STUDIES ON THE ENVIRONMENT-GENOTYPE INTERACTION IN MUNGBEAN
[*Vigna radiata* (L.) Wilczek]

A THESIS SUBMITTED TO
THE ORISSA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY, BHUBANESWAR
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MASTER OF SCIENCE IN AGRICULTURE
(PLANT PHYSIOLOGY)

By

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DEPARTMENT OF PLANT PHYSIOLOGY
COLLEGE OF AGRICULTURE
ORISSA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY
BHUBANESWAR

1995

THESIS ADVISOR Dr. T. PRADHAN

In Memory of
my
Loving Sister

Dr. Trinath Pradhan
Assistant Professor
Department of Plant Physiology
College of Agriculture
O.U.A.T., Bhubaneswar.

Bhubaneswar,
Dated, the 20th December, 1996.

CERTIFICATE-I

This is to certify that the thesis entitled "STUDIES **ON** THE ENVIRONMENT-GENOTYPE INTERACTION IN MUBGBEAN, *Vigna radiata* (L.) Wilczek" submitted to the Orissa University of Agriculture and Technology, Bhubaneswar, in partial fulfilment of the requirements for the degree of MASTER **OF** SCIENCE **IN** AGRICULTURE (PLANT PHYSIOLOGY) is a faithful record of *bona fide* research work carried out by Sri Dinesh Chandran under my supervision and guidance.

This research work is original and no part of this thesis has been submitted elsewhere for any other Degree or Diploma or published in any other form. The assistance and help received during the course of this investigation and source of literature have been duly acknowledged.

23/12/96
(T. Pradhan)
CHAIRMAN
Advisory Committee

CERTIFICATE-II

This is to certify that the thesis entitled "STUDIES ON **THE** ENVIRONMENT-GENOTYPE **INTERACTION** IN MUNGBEAN, *Vigna radiata* (L.) Wilczek" submitted by Sri Dinesh Chandran to the Orissa University of Agriculture and Technology, Bhubaneswar in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE IN AGRICULTURE (PLANT PHYSIOLOGY) has been approved by Student's Advisory Committee after an oral examination on the same in collaboration with an External Examiner.

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(**Dinesh Chandran**)

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A field experiment was conducted with three cultivars of mungbean [Vigna radiata(L.)Wilczek] viz.,OUM 11-4, OUM 11-5 and Dhauli at the Central Research Station of Orissa University of Agriculture and Technology, Bhubaneswar during Kharif 1995, to study the effect of different environmental factors such as temperature, photoperiod and solar radiation on growth and yield of the crop. The crop was sown on four different dates such as Aug. 22, Sept. 2, Sept.12 and Sept.22 to represent variation in environmental factors. The experiment was laid out in split plot design with three replications. Four dates of sowing were used as main plot and three cultivars as sub-plots. The results of the experiment revealed that the mean duration from seedling emergence to 50% flowering and maturity decreased in all the three cultivars with delayed sowing. However, duration for compound leaf emergence increased with delay in sowing. The growth parameters such as plant height, branch number, chlorophyll content, LAI, LAR and other physiological characters decreased in all the cultivars with successive sowing. The leaf, stem, root, inflorescence and pod dry weight declined due to delay in sowing. Other characters like pod number/plant, filled pods/plant, grain number/plant, test weight and finally the total dry matter, both at flowering and harvest, declined with delayed sowing. Highest (3.9 g/plant) and lowest (3.6 g/plant) grain yield was obtained when the crop was sown on Aug.22 and Sept.22 respectively. However, harvest index showed an increasing trend from 27.0 to 28.4 on Aug.22 and Sept.22 sowings, respectively. From the study it was concluded that environmental factors play a pivotal role in determining growth and yield of mungbean. These cultivars of mungbean were not stable under various environments to be grown at different times of the year. Hence, time of sowing might be suitably adjusted to obtain better plant growth and higher yield.

CHAPTER—I

INTRODUCTION

CHAPTER - I

INTRODUCTION

Human being has been the main focus of attraction of the creation which basically requires food, clothing and shelter. Food for nourishment no doubt comes directly from the plants or indirectly as derived products. Food source may be strictly vegetarian comprising of different plant products or strictly non-vegetarian having animal origin. However, combination of both vegetarian and non-vegetarian source of food has been the common practice. Cereals being the dietary mainstay of man since the civilizations began have drawn a lot of attention for their cultivation and subsequent improvement leading to green revolution in India during sixties. Supplementing the food value of cereals, pulses have played an important role in determining our food strategies being an inseparable component of nutritionally balanced diet. Apart from the significance of pulses in our diet they are capable of being one of the major sources of fodder and concentrates for cattle. The unique ability of pulses for biological nitrogen fixation of atmospheric nitrogen and their use as green manure crops have been a bonanza in integrated fertilzer management. Pulses as component crops in crop mixture and crop rotations have been a perennial concept of sustainable agriculture.

As a general rule, crop improvement is a bidirectional approach involving (i) Manipulation of genetic composition to maximize production relative to the environmental constraints and (ii) Manipulation of the environment to maximize production relative to genetic composition. Simultaneous operation of both these processes is inevitable for higher production. Always genotypes confer certain value and environment causes a deviation in either direction. Genotypic factor is the inherent ability of the crop variety to best use the available resources to produce a higher and better yield and environment is the aggregate of all the external conditions and influences affecting the growth and development of plants. Crop environment constitutes aerial environment and edaphic environment. Aerial environment has several components such as solar radiation (quality & quantity) and duration of light, temperature, relative humidity, rainfall and others. The edaphic environment has the broad categories such as physical environment (soil, air, soil water and soil temperature), chemical environment (soil solution, pH, electrical conductivity, nutrient concentration) and biological environment (living organisms in the soil and resultant reactions like immobilizations, mineralizations, etc.). Manipulation of genetic composition is achieved through plant breeding and manipulation of environment is brought about changes in agronomic practices. A physiological analysis of such variation in yield and yield attributes leads to derive certain principles which create avenues for manipulating genetic and environmental conditions.

Mungbean (Vigna radiata (L.) Wilczek) is traditionally a short duration crop best adopted to the tropics and subtropics of South-Eastern Asia (Rachie and Roberts,1974; Kay,1929). Nevertheless, the crop is cultivated throughout a wide range of latitudes (to 40° N or S) with an average diurnal temperature during the growing season warmer than about 20°C (Lawn & Ahn,1985). Mungbean has been one of the important pulses of India. The total pulse area and production in India is 22.43 mha and 13.10 m tonnes, respectively with mungbean having 14.53% of area and 10.84% of total production. In our State the total area under different pulses is 2129 thousand ha and under mungbean 752 thousand ha (35.31%) and the total pulse production is 1113 thousand tonnes of which mungbean contributes 370 thousand tonnes. Cultivation of mungbean is certainly influenced by various environmental factors although it can be grown under variable soil and climatic conditions. Mungbean has its origin in North-Eastern India-Burma region and widely cultivated in the countries like India, Burma, Thailand, Iran, Pakistan, Vietnam, China, Philippines, Korea, Indonesia and Sri Lanka. It is a short day warm season crop but can be grown upto an elevation of 1800 to 2000 metres and on a wide range of soil types. However, it performs better in deep loam and sandy loam soils with 600 to 1000 mm annual rainfall. In Orissa, it is cultivated in both coastal and some interior districts.

The present study on mungbean is to investigate its reactions to variation in planting date. Crop sown in different dates encounter differences in photoperiod, temperature, solar ratiation, relative humidity, rainfall as well as some other environmental variables. As mentioned earlier, variation in the environmental factors influences crop growth and development having detrimental or beneficial effects on yield and yield attributing characters. Mungbean has been suitable for multiple and mixed cropping and any kind of correlation between climatic factors and mungbean growth and development could establish a better growing period for higher production and productivity. A clear understanding of varietal differences in performance under different planting dates is thus important. Thus, the present investigation has been conducted with the objectives of studying the effect of environmental variables on;

i) Duration of different phases of crop growth,

ii) Drymatter production,

iii) Physiological growth parameters, and

iv) Yield and yield attributes

under different dates of sowing.

CHAPTER—II

REVIEW OF LITERATURE

CHAPTER - II

REVIEW OF LITERATURE

The influence of environmental variables such as photoperiod, temperature, solar radiation, relative humidity and rainfall on growth and yield of crop plants is well recognised. However, it may be different from crop to crop depending on the nature of the species. The present study is an attempt to analyse the reactions encountered by the crop sown under different planting dates.

The upto date review of relevant literature has been cited in the following paragraphs.

Effect of environmental variables on duration of different phases of growth of pulses

Hesketh *et al.*(1973) reported that temperature has adverse effects on the rate of leaf production. In soybean, a new leaf appears every 2.5 days at a mean temperature of 30°C compared with 6.2 days at 15°C.

Graman(1974) reported that decreasing the amount of photosynthetically active radiation (PAR) by 40-60 per cent through shading decreased both flower production and shedding of young pods in *Vicia faba*.

Streeter *et al.*(1975) reported that light enrichment reduced flower drop in soybean. Abscission of flowers and pods is particularly high during periods of water stress and is also promoted by long photoperiod and high temperature.

Kaul et al.(1976) reported that legumes in general shed numerous flower buds, flowers and young pods even under optimum agronomic conditions. In temperate region the per cent of shedding was around 50 per cent. Shedding of flowers and low pod setting percentage resulted lower yield in pulses.

Summerfield et al.(1978) observed greater number of matured fruits and higher yield under longer reproductive period. The flowers became matured fruits an about 30 days from anthesis in mungbean. Between 10th and 22nd day from anthesis rapid grain filling takes place (Chandra Babu et al.,1985). However, by staggered planting (9 Jan., 24 Jan., 8 Feb., 23 Feb.) it was observed that the duration of seed filling decreased with delayed sowing and was shortest (13.8 days after sowing) on 23 Feb. sowing (Sarabole et al.,1990).

Lawn(1979) reported that in black gram the rate of development during reproductive phase is dependent on day length and positively with mean minimum or maximum temperature.

Turk et al.(1980) reported that hot day temperature, large differences in day and night temperature and drought stress shortened the reproductive period and pod filling stage in cowpea.

Liyanage et al.(1981) reported that when mungbean varieties were subjected to shade during preflowering stage or throughout the growth period, decreased the number of open flowers produced per plant and the percentage of abscission of flower and immature pod increased with increasing shading intensities. The abscission of reproductive parts is due to deficiency of assimilate production under shade.

Singh and Saxena (1981) reported in black gram, green gram, cowpea and pigeonpea that days to flowering was affected by planting dates in all the crops. Days to flowering in black gram cultivar Sel-1 was negatively correlated with temperature. They also indicated that the short duration pulses were more responsive to temperature and day length.

Lawn (1981) reported that flowering in 11 cultivars of pigeonpea was delayed by 1 to 28 days when mean daily temperature was reduced from 24°C to 20°C in controlled environment.

Fernadez et al.(1989) studied the days to flowering in mungbean grown at 11.5 and 13.5 hours mean photoperiod(p) and 22 -30°C mean diurnal temperature(T) regime. Both linear and quadratic effects were significant on days to flowering and on the rate of progress towards flower initiation. The effect of T was more pronounced than that of P on days to flowering in photoperiod sensitive genotypes. The minimum number of days to flowering was estimated at 34 days after flowering at the optimum mean diurnal temperature of 28°C and optimum mean photoperiod of 12 hours. These flowering dates in photoperiod sensitive genotypes can be predicted which in turn will assist in the selection of proper planting dates.

Imrie *et al.*(1990) reported that all cultivars and hybrids of mungbean tested were significantly short day plants in which the flowering was delayed as temperature decreased in an 11 hour photoperiod. Under a 12 hour photo period both warm and cool temperature delayed flowering. Under a 13 hour photoperiod the greatest delay was caused by warm temperature. It was concluded that it was possible to manipulate different attributes and seed cultivars adopted to photothermal regime.

Effect of environmental variables on dry matter production of pulses

The first pre-requisite for high yield is a high production of total dry matter per unit area. Photosynthesis is the basic process for the building of organic substances by the plant, where sun light provides the energy required for reducing CO_2. The effectiveness of photosynthesis is dependant on: (a) large and efficient assimilatory area, (b) an adequate supply of solar energy and CO_2, and (c) favourable environmental conditions. The total product of photosynthesis throughout the life time of the crop growing in given circumstances will depend on the size of the assimilating areas, the efficiency with which it functions, and length of the period during which it is active (Stoy,1963).

Ezedinma(1973) while studying the partitioning of dry matter between vegetative and reproductive components of cowpea, found that effective flowering and fruiting curtailed negative development on both secondary and particularly the primary shoots with most of the dry weight occuring in the inflorescence peduncles and pods. It indicated that the pattern and duration of assimilate transloction to the pods depended on the canopy architecture of the plant while the increase in pod weight depended on the survival of pod bearing leaves.

Villers et al.(1974) reported that germination rate increased in all cultivars of dry bean with increase in temperature. Number of leaves, total leaf area and dry weight/plant were maximum at 30-20°C. Flowering began earlier at low temperature and the number of flowers/plant and percentage pod set were generally higher to 30-20°C.

Sinha(1977) summarised that plants accumulate about two third or more of dry matter at the time of flowering and beginning of pod development. Once the pod development begins the addition of dry matter to vegetative plant parts is almost insignificant. This suggests that most of the dry matter produced after flowering is directed towards developing pods. Since no dry matter is added after early pod development to the vegetative parts, it is possible that photosynthetic supply is limited.

Lawn(1979) reported that blackgram and greengram genotypes of temperate and subtropical origin might be more responsive to day temperature and those of tropical origin might be more sensitive to night temperature.

Usha Rani and Rao(1981) studied the dry matter production and partitioning in blackgram and reported that low yielding genotypes have low dry matter production irrespective of time of maturity. Accumulation of dry matter in the leaves continued upto the 50th day while that of shoots upto 60th day in all genotypes. At flowering leaves alone accounted for 51-56 per cent of total dry matter production in all the long duration genotypes. In medium duration genotypes it ranged from 35-52 per cent while it was 37-43 per cent in the short duration types. During vegetative stage accumulation of dry matter in the leaves as well as its distribution were in accordance with the yielding pattern. However, durng reproductive phase, dry matter production and its partitioning appeared to continue throughout entire crop duration.

Wein(1982) reported that rate of dry matter production by cowpea cultivars is dependant closely on the amount of incoming radiation intercepted by the crop canopy.

Nanda et al.(1989) reported that rate of dry matter production increased upto the highest green area index(GAI) of 3.0. Light interception was highest(95%) at GAI of 2.2. Changes in GAI and photosynthetically active radiation(PAR) were positively associated with changes in dry matter production.

Vijayalaxmi et al.(1993) studied the dry matter accumulation in green gram and summarised the relationship of partitioning ability. High yielders showed larger variation in harvest index than dry matter production. The medium yielders showed larger variation both as regards to dry matter production and yield. The low yielders showed a narrow range of variation in dry matter production and much more restricted value of harvest index.

Studies on character association of yield and yield attributing characters in pulses

Hayes(1971) reported that there is a gradual increase in harvest index and a decrease in plant height of different legume varieties during this century.

Jain(1975 a) reported that the major factors responsible for the lower grain yield in legumes is their harvest index and net photosynthetic limitations.

Ranga Reddy and Krishnalal(1978) reported that branches per plant, pods per plant and seeds per pod were found to be positively correlated with yield of urdbean. However, seed weight was not significantly associated with any other character. Further, it was observed that the genetic correlation of this character was negative with respect to branches per plant, pods per plant and seeds per pod.

Sandhu *et al*.(1980) conducted trials in 435 strains of *V. radiata* and concluded that seed yield was correlated positively with number of pods/plant, seeds/pod and 100 seed weight and negatively with pod length and number of branches/ plant. The most productive plants tended to have long periods of flowering and seed filling, to be stout and tall with few branches and to bear short pods on few nodes.

Path co-efficient analysis of the association of physiological traits with grain yield in mungbean studied by Singh and Singh(1981) revealed that all growth parameters such as leaf area ratio, net assimilation rate, crop growth rate, relative growth rate, specific leaf weight except leaf weight ratio and specific leaf area ratio have direct and indirect association with the seed yield of mungbean.

The major yield components for both green gram and black gram are the number of pods, the number of seeds per pod and the seed weight. Several workers have reported a higher positive correlation of mungbean yield with number of pods per plant, seeds per pod and 100 seed weight (Rahman,1982; Yohe and Poehlman,1975 and Shamsugyaman et al.,1982). Also primary and secondary branches per plant contribute significantly to seed yield. The path coefficient analysis of yield components indicated that the pods per plant, seeds per pod, seed weight and number of clusters per plant to be the direct and positive contributors to seed yield (Waldia et al.,1980; Rahman,1982).

Liyanage(1982) reported that when mungbean was grown under 8 hour photoperiod of bright light or under 8 hour of low irradiance, showed a short day response to flower production, which could be attributed mainly to a greater abscission of flower. Although percentage of pod setting under short photoperiod was higher than under long photoperiod, the actual number of flower setting, mature pods was similar. The abscission of immature pods and abortion of ovules were also similar under two photoperiods. The higher seed yield under short day photoperiod was ascribed to the greater number of pods/plant and seeds/pod and greater proportion of total dry matter partitioning into pod development.

Shanmugam et al.(1984) reported that there is a significant positive correlation between total dry matter and harvest index in early maturing blackgram genotypes indicating the efficient partitioning of photosynthates and less competition between source and sink for assimilate. However, this type of relationship was reverse in medium and late maturity groups.

Ramaswami and Oblisami(1984) reported that in blackgram the grain yield increased with increase in duration of the variety, but the increase in grain yield was not proportional to biological yield. Short duration varieties recorded significantly higher harvest index than medium or long duration varieties.

Mishra and Yadav(1992) carried out path analysis of yield components in 15 mungbean varieties and reported that harvest index, plant height, number of branches and biological yield/plant had a direct positive influence on seed yield.

Gill et al.(1992) studied 34 genotypes of mungbean for character association among yield and yield attributes and reported that grain yield was positively correlated with net assimilation rate, crop growth rate, specific leaf area at 30-45 days, leaf area duration and biomass duration at 30-90 days, 60-90 days; it was negatively correlated with specific leaf area at 30-45 days, leaf area ratio at 60-65 days and leaf weight ratio, leaf area ratio and leaf area index at 75-90 days.

Renganayaki et al.(1993) revealed high values of phenotypic and genotypic coefficient of variation and genetic advance for number of plants and seed yield. There was positive and significant association of seed yield with plant height, petiole length, leaf area, leaf area index, peduncle length and total dry matter production and significantly negative association with seeds per pod.

Naidu et al.(1993) studied some 20 diverse genotypes of greengram and reported strong G x E interactions. The rainy season and winter uplands were found to be the most favourable environments for the production of shoot dry matter and grain yield. Grain yield was positively correlated with shoot dry matter and shoot nitrogen at peak flowering in all the environments.

Effect of environmental variables on physiological growth parameters of pulses

Light is required for photosynthesis and for many other functions of plants, including seed germination, leaf expansion, growth of stem and root, flowering, fruiting and even dormancy (Stoughton,1955) and thermal condition is required for the other physiological functions of the plant. However, radiation also increases evapotranspiration. Transpiration rates increase almost in proportion to the intensity of solar radiation, while in many crops, the rate of photosynthesis increases rapidly.

Neales and Incoll (1968) reported that photosynthetic rate in leaves can be slowed down by the accumulation or stimulation by hormones.

Analysis of net assimilation rate(NAR) and crop growth rate (CGR) indicated that two peaks of photosynthetic activity occured during the growing season in soybean; one at the time of flowering and the other at pod filling (Kollar et al.,1970). The later increase was interpreted in terms of increased sink size stimulating photosynthesis, but the mechanism of stimulation is unknown.

Pandey et al.(1978) reported that in urdbean the leaf growth rate was higher in the early growth stages whereas NAR and RGR decreased with the age of plants. Long photoperiods and warm temperatures during summer delayed senescence of leaves. Thus, leaf area continued to be built up till attainment of harvestable maturity.

Singh and Singh(1982) reported that solar radiation showed a greater association with absolute growth rate,relative rowth rate and specific leaf weight in green gram, whereas, emperature influenced strongly the other growth parameters, iz., leaf area ratio, leaf area duration and specific leaf area. hough positive association was observed among the growth arameters except for net assimilation rate and specific leaf eight, the direct and indirect effects of net assimilation ate, relative growth rate, specific leaf weight on grain yield ere promising. The other growth parameters, viz., average rowth rate, leaf area ratio and specific leaf weight have hown non-substantiating direct and indirect effect.

Zhang and Liu(1983) found no significant correlation between leaf area index (3 to 6.49) and yield of soybean growing in different years. However, negative correlation was found between average leaf area index at all growth stages and grain yield. The average NAR at all growqth stages was positively correlated with the yield.

Effect of environmental variables on yield and yield attributes of pulses

Seed growth rate and/or growth duration in soybean increased at higher night temperature (Seddigh,1983). However, under high day temperature seed yield/plant reduced by half because all yield components were adversely affected (Huxley et al.,1976). The grain yield reduced when July and August temperatures were above average (Runge and Odell, 1960). Seed filling rate was found to be enhanced by temperature in the 26-30°C range compared with 16-18°C range (Thomas and Raper,1976).

Huxley et al.(1976) reported that warm nights hastened the onset of flowering and enhanced dry matter production in cowpea during the pre-flowering period. Warm days did not enhance dry matter production but shortened the growth period by about 21 days(20%). Warm days markedly decreased the number of pods/ plant (about 49%), as did warm nights and the longer day length. Warm nights decreased mean seed weights by 19 per cent, whereas, warm days increased it by 18 per cent.

Thomas and Raper(1976) reported that photoperiod affects pod production efficiency and seed filling rate in soybean. The number of pod set was greater when plants were exposed to short days at primary leaf stage.

Exposure to abundant solar radiation during the reproductive period improves mungbean yield which implies that increased photosynthesis during the reproductive period can result in increased seed yield (Kuo et al.,1977). Similarly, light enriched soybean plants retained more seeds, pods and had more number of branches, pods per node and seeds per pod than normal plants (Johnston et al.,1969).

Eriskine et al.(1977) reported that genotypic variance of seed yield for 6 diverse genotypes accounted for only 0.2% of overall variance and was not significant against genotype x environment interaction. However, environmental effects of seed yield accounted for 82% of total variance and the two factors moisture and soil condition were major causes of variation.

Whigham and Minor(1978) reported that light strongly influences the morphology of the soybean plant by causing changes in the time of flowering and maturity, which resulted in differences in plant height, pod length, leaf area, lodging and numerous other plant characteristics including grain yield. Longer day lengths delayed flowering and usually resulted in the development of a large number of flowers, but the percentage of flower and pod shedding also increases; short days caused the initiation of flowering in fewer days and took less time from flowering to maturity. There is usually a positive association between day length and plant height. When day length is changed from 6 to 18 hours, plant height, node number, internode length, leaf area, and days to flower all increases in both tropical and temperate cultivars when measured in terms of flowering (Byth,1968).

Talukdar(1981) studied the genotype x environment interactions and phenotypic stabilities for yield and yield characteristics of greengram in summer and rabi season. It was concluded that there was significant genotype-environment interaction for all characters.

Saharia(1981) noted that when crops were sown on different dates there was no significant yield difference but plant height, number of branches and pods per plant were generally reduced by delayed sowing.

Bueno et al.(1981) reported that photoperiod of 16-18 hour in soybean increased plant height, stem diameter, height of first pod insertion, internode number, number of pods/plant, number of seeds per plant and seed weight per plant. All the above parameters increased with each one hour increase in photoperiod.

Whigham(1983) reported that other environmental conditions being normal, atmospheric humidity may affect the growth and development of soybean plants. Low relative humidity may reduce yield more than high relative humidity. Low relative humidity may reduce node number and total dry weight. Yield reduction can be attributed to increase flower abortion and few pods.

Atmospheric humidity is concerned with many physiological activities of plants. In general, it influences water requirements of crops through its effect on evapotranspiration. With low relative humidity, the leaf temperature rises and to avoid much rise in transpiration rate the stomatal opening becomes contracted. This smaller stomatal opening substantially reduces CO_2 uptake, through that the photosynthesis and hence plant growth is reduced. This is ultimately the indirect effect of air moisture stress. The changes in relative humidity bring changes in transpiration due to changes in vapour pressure gradient from leaf to air (Kramer,1969). Hence, for almost all crops it is always safe to have a moderate relative humidity (above 40%) for good growth and seed setting (Kakde,1985).

Prisco and O'leary(1973) reported that vegetative growth of beans enhanced at high humidity while seed yield was found to be reduced at lower humidities. Cotyledonary bud growth also increased due to increase in relative humidity from 30-60 to 90 per cent (Mc Intyre,1973).

In addition to effects on dry matter production in plants, the morphological differences are also associated with humidity. Stem length in general is greater at higher humidities (Sale,1970). Leaf size is also affected. In coca, leaves are smaller at higher relative humidity, but leaf area increased with increasing relative humidity in bean (O'leary and Knecht,1971). In general, relative humidity that produced the best vegetative growth also resulted in most profuse flowering (Lee et al.,1972).

Yield of soybean grown with adequate supply of soil moisture can be affected by atmospheric humidity. A 21 per cent reduction in yield was noted in soybean grown at day/night relative humidity of 46/47 per cent as compared to 81/84 per cent (Woodward and Begg,1976).

Fisher and Weaver(1974) reported that higher humidity increased the pod set and retention in limaben, apparently by promoting good pollen germination but was unfavourable with high temperature.

Singh et al.(1986) reported that in blackgram seed yield decreased from 1.13 to 0.85 and 0.68 t/ha with delay in sowing from 20th March to 30th March and 10th April and increased from 0.63 to 1.18 tons with increase in sowing rates from 20 to 50 kg/ha.

Thiyagrajan et al.(1987) evaluated seven parents of cowpea and their F_1 bybrids for stability parameters with respect to grain yield in six environments. Pooled analysis of variance revealed that genotypes and environment were significant for grain yield. Mean square due to pooled deviation was non-significant, indicating the absence of non-linear portion of genotype-environment interaction. The mean square due to linear component was significant for yield. It was found that parent and their hybrids were stable for grain yield.

Chaudhury et al.(1988) reported that in blackgram delay in sowing of 4 black gram cultivars from 6th July to 20th July, 5th or 20th August decreased average seed yields. The delay in sowing decreased N, P, K uptake but increased N, P, K contents in seeds and leaves at harvest.

Balakrishnan et al.(1989) reported that none of the cultivars in pigeon pea over 3 different seasons could be identified for yield stability. However, SAI and PLS 361 were identified for the stability of number of branches, number of pods per plant, number of seeds per pod and 1000 grain weight. The genotype-environment interaction was highly significant for all the yield components except number of seeds per pod.

Khalil(1989) studied the effects of sowing in 7 dates from 6th March to 30th May on plant height, seed yield, pod length and 100 grain weight of mungbean. Plant height increased until May sowing. As sowing dates were delayed plant height ranged from 266 cm in M-19-19 variety sown on 6th May to 89.2 cm in NM-28 variety, sown on 16th May. Sowing from 6th March to 2nd May produced pods of similar length, sowing after 2nd May decreased pod length. Average 100 seed weight decreased from 3.22 to 2.23 g with delay in sowing date. Seed yield increased as sowing date was delayed until April.

Gupta and Lal(1989) reported that greengram sown on 1st, 10th or 20th March gave similar average seed yields of 1.41-1.57 t/ha compared with 1.14-1.24 t/ha in the crops sown on 30th March and 9th April. Sowing at 20-50 kg seeds/ha gave similar yields of 1.33 to 1.39 t/ha.

Sharma et al.(1989) reported that in green gram delay in sowing dates decreased the seed yield, also 1000 seed weight and seed protein content. CV ML-131 gave the highest yields of 0.71 tons/ha compared with 0.43-0.50 t in the other cultivars. Pusa Baisakhi had the highest 1000 seed weight of 30.30 g and protein.

Staggered sowing (30th June, 15th July, 30th July and 15th August) revealed that yield of blackgram was drastically reduced when crop was sown in later part of June or early part of August (Damodaran et al.,1989). Similarly, delay in sowing decreased seed yield, 1000 seed weight and protein content (Sharma et al.,1989).

Daque et al.(1990) conducted two trials in the dry and rainy season by taking local and foreign varieties of mungbean. It was found that foreign cultivar VC 27688 performed well with respect to yield in wet than in dry season in first trial. In the 2nd trial nodule development was significantly better in VC 27644 than in other varieties. However, nitrogen fertilizer had a greater effect on 100 seed weight, seed yield than innoculation.

Kler et al.(1991) reported that in mungbean bidirectional (E-W x N-S) sowing gave highest seed yield than unidirectional sowing. 20 kg seeds/ha and the normal sowing date gave higher yield than 15 or 25 kg/ha sowing rates or late sowing.

Baghel and Yadava(1992) reported that sowing on 25th june gave the highest leaf area index, net assimilation rate and crop growth rate whereas the highest seed yield was obtained with sowing on 10th July in blackgram. NAA was superior to GA and IAA in enhancing leaf area index, net assimilation rate and crop growth rate at all stages except crop growth rate at pod filling stage. The concentration of 30 ppm of growth regulators was optimum for increasing NAR and CGR where photosynthetic efficiency increased upto 40 ppm.

Green gram cultivars sown on 5 dates between 5th August and 15th September gave the highest seed yield when sown on 5th or 16th August (Saharia,1985). Yield of blackgram, mungbean cultivars was highest with sowing dates on 25th March and yield was generally higher in mungbean than in black gram (Rana and Singh,1992).

Taking fortyone cultivars Vieira et al.(1992) found that number of pods/plant was the main component of yield. In the rainy season, one to four harvests were needed, depending on cultivar and rainfall pattern though 70-80 per cent of total seed production was harvested, whereas, in dry season one harvest was required. Yield was 2 t/ha in wet season and 1.3 t/ha in dry season.

Pookpakdi and Pataradilok (1993) studied the response of mungbean and blackgram to planting dates and plant population densities and reported that mungbean yield was highest in wet season whereas blackgram produced higher yield in dry season.

Sekhon et al.(1993) studied the effect of dates of sowing and seed rate on summer blackgram and reported that seed yield was higher when sown on 25th March (890 kg/ha) than 1st March (79.7 kg/ha) and it increased with sowing rate upto 50 kg seed/ha.

Pookpakdi et al.(1993) reported higher yield in mungbean cv. Chaitan during wet season whereas blackgram cultivar 'Thung' produced higher yield in the dry season. Accordingly, summer blackgram yield was higher when sown on 25th March than 1st March (Sekhon et al.,1993).

CHAPTER-III

MATERIALS AND METHODS

CHAPTER-III

MATERIALS AND METHODS

A field experiment was conducted at the Central Research Station of Orissa University of Agriculture and Technology, Bhubaneswar during Kharif 1995 to study the Environment-Genotype interaction in mungbean [*Vigna radiata*(L.) Wilzeck].

3.2 Soil properties of the experimental site

Composite soil samples were collected from 0-15 cm depth of soil at the beginning of the field experiment in order to know the physical and chemical properties which have been presented below.

a. Physical properties

Texture - sandyloam

Depth - more than 100 cm

Field capacity - 16%

Wilting point - 5%

b. Chemical properties

pH - 5.5

E.C. - 0.04 dsm^{-1}

O.C - 0.042

Total N(%) - 0.042

Available P - 16 kg/ha

Soluble K - 125 kg/ha

3.3 Climatic conditions of the research station

The Central Research Station is situated at 20°15' North latitude and 85°52' East longitude with an elevation of 25.9 m above the mean sea level. The research station is characterised by warm and moist climate experiencing hot and humid summer and mild winter. It receives a mean annual rainfall of 1509.8 mm. May is the hottest month with the mean daily temperature of 31.5°C (36.7°C mean maximum and 26.4°C mean minimum) and December is the coldest month with the mean daily temperature of 21.7°C (28.6°C mean maximum and 14.8°C mean minimum). The relative humidity varies from 85% in August to 70% in December.

3.4 Experimental details

The field experiment was conducted in a split plot design with sowing dates as main plot and the cultivars as sub-plot treatments.

3.4.1 Detail of the experiment

Dates of sowing(main plot	Symbol
22nd August	August 22
2nd September	September 2
12 September	September 12
22nd September	September 22

Cultivars (sub-plot)

The following three varieties were grown.

V_1 - OUM 11-4

V_2 - OUM 11-5

V_3 - Dhauli

3.4.2 Field preparation

The field was ploughed thrice with bullock drawn mould board plough to obtain fine tilth. Well decomposed FYM at the rate of 10 tons per hectare was applied uniformly during last ploughing. After final ploughing laddering was done to level the field.

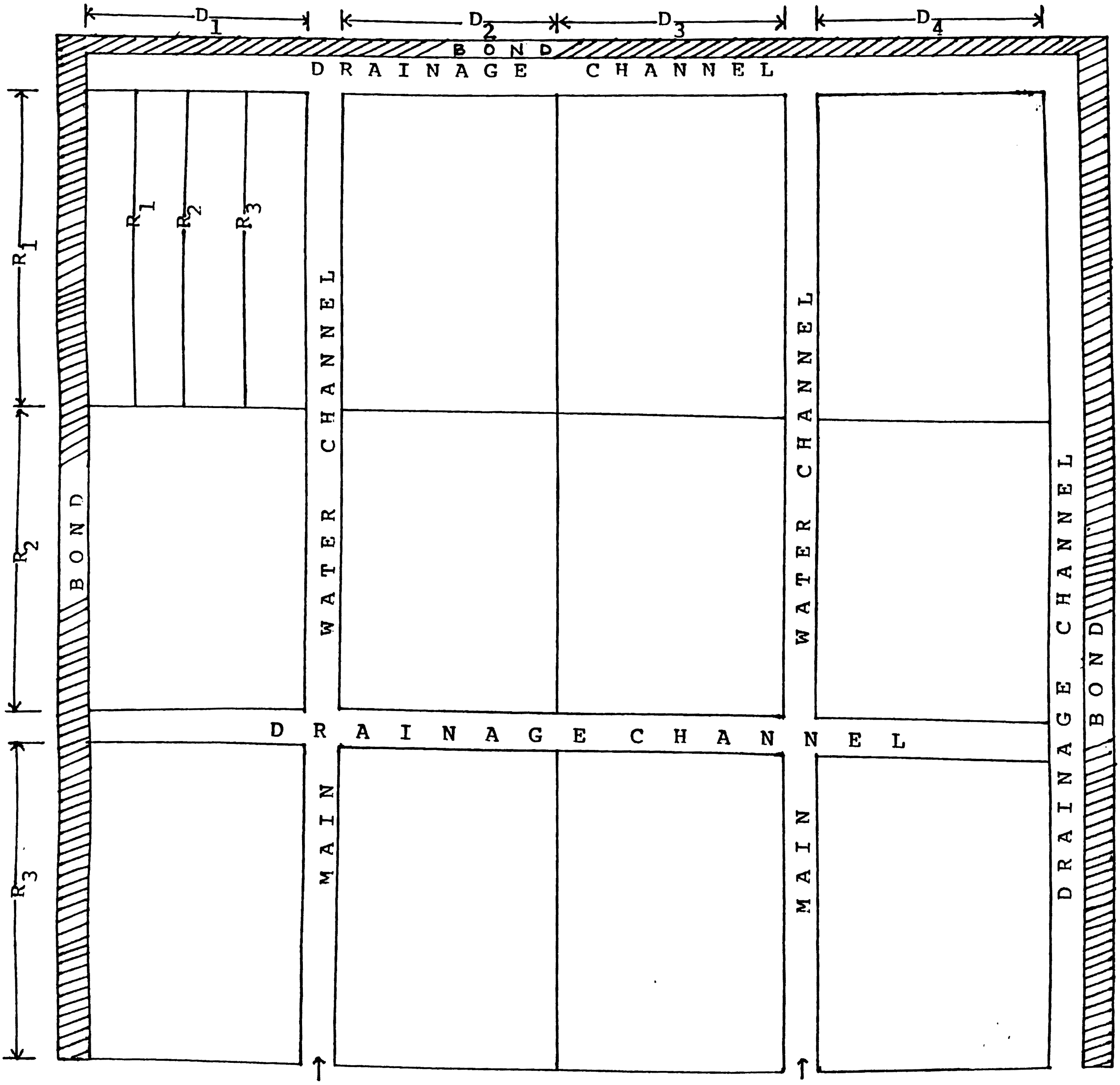
3.4.3 Field layout and sowing

Design	: Split plot
Name of the varieties	: OUM 11-4 OUM 11-5 Dhauli
Number of replications	: Three
Total number of sub-plots	: 4 x 3 x 3 = 36
Sub-plot size	: 0.75 m x 7.0 m = 5.25 m^2
Main plot size	: 7.2 m x 5.0 m = 36 m^2
Spacing	: 30 cm (row to row) x 10 cm (Plant to plant)
Seed rate	: 25 kg/ha

The seeds of these three varieties of mungbean were obtained from EB-II section of the Department of Plant Breeding and Genetics, College of Agriculture, Bhubaneswar.

3.4.4 Fertilizer application

A basal dose of urea at the rate of 40 kg/ha, single super phosphate at the rate of 250 kg/ha and muriate of potash atthe rate of 60 kg/ha was applied alongwith aldrin(5%) at the rate of 30 kg/ha and thoroughly mixed in the soil.



LAYOUT PLAN OF THE EXPERIMENTAL SITE

MAIN PLOT SIZE : 36.00 M^2

SUB-PLOT SIZE : 5.25 M^2

3.4.5 Planting

Seeds were sown at each planting date with a row to row spacing of 30 cm and plant to plant distance of 10 cm at a depth of about 3 to 4 cm.

3.4.6 Intercultural operations

The plots were kept weed free through manual weeding at 15 days after sowing. Thinning and hoeing were done at the same time to obtain uniform plant population and proper nodule development.

3.4.7 Irrigation

Irrigation was provided from time to time during dry spell and at flowering and pod formation as per the requirement of the crop.

3.4.8 Plant protection measures

Pre-sowing seed treatment was done with Thiram at the rate of 3 g/kg of seeds to protect the crop from seed borne diseases. To control the insect pests endosulfan 40 ml/ha was sprayed before flowering.

3.5 Weather Parameters

3.5.1 Daily mean, maximum and minimum temperature during crop growth period

Data on daily minimum and maximum temperature as well as mean temperature during crop growth period has been presented in Appendix-I. Accumulated temperature was calculated by summing up the mean daily temperature of crop growth period.

The mean of the mean daily temperature from sowing to flowering as well as from sowing to harvest was calculated.

3.5.2 Day length (photoperiod) during crop growth period

Data on daily day length (photoperiod) were computed for crop growth periods and has been presented in Appendix-II. Mean day length and change in photoperiod from sowing to flowering and flowering to crop maturity, also for entire crop growth period were calculated.

3.5.3 Bright sunshine hours during crop growth period

Daily sunshine hours recorded by the sunshine recorder was obtained from OUAT Meteorological Station and has been presented in Appenix-III. The mean of the daily sunshine hour as well as accumulated values from sowing to flowering, flowering to maturity and for entire crop growth period were calculated.

3.6 Pre-harvest observations

3.6.1 Duration of different phases of growth

Number of days taken for the emergence of 50% seedlings in all the varieties and all the sowing dates was recorded to be 3 days. Days taken for 50% flowering, for the production of first, second and third compound leaves and for maturity were recorded from the date of seedling emergence.

3.6.2 Plant height and number of branches per plant

Height of the plant in cm, and number of branches per plant were recorded at the first flower initiation stage.

3.6.3 Chlorophyll content of leaves

The amount of chlorophyll present (total chlorophyll) in mungbean leaves were determined at flowering stage of the plant by acetone extrction method (Anon,1949).

One hundred mg of fresh leaf was macerated in a clean mortar by adding 15 ml of 80% acetone to obtain a fine pulp. The pulp was then filtered to a 50 ml volumetric flask through Whatman No.1 filter paper. The mortar and pestle was rinced two to three times for complete collection of chlorophyll and then the volume was made up. The optical density was measured at 645 nm and 663 nm against the blank (80% acetone) by a spectocolorimeter. The amount of total chlorophyll per gram fresh tissue was calculated by using the following formula.

Total chlorophyll(mg/g fresh weight of leaf tissue)

$$= 20.2 \times (O.D\ 645) + 8.02 \times (O.D\ 663) \times \frac{V}{100 \times W}$$

Where,

O.D 645 = optical density at 645 nm

O.D 663 = Optical density at 663 nm

V = final volume of 80% acetone-chlorophyll extract in ml.

W = fresh weight of leaf in gram.

3.6.4 Dry matter production at flowering

Dry matter of different plant parts such as leaf, stem and roots as well as of whole plant at flower initiation stage was recorded. For this purpose, 10 plants were uprooted from each replication. Roots were washed thoroughly as well as the whole plant to ensure them free from soil stem, root, inflorescence were separated in the laboratory and put in paper bags, then oven dried at 90°C for 48 hours. Thereafter, the dry matter of different organs and total dry matter were computed.

3.6.5 Physiological growth parameters

After computing the dry matter of the plant materials the following growth parameters were calculated using the respective formulae.

a. Leaf Area Index (LAI)

LAI is defined as the ratio of leaf area(A) to the ground(P) occupied by the crop.

LAI = A/P.

b. Leaf Area Ratio (LAR)

LAR is defined as the ratio between leaf area(A) and total plant dry weight (W).

LAR = A/W.

c. Leaf Weight Ratio (LWR)

LWR is defined as the ratio between leaf dry weight(W_L) and total dry weight of plant (W).

LWR = W_L/W.

d. Specific Leaf Area (SLA)

SLA is the ratio of leaf area (A) to leaf dry weight(W_L).

SLA = A/W_L.

e. Specific Leaf Weight (SLW)

SLW is the ratio between leaf dry weight(W_L) and leaf area (A).

$SLW = W_L/A$.

3.7. Post harvest observations

At maturity 10 plants were uprooted and roots were washed thoroughly. Pods were plucked carefully and roots, stems, leaves and pods were kept separately. These were oven dried at 80°C for 48 hours. The following observations were recorded.

a) Leaf dry weight(g/plant)
b) Stem dry weight (g/ plant)
c) Root dry weight (g/plant)
d) Pod dry weight (g/plant)
e) Total dry matter at harvest(g) per plant
f) Number of pods/plant
g) Number of filled pods/plant
h) Number grains/pod
i) Grain yield (g/plant)
j) 1000 grain weight (g)
k) Harvest index(HI)
HI is the ratio of economic yield to total biological yield.

STATISTICAL ANALYSIS

Effect study (ANOVA)

The data obtained on various characters were arranged in appropriate tables to analyse them statistically as per split plot design to obtain the analysis of variance table and the variances were tested at 5 per cent level of significance (Panse and Sukhatme,1985). Standard error of means [SE(m)] were given in all the cases. The critical difference(CD) values worked out for comparing the critical mean difference have been given in summary table alongwith the treatments.

SE(m) was calculated as per the formulae given below:

(a) SE(m) for date of sowing: $\sqrt{\frac{E(a)}{r \times \alpha}}$

(b) SE(m) for variety : $\sqrt{\frac{E(b)}{r \times B}}$

(c) SE(m) for date of sowing at same level of variety : $\sqrt{\frac{E(b)}{r}}$

(d) SE(m) for variety at one or different level of date sowing : $\sqrt{\frac{(B-1)E(b)+E(a)}{r \times \alpha}}$

Where,

E(a) : Error(a) Mean sum of square

E(b) : Error(b) Mean sum of square

r : Number of replications

α : Number of main plot treatments

B : Number of sub-plot treatments

CD at 5 per cent level were calculated when 'F' test were significant, using the following formulae.

CD_1(0.05) for date of sowing : SE(m) for date of sowing $\times \sqrt{2}$ $\times$ t (0.05) at (a) df.

CD_2 (0.05) for variety	:	SE(m) for variety x $\sqrt{2}$ x 't'(0.05) at (b) df.
CD_3(0.05)for date of showing at same level of variety	:	SE(m) for date of sowing at same level of variety x $\sqrt{2}$ x 't'(0.05) at (b) df.
CD_4(0.05) for variety at one or different leve of date of sowing	:	SE(m) for variety at one or different date of sowing x $\sqrt{2}$ x pooled 't'.

Where,

Pooled 't' value was calculated as follows:

$$t = \frac{(B-1)\ E(b) \times t(b) + E(a) \times t(a)}{(V-1)\ E(b) + E(a)}$$

Where,

t(a) and t(b) 't' values at (a) and (b)dt.respectively.

Test of significance of Correlation Co-efficient

The observed values of correlation co-efficient was compared with the tabulated values for (n-2) degree of freedom. [The tabulated values of Fisher and Yates(1938)]. If the observed value is more than the tabulated value, the correlation co-efficient is said to be significant.

The other way to test the null hypothesis (r = 0) is through the application of 't' test (Singh and Choudhury,1985):

$$\frac{8}{\sqrt{(1-r^2)/n-2}}$$

Where,

r = Correlation coefficient

n = Total number of observations

This 't' value is tested against the tabulated value 't' for (n-2) degrees of freedom.

CHAPTER-IV

RESULTS

CHAPTER-IV

RESULTS

A field experiment was conducted in the Central Research Station of Orissa University of Agriculture and Technology, Bhubaneswar during Kharif 1995 to study the Environment-Genotype interaction in Mungbean. Sowing was done on four dates such as August 22, September 2, September 12 and September 22. Three mungbean varieties namely, OUM 11-4, OUM 11-5 and Dhauli were sown in split plot design with three replications. Date of sowing and varieties were the main plots and sub-plots respectively. The salient findings of the experiment are described below.

Days from seedling emergence to 50% flowering(Table 1)

The time taken for 50% flowering from seedling emergence was recorded on each date of sowing for every cultivar. There was significant difference among the four dates of sowing with respect to the above character. The mean number of days taken for 50% flowering was highest (32 days) when the crop was sown on August 22 and lowest (28 days) when sown on September 22.

Cultivar Dhauli took the highest mean number of days (34 days) for 50% flowering while cultivar OUM 11-4 and OUM 11-5 took the minimum number of days.

Table 1. Effect of date of sowing and cultivar on days from seedling emergence to 50% flowering

Variety	Aug.22	Sept.2	Sept.12	Sept.22	Mean
OUM 11-4	29.0	28.3	27.7	23.3	27.8
OUM 11-5	29.7	29.0	27.3	25.7	27.9
Dhauli	38.3	35.0	33.7	32.0	34.8
Mean	32.3	30.8	29.6	28.0	-

CD_1 = 0.41 CD_2 = 0.96 CD_3 = 1.66 CD_4 = 1.43

Table 2(a) Effect of date of sowing on cultivar on days from seedling emergence to first compound leaf stage

Variety	Aug.22	Sept.2	Sept.12	Sept.22	Mean
OUM 11-4	6.0	7.7	10.0	12.3	9.0
OUM 11-5	5.7	8.3	10.7	12.7	9.3
Dhauli	9.7	14.3	16.7	18.7	14.8
Mean	7.1	10.1	12.4	14.6	-

CD_1 = 0.48 CD_2 = 0.68 CD_3 = 1.17 CD_4 = 1.09

The interaction between the date of sowing and cultivar was found to be significant. Cultivar Dhauli took significantly the highest number of days among the three cultivars for 50% flowering on all four dates of sowing. OUM 11-4 and OUM 11-5 were at par with each other in all the dates of sowing with respect to the above character.

There was an decreasing trend in number of days for 50% flowering with each successive. date of sowing. All the cultivars took maximum number of days for 50% flowering when sown on August 22.

Days from seedling emergence to compound leaf stage [Table 2(a), 2(b), 2(c)]

There was gradual increase in duration from seedling emergence to compound leaf production stage with delay in sowing. There was significant difference among the dates of sowing. First compound leaf appeared as early as in 7 days on 22nd August sowing as compared to 14 days when the crop was sown on September 22. 2nd September and 12th September differed significantly for the above character.

The cultivars differed significantly. OUM 11-4 took only 9 days to have the 1st compound leaf as compared to 14.8 days taken by Dhauli. OUM 11-5 took 9.3 days for emergence of first compound leaf. OUM 11-4 and OUM 11-5 did not differ significantly.

The interaction between dates of sowing and cultivar was significant with respect to first compound leaf emergence.

Table 2(b). Effect of date of sowing and cultivar on days from seedling emergence to second compound leaf stage

Variety	Aug.22	Sept.2	Sept.12	Sept.22	Mean
OUM 11-4	9.7	13.3	14.7	16.0	13.4
OUM 11-5	9.3	12.7	14.7	16.0	13.2
Dhauli	14.3	17.7	19.3	20.0	17.8
Mean	11.1	14.6	16.2	17.3	-

$CD_1 = 0.59$ $CD_2 = 0.83$ $CD_3 =$ NS $CD_4 =$ NS

Table 2(c). Effect of date of sowing on cultivar on days from seedling emergence to third compound leaf stage

Variety	Aug.22	Sept.2	Sept.12	Sept.22	Mean
OUM 11-4	14.3	15.3	16.7	18.0	16.1
OUM 11-5	13.3	14.3	16.0	17.3	15.3
Dhauli	18.0	19.3	21.0	21.0	19.8
Mean	15.2	16.3	17.9	18.8	-

$CD_1 = 0.52$ $CD_2 = 1.09$ $CD_3 =$ NS $CD_4 =$ NS

Lowest (6 days) and highest (18.7 days) were tken by OUM 11-4 and Dhauli respectively. 22nd August sowing resulted in minimum (6 days) and 22nd September sowing took maximum (18.7 days) for this character.

Similar increasing trend was observed in the emergence of second and third compound leaf. There was significant difference among the dates of sowing. Mean minimum of 11.1 days and mean maximum of 17.3 days were taken for second compound leaf when the crop was sown on 22nd August and 22nd September, respectively.

The cultivars differed significantly among themselves. OUM 11-5 took minimum of 13.2 days and Dhauli took maximum of 17.8 days for emergence of second compound leaf. OUM 11-4 and OUM 11-5 were at par with each other with respect to the said character.

For the emergence of third compound leaf, there was significant difference among four dates of sowing. Minimum of 15.2 days and maximum of 18.8 days were taken when the crop was sown on 22nd August and 22nd September respectively. There was significant difference between 2nd September and 12th September sowing.

The cultivars varied similarly with respect to third compound leaf emergence. Cultivar OUM 11-5 took minimum of 15.3 days and Dhauli took maximum of 19.8 days.

The interaction between the dates of sowing and cultivar in both the second and third compound leaf emergence period was found to be insignificant.

Days from seedling emergence to maturity (Table 3)

The mean time taken by mungbean for maturity varied significantly when sown on different dates. Maturity duration gradually decreased with each successive sowing from 22nd August to 22nd September. The crop took 56.9 days and 51 days for maturity when sown on 22nd August and 22nd September respectively.

The maturity duration of each cultivar averaged over different dates of sowing was also different. Dhauli took significantly higher number of days (62 days) than both OUM 11-4 and OUM 11-5. However, the latter two cultivars had similar durations.

The interaction between cultivars and different dates of sowing was not signficant with respect to the above character.

Plant height (Table 4)

Plant height was recorded at first flowering of the plants. The mean plant height was siignificantly higher (34.4 cm) on 22nd August sowing and lower on 22nd September sowing (25.2 cm). There was gradual decrease in plant height with each successive dates of sowing.

Table 3. Effect of date of sowing and cultivar on days from seedling emergence to maturity

Variety	Aug.22	Sept.2	Sept.12	Sept.22	Mean
OUM 11-4	51.7	51.0	49.0	47.3	49.8
OUM 11-5	53.3	51.0	49.0	47.7	50.3
Dhauli	65.8	63.3	61.0	58.0	62.0
Mean	56.9	55.1	53.0	51.0	-

CD_1 = 0.91 CD_2 = 1.96 CD_3 = NS CD_4= NS

Table 4. Effect of date of sowing on cultivar on plant height (cm)

Variety	Aug.22	Sept.2	Sept.12	Sept.22	Mean
OUM 11-4	34.0	31.0	28.5	25.8	29.8
OUM 11-5	28.8	23.0	19.5	18.2	22.4
Dhauli	40.3	36.5	34.5	31.7	35.8
Mean	34.4	30.2	27.5	25.2	-

CD_1= 2.1 CD_2= 3.7 CD_3= NS CD_4= NS

The mean plant height of different cultivars averged over dates of sowing varied significantly. The plant height was highest(35.8 cm) in the cultivar Dhauli followed by OUM 11-4 (29.8 cm) and OUM 11-5 (22.4 cm). The interaction effect of cultivar and environment was insignificant.

Branch number (Table 5)

Number of branches per plant was counted for each date of sowing in all the cultivars. There was gradual but significant decline in number of branches per plant from the first date of sowing to fourth date of sowing. Highest mean number of branches (2.9) was obtained on first sowing and lowest (1.7) on last sowing. 22nd August sowing had significantly higher number of branches over 12th September and 22nd September sowing.

The cultivars varied widely among themselves with respect to their number of branches. Dhauli had highest (2.4) branches, comparable to OUM 11-5 (2.3) and OUM 11-4 had lowest (2.1) branches. The interaction component was insignificant.

Chlorophyll content (Table 6)

There was gradual but significant decline in the chlorophyll content of the leaf tissue from the first date to last date of sowing. Mean chlorophyll content was maximum (1.8 mg g^{-1} fresh weight) in the first sowing and minimum (1.6 mg g^{-1} fresh weight) was in the last sowing.

Table 5. Effect of date of sowing and cultivar on branch number

Variety	Aug.22	Sept.2	Sept.12	Sept.22	Mean
OUM 11-4	2.7	2.4	1.7	1.4	2.1
OUM 11-5	2.8	2.7	2.2	1.7	2.3
Dhauli	3.1	2.6	2.1	1.9	2.4
Mean	2.9	2.6	2.0	1.7	-

CD_1 = 0.84 CD_2 = 1.15 CD_3 = NS CD_4 = NS

Table 6. Effect of date of sowing on cultivar on chlorophyll content of leaves (mg/g.fr.wt.) at flowering

Variety	Aug.22	Sept.2	Sept.12	Sept.22	Mean
OUM 11-4	1.9	1.9	1.8	1.7	1.8
OUM 11-5	1.9	1.8	1.7	1.7	1.7
Dhauli	1.7	1.6	1.6	1.5	1.6
Mean	1.8	1.8	1.7	1.6	-

CD_1 = 0.04 CD_2 = 0.05 CD_3 = NS CD_4 = NS

All the three cultivars varied significantly in their mean chlorophyll content. OUM 11-4 had highest chlorophyll content (1.8 mg g^{-1} fresh weight) whereas Dhauli had the lowest (1.6 mg g^{-1} fresh weight), OUM 11-5 having the intermediate chlorophyll content (1.7 mg g^{-1} fresh weight). The interaction between date of sowing and cultivar was found to be insignificant.

Leaf Area Index (LAI) (Table 7)

The leaf area index gradually declined with each successive sowing. The mean highest LAI was recorded to be 2.6 on the first date of sowing and the lowest value of LAI was recorded to be 2.4 on fourth date of sowing. There was significant difference among all the four dates of sowing with respect to leaf area index.

Significant difference was observed among cultivars with respect to mean leaf area index being maximum in OUM 11-5 (2.5) and minimum in Dhauli (2.3). OUM 11-4 had intermediate leaf area index (2.4). The three cultivars also varied significantly in their mean leaf area index.

The interaction was significant. Dhauli had both highest and lowest values of 2.9 and 2.1 respectively. 22nd August sowing resulted in highest LAI and 22nd September sowing resulted in lowest LAI. All the three cultivars had their respective highest LAI values on first sowing and lowest values on last sowing.

Table 7. Effect of date of sowing and cultivar on leaf area index (LAI) at flowering

Variety	Aug.22	Sept.2	Sept.12	Sept.22	Mean
OUM 11-4	2.6	2.6	2.5	2.1	2.4
OUM 11-5	2.6	2.5	2.5	2.5	2.5
Dhauli	2.9	2.4	2.3	2.1	2.3
Mean	2.6	2.5	2.4	2.2	-

CD_1 = 0.05 CD_2 = 0.04 CD_3 = 0.06 CD_4 = 0.07

Table 8. Effect of date of sowing on cultivar on leaf area ratio (LAR) (cm^2 g^{-1}) at flowering

Variety	Aug.22	Sept.2	Sept.12	Sept.22	Mean
OUM 11-4	98.4	96.1	95.1	93.6	95.8
OUM 11-5	102.1	101.9	101.8	98.9	101.2
Dhauli	88.4	86.3	85.8	83.6	86.0
Mean	96.3	94.8	94.2	91.9	-

CD_1 = 0.04 CD_2 = 0.03 CD_3 = 0.05 CD_4 = 0.07

Leaf Area Ratio (LAR) (Table 8)

The leaf area ratio declined with delay in sowing. The difference with respect to date of sowing was significant. Highest (96.3 cm^2 g^{-1}) and lowest (91.9 cm^2 g^{-1}) was recorded on 22nd August and and 22nd September sowing respectively. LAR recorded on 2nd September and 12th September were at par.

The cultivars differed significantly among themselves with respect to LAR. OUM 11-5 recorded the highest (109.2 cm^2 g^{-1}) and Dhauli recorded the lowest (86.0 cm^2 g^{-1}). OUM 11-4 recorded intermediate (95.8 cm^2 g^{-1}) LAR value.

The interaction between the dates of sowing and cultivar was significant. OUM 11-5 recorded highest LAR when sown on 22 nd September.

Leaf Weight Ratio (LWR) (Table 9)

Leaf weight ratio was found to be similar throughout the four sowing dates. The difference was insignificant with respect to sowing dates. However, the cultivars differed significantly, the highest being 0.42 observed in both OUM 11-4 and OUM 11-5 and lowest (0.39) in Dhauli.

The interaction was significant. OUM 11-4 had highest (0.42) LWR on 22nd September sowing and Dhauli had lowest (0.39) LWR on both 22nd August and 2nd September sowing. Similar trend was observed on all the four dates of sowing.

Table 9. Effect of date of sowing and cultivar on leaf weight ratio (LWR) (g g^{-1}) at flowering

Variety	Aug.22	Sept.2	Sept.12	Sept.22	Mean
OUM 11-4	0.41	0.42	0.42	0.42	0.42
OUM 11-5	0.42	0.42	0.42	0.42	0.42
Dhauli	0.39	0.39	0.39	0.40	0.39
Mean	0.40	0.41	0.41	0.42	-

CD_1 = NS CD_2 = 0.008 CD_3 = 0.014 CD_4 = 0.016

Table 10. Effect of date of sowing on cultivar on specific leaf area (SLA) (cm^2 g^{-1}) at flowering

Variety	Aug.22	Sept.2	Sept.12	Sept.22	Mean
OUM 11-4	244.2	238.8	232.9	227.7	235.7
OUM 11-5	240.4	236.8	231.2	227.3	234.0
Dhauli	238.6	234.6	229.5	225.3	232.0
Mean	241.1	236.7	231.0	226.8	-

CD_1 = 1.4 CD_2 = 2.2 CD_3 = NS CD_4 = NS

Specific Leaf Area(SLA) (Table 10)

Mean specific leaf area declined gradually with each successive dates of sowing. Highest mean SLA of 241.1 was recorded on first sowing and the lowest SLA of 231.0 was recorded on last sowing. The SLA values on 22nd August sowing was significantly higher than all other dates of sowing.

There was significant variation among cultivars with respect to SLA. OUM 11-4 had highest SLA value of 235.7 and Dhauli had the lowest SLA value of 232.0. OUM 11-5 was at par with both OUM 11-4 and Dhauli. The interaction was insignificant.

Specific Leaf Weight Ratio (SLW) (Table 11)

The specific leaf weight remained almost constant except for 22nd August sowing. The mean highest SLW (0.005 g cm^{-2}) was recorded on 22nd August sowing. The difference in SLW was statistically significant between 22nd August sowing and other three dates.

The mean SLW of the cultivars varied significantly. The highest mean value was recorded in Dhauli. OUM 11-4 and OUM 11-5 were at par with each other. The interaction was significant. Dhauli and OUM 11-4 recorded the highest (0.005 g cm^{-2}) when sown on 22nd August and lowest (0.004 g cm^{-2}) when sown on 22nd September.

Table 11. Effect of date of sowing and cultivar on specific leaf weight (SLW) (g cm^{-2}) at flowering

Variety	Aug.22	Sept.2	Sept.12	Sept.22	Mean
OUM 11-4	0.005	0.004	0.004	0.004	0.004
OUM 11-5	0.004	0.004	0.004	0.004	0.004
Dhauli	0.005	0.005	0.005	0.005	0.005
Mean	0.005	0.004	0.004	0.004	-

CD_1 = 0.0002 CD_2 = 0.0003 CD_3 = 0.0006 CD_4 = 0.0005

Table 12(a) Effect of date of sowing on cultivar on leaf dry weight (g/plant) at flowering

Variety	Aug.22	Sept.2	Sept.12	Sept.22	Mean
OUM 11-4	2.5	2.4	2.3	2.3	2.4
OUM 11-5	2.5	2.5	2.4	2.3	2.4
Dhauli	2.3	2.2	2.2	2.2	2.2
Mean	2.4	2.4	2.3	2.3	-

CD_1= 0.02 CD_2= 0.03 CD_3= 0.05 CD_4= 0.05

Leaf Dry Weight [Table 12(a) and 12(b)]

There was gradual decline in leaf dry weight at flowering with respect to corresponding delay in sowing. The mean highest and lowest leaf dry weight of 2.4 g and 2.3 g were recorded on first and last sowing respectively. The difference in leaf dry weight recorded at four dates of sowing was significant.

The cultivars varied widely in their mean leaf dry weight at flowering. The cultivar OUM 11-5 had highest leaf dry weight (2.4 g) and the cultivar Dhauli had the lowest leaf dry weight (2.2 g). The cultivar OUM 11-4 had intermediate leaf dry weight (2.4 g).

The interaction was significant. Dhauli had highest leaf dry weight at flowering when sown on 22nd August and had lowest leaf dry weight when sown on 22nd September.

At harvest, the pattern of leaf dry weight accumulation was similar to that of at flowering. Highest mean leaf dry weight of 2.4 g was recorded on 22nd August and the lowest mean leaf dry weight (2.2 g) was obtained on 22nd September.

The mean dry weight was highest in the cultivar OUM 11-5 (2.4 g) and lowest in the cultivar Dhauli (2.2 g).

The interaction was significant. OUM 11-5 had highest leaf dry weight when sown on 22nd August and Dhauli had lowest leaf dry weight when sown on 22nd September.

Table 12(b) Effect of date of sowing and cultivar on leaf dry weight (g/plant) at harvest

Variety	Aug.22	Sept.2	Sept.12	Sept.22	Mean
OUM 11-4	2.4	2.4	2.3	2.3	2.4
OUM 11-5	2.5	2.4	2.3	2.3	2.4
Dhauli	2.2	2.2	2.2	2.1	2.2
Mean	2.4	2.3	2.3	2.2	-

CD_1 = 0.02 CD_2 = 0.01 CD_3 = 0.02 CD_4 = 0.03

Table 13(a) Effect of date of sowing on cultivar on stem dry weight (g/plant) at flowering

Variety	Aug.22	Sept.2	Sept.12	Sept.22	Mean
OUM 11-4	2.7	2.6	2.5	2.4	2.5
OUM 11-5	2.6	2.6	2.6	2.5	2.6
Dhauli	2.7	2.7	2.7	2.5	2.7
Mean	2.7	2.6	2.6	2.5	-

CD_1 = 0.05 CD_2 = 0.02 CD_3 = 0.04 CD_4 = 0.07

Stem Dry Weight [Table 13(a) and 13(b)]

Stem dry weight at flowering declined gradually from the first date of sowing to the last date of sowing. The highest mean stem dry weight (2.7 g) was recorded on 22nd August sowing and the lowest value (2.5 g) was recorded on 22nd September sowing. The difference in dry weight was significant.

There was significant variation among the cultivars with respect to stem dry weight at flowering. Cultivar Dhauli had the highest stem dry weight (2.7 g) followed by OUM 11-5 (2.6 g) and OUM 11-4 (2.5 g).

Similar pattern of variation in stem dry weight was observed at harvest. There was gradual decline in stem dry weight from the first date of sowing to last date of sowing. There was significant difference in stem dry weight among the dates of sowing. 22nd August sowing had the highest dry weight (3.3 g) and 22nd September had the lowest dry weight (3.2 g).

The cultivars also showed significant difference. The highest mean dry weight was recorded in Dhauli (3.3 g) followed by OUM 11-4 (3.3 g) and OUM 11-5 (3.2 g).

There was significant interaction response. At flowering, Dhauli had highest stem dry weight (2.7 g) when the crop was sown on 22nd August and OUM 11-4 had the lowest value (2.4 g) when sown on 22nd September.

Table 13(b) Effect of date of sowing and cultivar on stem dry weight (g/plant) at harvest

Variety	Aug.22	Sept.2	Sept.12	Sept.22	Mean
OUM 11-4	3.3	3.3	3.2	3.2	3.2
OUM 11-5	3.3	3.3	3.2	3.2	3.2
Dhauli	3.4	3.3	3.3	3.2	3.3
Mean	3.3	3.3	3.2	3.2	-

CD_1 = 0.02 CD_2 = 0.02 CD_3 = 0.03 CD_4 = 0.03

Table 14(a) Effect of date of sowing on cultivar on root dry weight at flowering

Variety	Aug.22	Sept.2	Sept.12	Sept.22	Mean
OUM 11-4	0.58	0.52	0.46	0.42	0.50
OUM 11-5	0.59	0.50	0.46	0.42	0.50
Dhauli	0.60	0.56	0.50	0.44	0.51
Mean	0.59	0.53	0.47	0.43	-

CD_1 = 0.03 CD_2 = 0.01 CD_3 = NS CD_4 = NS

Root Dry Weight [Table 14(a) and 14(b)]

The gradual decline in root dry weight was observed at the time of flowering from the first sowing to last sowing. The highest (0.59 g) and the lowest (0.43 g) root dry weights were recorded on 22nd August and 22nd September, respectively. The root dry weight obtained on four dates of sowing differed significantly.

There was significant variation among the cultivars with respect to root dry weight at flowering. Cultivar Dhauli had significantly higher root dry weight than OUM 11-4 and OUM 11-5. The cultivars OUM 11-4 and OUM 11-5 did not differ between them. The interaction was significant.

The pattern of dry weight accumulation by roots at harvest on four dates of sowing by the three cultivars was similar to that at flowering. There was a gradual decline in root dry weight with successive sowings, the highest (0.62 g) and the lowest (0.43 g) values being obtained on first and last date of sowing. The root dry weight obtained on four dates of sowing differed significantly among themselves.

The cultivars differed significantly among themselves with respect to dry weight at harvest, the highest value (0.47g) obtained by Dhauli and the lowest value (0.40 g) obtained in OUM 11-5. The interaction was non-significant.

Root Dry Weight [Table 14(a) and 14(b)]

The gradual decline in root dry weight was observed at the time of flowering from the first sowing to last sowing. The highest (0.59 g) and the lowest (0.43 g) root dry weights were recorded on 22nd August and 22nd September, respectively. The root dry weight obtained on four dates of sowing differed significantly.

There was significant variation among the cultivars with respect to root dry weight at flowering. Cultivar Dhauli had significantly higher root dry weight than OUM 11-4 and OUM 11-5. The cultivars OUM 11-4 and OUM 11-5 did not differ between them. The interaction was significant.

The pattern of dry weight accumulation by roots at harvest on four dates of sowing by the three cultivars was similar to that at flowering. There was a gradual decline in root dry weight with successive sowings, the highest (0.62 g) and the lowest (0.43 g) values being obtained on first and last date of sowing. The root dry weight obtained on four dates of sowing differed significantly among themselves.

The cultivars differed significantly among themselves with respect to dry weight at harvest, the highest value (0.47g) obtained by Dhauli and the lowest value (0.40 g) obtained in OUM 11-5. The interaction was non-significant.

Table 14(b). Effect of date of sowing and cultivar on root dry weight (g/plant) at harvest

Variety	Aug.22	Sept.2	Sept.12	Sept.22	Mean
OUM 11-4	0.64	0.58	0.48	0.42	0.53
OUM 11-5	0.59	0.55	0.45	0.40	0.50
Dhauli	0.64	0.58	0.52	0.47	0.55
Mean	0.62	0.57	0.48	0.43	-

CD_1 = 0.02 CD_2 = 0.02 CD_3 = NS CD_4 = NS

Table 15. Effect of date of sowing on cultivar on inflorescence dry weight (g/plant) at flowering

Variety	Aug.22	Sept.2	Sept.12	Sept.22	Mean
OUM 11-4	0.28	0.27	0.26	0.26	0.27
OUM 11-5	0.27	0.26	0.25	0.24	0.25
Dhauli	0.27	0.28	0.26	0.25	0.26
Mean	0.27	0.27	0.26	0.25	-

CD_1 = NS CD_2 = 0.01 CD_3 = NS CD_4 = NS

Inflorescence Dry Weight (Table 15)

There was gradual decline in inflorescence dry weight with delay in sowing, the highest (0.27 g) and the lowest (0.25g) dry weights were obtained on 22nd August and 22nd September sowings respectively. However, there was no significant difference between two successive dates of sowing.

There was a narrow variation among the cultivars with respect to inflorescence dry weight. The highest dry weight (0.27 g) was recorded in OUM 11-4 whereas the lowest dry weight (0.26 g) was obtainmed in OUM 11-5. The variation across the sowing dates and cultivars was insignificant.

Pod Dry Weight (Table 16)

There was gradual decline in pod dry weight from first date of sowing to last date of sowing. Highest (8.0 g) and lowest (7.2 g) mean pod dry weights were recorded on 22nd August and 22nd September respectively. Such reduction was significant among dates of sowing.

The cultivars varied significantly with respect to mean pod dry weight. Dhauli had the highest pod dry weight (7.8 g) followed by OUM 11-5 (7.6 g) and OUM 11-4 (7.3 g). The three cultivars varied significantly in their mean pod dry weight.

The interaction was significant. Dhauli had the highest yield when sown on 22nd August and OUM 11-4 had the lowest yield when sown on 22nd September. All the cultivars had their respective highest and lowest pod dry weight on 22nd August and 22nd September, respectively.

Table 16. Effect of date of sowing and cultivar on pod dry weight (g/plant)

Variety	Aug.22	Sept.2	Sept.12	Sept.22	Mean
OUM 11-4	7.5	7.4	7.2	7.2	7.3
OUM 11-5	7.9	7.6	7.4	7.4	7.6
Dhauli	8.5	8.3	7.2	7.2	7.8
Mean	8.0	7.8	7.3	7.2	-

CD_1 = 0.038 CD_2 = 0.025 CD_3 = 0.043 CD_4= 0.055

Table 17(a) Effect of date of sowing on cultivar on total dry matter (g/plant) at flowering

Variety	Aug.22	Sept.2	Sept.12	Sept.22	Mean
OUM 11-4	6.0	5.8	5.6	5.4	5.7
OUM 11-5	6.2	5.8	5.6	5.4	5.8
Dhauli	5.9	5.7	5.6	5.4	5.6
Mean	6.0	5.8	5.6	5.4	-

CD_1= 0.17 CD_2= 0.10 CD_3= NS CD_4= NS

Total Dry Matter [Table 17(a) and 17(b)]

There was gradual decline in total dry matter accumulation at flowering with corresponding delay in sowing. Such reduction was significant. Highest (6.0 g/plant) mean value was recorded on 22nd August sowing and the lowest (5.4 g/plant) mean value was recorded on 22nd September sowing.

The mean difference among cultivars was found to be significant. Cultivar OUM 11-5 had the highest (5.8 g/plant) dry matter and Dhauli had the lowest (5.6 g/plant) dry matter. The interaction between dates of sowing and cultivar was found to be insignificant.

Total dry matter accumulation at harvest exhibited a declining trend with corresponding delay in sowing. Highest (14.3 g/plant) and lowest (13.1 g/plant) mean values were recorded when the crop was sown on 22nd August and 22nd September respectively. Such reduction in dry matter was significant.

The dry matter accumulation by different cultivars at harvest differed significantly. Dhauli had the highest (13.8 g/plant) and OUM 11-4 had the lowest (13.5 g/plant) dry matter. OUM 11-5 had the intermediate (13.7 g/plant) dry matter at harvest.

The interaction was significant at harvest and Dhauli had the highest (14.3 g/plant) dry matter when the crop was sown on 22 nd August and OUM 11-4 had the lowest (13.1 g/plant) when sown on 22nd September.

Table 17(b) Effect of date of sowing and cultivar on total dry matter (g/plant) at harvest

Variety	Aug.22	Sept.2	Sept.12	Sept.22	Mean
OUM 11-4	13.9	13.6	13.2	13.0	13.5
OUM 11-5	14.3	13.8	13.4	13.2	13.7
Dhauli	14.7	14.4	13.2	13.0	13.8
Mean	14.3	14.0	13.3	13.1	-

CD_1 = 0.07 CD_2 = 0.07 CD_3 = 0.11 CD_4= 0.12

Table 18. Effect of date of sowing on cultivar on number of pods per plant

Variety	Aug.22	Sept.2	Sept.12	Sept.22	Mean
OUM 11-4	19.6	19.5	19.4	19.4	19.5
OUM 11-5	20.4	20.3	20.2	20.2	20.3
Dhauli	22.4	21.7	22.3	22.2	22.2
Mean	20.8	20.5	20.7	20.6	-

CD_1= NS CD_2= 0.67 CD_3= NS CD_4= NS

Total number of pods per plant (Table 18)

Statistical analysis of pod number per plant revealed that there was no effect of date of sowing on the number of pods. The pod number was almost same in all the four dates.

However, the mean pod number varied significantly among the three cultivars. Cultivar Dhauli had the highest number of pods (22.2) while OUM 11-4 had the lowest number of pods (19.5) per plant. OUM 11-5 had higher number of pods (20.3) as compared to OUM 11-4. The genotype and environment interaction was not significant.

Number of filled pods per plant (Table 19)

The number of filled pods gradually declined with each successive sowing. The reduction in the number of filled pods was significant. Highest (19.1) and lowest (18.8) mean number of filled pods were obtained on 22nd August and 22nd September sowing respectively.

The mean number of filled pods revealed significant difference among the cultivars. Dhauli recorded highest mean (20.5) and OUM 11-4 recorded lowest mean(17.7) with respect to the above characters. OUM 11-5 had intermediate number of filled pods (18.6) but significantly higher than OUM 11-4.

The interaction observed between the dates of sowing and cultivars was significant. Dhauli recorded the highest number of filled pods (20.8) while OUM 11-4 recorded lowest

Table 19. Effect of date of sowing and cultivar on number of filled pods per plant

Variety	Aug.22	Sept.2	Sept.12	Sept.22	Mean
)UM 11-4	17.8	17.8	17.7	17.6	17.7
)UM 11-5	18.8	18.6	18.6	18.5	18.6
'hauli	20.8	20.4	20.4	20.3	20.5
lean	19.1	19.0	18.9	18.8	-

CD_1 = 0.08 CD_2 = 0.14 CD_3 = 0.24 CD_4= 0.21

'able 20. Effect of date of sowing on cultivar on number of grains per pod

Variety	Aug.22	Sept.2	Sept.12	Sept.22	Mean
'UM 11-4	7.0	6.8	6.8	6.7	6.8
'UM 11-5	7.0	6.9	6.8	6.7	6.9
'hauli	7.0	6.9	6.9	6.9	6.9
lean	7.0	6.9	6.8	6.8	-

CD_1= 0.06 CD_2= 0.09 CD_3= NS CD_4= NS

number of pods (17.6), OUM 11-5 had higher number of pods than OUM 11-4. All the three cultivars exhibited similar trend with respect to the above character in all the four dates of sowing.

There was gradual decline in the number of filled pods in each cultivar on successive date of sowing from 22nd August to 22nd September. Highest and lowest number of pods were recorded in Dhauli and OUM 11-4 cultivars on 22nd August and 22nd September sowing respectively.

Grain number per pod (Table 20)

Grain number per pod exhibited a declining trend with corresponding delay in sowing. There was significant difference among the dates of sowing with respect to grain number per pod. Highest (7.0) mean was recorded when the crop was sown on 22nd August as compared to the lowest mean (6.8) when the crop was sown on 22nd September. 2nd September and 12th September sowing recorded similar pod number.

The cultivars differed significantly among themselves with respect to mean number of grains per pod. The highest value (6.9) was recorded by Dhauli followed by OUM 11-5 (6.9) and OUM 11-4 (6.8).

The interaction between the sowing dates and cultivars was not significant. However, there was gradual reduction in number of seeds per pod when sowing was delayed.

Grain yield per plant (Table 21)

Mean grain yield computed per plant indicated significant difference among dates of sowing. It declined gradually from first sowing to last sowing. Highest (3.9g)and lowest 3.6g) grain yield was recorded on 22nd August and 22nd September sowing, respectively. Each two successive sowings, however, at par with each other.

The cultivars differed significantly among themselves for mean grain yield per plant. Dhauli recorded the highest grain yield (4.1 g) followed by OUM 11-5 (3.7 g) and OUM 11-4 (3.5 g).

The interaction between the dates of sowing and cultivar was significant and it was recorded that Dhauli yielded highest (4.3 g) and OUM 11-4 yielded lowest (3.6 g) on 22nd August sowing. OUM 11-5 yielded inbetween the above two cultivars. The grain yield decreased in each cultivar with each successive sowing.

Thousand grain weight (Table 22)

The test weight declined gradually with each successive date of sowing. Mean highest (28.9 g) and lowest (28.6 g) test weights were recorded on 22nd August and 22nd September sowing respectively. Such differences among the dates of sowing were significant.

The cultivars differed significantly with respect to test weight. Dhauli recorded the highest (29.1 g) mean test

Table 21. Effect of date of sowing and cultivar on grain yield (g/plant)

Variety	Aug.22	Sept.2	Sept.12	Sept.22	Mean
OUM 11-4	3.6	3.6	3.4	3.4	3.5
OUM 11-5	3.8	3.7	3.7	3.5	3.7
Dhauli	4.3	4.1	4.1	4.1	4.1
Mean	3.9	3.8	3.7	3.6	-

CD_1 = 0.09 CD_2 = 0.09 CD_3 = 0.15 CD_4 = 0.16

Table 22. Effect of date of sowing on cultivar on 1000 grain weight (g)

Variety	Aug.22	Sept.2	Sept.12	Sept.22	Mean
OUM 11-4	28.7	28.7	28.7	28.6	28.7
OUM 11-5	28.8	28.8	28.8	28.2	28.7
Dhauli	29.2	29.0	29.0	29.0	29.1
Mean	28.9	28.8	28.8	28.6	-

CD_1 = 0.02 CD_2 = 0.05 CD_3 = 0.09 CD_4 = 0.07

weight followed by OUM 11-5 (28.7 g) and OUM 11-4 (28.7 g). The later two cultivars were at par with each other with respect to the above character.

The interaction between sowing dates and cultivars was significant. Dhauli recorded 29.1 g followed by OUM 11-5 and OUM 11-4 in that order. The trend was similar in all the four sowing dates. There was gradual decline in 1000 grain weight with delayed sowing. The effect of sowing date was similar in all the cultivars. The highest and lowest weights were recorded in Dhauli and OUM 11-4 respectively.

Harvest Index (HI) (Table 23)

Mean harvest index indicated that there was significant difference among dates of sowing. In contrast to other growth characters, it exhibited an upward trend. Highest harvest index (28.4) was recorded on 22nd September sowing and the lowest mean value(27.0) was obtained on 22nd August sowing. Two successive sowings, however, had similar harvest index.

The cultivars differed significantly among themselves for their mean harvest index values. Cultivar Dhauli recorded the highest (29.6) harvest index as compared to lowest mean value (26.2) recorded in OUM 11-4. Cultivar OUM 11-4 and OUM 11-5 were at par with each other and both had significantly lower harvest index than Dhauli. The interaction between the sowing dates and cultivars was not significant.

Table 23. Effect of date of sowing and cultivar on harvest index (HI)

Variety	Aug.22	Sept.2	Sept.12	Sept.22	Mean
OUM 11-4	25.8	25.9	25.9	27.3	26.2
OUM 11-5	26.3	26.7	27.2	27.2	26.9
Dhauli	28.9	28.8	30.1	30.6	29.6
Mean	27.0	27.1	27.8	28.4	-

CD_1 = 0.96 CD_2 = 1.50 CD_3 = NS CD_4 = NS

Table 24. Correlation between environmental variables and maturity duration, yield and yield attributing characters from seedling emergence to harvest

	Maturity duration	Pod dry weight	Pod number	Filled pod no.	Grains per pod	Grain yield	Thousand grain wt.
Mean Temperature	0.068	-0.056	0.948	0.098	0.150	0.098	0.214
Mean BSH	-0.926	-0.977*	-0.026	-0.918	-0.901	-0.918	-0.74
Mean Photo period	0.988*	0.983*	0.408*	0.990*	0.981*	0.990*	0.866

* Significance at 5% level

Correlation Studies

Correlation studies were carried out between environmental variables(mean temperature, mean bright sunshine hours and mean photo period) with several growth parameters, yield and yield attributing characters both at flowering and harvest.

Correlation between environmental variables and maturity duration, yield and yield attributing characters from seedling emergence to harvest (Table 24)

Correlation studies between environmental variables and grain yield, other yield attributing characters and maturity duration revealed that mean temperature had no correlation with maturity duration, pod dry weight, number of filled pods per plant, grains per pod, grain yield and 1000-grain weight. Mean bright sunshine hours was negatively associated with pod dry weight. Mean photoperiod was positively associated with maturity duration, pod dry weight, number of pods per plant, number of filled pods, grains per pod and grain yield.

Correlation between environmental variables and some other growth parameters from seedling emergence to flowering(Table 25)

Correlation studies between environmental variables and some other growth parameters from seedling emergence to flowering revealed that days taken from seedling emergence to 50% flowering, plant height, branch number, chlorophyll content, LAI, LAR, SLA, root dry weight at flowering, inflorescence dry weight and total dry matter at flowering were positively associated with mean temperature, mean BSH, mean bright

Table 25. Correlation between environmental variables (mean temperature, mean bright sunshine hours, mean photo period) and some other growth parameters from seedling emergence to flowering

	Days from seedling emergence to				Plant height	Branch number	Chloro-phyll content	LAI	LAR
	50% flowering	1st compound leaf	2nd compound leaf	3rd compound leaf					
Mean temperature	0.992**	-0.990*	-0.947	-0.996**	0.979*	0.998**	0.962*	0.960*	0.967*
Mean BSH	0.992**	-0.990*	-0.947	-0.996**	0.979*	0.998**	0.962*	0.960*	0.967*
Mean photo period	0.992**	-0.990*	-0.947	-0.996**	0.979*	0.998**	0.962*	0.060*	0.967*

Table 25 contd.

	LWR	SLA	SLW	Dry weight at flowering				Total dry matter at flowering
				Leaf dry weight	Stem dry weight	Root dry weight	Inflorescence dry wt.	
Mean temperature	-0.928	0.999**	0.732	0.918	0.928	0.992**	0.962*	0.997**
Mean BSH	-0.928	0.999**	0.732	0.918	0.928	0.992**	0.962*	0.997**
Mean photo period	-0.928	0.999**	0.732	0.918	0.928	0.992**	0.962*	0.997**

* and ** Significance at 5% and 1% levels, respectively

sunshine hours and mean photoperiod. However, there was significant negative association between duration from seedling emergence to first and third compound leaf stage and mean temperature, mean bright sunshine hours and mean photoperiod.

Significant positive association at 0.01 level was observed between duration from seedling emergence to 50% flowering, branch number, SLA, root dry weight at flowering and total dry matter at flowering and mean temperature, mean bright sunshine hours and mean photoperiod.

Correlation between environmental varibles and some growth parameters from flowering to harvest (Table 26)

Correlation studies between environmental variables with some other growth parameters from flowering to harvest revealed that mean temperature was positively associated with root dry weight at harvest and total dry matter at harvest. Mean photoperiod was positively associated with leaf dry weight, root dry weight at harvest and total dry matter at harvest. However, mean bright sunshine hours was negatively correlated with stem dry weight at harvest.

Table 26. Correlation between environmental variables with some growth parameters from flowering to harvest

	Dry weight at harvest			Total dry matter at harvest
	Leaf dry weight	Stem dry weight	Root dry weight	
Mean temperature	0.811	0.16	0.483*	0.404*
Mean BSH	0.086	-0.366*	-0.180	-0.2 70
Mean photo period	0.954*	0.883	0.988*	0.974*

CHAPTER-V

DISCUSSION

CHAPTER - V

DISCUSSION

In the present experiment mungbean was used as the experimental material to study its growth reactions to variable environmental factors due to variation in planting dates or change in seasons. Environmental factors change continuously having their effects on growth and development of crops. Solar radiation, air temperature and photoperiod are major environmental variables which influence physiological processes in a decisive way. The influence of these factors on growth and yield of mungbean has been briefly discussed in the following paragraphs.

Duration of different phases of growth

The duration from seedling emergence to 50% flowering and total duration of the crop varied with the date of sowing (Table 1,3). Variation was also recorded in the period from seedling emergence to initiation of compound leaves [Table 2(a),2(b),2(c)]. The cultivars differed among themselves in their response to various sowing dates. The time taken from seedling emergence to 50% flowering and maturity was highest on first date of sowing and declined gradually with subsequent delay in sowing. There was significant positive association between these two characters and mean temperature, mean bright sunshine hour(BSH) and mean photoperiod (Table 24,25). These above findings are in agreement with Chapman(1981), Sichkar and Khangil(1983). They concluded that decrease in day length reduce the duration from sowing to flowering. In the present study photoperiod was higher on first sowing and gradually decreased in subsequent sowings resulting in less time for 50% flowering and maturity. Federowaka and Sayrner (1983) reported high correlation between length of flowering stage and accumulated temperature.

There was delay in compound leaf initiation with successive dates of sowing. This finding is similar to that of Hesketh et al.(1973) who reported that temperature had adverse effect on rate of leaf production. In the present study there was significant negative association between first and third compound leaf initiation with mean temperature, mean BSH and mean photoperiod (Table 25). On first sowing temperature was higher and with delay in sowing, temperature decreased gradually which might have contributed to delay in compound leaf initiation.

Dry matter accumulation

There was significant variation in leaf dry weight, stem dry weight, root dry weight and total dry matter both at flowering and harvest due to delay in sowing. There was similar variation in inflorescence dry weight. The total dry matter accumulation in different plant parts gradually decreased with each successive sowing as compared to first sowing. Out of the four sowing dates, lowest dry matter recorded on last sowing (22nd September) (Table 17 a,b).

The cultivars differed among themselves with respect to their leaf, stem, root and inflorescence , dry weight which led to variation in total dry matter. Highest and lowest leaf dry weights were recorded in cultivar OUM 11-5 and Dhauli (Table 12 a,b), respectively. There was a fall in leaf dry weight from flowering to maturity which might be either due to senescence of old and matured leaves or mobilization of dry matter from the leaf to the developing sink. The leaf dry weight from seedling emergence to flowering and from flowering to harvest was positively correlated with mean temperature, mean bright sunshine hours and mean photoperiod (Table 25,26). The highest and lowest stem dry weight was recorded in cultivar Dhauli and OUM 11-5 (Table 13 a,b),respectively. The decrease in stem dry weight from flowering to harvest could be explained in terms of mobilization of dry matter from stem to pod for grain development. Correlation studies revealed that stem dry weight from seedling emergence to flowering (Table 25) was positively correlated with mean temperature and photoperiod. However, stem dry weight from flowering to maturity was negatively correlated with mean bright sunshine hours (Table 26). Root dry weight and inflorescence dry weight at flowering (Table 14,a,b; 15) were positively correlated with mean temperature, mean bright sunshine hours and mean photoperiod (Table 25) and root dry weight from flowering to maturity was positively associated with mean temperature and mean photoperiod (Table 26).

The total dry matter from seedling emergence to flowering was positively correlated with mean temperature, mean bright sunshine hours and mean photoperiod (Table 25). However, total dry matter at harvest had no correlation with mean bright sunshine hours though it was positively associated with mean temperature and photoperiod (Table 26). Similar findings were reported by Brown(1960), Seibles and Weber(1966), O'Leary(1973) and Thomas et al.(1981) in soybean, where the shoot dry matter was positively associated with the weather parameters such as mean photoperiod and accumulated temperature. The present investigation revealed the effect of mean temperature, mean bright sunshine hours and mean photoperiod.

Physiological growth parameters

The leaf area index (LAI) is an important determinant of crop growth and yield. Higher LAI was recorded on first date of sowing (Table 7) and then declined with each successive dates of sowing in all the three cultivars. The mean LAI was highest in Dhauli followed by OUM 11-5 and OUM 11-4 in that order. The reduction in LAI might be due to shortening of the period from seedling emergence to flowering. Shoot dry matter at flowering also determines the LAI as evident from the decrease in LAI value corresponding to decrease in shoot dry weight. Similar results were also reported by Byth(1968), Ciha and Brun(1975) and Sato (1979).

LAR and SLW decreased with delayed sowing while LWR did not. However, cultivars varied with respect to the above three parameters. Cultivar OUM 11-5 had the highest LAR

(Table 8) followed by OUM 11-4 and Dhauli. The results revealed that there was a gradual decline in LAR and SLA (Table 8, 10), plant height (Table 4) and branch number (Table 5) from first date to last date of sowing. It suggested that the leaf area decreased with delayed sowing while its thickness increased. It also indicated that the LAI was influenced by environmental factors but not the leaf weight.

Yield and Yield attributes

The highest and lowest grain yield of all the three cultivars were recorded on first and last sowings respectively which indicated a gradual decline with delayed sowing (Table 21). It was the result of a general decline in all the growth parameters and dry weight. The grain yield was highest in Dhauli followed by OUM 11-5 and OUM 11-4 in that order. The higher yield in Dhauli might be attributed to higher pod number (Table 18) with more filled ones (Table 19), higher seeds per pod (Table 20) and thousand grain weight (Table 22). The shoot dry matter and consequently total dry matter was highest in Dhauli among the three cultivars. The finding was in conformity with the results obtained by Puech et al.(1974) who reported that the yield reduced in some cultivars of soybean when temperature and bright sunshine hours were low. Cure(1981) observed that in soybean seed yield per plant was significantly higher in long days than in short days.

Correlation studies revealed that grain yield was positively correlated with mean photoperiod and negatively with mean bright sunshine hours (Table 24). All the yield attributing characters were positively associated with mean photoperiod (Table 24). The gradual decrease in mean values of yield attributing characters was similar to that of grain yield which might be due to gradual decline in photoperiod from first date of sowing to last date of sowing.

CHAPTER-V

SUMMARY AND CONCLUSION

compound leaf and mean temperature, mean bright sunshine hours and mean photoperiod (Table 25).

The mean duration from seedling emergence to maturity declined gradually with successive sowing dates. The longest duration (65.9 days) of the crop was on first sowing and shortest (51 days) on last sowing (Table 3). Maturity duration was positively correlated with mean photoperiod (Table 24).

Earlier sowing exhibited higher plant height and branch number in all the cultivars while subsequent delay in sowing gradually reduced the height and branch number. Cultivar Dhauli recorded highest mean with respect to plant height and branch number (Table 4 and 5). Plant height and branch number were positively correlated with mean temperature, mean bright sunshine hours and mean photoperiod (Table 25).

The chlorophyll content of leaf tissue gradually declined from first sowing to the last sowing. OUM 11-4 recorded significantly higher chlorophyll content followed by OUM 11-5 and Dhauli (Table 6). Chlorophyll content was positively associated with mean temperature, mean bright sunshine hours and mean photoperiod (Table 25).

The highest mean LAI at flowering was recorded on first sowing and subsequent delay in sowing gradually reduced the same. OUM 11-5 recorded highest mean among three cultivars (Table 7). There was significant positive correlation between LAI and mean temperature, mean bright sunshine hours and mean photoperiod (Table 25).

The mean LAR varied significantly with date of sowing being highest on first date of sowing and subsequently declined, the lowest being on the last date of sowing. OUM 11-5 had significant mean LAR (Table 8). LAR has positive association with mean temperature, mean bright sunshine hours and mean photoperiod (Table 25).

The mean LWR was unaffected by date of sowing. Cultivars OUM 11-4 and OUM 11-5 had the same mean LWR(Table 9).

The mean SLA reduced significantly with each successive sowing date. Cultivar OUM 11-4 recorded the highest mean SLA (Table 10). SLA was positively correlated with mean temperature, mean bright sunshine hour and mean photoperiod (Table 25).

The mean SLW varied significantly with date of sowing; the highest and lowest being observed on 22nd August and 22nd September, respectively. Cultivar Dhauli recorded the highest mean SLW (Table 11).

The mean dry weight of leaf, stem and root declined gradually with each successive date of sowing as compared to preceeding dates both at flowering and harvest [Table 12(a,b), 13(a,b), 14(a,b)]. Similar declining trend was also observed in inflorescence dry weight at flowering (Table 15). In all the above mentioned characters the difference was significant. Leaf dry weight was higher in OUM 11-4 and OUM 11-5 both at flowering and harvest. Stem dry weight and root dry weight were higher in Dhauli both at flowering and harvest. OUM 11-4 recorded highest inflorescence dry weight. Leaf dry weight at harvest was positively associated with mean temperature, mean bright sunshine hour and mean photoperiod. Stem dry weight at harvest was negatively associated with mean temperature, mean bright sunshine hour and mean photoperiod. Root dry weight at flowering was positively associated with mean temperature, mean bright sunshine hour and mean photoperiod. Root dry weight at harvest was positively associated with mean temperature and mean photoperiod only. Inflorescence dry weight had positive correlation with the environmental parameters (Table 25, 26).

The mean pod dry weight decreased with delay in sowing. Dhauli recorded the highest mean (7.8 g) per plant pod dry weight (Table 16). Pod dry weight was negatively associated with mean bright sunshine hour and mean photoperiod (Table 24).

Total dry matter accumulation at flowering and harvest declined gradually with successive date of sowing. In all the cultivars highest mean values were recorded on first date of sowing and lowest mean values were recorded on last date of sowing. OUM 11-5 recorded highest dry matter at flowering whereas Dhauli recorded highest dry matter at harvest [Table 17(a,b)]. Total dry matter at flowering had positive correlation with mean temperature, mean bright sunshine hour and mean photoperiod and total dry matter at harvest had positive association with mean temperature and mean photoperiod (Table 25,26).

Highest mean number of pods per plant, filled pods per plant and grains per pod was recorded on first sowing which gradually decreased with delay in sowing and lowest mean values were recorded on last date of sowing. Cultivar Dhauli recorded highest mean values of number of filled pods, pod number and grains per pod (Table 18,19,20). These characters had significant positive association with mean photoperiod only (Table 24).

Mean grain yield gradually decreased due to delay in sowing. Irrespective of genotype highest grain yield was obtained on first date of sowing and lowest grain yield was recorded on last date of sowing. Dhauli was the highest yielder among the three cultivars (Table 21). Grain yield was positively associated with mean photoperiod (Table 24).

Thousand grain weight declined gradually with successive dates of sowing. Dhauli recorded highest 1000 grain weight while OUM 11-4 and OUM 11-5 were at par with each other with respect to their mean 1000 grain weight (Table 22).

In contrast to other growth characters harvest index gradually increased with each successive dates of sowing. Highest mean HI vlues were recorded on last date of sowing in all the cultivars and lowest mean values were obntained on first date of sowing. Cultivar Dhauli recorded the highest mean HI value.

From the above experiment it might be concluded that under Bhubaneswar conditions, among the three cultivars tested no one showed consistency of yield under variable environmental factors. None of the growth parameters and yield components in any of the cultivars showed stability with changing crop environment. Thus it may be understood that environmental variables play a key role in determining the pattern of growth and development of mungbean and thus yield of mungbean might be modified due to variation in such factors. Hence, sowing time might be suitably adjusted to obtain better plant growth and higher yield.

BIBLIOGRAPHY

Ducan, W.G., Shaver, D.L. and Williams, W.A.(1973). Isolation and temperature effects on maize growth and yield. Crop Sci., 13: 187-191.

Eriskine, W. and Khan, T.N.(1977). Genotype, genotype x environmental effects on grain yield and related characters of Cowpea (Vigna unquiculata(L.). Austr. J. of Agrl. Research., 28(4): 609-617.

Ezedinma, F.O.C.(1973). Partition of dry matter between vegetative and reproductive components of semi upright cowpea (Vigna unquiculata(L.) Walp.). Nigerian Agric. J., 10(2): 156-159.

Federowaka, B. and Sayrner, J.(1983). Influence of temperature on flowering of varieties and strains of soybeans (Glysine max(L.) Merr.). Acta Agrobotanica, 36(1-2): 153-167.

Fernandez, G.C.J. and Chen, H.K.(1989). Temperature and photoperiod influence on reproductive development of reduced photoperiod-sensitive mungbean genotypes. J. of the American Soci. for Hort. Sci., 114(2): 204-209.

Fisher, R.A. and Yates, F.(1938). Statistical tables for bological, agricultural and medical research, 5 Aufl; Oliver and Boyd. Edinburgh, pp 63.

Fisher, V.J. and Weaver, C.K.(1974). Flowering pod set retention of lima bean in response to night temperature, humidity and soil moisture. Journal of the American Society for Horticultural Science, 99(50: 448-450.

Gill, D.S., Verma, M.M., Brar, G.S.(1992). Physiological parameters determining yield in mungbean. Crop Improvement, Dept.of Pl. Br., PAU, 19(1): 29-33.

Graman, J.(1974). The influence of some environmental factors on the formation and shedding of reproductive organs in horse bean. 2., Influence of shading and decreased day length. Sbornik Vysoke Skoly Zemedelske V. Praze Provozne Ekonomicke Fakulty V Ceskych Budejovicich. Biologicka, 12(2): 1-15,

Gupta, A., Lal, S.S.(1989). Response of Summer Bl.gr to date of sowing and seed rate. Indian Journal of Agronomy, 34(2): 197-199.

Hayes, J.D.(1971). In: Annu. Rep. Welsh Pl. Breed. Stn. for 1970, pp. 323.

Hesketh, J.D., Myhre, D.L. and Willey, C.R.(1973). Temperature control of time intervals between vegetative and reproroductive events in soybeans. Crop Sci., 13: 250-254.

Huxley, P.A. and Summerfield, R.J.(1976). Effect of day length and day/night temperatures on growth and seed yield of cowpea cv. 2809 grown in controlled environments. Ann. appl. Biol.,. 83: 259-271.

Huxley, P.A., Summerfield, R.J. and Hughes, A.P.(1976). Growth and development of soybean cv. TK 5 as affected by tropical day lengths, day/night temperature and nitrogen nutrition. Ann. of Applied Bology, 82: 117-133.

Jain, H.K.(1975a). Breeding for yield and other attributes in grain legumes. Indian J. Genet. Pl. Breed., 35: 169-187.

Johnston, T.J., Pendleton, J.W., Peters, D.B. and Hicks, D.R.(1969). Influence of supplemental light on apparent photosynthesis, yield and yield components of soybeans (Glycine max L.) Crop Sci., 9: 577-581.

Kakde, J.R.(1985). Agricultural Climatology. Metropolitan Book Co. Pvt. Ltd., New Delhi, India.

Kaul, J.N., Singh, K.B., and Sekhon, H.S.(1976). The amount of flower shedding in some kharif pulses. J. Agric. Sci., 86: 219.

Kay, D.E.(1979). Mungbean (Vigna radiata). In food legumes, 273-292. Crop and Crop product Digest No.3., Tropical Products Institute, London.

Khalil, S.K.(1989). Response of Mungbean cultivars to different planting dates. Sarhad Journl of Agril., 5(6): 555-560.

Kler, D.S., Sarbjeet Singh, Dhingr, K.K.(1991). Studies on bidirectional narrow row spacing, seeding date and date of sowing on grain yield of mungbean varieties. Environment and Ecology, 9(4): 934-938, PAU.

Kolarih, J., Marek, V. and Hrubyy, Z.(1980). On seed quality in soybean (Glycine max (L.). The effect of climatic factors on the content of the main nutrients. Rostlinna Vyroba. 26(10): 1103-1114.

Koller, H.R., Nyquist, W.E., and Chorush, I.S. (1970). Growth analysis of the soybean community. Crop Sci., 10: 407-412.

Kramer, P.J.(1969). Plant and Soil Water relationships: Modern Synthesis. McGraw Hill Book Co., New York.

Kuo, C.G., Wang, L.J., Chang, A.C., and Chou, M.H.(1977). Physiological basis for mungbean yield improvement. Proceedings of Int. Mungbean Symp., Philippines, pp. 205-209.

Laohasiriwong, S.(1985). Yield response of selected soybean cultivars to water stress during different reproductive growth periods. In soybean in tropical and sub-tropical cropping system (edited by Shannugasundaram, S.; Sulzberyer, E.W. and Mclean, B.J.). Shanhua, Jiwan. Asian Vegetable Research and Development Centre, 383-386.

Pandey, R.K., Saxena, M.C. and Singh, V.B.(1978). Growth analysis of urdbean (Vigna mungo L.) genotypes under humid tropical conditions of Pantnagar. Legume Res., (2): 59-63.

Panse, V.S. and Sukhatme, P.V.(1985). Statistical methods for Agricultural workers, published by ICAR, New Delhi.

Patel, D.B., Purohit, K.R., Shah, R.R.(1992). Physiological analysis of yield variation in mungbean (Vigna radiata). J. of Agronomy and Crop Science, 168(2): 182-192.

Poehlman, D.K. and Tripathi, R.S.(1984). Effect of soil moisture stress during different growth stges on field grown soybean (Glycine max (L.). Indian Journal of Agronomy, 29(4): 559-560.

Pookpakdi, A., Patradilok, H.(1993). Response of genotypes of mungbean and Blackgram to planting dates and plant population densities.Kasetstart J. Ntural Sci., 27(4): 395-400.

Prisco, J.T., and O'Leary, J.W.(1973). The effects of humidity and cytokinin on growth and water relatins of salt stressed bean plants. Plant and Soil.

Puech, J., Lencrerot, P. and Hernandez, M.(1974). Role of some environmental factors in the quantitative and qualitative yield of soybean. Annals Agronomiques, 25(5): 659-679.

Rachie, K.O. and Roberts, L.M.(1974). Grain Legumes of the lowland tropics.Advances in Agronomy, 26: 1-132.

Rahman, A.R.M.S.(1982). Correlation and path-coefficient studies in some quantitative characters of mungbean (Phaseolus aureus Roxb.). Proceedings of 6-7th Annual Conference of Bangladesh Association for Advancement of Science, 7-11 Feb., 1982, BARI, Joyedebpur, Dhaka.

Ramaswami, P.P. and Oblisami, G.(1984). Influence of duration of blackgram (Vigna mungo(L.) Hepper) on the harvest index among the different genotypes. Madras Agric. J., 71(4): 246-248.

Rana, K.S., Singh, B.N. (1992). Effect of planting dates on the yield and yield attributes of mungbean and urdbean. Crop Research (Hissar), 5(1): 154-156.

Ranga Reddy, S. and Krishnalal, V.V. (1978). Study of yield components and their inter-relationships in Blackgram. Andhra Agric. J., 25(3 & 4): 77-81.

Renganayaki, K. and Sreerengasamy, S.R.(1993). Path coefficient analysis in blackgram. Madras Agric. J., 79(1): 634-639.

Runge, E.C.A and Odell, R.T.(1960). The relation between precipitation temperature and the yield of soybeans of the Agronomy South Farm, Urban, Illinois, Agron.J.,52: 245-247.

Saharia, P.(1981). Effect of sowing date and row spacing on growth and grain yield of greengram. J. of Research, Assam Agril. University, 2(2): 193-195.

Saharia, P.(1985). Response of Gr. gram to sowing dates under rainfed conditions. Indian Journ. of Agr., 30(3):

Sale, P.J.M.(1970). Growth and Flowering of Cocao under controlled atmospherc relative humidities. J. hort. Sci., 45: 119-32.

Sandhu, T.S., Bhuller, B.S., Cheema, H.S. and Brar, J.S.(1980). Path coefficient analysis for grain yield and its attribute in greengram. Indian J. of Agric. Sci., 50(7): 541-544.

Sarbabole, E., Promkum, W. and Lairungrlang, C. (1990). Planting dates affect rate and duration of seed filling of mungbean (V. radiata). Proceedings of the mungbean meeting; Chaing Mai, Thailand.

Sato, K.(1979). The growth response of soybean to photoperiod and temperature 3. The effect of photoperiod and temperature on the deveelopment and anatomy of photosynthetic organ. Japanese J: Crop Sci., 48(1): 66-74.

Seddigh, M.(1983). Yield and Physiological Response of field grown soybeans to elevated night temperatures. Dissertation Abstracts International, 44(6): 1669.

Sekhon, H.S., Gill, A.S., Singh Griqbal, Singh, D.(1993). Effect of date of sowing and seed rate on Summer blackgram. Indian J. of Agril., 38(2): 315-316.

Shamsugyaman, K.M., Khan, M.H.R. and Sahaikh, M.A.Q.(1982). Genetic variability and character association in mungbean. Proceedings of 6-7th Annual Conference of Bangladesh Assocition for Advancement of Science, 7-11 Feb., 1982, BARI, Joyedebpur, Dhaka.

Shanmugam, A.S., Rathnaswamy, R., Sree Rangasamy, S.R. and Srinivàsan, P.S.(1984). Indian J. Agric. Sci., 54(12): 1081-3.

Sharma, M.L., Bharadwaj, G.C., Chauhan, Y.S., Sharma, S.D., Sharma, M.S.(1989). Response of greengram to sowing dates under rainfed conditions. Indian J. Agr., 34(2): 252-254.

Shibles, R.M. and Weber, C.R.(1966). Interception of solar radiation and dry matter production by various soybean planting patterns, Crop Sci., 6: 55-59.

Sichkar, V.I. and Khangil Din, V.V.(1983). Soybean response to short photoperiod. Sel. skokhozyaistvennaya Biologia, No.5: 6468.

Singh, B.G. and Singh, J.N.(1981). Path coefficient analysis of the association of physiological traits with grain yield in mungbean. Pulse crops News letter, 1(4): 15-16.

Singh, B.G. and Singh, J.N. (1982). Effect of seasonal changes on growth parameters of greengram (Vigna radiata (L.) Wilczek. Indian J. Plant Physiol., Vol.XXV, No.4, pp. 382-389.

Singh, H.P. and Saxena, M.C.(1981). Effect of dte of planting on the time of flowering in greengram, blackgram, cowpea and pigeonpea. Indian J. gric. Sci., 15(1): 33-7.

Singh, R.C., Singh, M., Dahiya, D.R., Phogat, S.R. (1986). Effect of dates of sowing and seed rate on summer season urdbean. Indian Journal of Agronomy, 31(2): 188-189.

Sinha, S.K.(1977). Food legumes: distribution, adaptability and biology of yield. FAO plant production and protection pap. 3. FAO, Rome, 124p.

Stoughton, R.H.(1955). Light and plant growth. J. Royal Hort. Soc., 80: 454-66.

Stoy, V.(1963). Some plant physiological aspects of breeding of high yielding varieties, pp. 264-75. In: Recent Plant Breeding Research, Wiley, New York.

Streeter, J.G., Schou, J.B. and Jeffers, D.L.(1975). Probing reproductive potential of soybeans. Ohio Report on Research and Development, 6: 75-7.

Summerfield, R.J., Minchin, F.R., Stewart, K.A. and Ndunguru, B.J. (1978b). Growth, reproductive development and yield of effectively nodulated cowpea plants in contrasting aerial environments. Ann. appl. Biol., 90: 277-191.

Talukdar, P., Hazarika, M.H.(1981). Response of Mungbean (Vigna radiata Wilczek) cultivars to environmental variability. 1. Phenotypic stability for yield and yield attributing characters. J. of Research, Assam Agril. University, 2(1): 6-10.

Thiyagarajan, K. and Rjasekaron, S.(1987). Genotype x Environment interaction for grain yield in cowpea. Madras Agrl. J., 74(1): 15-17.

Thomas, J.F., and Raper, C.D.(1976). Photoperiodic control of seed filling for soybeans. Crop Sci., 16: 667-672.

Thomas, J.F., Raper, C.D.(1981). Day and night temperature influence on carpel initiation and growth in soybean. Botanical Gazette, 142(2): 183-187.

Turk, K.J., Hall, A.E. and Asbell, C.!W.(1980). Drought adaptation of cowpea I. Influence of drought on seed yield. Agron. J., 72: 413-420.

Usha Rani, Y. and Rao, J.S. (1981). Dry matter production and assimilate partitioning in blackgram Vigna mungo (L. Hepper) genotypes. Pulse crop News Letter, 1(4): 28-29.

Vieira, R.F. and Nishihara, M.K.(1992). Performance of cultivars of mungbean in Vicosa, Minas Gerais. Revista Ceres., 39(221): 60-83.

Vijayalakshmi, C., Gopal Krishnan, and Radhakrishnan, S.R.(1993). Influence of genotypic variation of assimilate parttioning and productivity in blackgram. Madras Agril. J. 80(2): 12-16.

Villiers, V.De, Nel, P.C., and Hammes, P.S. (1974). The effect of Temperature on the development and reproduction of dry beans (Phaseolus spp.). Crop Production, 3: 7-11.

Waldia, R.S., Lal, S. and Arora, K. (1980). Association of grain yield and its components in advance generations of urdbean (Vigna mungo (L.) Hepper). Tropical Grain Legume Bulletin, No.17/18: 35-37.

Wein, H.C.(1982). Dry matter production, leaf area development and light interception of cowpea lines with broad and narrow leaflet shape. Crop Sci., 22: 733-737.

Whigham, D.K. (1983). Soybean. Symposium on potential productivity of field crops under different environments. IRRI. Los Banos, Laguna, Philippines, pp. 205.

Whigham, D.K. and Minor, H.C.(1978). Agronomic characteristics and environmental stress. In soybean physiology, Agronomy and utilization, edited by A.G.Norman, Academic Press, New York, pp.78.

Woodward, R.G. and Begg, J.E.(1976). The effect of atmospheric humidity on the yield and quality of soybean. Aust. J. Agric. Res., 27: 501-508.

Yohe, J.M. and Poehlman, J.M. (1975). Regressions, correlations and combining ability in mungbeans (Vigna radiata (L.) Wilczek). Tropical Agriculture, 52(4): 343-352.

Zhang, H.S. and Liu, J.Y. (1983). Studies on relation of leaf area and net assimilation rate to the yield of soybean. Chinese Oil Crops., No.3: 33-37.

APPENDICES

Maximum, minimum and mean temperature (°C) during crop growth period

Date	August Maximum	August Minimum	August Mean	September Maximum	September Minimum	September Mean
1.	32.0	27.7	29.8	31.5	26.0	28.7
2.	29.2	24.5	26.8	32.2	26.4	29.3
3.	30.5	25.2	27.9	30.8	26.6	28.7
4.	30.5	25.5	28.0	31.0	26.0	28.5
5.	33.3	25.8	29.4	32.2	25.0	28.1
6.	34.6	25.5	30.0	32.0	26.6	28.8
7.	33.4	26.0	29.7	33.1	25.0	29.4
8.	29.7	24.6	27.2	34.0	25.8	29.9
9.	28.8	25.0	26.9	34.6	26.0	30.3
10.	32.2	25.5	29.0	33.0	25.2	29.1
11.	32.4	26.5	29.4	33.6	24.6	29.1
12.	31.3	25.6	28.4	32.0	25.0	28.5
13.	34.2	25.2	29.7	30.5	23.6	27.5
14.	34.3	25.3	29.8	33.0	25.6	29.3
15.	32.0	25.5	28.7	33.3	25.8	29.5
16.	34.2	24.0	29.1	32.5	26.0	29.2
17.	32.4	24.0	28.2	31.6	24.0	27.8
18.	33.0	25.8	29.4	32.0	25.6	28.8
19.	32.5	26.8	29.6	32.2	25.8	29.0
20.	32.4	26.6	29.5	33.0	26.2	29.1
21.	32.5	25.5	29.	32.8	27.0	29.9
22.	31.6	27.0	29.3	32.6	27.0	29.8
23.	32.5	26.0	29.2	32.2	25.2	28.7
14.	32.8	26.4	29.6	32.8	26.0	29.4
25.	34.0	25.0	29.5	23.0	26.2	29.6
26.	33.0	25.3	29.1	30.7	24.8	27.8
27.	33.5	26.0	29.7	28.7	23.5	26.2
28.	33.6	26.6	30.1	26.7	24.5	25.6
29.	32.5	26.3	29.4	27.8	24.2	26.0
30.	32.5	26.0	29.2	31.5	24.6	28.0
31.	32.0	26.0	29.0	-	-	-
Total	1003.4	796.6	999.6	956.6	764.1	859.5
Mean	32.4	25.7	29.0	31.9	25.5	28.7

APPENDIX-II

Bright Sunshine hours during crop growth period

Date	August	September	October	November
1	0.9	5.6	7.7	7.8
2	0.7	0.0	8.8	7.9
3	0.2	2.4	4.7	10.1
4	8.5	0.0	8.8	10.0
5	10.4	1.3	9.3	10.0
6	4.7	4.6	7.4	9.8
7	0.0	4.7	3.1	7.9
8	0.0	7.4	0.0	0.5
9	6.3	5.8	0.0	0.5
10	5.1	5.9	3.6	9.9
11	4.5	5.4	5.4	10.5
12	7.2	1.8	3.5	9.7
13	6.5	10.1	5.5	9.2
14	7.5	9.8	7.8	9.5
15	7.7	7.0	6.6	9.4
16	0.7	0.0	0.2	5.4
17	3.8	3.1	7.4	6.9
18	3.8	8.0	7.7	1.6
19	2.9	6.5	7.6	8.1
20	0.0	7.3	5.2	9.8
21	0.0	7.1	7.3	9.7
22	3.1	2.9	4.4	9.1
23	4.5	5.2	9.1	3.3
24	5.4	6.0	10.1	0.0
25	7.6	2.6	10.4	9.5
26	10.5	0.0	10.6	8.8
27	7.7	0.0	10.2	9.7
28	7.5	0.0	10.4	9.7
29	8.9	8.9	9.6	9.7
30	9.7	8.3	0.0	9.5
31	4.8	-	1.9	-
Total	148.9	142.7	193.7	235.0
Mean	4.8	4.8	6.2	7.8

Photoperiod during crop growth period

Date	August	September	October	November
1	12.78	12.28	11.73	11.18
2	12.76	12.27	11.72	11.17
3	12.74	12.25	11.68	11.13
4	12.72	12.23	11.67	11.13
5	12.71	12.22	11.65	11.12
6	12.69	12.20	11.63	11.10
7	12.67	12.18	11.62	11.08
8	12.66	12.17	11.62	11.10
9	12.64	12.13	11.58	11.07
10	12.62	12.13	11.57	11.05
11	12.60	12.12	11.55	11.03
12	12.59	12.10	11.53	11.02
13	12.57	12.08	11.52	11.00
14	12.55	12.07	11.50	10.98
15	12.54	12.05	11.48	10.97
16	12.52	12.03	11.47	10.95
17	12.50	12.00	11.45	10.95
18	12.48	11.98	11.43	10.93
19	12.47	11.97	11.42	10.93
20	12.45	11.95	11.40	10.92
21	12.43	11.92	11.38	10.90
22	12.42	11.90	11.37	10.88
23	12.40	11.88	11.33	10.87
24	12.38	11.87	11.32	10.85
25	12.36	11.85	11.30	10.85
26	12.35	11.83	11.28	10.83
27	12.34	11.82	11.27	10.83
28	12.32	11.80	11.25	10.82
29	12.31	11.77	11.23	10.82
30	12.30	11.75	11.22	10.80
31	12.28	-	11.20	-