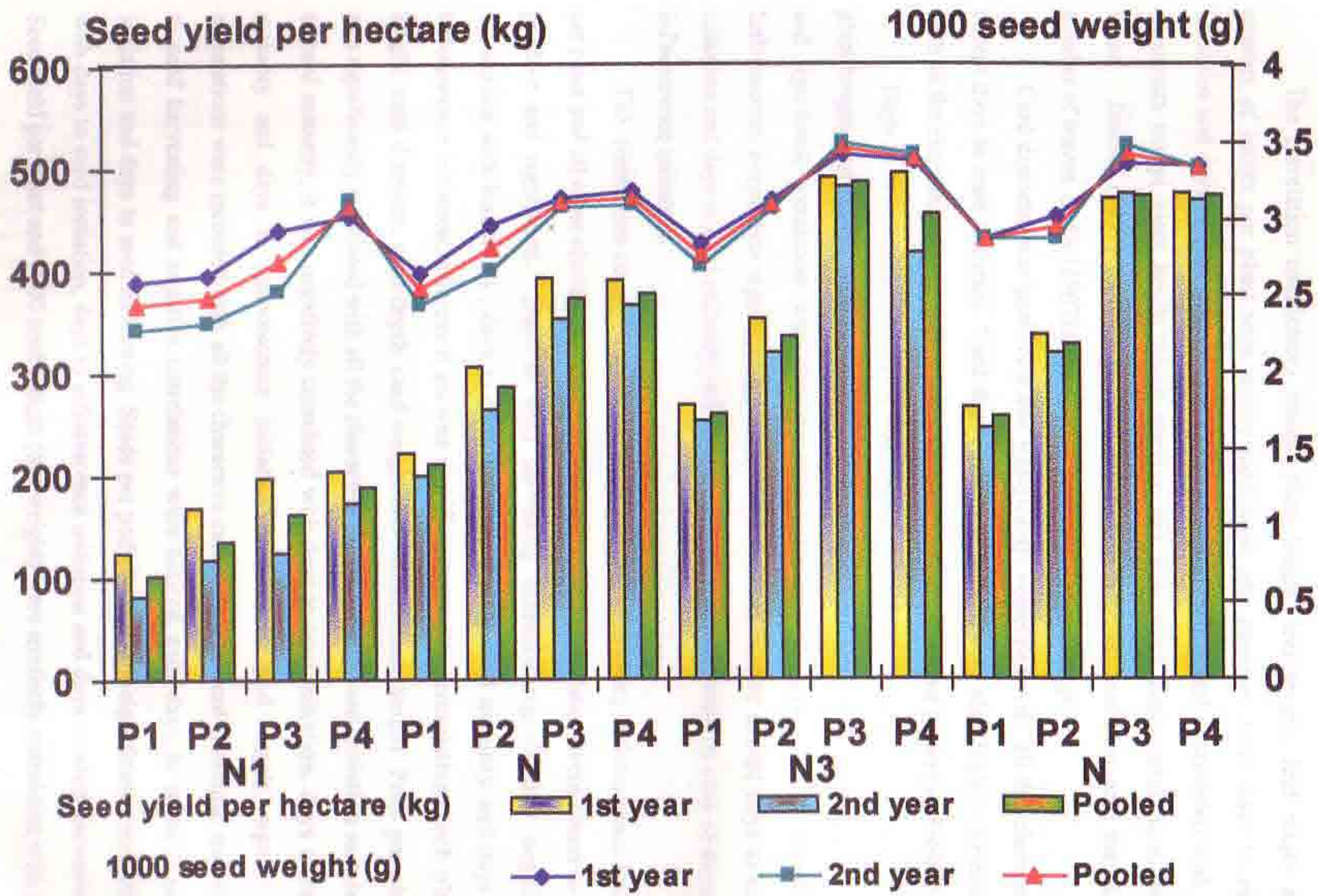


Fig. 22. Interaction effect of levels of nitrogen and phosphorus on seed yield per hectare and 1000 seed weight in cauliflower.

4.2.21 Correlation studies

Correlation among different characters of cauliflower variety Aghani under varying nitrogen and phosphate levels were computed to understand the nature and extent of character association which might be utilized in selection programmes.

The correlation coefficients among plant height, leaf length, leaf width and number of leaves per plant were highly significant and positive. Both days to curd initiation and days to curd maturity were positively and significantly correlated with all characters except plant height where positive and non- significant correlations were found. Jensma (1957) found a positive correlation between earliness and the final number of leaves. Sadik (1967) also reported similar associationship.

Curd diameter was positively and significantly correlated with all the characters except days to curd initiation. Curd depth and curd weight were also highly correlated with all the characters except days to curd initiation and days to curd maturity (Table 21).

Days to inflorescence initiation was negatively and significantly associated with plant height, leaf length, curd diameter, curd depth and curd weight. It showed positive and significant correlation with days to curd initiation and days to curd maturity. Inflorescence height was significantly correlated with all characters except days to curd initiation and days to curd maturity and negative correlation was found in case of days to inflorescence initiation.

The correlation co-efficients between the number of primary inflorescence stalks per plant and all other characters except days to inflorescence initiation were found to be positive and significant. Days to seed harvesting exhibited significantly negative association with leaf width , days to curd initiation, days to curd maturity and days to inflorescence initiation, whereas it showed significantly positive correlations with plant height, curd diameter, curd depth, curd weight and inflorescence height. Pods per plant was significantly correlated with all the characters except days to curd initiation and days to curd maturity. It was negatively correlated with days to curd initiation, days to curd maturity and days to inflorescence initiation. In case of pod length, significant correlations were recorded with all the characters except days to curd initiation and days to seed harvesting and negative correlations were noticed with days to inflorescence initiation and days to seed harvesting. Seeds per pod showed non-significant correlation with days to curd initiation, days to inflorescence initiation and days to seed harvesting. Seed yield per plant and 1000 seed weight (test weight) were similarly correlated with all

Table 21. Correlation co-efficients for different pairs of charceters in cauliflower seed crop.

Characters	Leaf length (cm)	Leaf width (cm)	No. of leaves	Days to curd initiation	Days to curd maturity	Curd diameter (cm)	Curb depth. (cm)	Curb weight (g)	Days to inf. initiation	Inf. height(cm)	Primary inf. stalks / plant	Days to harvesting	Pods / plant	Pod length (cm)	Seeds / pod	Seed yield/ plant (g)	Seed yield /ha (kg)	1000 seed wt. (g)	Germ. p.c.
Plant height (cm)	0.881**	0.708**	0.704**	0.091	0.126	0.936**	0.941**	0.954**	-0.516**	0.708**	0.716**	0.362**	0.846**	0.655**	0.524**	0.830**	0.854**	0.662**	0.887**
Leaf length (cm)		0.796**	0.711**	0.293**	0.288**	0.878**	0.874**	0.892**	-0.326**	0.681**	0.710**	0.140	0.772**	0.690**	0.578**	0.827**	0.837**	0.653**	0.885**
Leaf width (cm)			0.794**	0.532**	0.631**	0.744**	0.714**	0.750**	0.051	0.568**	0.731**	-0.228*	0.580**	0.688**	0.587**	0.739**	0.709**	0.600**	0.783**
Number of leaves				0.427**	0.406**	0.731**	0.725**	0.743**	-0.101	0.630**	0.753**	-0.142	0.623**	0.690**	0.663**	0.769**	0.699**	0.628**	0.779**
Days to curd initiation					0.804**	0.180	0.132	0.099	0.592**	-0.061	0.260**	-0.701**	-0.111	0.098	0.141	0.100	0.012	0.008	0.232**
Days to curd cmaturity						0.211*	0.166	0.154	0.623**	0.040	0.390**	-0.717**	-0.028	0.235*	0.259**	0.184	0.138	0.174	0.276**
Curd diameter (cm)							0.944**	0.934**	-0.452**	0.710**	0.705**	0.275**	0.766**	0.626**	0.546**	0.805**	0.825**	0.662**	0.868**
Curd depth. (cm)								0.934**	-0.465**	0.687**	0.702**	0.303**	0.823**	0.668**	0.511**	0.804**	0.842**	0.685**	0.876**
Curb weight (g)									-0.488**	0.745**	0.749**	0.322**	0.878**	0.718**	0.587**	0.873**	0.903**	0.731**	0.922**
Days to inf. initiation										-0.397**	-0.157	-0.814**	-0.575**	-0.233*	-0.099	-0.377**	-0.447**	-0.290**	-0.360**
Inf. height (cm)											0.612**	0.274**	0.673**	0.632**	0.545**	0.786**	0.756**	0.635**	0.704**
Primary inf . stalks / plant												-0.051	0.721**	0.802**	0.719**	0.811**	0.796**	0.750**	0.809**
Days to seed harvesting													0.387**	-0.012	-0.146	0.139	0.204*	0.100	0.109
Pods / plant														0.764**	0.558**	0.879**	0.913**	0.782**	0.855**
Pod length (cm)															0.718**	0.841**	0.838**	0.784**	0.791**
Seeds /pod																0.713**	0.690**	0.665**	0.631**
Seed yield/plant (g)																	0.960**	0.791**	0.897**
Seed yield /ha (kg)																		0.814**	0.911**
1000 seed wt. (g)																			0.747**

* Significant at 5% level, ** Significant at 1% level.

the characters. These two characters exhibited strong correlation with all the characters except days to curd initiation, days to curd maturity and days to seed harvesting. Seed yield per hectare was strongly correlated with all the characters except days to curd initiation and days to curd maturity. Strong correlations were also noted between germination percentage and other characters except days to seed harvesting.

4.2.22 Effect of Different Levels of Nitrogen and Phosphorus on Nitrogen, Phosphorus and Potassium Content in Leaves of Cauliflower

4.2.22.1 Nitrogen percentage in leaves

Parcentage of nitrogen in the leaves was found to be the highest with the application of 150 kg nitrogen per hectare (Table 22). Application of phosphorus also tended to increase the nitrogen content in leaves. Application of 120 kg phosphate per hectare, during 1996-97 and 80 kg phosphate per hectare during 1997-98 exhibited highest nitrogen content in leaves at curd initiation stage. Percentage of nitrogen in the leaves was also affected by levels of phosphorus application. In fact, supply of high dose of nitrogen brought about changes in tissue composition almost similar to those brought about by the application of high dose of phosphorus, because of enhancement of nitrogen uptake by the plant due to phosphorus fertilization.

4.2.22.2 Phosphorus percentage in leaves

Application of 150 kg nitrogen per hectare recorded the highest phosphorus content in the leaves at curd initiation stage. Application of phosphorus tended to increase the phosphorus content in leaves of cauliflower and highest phosphorus content in the leaves was noted with the application of 80 kg phosphate per hectare.

Table 22. Concentration of nitrogen, phosphorus and potassium in leaves of cauliflower at curd initiation stage.

Levels	Nitrogen (%)		Phosphorus (%)		Potassium (%)	
	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98
N_1	2.74	3.15	0.20	0.32	2.05	2.38
N_2	3.02	3.27	0.26	0.35	3.31	3.62
N_3	4.26	4.48	0.47	0.59	3.64	4.21
N_4	4.38	4.49	0.47	0.61	3.33	3.98
P_1	2.74	3.15	0.20	0.32	2.05	2.38
P_2	2.98	3.21	0.37	0.42	3.26	3.59
P_3	4.06	4.36	0.51	0.58	3.63	4.17
P_4	4.28	4.31	0.48	0.55	3.60	3.74

4.2.22.3 Potassium percentage in leaves

Application of nitrogen tended to increase the potassium content in the leaves and highest potassium content in leaves was accumulated when 100 kg nitrogen per hectare was applied. Similarly, highest leaf potassium content was recorded when 80 kg phosphate per hectare was applied.

4.2.23 Response Function between Seed Yield and Different Leaves of Fertilizers

Input-output relationship between levels of nitrogen and seed yield of cauliflower were studied with pooled data. Functional relationship between levels of nitrogen and seed yield was characterised by a quadratic form. The functional relationships in nitrogen are described by the following equation and presented in Fig. 23.

$$Y = 149.827 + 4.0187\ N - 0.0165\ N^2$$

Where, Y is the expected seed yield of cauliflower in kg/ha due to an application of N unit of nitrogen per hectare, where one unit is 50 kg N/ha. The optimum dose as found out, was 122.08 kg N/ha with 395.12 kg seed yield per hectare.

Levels of phosphate and corresponding seed yield showed an increasing trend, thereby indicating that the data could be fit in the form of linear trend equation. But in practice, continuous increase in levels of phosphate or any fertilizer can not increase yield continuously. Hence, the formation of fnctional relationship between levels of P_2O_5 and yield was dropped out. Otherwise it might have reached to a misleading conclusion.

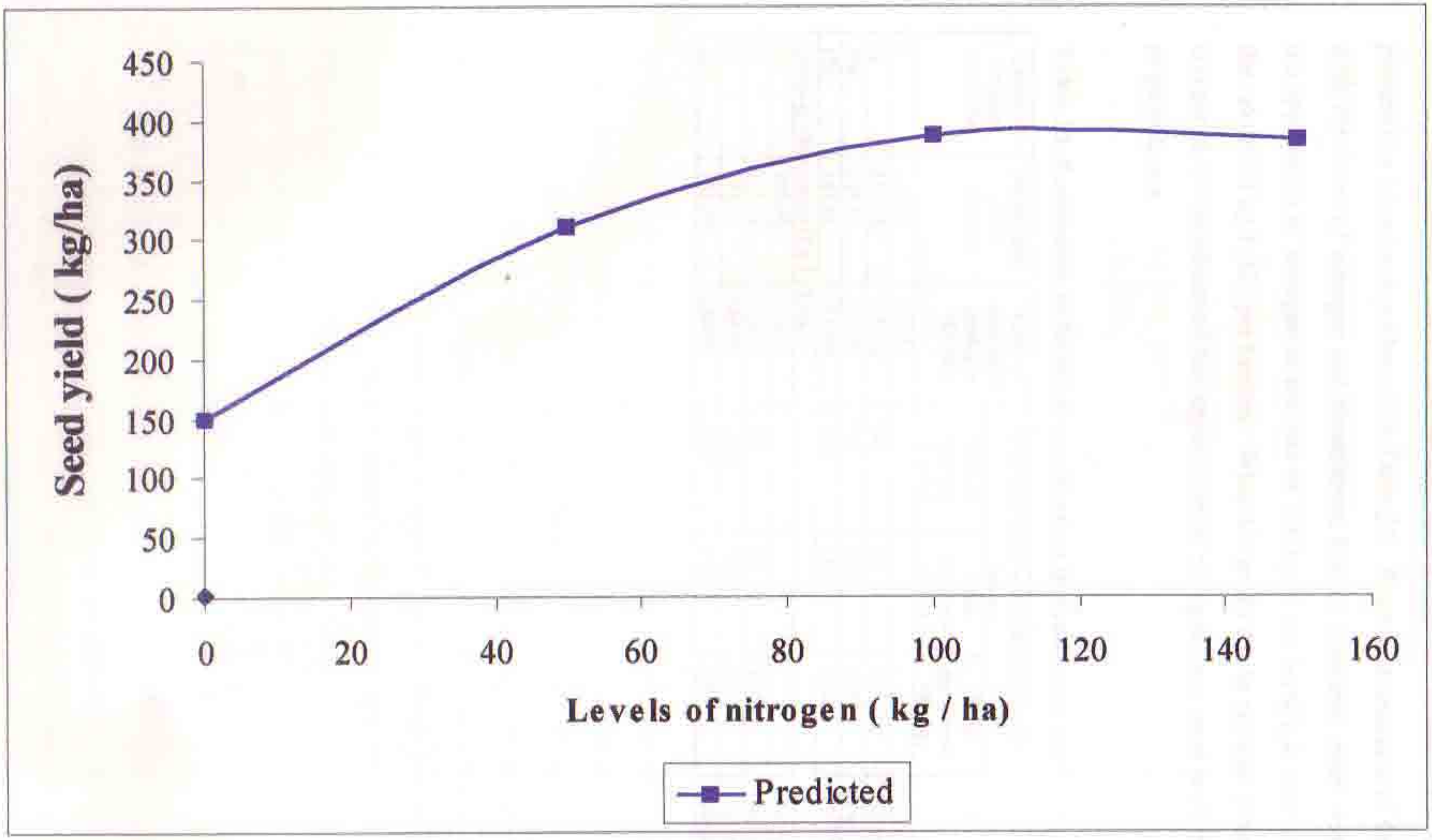


Fig. 23. Response function between seed yield of cauliflower and different levels of nitrogen

4.2.24 Economics of Fertilizer Application

The economic return per hectare worked out for various doses of nitrogen and phosphorus have been presented in Table 23. From an assessment of the economics of different doses of nitrogen and phosphorus, highest economic return was obtained from the application of nitrogen at the rate of 100 kg N per hectare as well as phosphorus at the rate of 80 kg P_2O_5 per hectare. When the profit due to nitrogen and phosporus were compared, it was observed that application of nitrogen gave more profit than application of phosphorus.

Table 23. Economics of fertilizer application in cauliflower seed crop

Levels of Nitrogen (kg N/ha)	Pooled seed yield (kg/ha)	Value of seed yield produced (Rs./ha)	Cost of fertilizer and other expenses per hectare			Actual return (Rs./ha)	Added return (Rs./ha)
			Cost of fertilizer (Rs./ha)	Other expenses (Rs./ha)	Total expenditure (Rs./ha)		
0	149.07	74535	-	-	-	74535	-
50	311.88	155940	396	60	456	155484	80949
100	384.81	192405	792	120	912	191493	116958
150	383.01	191505	1188	180	1368	190137	115602
Levels of Phosphorus (Kg P_2O_5/ha)							
0	208.06	104030	-	-	-	104030	-
40	273.35	136675	750	80	830	135845	31815
80	373.57	186785	1500	160	1660	185125	81095
120	373.79	186895	2250	240	2490	184405	80375

4.3 Experiment -3 : Effect of boron, molybdenum, zinc and their interactions on growth and seed production of cauliflower, variety Aghani.

In this experiment also variety Aghani of Group II was employed because of its high performance in terai agroclimatic zone as visualised from an earlier preliminary trial. With a view to keep uniformity with the condition of fertilizer experiment, this experiment was also laid out with the seedlings raised from 31st August sowing. The results have been presented and discussed below chapterwise.

4.3.1 Plant height

Effect of boron on plant height was highly significant. Soil application of borax at the rate of 20 kg per hectare (B_2) produced height of 55.49 cm whereas the plants under control (no boron application) were only 46.98 cm tall in pooled analysis (Table 24). Application of molybdenum as soil application brought about no marked effect in this character in both the years. Plants received 25 kg zinc sulphate per hectare produced smaller plants but the difference was not so pronounced in the first year and pooled analysis whereas in the second year, it was significant. In pooled analysis, the plant height under control (Z_1) was 51.64 cm while the soil application of 25 kg zinc sulphate per hectare (Z_2) decreased the height to 50.82 cm. The interaction of boron and zinc produced significant effect only on plant height. Plant height of 56.27 cm was recorded with 20 kg borax and 25 kg $ZaSo_4$ per hectare (B_2Z_2). The interactions between boron and molybdenum, molybdenum and zinc and boron, molybdenum and zinc showed no significant difference in plant height in both the years and in pooled analysis. While considering the combined effect of boron, molybdenum and zinc, the tallest plant of 56.54 cm was produced by the application of 20 kg borax, 1.5 kg ammonium molybdate and 25 kg zinc sulphate per hectare. ($B_2M_2Z_2$).

4.3.2 Leaf length

It is evident from the data in Table 24 that the effect of boron on leaf length was highly significant. In pooled analysis, B_2 showed the leaf length of 51.66 cm whereas B_1 showed 45.94 cm. Rise in the levels of molybdenum showed no effect in this character in both the years. M_2 resulted the leaf length of 48.58 cm in comparison with 49.01 cm

Table 24. Effect of boron, molybdenum, zinc and their interactions on plant height, leaf length and leaf width of cauliflower variety Aghani.

Treatments	Plant height (cm)			Leaf length (cm)			Leaf width (cm)		
	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled
B_1	48.14	45.82	46.98	46.42	45.46	45.94	12.38	12.33	12.36
B_2	55.57	55.41	55.49	51.72	51.60	51.66	21.57	21.62	21.60
S.Em±	0.53	0.45	0.37	0.50	0.36	0.30	0.42	0.54	0.31
C.D. at 5%	1.61	1.37	1.12	1.52	1.09	0.91	1.27	1.64	0.94
M_1	51.97	50.88	51.43	48.92	49.11	49.01	16.59	16.58	16.58
M_2	51.73	50.35	51.04	49.21	47.95	49.58	17.36	17.38	17.37
S.Em±	0.53	0.45	0.37	0.50	0.36	0.30	0.42	0.54	0.31
C.D. at 5%	NS	NS	NS	NS	1.09	NS	NS	NS	NS
Z_1	51.90	51.38	51.64	49.12	48.27	48.69	16.70	16.98	16.84
Z_2	51.80	49.85	50.82	49.02	48.79	48.90	17.25	16.98	17.11
S.Em±	0.53	0.45	0.37	0.50	0.36	0.30	0.42	0.54	0.31
C.D. at 5%	NS	1.37	NS	NS	NS	NS	NS	NS	NS
B_1M_1	48.15	46.60	47.37	46.39	46.60	46.69	11.82	11.90	11.86
B_1M_2	48.13	45.04	46.58	46.44	44.32	45.38	12.95	12.77	12.86
B_2M_1	55.80	55.15	55.48	51.45	51.62	51.53	21.36	21.26	21.31
B_2M_2	55.33	55.67	55.50	51.98	51.58	51.78	21.78	21.99	21.88
S.Em±	0.74	0.64	0.52	0.70	0.51	0.43	0.60	0.76	0.44
C.D. at 5%	NS	NS	NS	NS	1.55	NS	NS	NS	NS
B_1Z_1	48.99	48.17	48.58	46.89	45.22	46.05	11.90	12.39	12.14
B_1Z_2	47.29	43.47	45.38	45.95	45.70	45.82	12.86	12.28	12.57
B_2Z_1	54.82	54.59	54.71	51.35	51.32	51.33	21.51	21.57	21.54
B_2Z_2	56.31	56.23	56.27	51.88	51.88	51.98	21.64	21.68	21.66
S.Em±	0.74	0.64	0.52	0.70	0.51	0.43	0.60	0.76	0.44
C.D. at 5%	2.24	1.94	1.58	NS	NS	NS	NS	NS	NS
M_1Z_1	52.55	51.89	52.22	49.05	49.05	49.14	16.46	16.69	16.57
M_1Z_2	51.40	49.86	50.63	49.16	49.16	48.89	16.72	16.47	16.59
M_2Z_1	51.26	50.87	51.06	47.49	47.49	48.25	16.94	17.28	17.11
M_2Z_2	52.20	49.83	51.02	48.41	48.41	48.91	17.79	17.48	17.63
S.Em±	0.74	0.64	0.52	0.51	0.51	0.43	0.60	0.76	0.44
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
$B_1M_1Z_1$	49.56	49.40	49.48	46.35	46.65	46.91	11.39	12.19	11.79
$B_1M_1Z_2$	46.73	43.79	45.26	46.54	46.54	46.08	12.24	11.60	11.92
$B_1M_2Z_1$	48.41	46.94	47.67	43.79	43.79	45.20	12.40	12.60	12.50
$B_1M_2Z_2$	47.85	43.14	45.49	44.86	44.86	45.57	13.49	12.95	13.22
$B_2M_1Z_1$	55.54	54.38	54.96	51.45	51.45	51.37	21.53	21.18	21.36
$B_2M_1Z_2$	56.07	55.93	56.00	51.78	51.78	51.70	21.20	21.34	21.27
$B_2M_2Z_1$	54.10	54.81	54.50	51.19	51.19	51.30	21.48	21.96	21.72
$B_2M_2Z_2$	56.56	56.53	56.54	51.97	51.97	52.26	22.08	22.01	22.05
S.Em±	1.05	0.90	0.74	0.73	0.73	0.61	0.85	1.08	0.62
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS

N.S. = Not significant

under control (M_1). Plants treated with zinc sulphate produced longer leaf but the difference between the two levels of zinc was not so pronounced. In pooled analysis, the leaf length under control (Z_1) was 48.69 cm and the soil application of 25 kg zinc sulphate per hectare (Z_2) increased the leaf length to 48.90 cm. The interaction effect of boron and molybdenum was non-significant in first year and pooled analysis whereas in the second year it was significant. The interaction between molybdenum and zinc, boron and zinc and boron, molybdenum and zinc showed no significant difference in leaf length in both the years and in pooled analysis also. While considering the combined effect of boron, molybdenum and zinc, the highest leaf length of 52.26 cm was obtained by the application of 20 kg borax, 1.5 kg ammonium molybdate and 25 kg zinc sulphate per hectare. ($B_2M_2Z_2$).

4.3.3 Leaf width

Leaf width was highly increased as a result of boron application. Soil application of borax (B_2) increased the leaf width of 21.60 cm whereas B_1 showed 12.36 cm in pooled analysis (Table 24). Rise in the level of molybdenum showed no marked effect on this character in both the years. M_2 resulted the leaf width of 17.37 cm as compared to 16.58 cm under control (M_1). The plants treated with zinc sulphate produced larger leaf width but the difference between the two levels of zinc was not so pronounced. In pooled analysis, the leaf width under control (Z_1) was 16.84 cm and the application of zinc sulphate (Z_2) increased this to 17.11 cm. The interactions between and among these micronutrients showed no significant difference in leaf width in both the years and in pooled analysis also. While considering the combined effect of boron, molybdenum and zinc, the highest leaf width of 22.05 cm was obtained by the application of 20 kg borax, 1.5 kg ammonium molybdate and 25 kg zinc sulphate per hectare. ($B_2M_2Z_2$).

4.3.4 Number of leaves

It was recorded that the number of leaves was relatively less under control (B_1) in comparison with the application of boron (B_2) in both the years and also in pooled analysis. B_2 showed 18.42 leaves per plant, while it was 14.32 under control in pooled analysis. This result was in agreement with the reports of Ghosh and Hasan (1997) that number of leaves increased with the application of borax at the rate of 15 kg per hectare in variety Early Kunwari. Rise in the levels of molybdenum brought about no marked

Table 25. Effect of boron, molybdenum, zinc and their interactions on number of leaves, day to curd initiation and days to curd maturity of cauliflower variety Aghani.

Treatments	No. of leaves			Day to curd initiation			Days to curd maturity		
	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled
B_1	15.08	13.56	14.32	88.92	87.75	88.33	96.08	92.00	94.04
B_2	19.24	17.59	18.42	83.25	80.25	81.75	91.92	88.42	90.17
S.Em±	0.28	0.29	0.19	0.25	0.28	0.21	0.24	0.25	0.20
C.D. at 5%	0.85	0.88	0.58	0.76	0.85	0.64	0.73	0.76	0.61
M_1	16.91	15.52	16.21	86.33	84.00	85.17	94.17	89.92	92.04
M_2	17.41	15.63	16.52	85.83	84.00	84.92	93.83	90.50	92.17
S.Em±	0.28	0.29	0.19	0.25	0.28	0.21	0.24	0.25	0.20
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
Z_1	16.96	15.61	16.29	86.08	83.50	84.79	94.17	90.17	92.17
Z_2	17.35	15.54	16.45	86.08	84.50	85.29	93.83	90.25	92.04
S.Em±	0.28	0.29	0.19	0.25	0.28	0.21	0.24	0.25	0.20
C.D. at 5%	NS	NS	NS	NS	0.85	NS	NS	NS	NS
B_1M_1	14.83	13.48	14.16	89.33	87.67	88.50	96.67	91.33	94.00
B_1M_2	15.32	13.64	14.48	88.50	87.83	88.17	95.50	92.67	94.08
B_2M_1	18.98	17.56	18.27	83.33	80.33	81.83	91.67	88.50	90.08
B_2M_2	19.49	17.63	18.56	83.17	80.17	81.67	92.17	88.33	90.25
S.Em±	0.40	0.41	0.26	0.36	0.39	0.30	0.34	0.35	0.28
C.D. at 5%	NS	NS	NS	NS	NS	NS	1.03	1.06	NS
B_1Z_1	14.97	13.80	14.38	88.67	87.00	87.83	96.00	92.00	94.00
B_1Z_2	15.19	13.32	14.26	89.17	88.50	88.83	96.17	92.00	94.08
B_2Z_1	18.96	17.43	18.19	83.50	80.00	81.75	92.33	88.33	90.33
B_2Z_2	19.51	17.76	18.64	83.00	80.50	81.75	91.50	88.50	90.00
S.Em±	0.40	0.41	0.26	0.36	0.39	0.30	0.34	0.35	0.28
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
M_1Z_1	16.73	15.66	16.20	86.33	83.67	85.00	94.33	89.83	92.08
M_1Z_2	17.08	15.38	16.23	86.33	84.33	85.33	94.00	90.00	92.00
M_2Z_1	17.20	15.57	16.38	85.83	83.33	84.58	94.00	90.50	92.25
M_2Z_2	17.62	15.70	16.66	85.83	84.67	85.25	93.67	90.50	92.08
S.Em±	0.40	0.41	0.26	0.36	0.39	0.30	0.34	0.35	0.28
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
$B_1M_1Z_1$	14.79	13.69	14.24	89.33	87.33	88.33	96.67	91.33	94.00
$B_1M_1Z_2$	14.87	13.27	14.07	89.33	88.00	88.67	96.67	91.33	94.00
$B_1M_2Z_1$	15.14	13.90	14.52	88.00	86.67	87.33	95.33	92.67	94.00
$B_1M_2Z_2$	15.50	13.38	14.44	89.00	89.00	89.00	95.67	92.67	94.17
$B_2M_1Z_1$	18.67	17.62	18.15	83.33	80.00	81.67	92.00	88.33	90.17
$B_2M_1Z_2$	19.29	17.49	18.39	83.33	80.67	82.00	91.33	88.67	90.00
$B_2M_2Z_1$	19.25	17.23	18.24	83.67	80.00	81.83	92.67	88.33	90.50
$B_2M_2Z_2$	19.73	18.03	18.88	82.67	80.33	81.50	91.67	88.33	90.00
S.Em±	0.56	0.59	0.37	0.51	0.55	0.43	0.48	0.49	0.39
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS

N.S. = Not significant

effect in this character in both the years (Table 25). The plants treated with 25 kg zinc sulphate per hectare produced larger number of leaves but the difference between the two levels of zinc was not so pronounced. In pooled analysis, the number of leaves under control (Z_1) was 16.29 and application of zinc sulphate (Z_2) increased this to 16.45. The interactions between boron and molybdenum, boron and zinc, molybdenum and zinc, and boron, molybdenum and zinc showed no significant difference in number of leaves in both the years and in pooled analysis also. While considering the combined effect of boron, molybdenum and zinc, the highest number of 18.88 leaves was obtained by the application of 20 kg borax, 1.5 kg ammonium molybdate and 25 kg zinc sulphate per hectare. ($B_2M_2Z_2$).

4.3.5 Days to curd initiation

Effect of boron on days to curd initiation was highly significant and days to curd initiation was relatively more under control (B_1). Plants under B_2 took 81.75 days to curd initiation whereas B_1 took 88.33 days in pooled analysis (Table 25). Rise in the levels of molybdenum showed no marked effect in this character in both the years. In M_2 it took 84.92 days for curd initiation in comparison with 85.17 days under control (M_1). Plants treated with zinc sulphate took more time for curd initiation but the difference was not so pronounced in first year and pooled analysis, whereas significant effect was observed in second year. In pooled analysis, the days to curd initiation under control (Z_1) was 84.79 days and application of zinc sulphate (Z_2) increased this to 85.29 days. The interactions showed no significant difference in days to curd initiation in both the years. With regard to the combined effect of boron, molybdenum and zinc, the earliest curd initiation was after 81.50 days with the application of 20 kg borax, 1.5 kg ammonium molybdate and 25 kg zinc sulphate per hectare ($B_2M_2Z_2$).

4.3.6 Days to curd maturity

A significant variation on days to curd maturity was recorded with boron application. Days to curd maturity was relatively high under control (B_1) in comparison with the application of boron (B_2) in both the years and also in pooled analysis. Plants under B_2 showed 90.17 days to curd maturity whereas control plants (B_1) showed 94.04 days in pooled analysis. Similar results were recorded by Thakur *et al.* (1991). Rise in the levels of molybdenum brought about no marked effect in this character in both the years. Plants under M_2 took 92.17 days to curd maturity in comparison with 92.04 days under control (Table 25). Plants treated with zinc sulphate required shorter period to curd maturity but the difference between the two levels of zinc was not so pronounced. In pooled analysis, the days to curd maturity under control (Z_1) was 92.17 days and the soil application of zinc sulphate (Z_2) decreased this to 92.04 days. The non-significant effect of zinc application on days to curd harvesting was also observed by Balyan *et al.* (1988). The interaction effect of boron and molybdenum was significant in both the years but not in pooled analysis. The interactions produced no significant results. Minimum days to curd maturity (90.00 days) was obtained by the application of 20 kg borax, 0 or 1.5 kg ammonium molybdate and 25 kg zinc sulphate per hectare. ($B_2M_1Z_2$ and $B_2M_2Z_2$).

4.3.7 Curd diameter

Effect of boron on curd diameter was markedly significant. Plants under B_2 showed curd diameter of 14.18 cm whereas, B_1 showed 6.29 cm curd diameter in pooled analysis (Table 26). Rise in the level of molybdenum produced no marked effect in this character in both the years. Plants under M_2 resulted the curd diameter of 10.17 cm in comparison with 10.30 cm under control (M_1). Plants treated with zinc sulphate produced greater curd diameter but the effect was not so pronounced. In pooled analysis, the curd diameter under control (Z_1) was 10.13 cm but the same under Z_2 was only 10.34cm. The interactions between boron and molybdenum, boron and zinc, molybdenum and zinc and boron, molybdenum and zinc produced no significant difference in curd diameter in both the years and in pooled analysis also.

4.3.8 Curd depth

Boron exercised considerable influence on the curd depth, and plants under B_2 showed the curd depth of 8.14 cm while control plants showed 4.58 cm only in pooled analysis (Table 26). Molybdenum application brought about no marked effect in this character in both the years. Similar was the case for zinc application. The interactions between boron and molybdenum, boron and zinc, molybdenum and zinc and boron, molybdenum and zinc could not register any significant difference in curd depth in both the years and in pooled analysis also. However, the highest curd depth of 8.34 cm was obtained by the application of 20 kg borax, 1.5 kg ammonium molybdate and 25 kg zinc sulphate per hectare. ($B_2M_2Z_2$).

Table 26. Effect of boron, molybdenum, zinc and their interactions on curd diameter, curd depth. and curd weight of cauliflower variety Aghani.

Treatments	Curd diameter (cm)			Curd depth. (cm)			Curd weight (g)		
	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled
B_1	6.45	6.12	6.29	4.97	4.20	4.58	142.32	177.01	159.66
B_2	14.63	13.73	14.18	8.19	8.09	8.14	570.83	563.27	567.05
S.Em±	0.41	0.47	0.29	0.15	0.16	0.11	16.24	14.03	9.98
C.D. at 5%	1.24	1.43	0.88	0.46	0.49	0.33	49.26	42.56	30.27
M_1	10.50	10.11	10.30	6.55	6.09	6.32	350.23	365.46	357.85
M_2	10.59	9.74	10.17	6.61	6.20	6.40	362.92	374.82	368.87
S.Em±	0.41	0.47	0.29	0.15	0.16	0.11	16.24	14.03	9.98
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
Z_1	10.41	9.85	10.13	6.44	6.04	6.24	351.58	360.02	355.80
Z_2	10.67	10.01	10.34	6.72	6.25	6.48	361.57	380.26	370.91
S.Em±	0.41	0.47	0.29	0.15	0.16	0.11	16.24	14.03	9.98
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
B_1M_1	6.42	6.50	6.46	4.89	4.19	4.54	134.69	164.53	149.61
B_1M_2	6.48	5.75	6.11	5.04	4.21	4.62	149.95	189.49	169.72
B_2M_1	14.57	13.72	14.15	8.20	7.99	8.10	565.77	566.40	566.09
B_2M_2	14.59	13.74	14.22	8.18	8.19	8.18	575.89	560.15	568.02
S.Em±	0.58	0.66	0.41	0.22	0.22	0.15	22.97	19.84	14.11
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
B_1Z_1	6.13	5.93	6.03	4.73	4.17	4.45	139.62	168.58	154.10
B_1Z_2	6.78	6.31	6.54	5.20	4.22	4.71	145.05	185.43	165.22
B_2Z_1	14.69	13.76	14.23	8.16	7.91	8.03	563.54	551.46	557.50
B_2Z_2	14.57	13.70	14.14	8.23	8.27	8.25	578.12	575.09	576.60
S.Em±	0.58	0.66	0.41	0.22	0.22	0.15	22.97	19.84	14.11
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
M_1Z_1	10.19	10.20	10.20	6.39	6.01	6.20	344.31	353.11	348.71
M_1Z_2	10.80	10.02	10.41	6.71	6.17	6.44	356.15	377.82	366.99
M_2Z_1	10.63	9.49	10.06	6.50	6.07	6.28	358.85	366.93	362.89
M_2Z_2	10.54	10.00	10.27	6.72	6.32	6.52	366.98	382.70	374.84
S.Em±	0.58	0.66	0.41	0.22	0.22	0.15	22.97	19.84	14.11
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
$B_1M_1Z_1$	5.56	6.49	6.02	4.58	4.16	4.37	126.23	150.94	138.59
$B_1M_1Z_2$	7.29	6.51	6.90	5.21	4.23	4.72	143.14	178.12	160.63
$B_1M_2Z_1$	6.70	5.37	6.04	4.88	4.19	4.54	153.00	186.23	169.61
$B_1M_2Z_2$	6.26	6.12	6.19	5.19	4.22	4.71	146.90	192.74	169.82
$B_2M_1Z_1$	14.82	13.91	14.37	8.20	7.86	8.03	562.38	555.28	558.83
$B_2M_1Z_2$	14.32	13.53	13.92	8.21	8.11	8.16	569.17	577.52	573.34
$B_2M_2Z_1$	14.56	13.61	14.09	8.11	7.95	8.03	564.71	547.63	556.17
$B_2M_2Z_2$	14.82	13.87	14.35	8.26	8.42	8.34	587.07	572.66	579.86
S.Em±	0.82	0.94	0.58	0.31	0.31	0.22	32.49	28.05	19.96
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS

4.3.9 Curd weight

The data presented in Table 26 revealed that the effect of boron on curd weight was highly significant. The curd weight was relatively less under control (B_1) in comparison with the application of boron in soil as borax at the rate of 20 kg per hectare (B_2) in both the years and also in pooled analysis. Application of borax (B_2) produced the curd weight of 567.05 g whereas control plants (B_1) showed 159.66 g in pooled analysis. Thakur *et al.* (1991) and Ghosh and Hasan (1997) also observed increased curd weight with the application of boron. Molybdenum application brought about no marked effect on this character in both the years. Plants treated with molybdenum (M_2) gave curd weight of 368.87 g in comparison with 357.85 g under control (M_1). Plants treated with zinc sulphate produced greater curd weight but the increase was not significant over control (Z_1). In pooled analysis, the curd weight of control plants (Z_1) was 355.80 g and in zinc treated plants it increased to 370.91 g. The interactions showed no significant difference in curd weight in both the years and in pooled analysis also. However, the highest curd weight of 579.86 g was obtained by the application of 20 kg borax, 1.5 kg ammonium molybdate and 25 kg zinc sulphate per hectare. ($B_2M_2Z_2$).

4.3.10 Days to inflorescence initiation

It is evident from the data that the effect of boron on days to inflorescence initiation was highly significant. Inflorescence initiation was delayed high under control plants (B_1). Inflorescence emerged after 102.17 days in boron treated plants (B_2) compared to 108.42 days in control plants (B_1). Molybdenum had no marked effect on this character in both the years. Inflorescence initiated in the molybdenum treated plants after 105.29 days (Table 27). Zinc application slightly delays inflorescence intiation (105.38 days) as compared to control plants (105.21 days). The interaction effects showed no significant difference in days to inflorescence initiation in both the years.

4.3.11 Height of inflorescence

Height of inflorescence was significantly low (64.94 cm) under control (B_1) in comparison with boron treated plants (72.85 cm). Molybdenum brought about no marked effect on height of inflorescence in both the years (Table 27). M_2 gave the height of inflorescence of 69.22 cm in comparison with 68.57 cm under control (M_1). In pooled analysis, the height of inflorescence under control (Z_1) was 68.55 cm and application of

Table 27. Effect of boron, molybdenum, zinc and their interactions on days to inflorescence initiation, height of inflorescence and primary inflorescence stalks per plant of cauliflower variety Aghani.

Treatments	Days to inflorescence initiation			Height of inflorescence (cm)			Primary inflorescence per plant		
	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled
B_1	110.00	106.83	108.42	67.14	62.73	64.94	3.55	3.27	3.41
B_2	103.42	100.92	102.17	74.06	71.65	72.85	7.83	7.53	7.68
S.Em±	0.29	0.33	0.21	0.41	0.67	0.37	0.31	0.27	0.18
C.D. at 5%	0.88	1.00	0.64	1.24	2.03	1.12	0.94	0.82	0.55
M_1	106.58	104.00	105.29	70.31	66.83	68.57	5.65	5.27	5.46
M_2	106.83	103.75	105.29	70.89	67.56	69.22	5.73	5.54	5.63
S.Em±	0.29	0.33	0.21	0.41	0.67	0.37	0.31	0.27	0.18
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
Z_1	106.58	103.83	105.21	70.40	66.71	68.55	5.63	5.38	5.51
Z_2	106.83	103.92	105.38	70.80	67.68	69.24	5.74	5.43	5.58
S.Em±	0.29	0.33	0.21	0.41	0.67	0.37	0.31	0.27	0.18
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
B_1M_1	109.83	107.00	108.42	66.87	62.57	64.72	3.55	3.27	3.41
B_1M_2	110.17	106.67	108.42	67.42	62.90	65.16	3.55	0.33	3.41
B_2M_1	103.33	101.00	102.17	73.74	71.09	72.42	7.75	7.26	7.50
B_2M_2	103.50	100.83	102.17	74.37	72.22	73.29	7.91	7.81	7.86
S.Em±	0.41	0.46	0.29	0.58	0.94	0.53	0.44	0.38	0.26
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
B_1Z_1	109.83	106.83	108.33	66.90	62.30	64.60	3.48	3.23	3.36
B_1Z_2	110.17	106.83	108.50	67.38	63.17	65.28	3.61	3.30	3.46
B_2Z_1	103.33	100.83	102.08	73.90	71.11	72.51	7.79	7.52	7.65
B_2Z_2	103.50	101.00	102.25	74.21	72.19	73.20	7.87	7.55	7.71
S.Em±	0.41	0.46	0.29	0.58	0.94	0.53	0.44	0.38	0.26
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
M_1Z_1	106.50	103.67	105.08	69.84	66.26	68.05	5.61	5.17	5.39
M_1Z_2	106.67	104.33	105.50	70.77	67.40	69.09	5.68	5.36	5.52
M_2Z_1	106.67	104.00	105.33	70.97	67.15	69.06	5.66	5.58	5.62
M_2Z_2	107.00	103.50	105.25	70.82	67.96	69.39	5.80	5.49	5.64
S.Em±	0.41	0.46	0.29	0.58	0.94	0.53	0.44	0.38	0.26
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
$B_1M_1Z_1$	109.67	106.67	108.17	66.34	61.89	64.12	3.42	3.16	3.29
$B_1M_1Z_2$	110.00	107.33	108.67	67.39	63.26	65.33	3.67	3.38	3.53
$B_1M_2Z_1$	110.00	107.00	108.50	67.46	62.71	65.09	3.55	3.31	3.43
$B_1M_2Z_2$	110.33	106.33	108.33	67.37	63.08	65.23	3.55	3.22	3.39
$B_2M_1Z_1$	103.33	100.67	102.00	73.34	70.63	71.99	7.80	7.18	7.49
$B_2M_1Z_2$	103.33	101.33	102.33	74.15	71.54	72.85	7.69	7.35	7.52
$B_2M_2Z_1$	103.33	101.00	102.17	74.47	71.59	73.03	7.77	7.86	7.82
$B_2M_2Z_2$	103.67	100.67	102.17	74.27	72.84	73.55	8.04	7.75	7.90
S.Em±	0.59	0.65	0.41	0.83	1.33	0.75	0.62	0.53	0.37
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS

zinc sulphate (Z_2) increased this only to 69.24 cm. The interactions among these micronutrients produced no significant difference on the height of inflorescence in both the years. However, maximum height of inflorescence (73.55 cm) was obtained by the application of 20 kg borax, 1.5 kg ammonium molybdate and 25 kg zinc sulphate per hectare. ($B_2M_2Z_2$).

4.3.12 Primary inflorescence stalks per plant

Number of primary inflorescence stalks per plant was significantly less under control (B_1) as compared to boron treated plant (B_2) in both the years and also in pooled analysis. Plants under B_2 showed the maximum number of primary inflorescence stalks per plant of 7.68 whereas B_1 showed 3.41 in pooled analysis (Table 27). Mishra (1992) also noted similar observation in the variety Patna Main with the application of boron. Molybdenum brought about no marked effect in this character in both the years. M_2 resulted 5.63 number of primary inflorescence stalks per plant as compared to 5.46 under control (M_1). Zinc application produced larger number of primary inflorescence stalks per plant but the increase over control was not significant. In pooled analysis, the number of primary inflorescence stalks per plant under control (Z_1) was 5.51 and zinc application (Z_2) increased this to 5.58. The interaction effects were not significant in this respect. The highest number of primary inflorescence stalks per plant (7.90) was obtained by the application of 20 kg borax, 1.5 kg ammonium molybdate and 25 kg zinc sulphate per hectare. ($B_2M_2Z_2$).

4.3.13 Days to seed harvesting

The plants received boron (B_2) took 195.08 days for seed harvesting whereas control plants (B_1) took 197.33 days (Table 28). Molybdenum application had no marked effect on this character in both the years. Plants under M_2 took 196.29 days for seed harvesting in comparison with 196.13 days under control (M_1). Similar was the case for application of zinc to the plants. Days to seed harvesting under control (Z_1) was 196.00 days and application of zinc sulphate (Z_2) increased this marginally to 196.42 days. The lowest of 195.00 days to seed harvesting was recorded with treatment combination $B_2M_1Z_2$.

Table 28. Effect of boron, molybdenum, zinc and their interactions on days to harvesting,pods per plant and pod length of cauliflower variety Aghani.

Treatments	Days to harvesting			Pods per plant			Pod length (cm)		
	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled
B_1	194.75	199.92	197.33	152.00	182.33	167.16	5.23	5.12	5.17
B_2	192.67	197.50	195.08	982.30	956.22	969.26	6.32	6.04	6.19
S.Em±	0.21	0.30	0.18	25.35	18.25	15.39	0.13	0.07	0.07
C.D. at 5%	0.64	0.91	0.55	76.90	55.36	46.69	0.39	0.21	0.21
M_1	193.83	198.42	196.13	563.05	589.09	576.07	5.78	5.60	5.69
M_2	193.58	199.00	196.29	571.25	549.45	560.35	5.78	5.56	5.67
S.Em±	0.21	0.30	0.18	25.35	18.25	15.39	0.13	0.07	0.07
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
Z_1	193.58	198.42	196.00	557.42	574.43	565.92	5.70	5.62	5.66
Z_2	193.83	199.00	196.42	576.88	564.12	570.50	5.86	5.54	5.70
S.Em±	0.21	0.30	0.18	25.35	18.25	15.39	0.13	0.07	0.07
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
B_1M_1	195.00	199.50	197.25	151.13	193.25	172.19	5.22	5.15	5.18
B_1M_2	194.50	200.33	197.42	152.87	171.40	162.13	5.25	5.08	5.16
B_2M_1	192.67	197.33	195.00	974.97	984.93	979.95	6.34	6.05	6.20
B_2M_2	192.67	197.67	195.17	989.63	927.50	958.57	6.31	6.04	6.17
S.Em±	0.30	0.42	0.26	35.85	25.82	21.77	0.19	0.10	0.10
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
B_1Z_1	194.33	199.50	196.92	127.72	189.32	158.52	5.16	5.07	5.12
B_1Z_2	195.17	200.33	197.75	176.28	175.33	175.81	5.30	5.16	5.23
B_2Z_1	192.83	197.33	195.08	987.12	959.53	973.33	6.23	6.16	6.20
B_2Z_2	192.50	197.67	195.08	977.48	952.90	965.19	6.42	5.93	6.17
S.Em±	0.30	0.42	0.26	35.85	25.82	21.77	0.19	0.10	0.10
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
M_1Z_1	193.83	198.00	195.92	537.22	594.92	566.07	5.68	5.70	5.69
M_1Z_2	193.83	198.83	196.33	588.88	583.27	586.08	5.87	5.50	5.69
M_2Z_1	193.33	198.83	196.08	577.62	553.93	565.78	5.71	5.54	5.62
M_2Z_2	193.83	199.17	196.50	564.88	544.97	554.93	5.85	5.59	5.72
S.Em±	0.30	0.42	0.26	35.85	25.82	21.77	0.19	0.10	0.10
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
$B_1M_1Z_1$	194.67	199.00	196.83	125.43	190.43	157.93	5.10	5.15	5.12
$B_1M_1Z_2$	195.33	200.00	197.67	176.83	196.07	186.45	5.33	5.15	5.24
$B_1M_2Z_1$	194.00	200.00	197.00	130.00	188.20	159.10	5.22	5.00	5.11
$B_1M_2Z_2$	195.00	200.67	197.83	175.73	154.60	165.17	5.27	5.17	5.22
$B_2M_1Z_1$	193.00	197.00	195.00	949.00	999.40	974.20	6.27	6.25	6.26
$B_2M_1Z_2$	192.33	197.67	195.00	1000.93	970.47	985.70	6.41	5.85	6.13
$B_2M_2Z_1$	192.67	197.67	195.17	1025.23	919.67	972.45	6.20	6.08	6.14
$B_2M_2Z_2$	192.67	197.67	195.17	954.03	935.33	944.68	6.42	6.01	6.21
S.Em±	0.43	0.60	0.36	50.70	36.51	30.78	0.26	0.14	0.14
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS

N.S. = Not significant

4.3.14 Pods per Plant

The data presented in Table 28 showed that the effect of boron on number of pods per plant was highly significant. Plants under B_2 showed 969.26 pods per plant (Fig. 24) whereas 167.16 pods were produced in the control plants (B_1). Mishra (1992) also noted similar trend in variety Patna Main. Molybdenum produced no marked effect in this character in both the years. Plants under M_2 resulted 560.35 pods per plant as compared to 576.07 under control (M_1). Plants treated with zinc sulphate produced slightly higher number of pods per plant but the difference was not so pronounced. In pooled analysis, the pods per plant under control (Z_1) was 565.92 and application of zinc sulphate (Z_2) produced 570.50 pods per plant. The interactions between boron and molybdenum, boron and zinc, molybdenum and zinc and boron, molybdenum and zinc showed no significant difference in number of pods per plant in both the years and in pooled analysis also. However, the highest of 985.70 pods per plant was obtained with the application of 20 kg borax and 25kg zinc sulphate per hectare ($B_2M_1Z_2$).

4.3.15 Pod length

The effect of boron on pod length was highly significant and showed pod length of 6.19 cm compared to 5.17 cm in the control plants (B_1). The results obtained in this study was in line with the findings of Mishra (1992). Sole effect of molybdenum was not pronounced on this character in both the years, and similar was the effect of zinc (Table 28). The interactions of the micronutrients showed no significant variation in pod length.

4.3.16 Seeds per pod

Effect of boron on number of seeds per pod was highly significant in both the years and also in pooled analysis (Fig. 24). Plants treated with boron (B_2) produced 21.06 seeds per pod as against 10.02 seeds per pod in the control plants. Mishra (1992) also recorded similar trend in the number of seeds per pod with the soil application of boron. Application of molybdenum brought about no significant variations in this character in both the years. Similarly application of zinc could not influence seed number per pod significantly. The interactions between and among these micronutrients could produce no significant difference in number of seeds per pod in both the years. The highest of 21.39 seeds per pod was obtained by the sole application of borax without molybdenum and zinc (Table 29).

Table 29. Effect of boron, molybdenum, zinc and their interactions on seeds per pod, seed yield per plant and seed yield hectare of cauliflower variety Aghani.

Treatments	Seeds per pod			Seed yield per plant (g)			Seed yield per hectare (kg)		
	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled
B_1	11.55	8.49	10.02	3.01	3.48	3.24	46.96	51.59	49.28
B_2	20.96	21.15	21.06	16.72	16.14	16.43	487.11	468.97	478.04
S.Em±	0.35	0.39	0.31	0.30	0.42	0.26	5.39	4.12	3.36
C.D. at 5%	1.06	1.18	0.94	0.91	1.27	0.79	16.35	12.50	10.19
M_1	16.24	14.82	15.53	9.69	9.55	9.62	262.11	257.84	259.98
M_2	16.27	14.83	15.55	10.04	10.07	10.05	271.96	262.72	267.34
S.Em±	0.35	0.39	0.31	0.30	0.42	0.26	5.39	4.12	3.36
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
Z_1	16.24	14.72	15.48	9.68	9.17	9.43	261.99	254.68	258.33
Z_2	16.26	14.92	15.59	10.05	10.44	10.25	272.08	265.89	268.98
S.Em±	0.35	0.39	0.31	0.30	0.42	0.26	5.39	4.12	3.36
C.D. at 5%	NS	NS	NS	0.91	NS	NS	NS	NS	10.19
B_1M_1	11.35	8.53	9.94	3.08	3.56	3.32	45.84	50.87	48.35
B_1M_2	11.74	8.45	10.10	2.94	3.39	3.16	48.08	52.32	50.20
B_2M_1	21.13	21.10	21.12	16.29	15.54	15.92	478.38	464.82	471.60
B_2M_2	20.79	21.21	21.00	17.14	16.75	16.94	495.84	473.12	484.48
S.Em±	0.50	0.55	0.44	0.43	0.60	0.36	5.83	4.75	3.38
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
B_1Z_1	11.31	8.46	9.89	3.26	2.91	3.09	45.72	51.22	48.47
B_1Z_2	11.78	8.52	10.15	2.75	4.04	3.40	48.20	51.97	50.09
B_2Z_1	21.17	20.98	21.08	16.09	15.43	15.76	478.26	458.14	468.20
B_2Z_2	20.75	21.32	21.04	17.34	16.85	17.10	495.96	479.80	487.88
S.Em±	0.50	0.55	0.44	0.43	0.60	0.36	5.83	4.75	3.38
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
M_1Z_1	15.98	14.71	15.34	9.66	9.18	9.42	252.44	254.28	253.36
M_1Z_2	16.50	14.93	15.71	9.71	9.92	9.81	263.25	265.68	264.47
M_2Z_1	16.51	14.74	15.62	9.69	9.17	9.43	256.92	262.39	259.66
M_2Z_2	16.03	14.92	15.47	10.38	10.97	10.68	268.52	272.29	270.41
S.Em±	0.50	0.55	0.44	0.43	0.60	0.36	5.83	4.75	3.38
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
$B_1M_1Z_1$	10.45	8.15	9.30	3.67	3.00	3.33	50.07	47.23	48.65
$B_1M_1Z_2$	12.25	8.92	10.58	2.49	4.12	3.30	51.66	49.48	50.57
$B_1M_2Z_1$	12.17	8.77	10.47	2.85	2.83	2.84	52.37	49.70	51.04
$B_1M_2Z_2$	11.31	8.13	9.72	3.02	3.96	3.49	52.28	50.70	51.49
$B_2M_1Z_1$	21.51	21.26	21.39	15.66	15.36	15.51	454.81	461.32	458.07
$B_2M_1Z_2$	20.75	20.94	20.85	16.93	15.72	16.32	474.84	461.89	468.37
$B_2M_2Z_1$	20.84	20.70	20.77	16.53	15.51	16.02	461.48	475.09	468.29
$B_2M_2Z_2$	20.75	21.71	21.23	17.75	17.99	17.87	484.77	493.88	489.33
S.Em±	0.71	0.77	0.62	0.61	0.84	0.51	8.24	6.72	5.84
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS

N.S. = Not significant

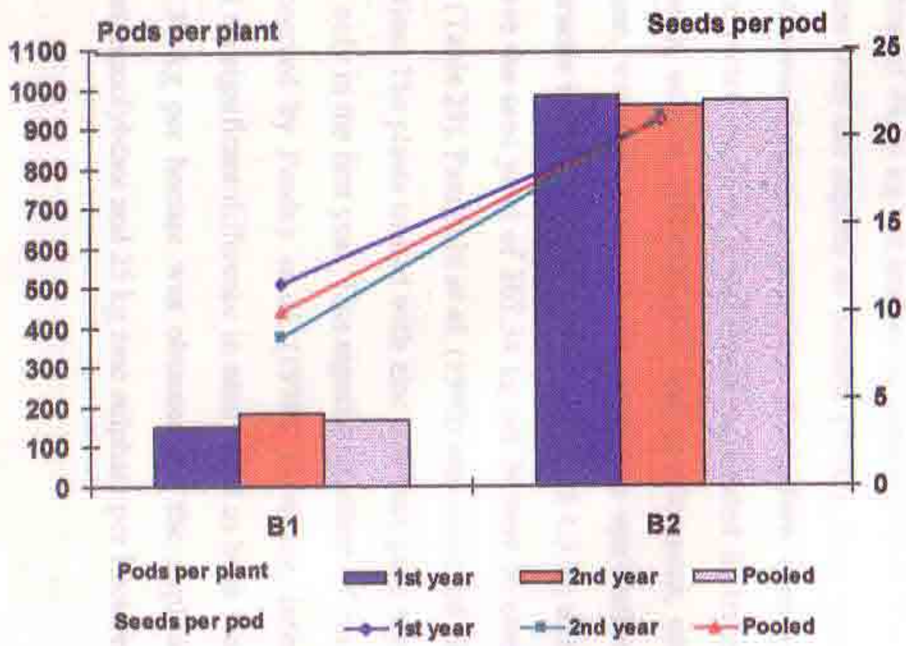


Fig. 24. Effect of boron on pods per plant and seeds per pod in cauliflower.

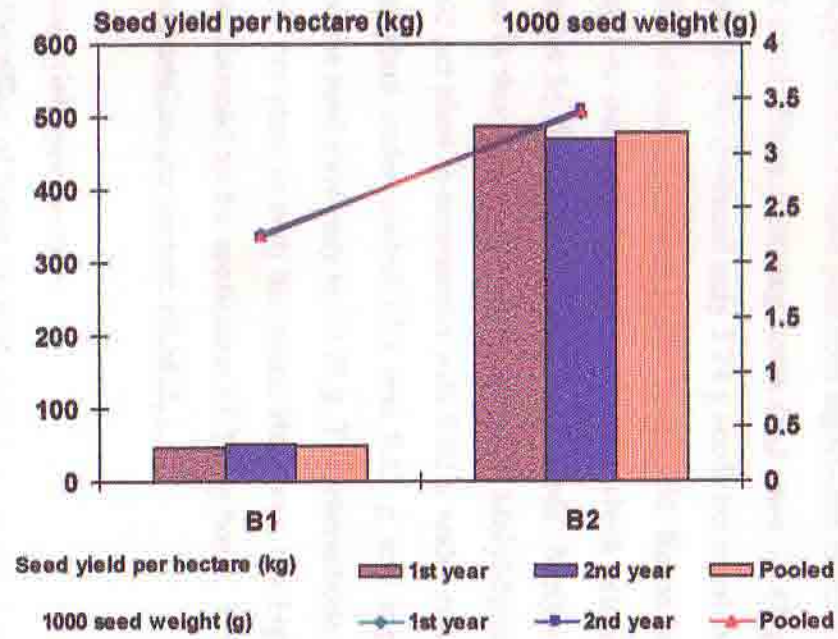


Fig. 25. Effect of boron on seed yield per hectare and 1000 seed weight in cauliflower.

4.3.17 Seed yield per plant

Application of boron produced significant effect on the seed yield over control in both the years. Plants receiving borax (B_2) gave 16.43 g seed yield per plant whereas control plants (B_1) produced only 3.24 g seeds per plant. Mishra (1992) also reported that application of boron produced higher seed yield. Boron helpes to check the formation of hollowness in stem and browning of curd which ultimately gave proper bolting and development of flower stalks, pods and seeds. Molybdenum application showed no variations in this character in both the years. Molybdenum application recorded 10.05g seed yield per plant in comparison with 9.62 g under control (Table 29). Similarly, seed yield per plant under control (Z_1) was 9.43 g and application of zinc sulphate (Z_2) increased the seed yield only to 10.25 g. The interactions showed no marked variation in seed yield per plant in both the years. However, the highest seed yield of 17.87 g per plant was obtained by the application of 20 kg borax, 1.5 kg ammonium molybdate and 25 kg zinc sulphate per hectare. ($B_2M_2Z_2$).

4.3.18 Seed yield per hectare

The effect of boron on seed yield per hectare was highly significant and 478.04 kg per hectare seed yield was recorded in the plants, which received boron (B_2) as against production of 49.28 kg per hectare in control plants (Fig. 25). The above results are in agreement with the reports of Mishra (1992). Low seed yield in control was due to different boron deficiency symptoms like hollow stem and brown rot. Application of boron corrected these as it had been implicated in transportation of sugar across cell membranes, cellular differentiation and development, nitrogen metabolism, active salt adsorption, water relations, etc. Molybdenum application showed no marked effect in this character in both the years. Plants received 1.5 kg ammonium molybdate per hectare (M_2) gave the seed yield of 267.34 kg per hectare in comparison with 259.98 kg under control (Table 29). Panigrahi *et al.* (1990) also recorded similar response of molybdenum application. The plants treated with zinc sulphate gave significantly higher seed yield per hectare only in the first year. This significant effect of zinc application on seed yield was also observed by Pandey *et al.* (1978). However, interactions of the micronutrients showed no significant difference in seed yield in both the years. The highest seed yield of 489.33 kg per hectare was obtained by the application of 20 kg borax, 1.5 kg ammonium molybdate and 25 kg zinc sulphate per hectare. ($B_2M_2Z_2$). Sharma (1995)

Table 30. Effect of boron, molybdenum, zinc and their interactions on 1000 seed weight, germination percentage of cauliflower variety Aghani.

Treatments	1000 seed weight(g)			Germination percentage		
	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled
B_1	2.27	2.23	2.25	73.25	74.83	74.04
B_2	3.37	3.40	3.38	91.25	90.25	90.75
S.Em±	0.04	0.05	0.03	0.41	0.43	0.32
C.D. at 5%	0.12	0.15	0.09	1.24	1.30	0.97
M_1	2.80	2.83	2.82	82.50	82.58	82.54
M_2	2.83	2.79	2.81	82.00	82.50	82.25
S.Em±	0.04	0.05	0.03	0.41	0.43	0.32
C.D. at 5%	NS	NS	NS	NS	NS	NS
Z_1	2.79	2.81	2.80	82.42	82.42	82.42
Z_2	2.85	2.82	2.83	82.08	82.67	82.38
S.Em±	0.04	0.05	0.03	0.41	0.43	0.32
C.D. at 5%	NS	NS	NS	NS	NS	NS
B_1M_1	2.22	2.24	2.23	74.33	75.50	74.92
B_1M_2	2.32	2.21	2.26	72.17	74.17	73.17
B_2M_1	3.38	3.42	3.40	90.67	89.67	90.17
B_2M_2	3.35	3.37	3.36	91.83	90.83	91.33
S.Em±	0.06	0.07	0.05	0.58	0.61	0.45
C.D. at 5%	NS	NS	NS	1.76	NS	1.37
B_1Z_1	2.20	2.25	2.22	74.00	75.00	74.50
B_1Z_2	2.34	2.21	2.28	72.50	74.67	73.58
B_2Z_1	3.38	3.37	3.37	90.83	89.83	90.33
B_2Z_2	3.36	3.43	3.39	91.67	90.67	91.17
S.Em±	0.06	0.07	0.05	0.58	0.61	0.45
C.D. at 5%	NS	NS	NS	NS	NS	NS
M_1Z_1	2.80	2.81	2.81	83.00	82.50	82.75
M_1Z_2	2.80	2.85	2.83	82.00	82.67	82.33
M_2Z_1	2.77	2.81	2.79	81.83	82.33	82.08
M_2Z_2	2.90	2.85	2.88	82.17	82.67	82.42
S.Em±	0.06	0.07	0.05	0.58	0.61	0.45
C.D. at 5%	NS	NS	NS	NS	NS	NS
$B_1M_1Z_1$	2.20	2.21	2.21	75.67	76.00	75.83
$B_1M_1Z_2$	2.24	2.27	2.26	73.00	75.00	74.00
$B_1M_2Z_1$	2.19	2.28	2.24	72.33	74.00	73.17
$B_1M_2Z_2$	2.44	2.14	2.29	72.00	74.33	73.17
$B_2M_1Z_1$	3.41	3.41	3.41	90.33	89.00	89.67
$B_2M_1Z_2$	3.36	3.44	3.40	91.00	90.33	90.67
$B_2M_2Z_1$	3.35	3.33	3.34	91.33	90.67	91.00
$B_2M_2Z_2$	3.35	3.42	3.39	92.33	91.00	91.67
S.Em±	0.08	0.10	0.06	0.82	0.86	0.63
C.D. at 5%	NS	NS	NS	NS	NS	NS

N.S. = Not significant

also recorded the highest seed yield per hectare with application of 20 kg borax along with 1.5 kg ammonium molybdenum per hectare.

4.3.19 1000 seed weight

Effect of boron on 1000 seed weight was highly pronounced over control (Fig. 25). The plants treated with borax (B_2) gave the maximum 1000 seed weight (3.38 g) whereas plants grown without boron (B_1) showed only 2.25 g seed weight in pooled analysis. Mishra (1992) also recorded that 1000 seed weight increased with the application of boron. Application of molybdenum brought about no significant variations in this character in both the years. Similarly, plants treated with zinc sulphate could not produce significantly higher seed yield per hectare (Table 30). Micronutrient combinations could not produce significant difference in weight of 1000 seeds in both the years and in pooled analysis also. The highest 1000 seed weight of 3.41 g was obtained by the sole application of borax.

4.3.20 Germination percentage

Effect of boron on germination percentage of the produced seeds was highly significant. Seeds in the plants receiving borax (B_2) showed 90.75% germination whereas seeds of the control plants (B_1) showed 74.04% germination in pooled analysis (Table 30). Application of molybdenum and zinc brought about no marked effect in this character in both the years. The interaction effect of boron and molybdenum was found to be more pronounced in first year and in pooled analysis. The germination percentage of 91.33 was found with the application of 20 kg borax and 1.5 kg ammonium molybdate per hectare (B_2M_2). However, the highest germination percentage of 91.67 was obtained by the application of 20 kg borax, 1.5 kg ammonium molybdate and 25 kg zinc sulphate per hectare. ($B_2M_2Z_2$).

Chapter - V

Summary and Conclusion

SUMMARY AND CONCLUSION

Experiment 1. Effect of sowing dates, varieties and their interactions on growth and seed production of cauliflower.

The experiment was conducted during rabi seasons of 1996-97 and 1997-98 on sandy loam soil at the Instructional Farm, Bidhan Chandra Krishi Viswavidyalaya, North Bengal Campus, Pundibari, Cooch Behar, West Bengal in 3x5 factorial randomized block design with three replications having fifteen treatment combinations composed of three sowing dates of 15th August, 31st August and 15th September and five open pollinated varieties *viz.* Early Kunwari, First Crop, Kartika, Aghani and Improved Japanese. The results of the investigation are summarised below.

1. Early sowing of seeds on 15th August exhibited increase in all growth characters like plant height (49.18 cm), leaf length (46.71 cm), leaf width (20.79 cm) and number of leaves (20.24) and delay in sowing after 31st August resulted decrease in curd weight.

2. Early sown plants took longer duration to curd initiation and days to curd maturity.

3. Seed sowing in the nursery bed on 15th August produced maximum seed yield attributing characters like height of inflorescence (81.64 cm), number of primary inflorescence stalks per plant (8.71), pods per plant (790.95), pod length (6.31 cm), seeds per pod (20.18) and seed yield (483.24 kg/ha) and delay in sowing caused decrease in seed yield due to decrease in yield attributing characters.

4. Early sowing of seed took longer period for initiation of inflorescence stalk and days to seed harvesting than later sown crop.

5. 1000 seed weight and germination percentage of the produced seed were increased when seeds were sown early.

6. Among the five varieties, Aghani of maturity group II produced maximum curd weight (499.73 g) and exhibited increase in seed yield and quality attributing characters like number of primary inflorescence stalks per plant (9.10), pods per plant (887.07), pod

length (6.33 cm), seeds per pod (19.92), seed yield per plant (18.00 g), 1000 seed weight (3.18 g), germination percentage (88.78%) of produced seeds and seed yield per hectare (493.04 kg).

7. Of the maturity group II varieties, Aghani sown on 15th August produced the maximum seed yield of 579.57 kg/ha and the produced seed showed higher seed weight of 1000 seeds (3.54 g) and germination percentage (89.67%).
8. Of the group I varieties, Kartika sown on 15th August produced the highest seed yield of 454.68 kg/ha. The produced seeds registered appreciable weight of 3.88 g per 1000 seeds and high of 83.33% germination.

Experiment 2. Effect of nitrogen, phosphorus and their interactions on growth and seed production of cauliflower variety Aghani.

With a view to find out the optimum doses of nitrogen and phosphate in cauliflower seed crop, an experiment was conducted at the Instructional Farm, Bidhan Chandra Krishi Viswavidyalaya, North Bengal Campus, Pundibari, Cooch behar, West Bengal in 4x4 factorial randomized block design with three replications having sixteen treatment combinations composed of four levels each of nitrogen and phosphate during 1996-97 and 1997-98. The results of this investigation are given below :

1. Application of 150 kg nitrogen per hectare markedly increased plant height (55.56 cm), leaf length (51.25 cm), leaf width (21.24 cm), number of leaves (20.06), curd diameter (13.82 cm), curd depth (8.49 cm) and curd weight (513.86 g) over control in both the years.

2. Maximum seed yield per hectare (391.56 kg) and all seed yield attributing characters like number of primary inflorescence stalks per plant (7.50), pods per plant (746.80), seeds per pod (20.26) and seed yield per plant (14.81 g) were recorded with 100 kg nitrogen per hectare.

3. The highest 1000 seed weight of 3.18 g and germination percentage of 88.71% were also recorded with 100 kg nitrogen per hectare.

4. Application of 120 kg phosphate per hectare exhibited the highest values of all growth and seed yield parameters over control in both the years and it was statistically at per with the application of 80 kg phosphate per hectare in respect of leaf width, number of leaves, days to curd maturity, curd diameter, curd depth, days to inflorescence initiation, number of primary inflorescence stalks per plant, pods per plant, seeds per pod, seed yield per plant, seed yield per hectare and 1000 seed weight.

5. No significant effects were obtained among different treatment combinations of nitrogen and phosphorus in respect of plant height, leaf length, leaf width, days to curd maturity, days to inflorescence initiation, inflorescence height, number of primary inflorescence stalks per plant, days to seed harvesting, seeds per pod, 1000 seed weight and germination percentage.

6. Plant height and leaf length were maximum in treatment combination of 150 kg nitrogen and 120 kg phosphate per hectare (N_4P_4).

7. Application of 150 kg nitrogen and 80 kg phosphate per hectare (N_4P_3) produced the highest leaf width (21.69 cm), number of leaves per plant (20.57), curd diameter (13.99 cm), curd depth (8.95 cm) and curd weight (582.68 g) in both the year.

8. Cauliflower plants needed maximum days to curd initiation (84.33) when plants were fertilized with 150 kg nitrogen and 0 kg phosphate per hectare (N_4P_1) and took maximum days to curd maturity (93.33) with 150 kg nitrogen and 40 kg phosphate per hectare (N_4P_2).

9. The treatment combination of 100 kg nitrogen and 80 kg phosphate per hectare (N_3P_3) significantly increased the number of pods per plant (904.55), number of seeds per pod (21.53), seed yield per plant (18.55 g), seed yield per hectare (486.28 kg) and 1000 seed weight (3.46 g) in both the year.

10. As a result of application of 100 kg nitrogen and 120 kg phosphate per hectare (N_3P_4) plants took minimum days to inflorescence initiation (101.17) and maximum number of

primary inflorescence stalks per plant (8.15), individual pod length (6.41 cm), and germination percentage of produced seed (92.33%).

11. Application of 150 kg nitrogen and 120 kg phosphate per hectare (N_4P_4) exhibited maximum inflorescence height (77.75 cm) and days to seed harvesting (196.17).

Experiment 3 : Effect of boron, molybdenum, zinc and their interactions on growth and seed production of cauliflower variety Aghani.

The effect of soil application of two levels each of boron (0 and 20 kg borax per hectare), molybdenum (0 and 1.5 kg ammonium molybdate per hectare) and zinc (0 and 25 kg zinc sulphate per hectare) and their interactions were studied on growth and seed production of cauliflower variety Aghani at the Instructional Farm, Bidhan Chandra Krishi Viswavidyalaya, North Bengal Campus, Pundibari, Cooch Behar, West Bengal in 2^3 factorial randomised block design with three replications during 1996-97 and 1997-98. The important results obtained in this experiment are summerised below.

1. Application of boron markedly enhanced all growth characters like plant height (55.49 cm), leaf length (51.66 cm), leaf width (21.60 cm), number of leaves (18.42), curd diameter (14.18 cm), curd depth (8.14 cm) and curd weight (567.05 g) and markedly reduced days to curd initiation (81.75) and days to curd maturity (90.17).

2. In respect to seed production, application of boron was found to increase the height of inflorescence (72.85 cm), number of primary inflorescence stalks per plant (7.68), pods per plant (969.26), pod length (6.19 cm), seeds per pod (21.06), seed yield per plant (16.43 g), seed yield per hectare (478.04 kg), 1000 seed weight (3.38 g) and germination percentage of produced seeds (90.75%) and to reduce the days to inflorescence initiation (102.17) and days to seed harvesting (195.08).

3. Application of molybdenum had no marked effect on both growth and seed yield characters.

4. Application of zinc also exhibited non-significant effect in respect of all the characters except seed yield per hectare. Seed yield per hectare was markedly increased (268.98 kg) with zinc application.

5. The interaction effects of boron and molybdenum, molybdenum and zinc, boron and zinc and boron, molybdenum and zinc showed no significant difference in respect of all the growth and seed yield characters except in two cases. The treatment combination of 20 kg borax and 1.5 kg ammonium molybdate per hectare (B_2M_2) significantly increased the germination percentage of produced seeds (91.33%) and the treatment combination of 20 kg borax and 25 kg zinc sulphate per hectare (B_2Z_2)markedly increased the plant height (56.27 cm).

Conclusion

The seed production of cauliflower variety Aghani of maturity group II and Kartika of group I may be successfully done under terai agro-climatic region of West Bengal. The seed crop should be sown in nursery bed in the middle of August. Application of 100 kg nitrogen, 80 kg phosphate, 20 kg borax and 25 kg zinc sulphate per hectare may be recommended for successful cauliflower seed production in this region with particular reference to variety Aghani.

Chapter - VI

Future Scope of Research

FUTURE SCOPE OF RESEARCH

The present investigations indicated that there was ample scope for increasing the seed production of cauliflower of maturity group I and II in terai zone of West Bengal. Although comprehensive studies have been undertaken to find out suitable varieties and influence of both macro and micronurients on growth, development and seed production of cauliflower, yet there are ample scope for further research to confirm the present findings as well as to study the following areas which remain uninvestigted in the present experiments.

1. Further studies may be carried out on the effects of the environmental parameters like temperature, rainfall, relative humidity, light intensity, etc. on growth, yield and quality of seed as well as yield contributing characters of group I and II of cauliflower under terai agro-climatic region of West Bengal, in particular.

2. The pattern of both macro-and micromutrient uptake at different stages of crop growth needs to be investigated.

3. Investigations may be taken up to study the effect of varying levels of potassium on the improvement of cauliflower seed yield and quality.

4. It was frequently observed that there was thickening and outward curling of leaves followed by ceasation of plant growth in nursery as well as in the field and brown-rot of curd due to boron deficiency. So, requirement of boron may properly be assessed along with the method and schedule of application for cauliflower seed crop for obtaining high yield of good quality seeds.

5. Influence of secondary nutrients like calcium, magnesium and sulphur on the seed yield and quality should be investigated for this growing region.

6. Performance of produced seed of this agro-climatic region for the next year crop production should be investigated for various varieties of these two maturity groups of cauliflower.

7. Investigations on management of water, weed and insect pest and diseases particularly, dry rot of inflorescence stalk of cauliflower seed crop need to be initiated.

8. Investigations on seed storage and marketing of the produced seed of this terai region will be helpful in encouraging seed production of cauliflower on commercial basis.

9. Self-incompatibility of different cultivars of cauliflower needs to be studied for obtaining high quantity of good quality seed for a particular variety.

10. Economics of seed production need to be framed with a veiw to diseminate the full package of practice to the farmers.

Chapter - VII

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