"PHYSIOLOGICAL ANALYSIS OF GROWTH AND YIELD OF GREEN GRAM (*Vigna radiata* (L.) Wilczek) CULTIVARS"

BY

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B.Sc. (Agri.)

DEPARTMENT OF AGRICULTURAL BOTANY

(**Plant Physiology**)

COLLEGE OF AGRICULTURE, PARBHANI

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PARBHANI 431 402 (M.S.), INDIA

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DISSERTATION

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requirement for the award of the degree of

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PARBHANI 431 402 (M.S.), INDIA

2020

CANDIDATE'S DECLARATION

I hereby declare that the dissertation

or part thereof has not been

previously submitted by

me for a degree of

any University

or Institute

Place: Parbhani **(Mote S. M.)**

Date: 30 / 09/2020 **Reg. No :- 2018A/36M**

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CERTIFICATE-I

This is to certify that dissertation entitled **"PHYSIOLOGICAL ANALYSIS OF GROWTH AND YIELD OF GREEN GRAM (*Vigna radiata* (L.) Wilczek) CULTIVARS"** submitted to Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani in partial fulfillment of the requirement for the award of degree of **MASTER OF SCIENCE (Agriculture)** in the subject of **Agricultural Botany (Plant Physiology)** embodies the result of bonafide research carried out by **Mr. MOTE SUNIL MANIK** under my guidance and supervision and that no part of this dissertation has been submitted for any degree or diploma.

The assistance and help received during the course of this investigation have been fully acknowledged.

Place : PARBHANI
Date : 30 / 09/ 2020

(Prof. H. H. BHADARGE)
Research Guide

<u>CERTIFICATE-II</u>

This is to certify that dissertation entitled **"PHYSIOLOGICAL ANALYSIS OF GROWTH AND YIELD OF GREEN GRAM (*Vigna radiata* (L.) Wilczek) CULTIVARS"** submitted by **Mr. SUNIL MANIK MOTE** to the Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani in partial fulfillment of the requirement for the degree of **MASTER OF SCIENCE (Agriculture)** in the subject of **Agricultural Botany (Plant Physiology)** has been approved by the student's advisory committee after oral examination in collaboration with the external examiner.

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"All power is within you,
You can do anything and everything,
Believe in that do not believe that you are weak,
Stand up and express the divinity with you"

- Swami Vivekananda

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Place: Parbhani

Date: 30 / 09 /2020

MOTE. S. M.

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ABBREVIATIONS

Fig.	=	Figure
%	=	Per cent
@	=	at the rate of
a.i	=	active ingradients
g	=	gram(s)
qtl.	=	quintal
viz.,	=	videlicet (namely)
No.	=	Number
N	=	North
SE.	=	Standard error
Lit	=	liter
t	=	tone(s)
/	=	Per
GM	=	Gross mean
CD	=	Critical difference
cm	=	Centimeter(s)
et al.	=	And others
ha	=	Hectare
i.e.	=	That is
kg	=	Kilogram(s)
ha^{-1}	=	per hectare
m	=	Meter
mg	=	Milligram
ml	=	Milliter(s)
mm	=	Millimeter
nm	=	Nano meter
NS	=	Non significant
^{o}C	=	Degree celsius
pp	=	Pages
ppm	=	Parts per million
var.	=	Variety
ug	=	microgram
spp	=	species
cv.	=	cultivar
TNAU	=	Pulse wonder
TOM	=	Total organic matter
LTR	=	Light transmission ratio
LI	=	Light interception
SOD	=	Superoxide Dismutase
BMD	=	biomass duration
$MgSo_4$	=	Magnesium sulfate
$ZnSo_4$	=	Zinc sulfate
NAA	=	Naphthalene acetic acid

IAA	=	Indole acetic acid
EPS	=	Exopolysaccharides
BR	=	Bradyrhizobium
GABA	=	Mixture of GA_3 and ABA
GA_3	=	Gibberellic acid
ABA	=	Abscisic acid
DAS	=	days after sowing
RDF	=	Recommended dose of fertilizer
DM	=	dry matter
TDM	=	Total dry matter
AGR	=	Absolute growth rate
RGR	=	Relative growth rate
NAR	=	Net assimilation ratio
LAI	=	Leaf area index
CGR	=	Crop growth rate

Thesis Abstract

THESIS ABSTRACT

Research topic	:	**"Physiological Analysis of Growth and Yield of Green Gram (*Vigna radiata* L. Wilczek) Cultivars"**
Name of student	:	Mote Sunil Manik
Registration No.	:	2018A/36M
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Major subject	:	Agricultural Botany (Plant Physiology)
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ABSTRACT

The experiment was carried out at Department of Agricultural Botany, VNMKV Parbhani to study the " Physiological Analysis of Growth and Yield of Green Gram (*Vigna radiata* L. Wilczek) Cultivars'' during *kharif* season of 2019-2020. The soil of the experimental field was deep black, well drained, The experiment was laid out in randomized block design with three replications which comprised of Seven varieties *viz;* BM-4, BM-2002-1, BM-2003-2, BPMR-145, PKV AKM-4, PKV Green Gold, VAIBHAV. Sowing was done by dibbling on 03 July, 2019.

From the experimental findings, the variety BM-2003-2 recorded overall better performance over other varieties in respect of growth attributes, yield contributing characters and yield in the given environment. This variety needs to be tested further in future.

Introduction

CHAPTER-I

INTRODUCTION

The word legume is derived from the word ‘lerge’ which means ‘to gather’ because the pods have to be gathered or picked by hands, as distinct from reaping the cereal crops. Pulses, best known as “poor man’s meat”, constitute the major source of dietary protein of the large section of vegetarian population of the world. On an average, pulses contain 20 to 30 per cent protein, which is almost 2.5 to 3.0 times the value normally found in cereals. Besides their high nutritional value, they have a unique characteristic of maintaining and restoring soil fertility through biological nitrogen fixation and thus play a vital role in sustainable agriculture (Asthana, 1998). Pulses occupy 68.32 m. hectares and contribute 57.51 million tonnes to the world food basket (Chaturvedi and Ali 2002). India is the largest producer and consumer of pulses in the world accounting for 33 per cent of world area and 22 per cent of world production. There is big gap between pulses production and requirement of growing population.

The important pulse crops grown in India are Bengal gram, lentil, green gram, black gram, cowpea, red gram, and pea. Among these, green gram (*Vigna radiata* L.) is an ancient and well known leguminous crop of Asia, on account of its nutritional quality and the suitability to cropping system. Green gram is the third most important pulse crop in India covering an area of 3.53 million hectare with a total production of 1.49 mt. and the average productivity of 532 kg/ha (Iranna and Kajjidoni, 2008). Important green gram growing states in India are Orissa, Andhra Pradesh, Maharashtra, Karnataka and Bihar. The area under green gram in Maharashtra is 3.85 lakh ha with production of 0.72 lakh tonnes and productivity of 187 Kg/ha. During 2015-16 (Anonymous 2016). This is less than half of the national productivity there by indicating the scope to improve its productivity potential.

The mung bean (*Vigna radiata* (L.) Wilczek, Syn, *Phaseolus aurius* Roxb., *Phaseolus radiata* (L.) is one of the thirteen food legumes grown in India and third most important pulse crop of India after chickpea and pigeonpea. Mung bean has many common names *viz.*, mung, mooong, mungo, greengram, goldengram, Chickasaw pea and oreganpea. In India, the name greengram is more commonly used than mungbean. The mungbean is native to India-Burma region of South-East Asia. It is cultivated extensively in the India-Burma-Thailand regions of Asia.

Mung bean has a tremendous potential for horizontal expansion. The crop is not only ideal for catch cropping but also serve as a excellent cover crop to protect soil erosion and also as a green manure crop to maintain the soil fertility. The crop being leguminous one, it fixes the atmospheric nitrogen with the help of Rhizobia and helps to maintain soil fertility.

Apart from soil fertility improvement, mungbean serves as a source of protein to vegetarian people of India. Amongst the pulses, mungbean ranks second in the nutritive value.

Approximate food values in whole seed and *dhal* of green gram.

Sr. No.	**Content**	**Whole seed**	***Dhal***
1.	Moisture %	10.4	10.1
2.	Protein %	24.00	24.5
3.	Fat %	1.3	1.2
4.	Mineral %	3.5	3.5
5.	Fibre %	4.1	0.8
6.	Carbohydrate %	56.7	59.9
7.	Ash %	3.6	---
8.	Phosphorus (mg/100g)	326	405
9.	Calcium (mg/100g)	124	75
10.	Iron (mg/100g)	7.3	8.5
11.	Vitamin A (I.U.)	158	83
12.	Calories	334	451

India is the largest producer and consumer of pulses in the world accounting for 33 per cent of world's area and 22 per cent of world's production of pulses. Production of pulses in India is around 13.60 million tonnes (Source: Government of India-2016). In India, mung bean is grown on an area of 34.4 lakh ha, with a production of 14 lakh million tones and average productivity of 406 kg/ha. The major mung bean producing states in India are Andhra Pradesh, Orissa, Maharashtra, Madhya Pradesh and Rajasthan; accounting for about 70 per cent of total production.

Green gram is one of the important pulse crop in India. It has been reported that green gram has been cultivated in India since ancient times**.** It is believed that green gram is a native of India and Central Asia and grown in these regions since prehistoric times. It is widely cultivated throughout the Asia, including India, Pakistan, Bangladesh, Sri Lanka, Thailand, Laos, Cambodia, Vietnam, Indonesia, Malaysia, South China, and Formosa. In Africa and U.S.A. it is probably recent.

Green gram is a protein rich staple food. It contains about 24 percent protein, which is almost three times that of cereals. It supplies protein requirement of vegetarian population of the country. It is consumed in the form of split pulse as well as whole pulse, which is an essential supplement of cereal based diet. The mung dal Khichdi is recommended to the ill or aged person as it is easily digestible and considered as complete diet with roti.

Mung dal and Mung dal chawal is an important ingredient in the average Indian diet. The biological value improves greatly, when wheat or rice is combined with green gram because of the complementary relationship of the essential amino acids. It is particularly rich in Leucine, Phenylalanine, Lysine, Valine, Isoleucine, etc.

In addition to being an important source of human food and animal feed, green gram also plays an important role in sustaining soil fertility by improving soil physical properties and fixing atmospheric nitrogen. It is a drought resistant crop and suitable for dry land farming and predominantly used as an intercrop with other crops.

Marathwada region of Maharashtra state is known for the cultivation of *Kharif* pulses particularly red gram, green gram and black gram.

The efforts are being made to boost the yield of pulses by using the different technology like release of new varieties, fertilizer application, cultivation practices and pest management etc, even though yield level is not increased upto expectation. In analysis studies, it is observed that yield fluctuation is due to late sowing, poor management and unstable prices also. The crop is mainly grown under rainfed conditions, and sowing is completely depending upon onset of monsoon. The late sown crop always yields less than the early sown crop.

Therefore, it is felt necessary to study growth and development performance of different varieties under rainfed conditions and find out a suitable variety which gives more yields. Hence the present experiment is planned namely "**Physiological Analysis of Growth and Yield of Green gram (*Vigna radiata* L. Wilczek) Cultivars" with following objectives**

Objectives:

1. To study the varietal differences in growth, development and yield
2. To study the physiological basis for yield differences among the Green gram varieties
3. To study the accumulation of dry matter among different plant parts.

Review of Literature

CHAPTER II

REVIEW OF LITERATURE

The investigation was concerned with different aspects of growth and yield in Green gram (*Vigna radiata* L. Wilczek) varieties. Research work pertaining to following aspects is reviewed and presented.

2.1) Vegetative growth.

2.2) Dry matter production.

2.3) Physiological growth parameters.

2.4) Yield and yield components.

2.5) Leaf area.

2.6) Chemical analysis.

2.6.1) Chlorophyll content

2.6.2) Protein content

2.7) Correlation studies

2.1. Vegetative growth

Giriraj (1973) studied 55 varieties of green gram at College Farm at Dharwad, for plant height, days to flower, pod length and concluded that a wide range of genetic variability existed in these characters.

Singh *et al.* (1985) studied the four varieties of green gram in summer and *Kharif* season and observed that the values of AGR, RGR, LAI, leaf: height ratio and harvest index were higher in all the cultivars and yield was 50-80 per cent higher in the summer than in the *Kharif* season.

Patil and Deshmukh (1989) conducted experiment and observed the varietal differences for plant height, number of leaves, leaf area, dry matter, and number of pods per plant, number of grains per pod, 1000 grain weight and yield in black gram.

Reddy *et al.* (1991) studied the growth and yield analysis in urd genotypes for *kharif* season and reported that, there were variation amongst the genotypes of plant height, number of pods, leaf area, dry matter accumulation in different plant parts and yield. The maximum grain yield was obtained by regular sowing *i.e.* of *Kharif* as compare to other sowing. The yield was drastically reduced when sowing was delayed beyond 15th July.

Ashraf and Karim (1993) screened the urd cultivars for drought resistance and drought susceptibility and reported that, drought resistant cultivars have the marked ability of osmotic adjustment, greater biomass accumulation, leaf hairyness etc. as compared to drought susceptible cultivars.

Vijaykumar *et al.* (1995) studied the adaptability of urd mutant along with the check T-9 and observed that, the mutant was found resistant to yellow mosaic and it has wide adoptability to various climatic regions such as south-central and north Himalaya zone of India. The performance was better than that of T-9 at all the centers.

Hasan *et al.* (1996) studied varietal differences in black gram for its morphological, physiological characters and yield related traits and reported that, there was a variation amongst the genotypes for its morphological phenological and yield attributing characters like number of pods, 1000 seed weight, grain size etc.

Yadahalli *et al.* (2006) conducted experiment and reported that higher seed yield of TAU-1 over other genotypes is attributed to higher values of yield components *viz.* seed weight plant^{-1} and 1000 seed weight. The higher values of growth components such as plant height, number of branches, leaf area, leaf area index and total dry matter production were recorded in genotype K-3 compared to other two genotypes of black gram.

Baskaran *et al.* (2009) studied effect of effluent content of sugar mills and reported that in green gram all morphological growth parameters, biochemical contents, enzyme activities and yield parameters were found to increase at 10% effluent concentration and it decreased from 25% effluent concentration onwards. So, these results indicate that the sugar mill effluent is toxic to crop.

Marimuthu and Surendran (2015) found that the application of 100% recommended dose of NPK + DAP 2% + TNAU (pulse wonder) 5.0 Kg ha^{-1} was statistically significant and recorded higher plant growth (37.62 cm), number of pods plant^{-1} (37.15), yield of black gram (1162 Kg ha^{-1}), and benefit cost ratio (2.98) over the other treatments. The lowest black gram yield (730 Kg ha^{-1}) was recorded for control.

Hariharasudhan and Kalaiarasu (2015) reported that the inoculation of BGR (black gram rhizobia) of varitey CN-6M to black gram in acid soil significantly increased the growth parameters such as plant height and dry matter production and yield parameters such as number of branches plant^{-1}, number of pods plant^{-1}, number of clusters plant^{-1}, test weight and grain yield at all levels of N tested.

Lolesh *et al.* (2018) Conducted experiment during *Kharif* and summer seasons of 2013-14 and 2014-15 with twenty genotypes of greengram. They found mean monthly soil moisture content was 23.46 per cent for *kharif* season and 12.95 per cent for summer season. Significant variations in morpho-physiological, biochemical attributes and seed yield were recorded in all the genotypes. The genotype Pusa Baisakhi showed the highest value for leaf area per plant, in vivo leaf nitrate reductase activity, leaf photosynthetic rate, total dry matter content per plant and number of pods per plant.

2.2 Dry matter production

Pawar and Bhatia (1980) studied eight mung cultivars for its morphological and physiological characters and observed that, there were differences amongst the cultivars for its dry matter accumulation. The high dry matter accumulation was more advantageous in short duration varieties for high yield.

Reddy *et al.* (1991) conducted experiment for the growth and yield analysis in urd genotypes for *Kharif* season and reported that, there was variation amongst the genotypes in plant height, number of pods, leaf area, dry matter accumulation in different plant parts and yield etc. The maximum grain yield was obtained by regular sowing *i.e*. of *Kharif* as compared to other sowing. The yield was drastically reduced by sowing was delayed beyond 15th July.

Rahman *et al.* (1993) evaluated black gram varieties for total dry matter (TDM) accumulation and distribution of TOM (total organic matter) in different plant components, seed yield and yield components of black gram. Genotypes differed significantly in plant height, grain yield and mean seed size. Genotypes with higher number of pods per plant produced higher yields. Leaf area index, crop growth rate and total dry matter production were positively correlated with grain yield.

Parbahar and Ganapathy (1996) reported that, in black gram number of primary branches, number of pods, total dry matter production was positively correlated with yield. The genotypes having the capacity to produce maximum dry matter and the capacity to translocation it towards sink found high yielders.

Chowdhury *et al.* (2000) observed total dry matter production prior to and at flowering was about 20 and 50% of total dry matter at maturity. Dry matter accumulation after flowering greatly influenced seed yield, as most of the photosynthetate produced at this stage is used for pod and seed development. Seeds contributed the majority of dry matter content at harvest.

Karim *et al*. (2001) stated that at maturity the rank of biomass accumulation (at 100 mm NaCl) in different plant parts of black gram was in decreasing order by seeds per pod (97%), branch per plant (88%), 1000-grain weight (79%), plant height (72%), pods per plant (50%), leaf weight and root mass(both 49%) and stem weight (48%). In mung bean, the rank was decreasing order by 1000-grain weight (57%), leaf weight (54%), plant height (52%), seeds per pod (50%), and branch plant (41%), root weight (34%), stem weight (24%) and pods per plant (6%). Therefore, salinity reduced grain yield more than straw and roots of the *Vigna spp*., and black gram is relatively more salt-tolerant than mungbean.

Abraham and Lal (2004) conducted experiment and concluded that the effect of fertilizer levels, organic manures and biofertilizer along with organic spray on the yield of black gram under black gram – wheat – green gram system. Plant dry weight values showed no significant difference between one hundred per cent and 33% RDF (recommended dose of fertilizer) levels.

Kulsum *et al.* (2007) evaluated varieties for the dry matter accumulation in different organs of plant which was maximum with 80 Kg N $ha^{-1.}$The dry matter accumulation in different vegetative organs continued to increase until pod filling stage and then declined gradually contrary, the dry matter accumulation in reproductive organ increased up to maturity. Light Transmission ratio (LTR) was decreased while light interception (LI) increased with the increasing level of nitrogen as well as with the plant ontogeny in black gram.

Hossain *et al.* (2009) conducted experiment and observed the treatments which gave a mean value of plant dry mass of 38510 mg and 45530 mg under low N and high N level, respectively. Hence an increased nitrogen supply induced an increase in dry matter production by some 18 per cent that corresponds to the generally positive effects of this nutrient in mung bean.

Nayak *et al.* (2014) conducted the field experiment during *kharif* season of 2012 on PG research farm, department of Agronomy, College of Agriculture, VNMKV, Parbhani. It was observed from investigation, that the plant spacing 30 x10 cm with variety BDU-1 was found be significantly superior over rest of the plant spacing and varieties in respect to plant height (cm), number of leaves, leaf area (cm), mean dry matter production, number of branches per plant, leaf area index, biological yield (Kg/ha), and seed yield (Kg/ha) in black gram.

Dry matter studies

The production of dry matter and its conversion into economic yield is the cumulative results of various physiological and biochemical events occuring in the lifecycle of plant system. Dry matter accumulation can be said as balance between anabolic and catabolic processes. The growth of the plant and development is very complex process principally under the control of genetic and environmental factors.

2.4.1 Dry matter accumulation in vegetative plant parts

Augustinussen (1973) conducted experiment and observed that production of dry matter in field bean and revealed that both stem and leaves reached their maximum dry matter production shortly after pod formation begin and quantity of dry matter was highest just before crop maturity.

Jagmohanrao and Singh (1985) observed that the dry weight of stem and root increased continuously and there was not much increase in the dry weight of these parts at the final stage of crop growth during both *kharif* and summer seasons. In contrast the leaf dry weight continued to increase upto 45 days after sowing and thereafter showed decreasing trend in both the seasons due to contribution to the developing pods and also leaf fall in mungbean.

Thandapani and Rao (1986) revealed that dry matter production of stem was 14 higher upto the vegetative stage of the crop in the high yielding varieties while lower in medium and low yielder varieties in mungbean.

2.4.2 Dry matter accumulated in reproductive plant parts

Jagmohan Rao and Singh (1985) observed in mung bean pod dry weight went on increasing from 45 days onwards till the maturity. The result was also indicated that for an every unit of increase in dry weight there was proportionate increase in seed yield.

Natarajan and Palanisamy (1988) conducted experiment and concluded that maintaining fairly high total dry matter with stimulus enhancement of harvest index may contributes to increase seed yield in mungbean. Total dry matter and its relation to yield the higher dry matter accumulation and higher partioning of dry matter are to be mobilized into economic sink for further selections and improvement in mungbean

Jagamohan Rao and Singh (1985) observed that total dry weight of all cultivar of mung viz., PBM-144--127, PS—18 and PISM-3 continued to increase throughout the growth period being more in summer than in *kharif* grown mung bean and also observed that for an every unit of increase in plant dry weight, there was proportionate increase in seed yield.

Natarajan and Palanisamy (1988) conducted experiment and concluded that, maintaining fairly higher total dry matter production with stimulus enhancement of harvest index may contribute to increased seed yield in mungbean.

Vijay lakshmi *et al*. (1993) observed dry matter yield which was related mainly to growth achieved by 45 days after sowing and the subsequent rate of leaf production.

Singh and Malhotra (1970) observed in mungbean seed yield had positive association with branches per plant, pods per plant, seeds per plant and pod length.

2.3 Physiological growth parameters

Balkrishna *et al.* (1982) studied the growth parameters *i.e*. LAI, NAR and CGR in black gram and reported that, CGR and LAI were highest at first flowering and at 50 days stage of crop growth, the NAR declined from 50 days to harvest

Sarma and Sarma (1993) conducted experiment and observed fifteen soybean cultivars under *rainfed* condition, the result showed that leaves per plant, plant height, crop growth rate, leaf area and leaf area index had the strongest positive correlation with seed yield.

Biswas *et al.* (2002) conducted experiment and observed that the black gram two varieties *i.e*. BARI mash 3 and BIN Amash 1 showed identical results in LAI, CGR, NAR, RGR as well as grain yield**.** But planting density had significant effects on LAI and CGR of the black gram varieties. The highest planting density showed the highest LAI and CGR but the highest grain yield was recorded from intermediate population density due to the highest number of pods per unit area. The NAR and RGR did not differ due to different population densities.

Patil and Salimath (2003) observed that significant genotypic differences were for all the physiological traits *viz*., TDM at 25,45 and 75 DAS, CGR 25- 45 and 45- 75DAS, BMD (biomass duration) 25- 45 and 45- 75 DAS, RGR 25-45 and 45-75 DAS, LAI at 25 and 45 DAS and harvest index. High

GCV and PCV estimates were found for CGR 45-75 DAS, LAI at 25 and 45 DAS, CGR 25-45 DAS, BMD 25-45and TDM at 45 DAS. High heritability estimate was observed for LAI at 45 DAS.BMD 45-75 DAS, LAI at 25 DAS, TDM at 75 DAS and CGR 45-75 DAS. Significant correlation of CGR 45-75 DAS, TDM at 75 DAS, BMD 45-75 DAS and RGR45-75 DAS with yield was noticed. Post flowering growth parameters appeared to be important for realizing higher productivity in black gram.

Baskaran *et al.* (2009) examined in green gram that all morphological growth parameters, biochemical contents, enzyme activities and yield parameters were found to increase at 10% effluent concentration and it decreased from 25% effluent concentration onwards. So, these results reflect that the sugar mill effluent is toxic to crop and it can be used for irrigation purpose after a proper treatment with appropriate dilutions.

Rathore *et al.* (2010) found that 20 Kg seed per ha recorded significantly higher grain and straw yield in black gram, while all growth characters (except plant height) and all yield attributing traits were higher with 10 Kg seed/ha. Application of 75% RDF recorded significantly higher seed and straw yield than 50% RDF. The other yield attributes like pod length; seeds per pod and seed index remained unaffected due to fertilizer doses.

Ali *et al.* (2013) conducted experiment and observed comparison of yield performance of soybean varieties under semi arid condition and concluded that soybean varieties PSC-60 showed best performance as it gave significantly higher plant height, biomass, seed yield, seed per pod, and seeds per plants.

Patil *et al.*(2015) conducted experiment and results revealed that plant height, number of branches, total dry matter (TDM) were significantly increased by the application of $MnSO_4$ (0.3%) followed by $MgSO_4$ (0.5%). The growth parameters *viz*., LAI, LAD, Significantly increased with the application of $MnSO_4$ (0.3%) in black gram whose influence on dry matter content seemed to be larger during both *kharif* and summer season. Further it was observed that increase in (AGP) upto pod filling and maturity stage respectively in *kharif* and summer.

Kulubarme and Pandey (1979) reported that in mungbean absolute growth rate (AGR) was very slow during early vegetative phase 18-21 days after planting and increased with advancement in the growth period. Pusa baishakhi and S-8 attain maximum (AGR) at 49-60 days after sowing.

2.2.2 Relative growth rate (RGR)

Singh and Singh (1996) observed positive inter-relations among RGR, LAD, NAR and TDM which was the indication of combined effects of growth, assimilation and dry matter towards increasing seed yield in mung bean. In mung bean Singh *and* Hiremath (1990) reported that CGR, RGR and LAI increased by applying 20 or 50 kg P2O5 per hectare.

2.2.3 Net assimilation rate (NAR)

Kulubarme and Pandey (1979) conducted experiment and observed in mung bean maximum NAR was observed at 28-35 days after sowing in most, of the varieties and latter on it is steady decline and increase sharp at 49-60 days after sowing in mungbean.

2.4. Yield and yield components

Ali and Meena (1986) conducted a field experiment at Kanpur (U.P.) on different genotypes of mung bean and revealed that variety PPM-11 gave significantly higher yield (1528 kg ha"1) and pods plant"1 (25.9) followed by PS-16 (1075 kg ha"1 and 20.1), T-44 (1072 kg ha"1 and 15.9) and K-851 (940 kg ha1 11.3), respectively.

2.5 **Yield components and yield contributing characters**

Grain yield is determined by several components. It is therefore, essential to assess the relative importance of yield components, some of the growth characters and their inter relationship with yield.

Singh and Malhotra (1970) reported that in mungbean seed yield had positive association with branches per plant, pods per plant, seeds per plant and pod length.

Sandhu *et al.* (1980) observed in mungbean that pod per plant, seeds per pod and 100 grain weight were the important factors for improving the yield.

Khan and Stoffella (1985) conducted experiment and concluded that, in cowpea pod number per plant was the single component most strongly and consistantly related to seed yield. While seeds per pod and seed size provided little additional indication of crop yield.

Yadav *et al.* (1979) reported that in mungbean yield was positively associated with NAR at post flowering stage and LAR at pre flowering stage.

Pati1 and Deshmukh (1989) reported that in black gram, grain yield was significantly correlated with plant height, pods per plant, grains per pod, pods length and 100 grain weight. while days to flower and days to maturity were negatively related with grain yield. The pods per plant had maximum positive effect on grain yield.

Singh and Singh (1996) observed positive interrelations among PGR, LAD, NAR, TDM which was the indication of combined effects of growth assimilation and dry matter towards increasing seed yield in mungbean.

Reddy *et al*. (1991) studied the growth and yield analysis in urd genotypes for *Kharif* season and reported that, there was variation amongst the genotypes in plant height, number of pods, leaf area, dry matter accumulation in different plant parts and yield etc. The maximum grain yield was obtained by regular sowing *i.e*. of *Kharif* as compared to other sowing. The yield was drastically reduced when the sowing was delayed beyond 15th July.

Singh *et al.* (1992) studied physiological parameters and yield attributing characters in urd genotypes and reported that, at flowering stage high AGR, RGR and LAI was positively associated with seed yield and vice-versa

Hudge *et al*. (1993) observed in black gram that, the reduction in light intensity increased the leaf area of plants on 50th and 70th day. In general, there is reduction in number of pods per plants, number of seeds per plant and grain yield per plant in black gram genotypes which were grown under light stress condition.

Rahman *et al*. (1993) reported that the highest yield was obtained from the black gram genotype MAK which was similar to that of the genotype ISO-LOCAL. The genotype B-23 recorded the lowest yield (480 Kg/ ha).High yielding genotypes produced higher number of pods per plant (r = 0.99). Genotypes did not differ significantly.

Hasan *et al.* (1996) studied the varietal performance in black gram genotypes for its morphological, phenological characters and yield related traits, and observed that, there was variation amongst the genotypes for above characters. The late sown crop was adversely affected for these characters.

Patil *et al.* (1997) compared the morphological and phonological characters of urd bean genotypes and observed that, the characters *viz*. number of pods per plant, number of grains per pod, test weight, dry matter accumulation, leaf area significantly positive correlated with yield. The character *i.e*. days to maturity was not correlated with yield.

Nag *et al*. (1998) reported in black gram that, early sowing influenced the yield attributing characters like number of pods, test weight, number of seeds per plant, grain yield per plant which was resulted in high yield. Whereas, late sown crop adversely affected these yield attributing characters.

Ayyangouda *et al*. (2003) conducted that and concluded that two lines and ten testers with their 20 F1 of green gram were subjected for genetic analysis of different morpho-physiological traits. Selection 4 was good general combiner for most of the traits under study. Among testers, TM 98-50 was good general combiner for seed yield and seed weight. Similar was the response of ML-3 for early flowering, TARM-18 for leaf area and leaf area index, TM 97-55 and TM 97-52 for harvest index traits. Two parents *viz*., M-1 and TARM-12 were good general combiners for biomass duration. The cross selection - 4 x M- 446 was good specific combiner for physiological traits associated with seed yield.

Yadahalli and Palled (2004) revealed that the yield, yield components, nutrient uptake as well as economics were significantly influenced by black gram genotypes and dates of sowing. The phosphorus levels had no significant influence. Black gram genotype, TAU-1 produced significantly higher seed yield (845.41 Kg/ha) over Manikya and K-3, crop sown on 16^{th} June recorded significantly higher seed yield (1068.87 Kg/ha) over other dates of sowing.

Yadahalli *et al*. (2006) found that the higher seed yield of TAU-1 over other genotypes is attributed to higher values of yield components (seed weight $plant^{-1}$ and 1000 seed weight). The higher values of growth components such as plant height, number of branches, leaf area, leaf area index and total dry matter production were recorded in variety K-3 as compared to other two genotypes of black gram.

Pandey and Gupta (2012) observed that the foliar spray of Zn [0.01 and 0.5% zinc sulfate ($ZnSO_4$)] on black gram improved not only the flowering, pollen producing capacity, pollen viability, stigma-receptivity and pollen-stigma interaction but also the yield parameters like number, size and weight of pods and seeds. Foliar application of 0.5% $ZnSO_4$ after bud formation was most beneficial not only for reproductive yield but also seed Zn content.

Narasimhan *et al.* (2013) examined that selection for genotypes with higher plant height, more number of branches, bunches and number of pods could facilitate augmentation of seed yield in urd bean.

Karande *et al.* (2013) observed the mid parent, better parent and standard check parent values for ten yield and yield attributing components in 7 different genotypes of black gram. High hetrotic effects were observed for branches/plant, flowers/plant, pods/plant, seeds/pod, biological yield and seed yield.

Reni *et al.* (2013) found that higher estimates of heritability and genetic advance as percent of men were observed for grain yield (97.0%, 79.93%), pods per plant (91.0%, 65.50% and plant height (78.0%, 31.74%)

indicating that these characters were mainly controlled by additive genes and selection of such traits might be effective for the improvement of grain yield. Pods per plant, 100 seed weight, days to maturity and days to 50% flowering had positive direct effect on grain yield. Pods per plant and plant height had highly significant genotypic and phenotypic correlation with grain yield; hence these traits could be used for the improvement of grain yield resulting in the evolution of high yielding varieties of black gram.

Nayak *et al.* (2015) conducted experiment during *kharif* season of 2012 on PG research farm, department of Agronomy, College of Agriculture, Vasantrao Naik Marathwada Agriculture University Parbhani. It was observed from that investigation, the plant spacing 30 x 10 cm of black gram with variety BDU-1 was found significantly superior over rest of the plant spacing and varieties in respect to pods/plant, seeds/pod, pod weight/plant, yield/plant, test weight, harvest index, seed yield (Kg/ha),gross monetary return, net monetary return Benefit: Cost ratio.

2.5 Leaf area

Vanaja *et al.* (2006) conducted experiment and concluded that the germination percentage, emergence index, germination speed and vigor index were increased with elevated Co_2 under both irrigated and moisture stress conditions. Plants grown with elevated Co_2were taller and attained a greater leaf area along with more biomass than ambient Co_2levels under irrigated and moisture stress conditions at all time intervals. The increase in the germination, larger leaf area and dry matter of root, shoot and leaf proved that Co_2enrichment of the atmosphere will be beneficial for the black gram crops for better establishment and greater productivity.

Khan and Khalil (2010) concluded from the study on mung bean dry matter Production is direct function of the leaf area, which is further affected by priming technique. Greater the leaf area due to priming had developed greater dry matter into plant tissue as a result of vigorous plant growth and photosynthetic ability.

Mondal *et al.* (2011) conducted experiment and found that the maximum crop growth rate (CGR) was observed due to maximum leaf area (LA) development during the pod filling stage in all the genotypes. LA and CGR contributed to the superior TDM production. It appeared that a high yielding mung bean genotype should possess larger LA, high TDM production ability, superior CGR at all the growth stages, high relative growth rate and net assimilation rate at the vegetative stage as superior yield components.

Baroowa and Gogoi (2012) studied the Positive correlations of soil moisture with leaf chlorophyll; chlorophyll stability index, plant height, leaf area; cell membrane stability and yield were obtained while it is found to be negatively correlated with leaf Proline concentration. Black gram variety PU-19 was found to be more resistant than green gram variety Pratap against drought stress.

Nayak et *al.* (2014) conducted field experiment during *Kharif* season of 2012 on PG research farm, department of Agronomy, College of Agriculture, VNMKV, Parbhani. It was observed from the investigation that the plant spacing 30 x 10 cm in black gram with variety BDU-1 was found be significantly superior over rest of the plant spacing and varieties in respect to plant height (cm), number of leaves, leaf area (cm), mean dry matter production, number of braches per plant, leaf area index, biological yield (Kg/ha) and seed yield (Kg/ha).

Usharani *et al.* (2014) found that the isolate BR-3 was selected as an efficient strain based on Indole acetic acid (IAA) production and Exopolysaccharides (EPS) production. Among the five treatments, the treatment T5 which contains BR-3 (Bradyrhizobium) + 75% recommended dosage fertilizer recorded maximum plant height, leaf area index, dry matter production, number of branches per plant and number of pods per plant in black gram.

2.6. Chemical analysis

2.6.1. Chlorophyll content

Patel *et al.* (1998) observed that, chlorophyll content increased until flowering (60 DAS) and there after, it declined. Biomass accumulation in all genotypes increased till harvest. Leaf chlorophyll content and dry matter accumulation were highest in soybean variety cv. JS-75-46.

Djanaguiraman *et al.* (2005) concluded that the leaf leachate application also influenced the metabolism of seedlings *viz.*, chlorophyll a, b and total chlorophyll, soluble protein, proline and phenol content. In general, leaf leachate increased the proline and phenol content, and decreased the chlorophyll and soluble protein contents, in all the test crops over control. Among the parameters studied, proline was found to be associated with higher seedling growth of black gram (94% increase over control) and sorghum (183% increase over control).

Islam *et al.* (2010) conducted experiment and results revealed that GABA (A mixture of GA_3 and ABA) @ 1.0 mg/l significantly increased the plant height, number of branches per plant, number of leaves per plant, total chlorophyll content, number of pods per plant, pod length, number of seeds per pod and seed yield of black gram.

Baroowa and Gogoi (2012) found the Positive correlations of soil moisture with leaf chlorophyll, chlorophyll stability index, plant height, leaf area, cell membrane stability and yield were obtained while it is found to be negatively correlated with leaf Proline concentration. Black gram variety PU-19 was found to be more resistant than green gram variety Pratap against drought stress.

Sritharan *et al.* (2015) conducted experiment and concluded that the foliar spray of 2% urea had the profound effect on black gram in improving the growth attributes, chlorophyll content, soluble protein and nitrate reductase activity. Further foliar spray of 2% urea recorded the highest yield of 900 Kg/ha with a yield increment of 20% over control. The yield enhancement might be due to the improved morpho-physiological traits and yield attributes.

2.6.2. Protein content

Djanaguiraman *et al.* (2005) examined that the leaf leachate application also influenced the metabolism of seedlings *viz.*, chlorophyll a, b and total chlorophyll, soluble protein, Proline and phenol content. In general, leaf leachate increased the Proline and phenol content, and decreased the chlorophyll and soluble protein contents, in all the test crops over control. Among the parameters studied, Proline was found to be associated with higher seedling growth of black gram (94% increases over control) and sorghum (183% increase over control).

Ramesh and Ramprasad (2013)observed that increase in the seed protein content in soybean was also noticed with the application of NAA (20 ppm), brassinosteroid (25 ppm), mepiquat chloride 5%AS (5%) and chlormequat chloride at different concentrations, compared to control and water spray.

Rajesh *et al.* (2014) conducted experiment and found that the morphological traits *viz.*, plant height, number of branches per plant, number of trifoliate per plant and days to 50% flowering and maturity were significantly increased by NAA @ 20 ppm, whereas total dry matter production (TDM) over growth regulator treatments at all stages NAA (20 ppm) and brassinosteroid (20ppm) recorded significantly higher values. Among the quality parameters highest seed protein content (%) and highest nitrogen harvest index values were recorded with growth retarding substance chlormequat chloride (187.5 g a.i ha^{-1}) in green gram.

Sritharan *et al.* (2015) found that the foliar spray of 2% urea had the profound effect on black gram in improving the growth attributes, chlorophyll content, soluble protein and nitrate reductase activity. Further foliar spray of 2% urea recorded the highest yield of 900 Kg/ha with a yield increment of 20% over control. The yield enhancement might be due to the improved morpho-physiological traits and yield attributes.

2.7 Correlation studies.

Rathod *et al.* (1994) observed that, the plant height, number of pods, pod weight and number of clusters crop per plant showed significant positive correlation with seed yield.

Prabahar and Ganapathy (1996) observed in correlation coefficient studies in black gram that, number of primary branches, number of pods, total dry matter production and harvest index were positively correlated with yield.

Patil *et al.* (1997) found that in correlation coefficient studies in black gram that, days to flowering, plant height, number of primary branches, and number of clusters per plant were positively correlated with seed yield per plant.

Singh (1998) observed in black gram that , grain yield was positively correlated with pods per plant, seeds per pod and 1000 seed weight and negatively correlated with days to flowering, days to maturity and plant height.

Shivade *et al.* (2011) observed that thirty six genotypes of black gram were studied in randomized block design with three replications for correlations, and direct and indirect effects for fifteen quantitative characters. The yield contributing characters *viz*., plant height, number of branches per plant, number of clusters per plant, number of pods per plant, number of pods per cluster, length of pod, number of seeds per pod and dry matter per plant had strong positive association with seed yield per plant at both the phenotypic and genotypic level.

Parveen *et al.* (2011) conducted experiment and concluded that correlation coefficient and path analysis studies was conducted with eight parents and their 28 F1 crosses for twelve component characters including seed yield and revealed significant positive association of pods per plant, harvest index and clusters per plant with seed yield in parental generation whereas in F1 generation, significant positive association of clusters per plant, pods per plant, days to maturity, days to 50% flowering, pods per cluster and 100-seed weight with seed yield was observed in black gram.

Bharti *et al.* (2013) found that correlation and path analysis in black gram identified biological yield per plant followed by harvest index, as the direct positive contributors towards seed yield. The number of clusters per plant, number of pods per cluster and seeds per pod *via* biological yield per plant contributed indirectly towards grain yield. But biological yield per plant contributed substantial negative indirect effect on it *via* harvest index and also harvest Index contributed substantial negative indirect effect on it *via* biological yield per plant.

Mathivathana *et al.* (2015) studied sixty five genotypes of urd-bean for correlation and path effects for eleven traits. In that plant height, number of primary per plant, number of clusters per plant, number of pods per cluster, number of pods per plant, number of seeds per pod, 100 seed weight, total dry matter production had significantly positive association with seed yield per plant. These nine traits can be used as a selection index for improving seed yield. Path analysis revealed that dry matter production was the principle component responsible for increasing seed yield in black-gram and it showed high positive direct effect on seed yield.

Kumar *et al*. (2015) found that the branches per plant, pods per plant, seeds per pod, seeds per plant, 100 seed weight, pod weight and harvest index were highly significant and positively correlated with seed yield at both phenotypic and genotypic level in all three seasons and pooled over seasons. However four characters *viz*., seed yield, branches per plant, pods per plant and seeds per pod were highly significantly and positively correlated among themselves revealing their significant influence on seed yield. Selections of these traits are expected to lead positive results in improvement of seed yield in black gram.

Material and Methods

CHAPTER III

MATERIAL AND METHODS

The details of material used and methods adopted for conducting the course of present investigation are presented in this chapter.

3.1. Experimental site and soil

The field experiment was conducted at the Department of Agril.Botany, College of Agriculture, Vasantrao Naik MarathwadaKrishiVidya peeth, Parbhani (M.S.) during *Kharif* 2019-2020.

3.2. Soil

The topography of experimental plot was fairly leveled. The soil was medium black, high in moisture retention, and fairly well drained.

3.3. Climate and weather conditions

3.3.1. Climate

Geographically, Parbhani is situated at 409 m mean sea level on altitude 19^0 16' North latitude and 76^0 47' east longitude and has a subtropical climate. The total precipitation during crop growth is 400 mm with 34 rainy days. The winter rains were low and uncertain. Most of the rainfall is received from south-west monsoon. The precipitation is assured for *Kharif* crops and limited for *Rabi* crops. The mean maximum temperature is 33.09^0C where as mean minimum temperature is 22.08^0C. The mean relative humidity ranges from 71.32 to 42.01 per cent. Thus, Parbhani has dry *summer* and cool winter. However, July, August and September months are humid. The rest of the period of the year is dry. Hence, Parbhani is grouped in assured rainfall zone with *Kharif* cropping pattern.

3.3.2. Weather

The meteorological data for corresponding period of crop season recorded at meteorological observatory, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani are presented in appendix **Table 1**.

Table 1. Weekly weather data for the year 2019- 20 at Parbhani

MW	Period	RF (mm)	Temperature ^{o}C		Humidity (%)		EVP (mm day^{-1})	BSS (Hr.)	W V (Km h^{-1})
			Max.	Min	AM	PM			
13	26-01 April	0.0	41.1	19.9	51	16	11.4	9.3	3.9
14	02-08 April	0.0	40.9	21.3	40	12	12.1	8.6	4.6
15	09-15 April	1.6	42.0	22.2	38	9	11.8	9.6	4.5
16	16-22 April	0.0	39.3	21.4	40	14	9.4	9.3	4.4
17	23-29 April	0.0	43.9	24.5	36	8	13.6	9.3	5.1
18	30-06 May	0.0	41.6	24.2	39	11	13.3	9.8	6.1
19	07-13 May	0.0	41.8	26.1	35	14	13.6	9.7	6.4
20	14-20 May	0.0	42.4	24.8	41	12	13.3	10.3	5.3
21	21-27 May	0.0	44.1	27.1	38	14	14.1	10.3	5.4
22	28-03 June	0.0	43.9	28.7	36	14	14.6	8.6	5.9
23	04-10 June	33.7	40.9	24.8	76	24	8.5	5.9	6.8
24	11-17 June	0.0	39.3	25.2	62	30	10.4	9.8	7.9
25	18-24 June	10.5	35.3	24.7	69	48	8.6	6.4	7.3
26	25-01 July	46.9	33.2	22.7	85	59	4.9	4.8	5.6
27	02-08 July	10.6	33.2	23.1	76	58	5.1	2.7	8.3
28	09-15 July	34.2	33.5	22.6	83	49	5.5	6.7	7.0
29	16-22 July	11.2	34.2	22.9	79	46	6.6	7.7	5.8
30	23-29 July	64.3	30.6	22.6	81	62	4.5	4.1	6.3
31	30-05 Aug	85.4	28.1	21.8	92	85	2.1	1.2	6.6
32	06-12 Aug	62.2	30.5	22.0	89	65	4.0	3.5	6.2
33	13-19 Aug	9.7	32.3	21.5	80	57	4.6	5.4	4.6
34	20-26 Aug	1.2	32.2	22.0	80	56	5.6	6.5	6.0
35	27-02 Sept	78.0	31.2	21.5	88	59	4.6	5.6	4.7
36	03-09 Sep	13.2	30.1	21.6	83	70	2.9	2.0	4.7
37	10-16 Sep	30.0	21.2	88	68	2.8	4.7	5.4	5.4
38	17-23 Sep	118.8	30.9	21.9	94	67	2.3	5.1	3.5
39	24-30 Sep	35.6	31.3	21.1	92	62	3.7	6.5	3.3
40	01-07 Oct.	21.2	31.4	20.5	88	60	3.8	7.3	2.8
41	08-14 Oct.	5.1	31.5	20.1	87	53	4.1	7.0	2.7
42	15-21 Oct.	121.4	30.1	18.6	82	55	3.5	5.9	4.1
43	22-28 Oct.	100.0	29.7	20.6	82	63	2.4	4.3	3.6
44	29-04 Nov.	13.0	30.4	20.7	84	62	3.2	6.9	3.8
45	05-11 Nov.	0.0	31.4	18.4	89	48	3.4	8.6	1.6
46	12-18 Nov.	0.0	30.0	14.7	77	45	3.7	8.3	2.7
47	19-25 Nov.	0.0	30.0	13.2	81	44	3.4	8.5	2.1
48	26-02 Dec.	0.0	30.1	15.4	80	46	3.8	7.9	2.6
49	03-09 Dec.	0.0	28.9	14.8	76.3	46.4	4.2	7.4	3.5
50	10-16 Dec.	0.0	30.0	15.6	86.4	44.3	3.6	7.1	2.5
51	17-23 Dec.	0.0	28.3	14.9	88.3	44.6	3.3	6.1	2.9
52	24-31 Dec.	4.4	26.2	15.2	81.1	49.0	2.7	3.0	4.1
Total/Mean		912	33.9 25	22.8	71.32	42.1 0	6.5	6.81	3.05

The data presented in above table indicated that the average maximum temperature progressively increases with crop life attaining maximum value at the ripening phase (pod development stage).

The average weekly minimum temperature was fluctuating during the season. The mean relative humidity (RH) was decreased progressively with increase in crop life and pan evaporation progressively increased with advancement of crop grown to harvest.

The precipitation received during crop growth period and bright sunshine hours fluctuates slightly from normal. The climate favors for normal growth of crop and may increase its water requirement.

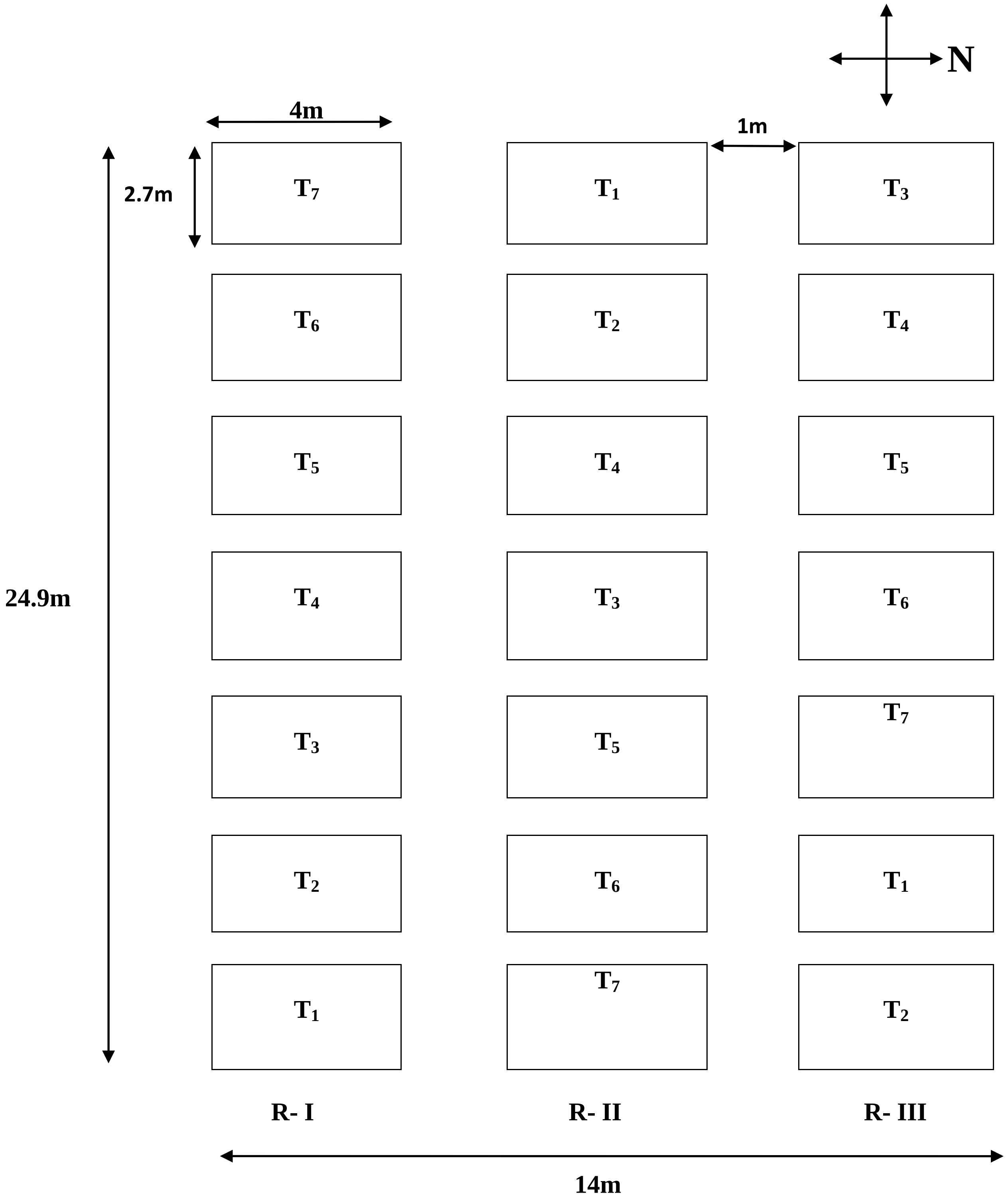
3.4. Experimental details

The details of field experiment were carried out are as follows.

Season	:	*Kharif* (2019-2020)
Experimental design	:	Randomized Block Design (RBD).
Replication	:	3
Crop	:	Green gram
Treatment	:	7
Varieties	:	1) BM-4
	:	2) BM-2002-1
	:	3) BM-2003-2
	:	4) BPMR-145
	:	5) PKV AKM-4
	:	6) PKV Green Gold
	:	7) VAIBHAV
Spacing	:	45 cm x 15 cm.
Plot size	:	2.7 m x 4 m.

3.5. Cultural operation

The details of the preparatory tillage and intercultural operation carried out in the experiment plot are given in **Table 2**.



Design : RBD
Treatment : Seven
Replication : Three
Plots : 21
Net Plot Size : 2.7m x 4m

Varieties: T_1 = BM-4
T_2 = BM-2002-1
T_3 = BM-2003-2
T_4 = BPMR-145
T_5 = PKV AKM-4
T_6 = PKV GREEN GOLD
T_7 = VAIBHAV

Fig.1: Plan of Layout

3.5.1. Preparatory cultivation

An experimental area was ploughed once and harrowed twice to obtain the good tilth. The experimental field was laid out as per the plan of layout. The schedule of cultural operations undertaken is prescribed in **Table 2**.

3.5.2. Fertilizer application

The experimental plots were fertilized with 25 Kg N ha^{-1} and 50 Kg P_2O_5 ha^{-1}, as per the recommendation by using fertilizer *viz.* urea for nitrogen and DAP (Diammonium phosphate) for P_2O_5. Urea and DAP were mixed thoroughly in required proportion and drilled in field before dibbling the seeds.

3.5.3. Seeds and sowing

The seed of green gram varieties namely BM-4, BM-2002-1, BM-2003-2, BPMR-145, PKV AKM-4, PKV Green Gold, and VAIBHAV. was obtained from Agricultural Research Station, Badnapur and sown with spacing row to row 45 cm and plant to plant 15 cm in date 03 July, 2019.

3.5.4. Intercultivation

Two weeding at 20 DAS and 45 DAS were carried out to control weeds and conserve soil moisture.

3.5.5. Gap filling and thinning

Gap filling was done on 8th days after sowing. Thinning was completed by keeping one plant per hill on 15^{th} days after sowing.

Table 2: Date wise schedule of cultural operations carried out in experimental plot.

Sr. No.	Particulars	Frequency	Date of operation
A) Pre sowing cultural operation			
1	Ploughing	1	1-06-2019
2	Harrowing	2	10-06-201918-06-2019
3	Cleaning of field	1	30-06-2019
4	Layout of experiment	1	1-07-2019
6	Fertilizer application	1	03-07-2019
7	Sowing	1	03-07-2019
B) Post sowing cultural operation			
1	Irrigation	2	03-07-2019 18-07-2019
1	Gap filling	1	12-07-2019
2	Thinning	1	19-07-2019
3	Hand weeding	2	26-07-2019, 20-08-2019
4	Spraying of insecticide	2	09-08-2019 19-08-2019
5	Harvesting	2	12-09-2019, 16-09-2019
6	Threshing	1	20-09-2019

3.5.6. Plant protection

One spray of monocrotophos undertaken to control sucking pest and pod borer and another spray of sulphur was taken to control powdery mildew disease.

3.5.7. Harvesting and drying

The crop was harvested at maturity, *i.e.* At 65 DAS. At maturity the crop was harvested manually by picking the dry pods from net plot as per the treatments separately. The threshing was done manually. After winnowing, clean seed was dried for three days and weighted as per the treatments.

3.6. Collection of data

For collection of the biometric observations, five plants were randomly selected from each net plot and labeled properly. The details of observations along with frequency are presented in Table 3.

Table 3: Details of bio-metric and other observations recorded during present investigation.

Sr. No.	Particulars	Frequency	DAS	Sampling unit
A) Phenological studies				
1.	Days to 50% flowering	1	08-08-2019	Net plot
2.	Days for physiological maturity	1	06-09-2019	Net plot
B) Pre-harvest studies				
1.	Emergence count	1	10	Net plot
2.	Plant height (cm)	4	30,45,60 and at harvest	Five plants/ ne t plot
3.	No. of leaves /plant	4	30,45,60 and at harvest	Five plants/ ne t plot
4.	Leaf area /plant (cm^2)	4	30,45,60 and at harvest	Five plant/ net plot
C) Dry matter studies				
1.	Stem dry weight/plant (g)	2	30,45, and at harvest	Five plants/ ne t plot
2.	Leaf dry weight/plant (g)	2	30,45, and at harvest	Five plants/ ne t plot
3.	Total dry weight/plant (g)	2	30,45, and at harvest	Five plants/ ne t plot
D) Growth analysis				
1.	Absolute growth rate (AGR).	4	30,45,60 and at harvest	Five plants/ net plot
2.	Relative growth rate (RGR)	4	30,45,60 and at harvest	One plant/ net plot
3.	Net assimilation rate (NAR)	4	30,45,60 and at harvest	One plant/ net plot
4.	Leaf area index (LAI)	4	30,45,60 and at harvest	Five plants/ net plot
5.	Crop growth rate (CGR)	4	30,45,60 and at harvest	Five plants/ net plot
E) Post harvest studies				
1.	No. of pod/ plant	1	At harvest	Five plants/ ne t plot

2.	No. of grains/pod	1	At harvest	Five plants/ net plot
3.	Grain yield/ plant (Kg.)	1	At harvest	Five plants/ net plot
4.	Grain yield/ plot (Kg.)	1	At harvest	Net plot
5.	Grain yield /ha (qt/ha)	1	At harvest	Net plot
6.	Test weight (100 seed)	1	At harvest	Composite sa mples from each net plot
7.	Harvest index	1	At harvest	Composite samples from each net plot produce
F) Chemical analysis studies				
1.	Chlorophyll content	3	30, 45 and 60 DAS	Five plants/ net plot
2.	Protein percentage in seed	1	At harvest	Composite samples from each netplot

3.6.1. Emergence

The emergence count was taken at 10 days after sowing.

3.6.2. Height of plant (cm)

Height of the randomly selected five plants was measured from ground level to the base of last fully opened leaf at various dates of observation starting from 30 DAS with 15 days interval.

3.6.3. Number of leaves per plant

Numbers of functional leaves of observation plants from each net plot were recorded. The first observation was recorded on 30 days after sowing and next it was taken 15 days interval up to 65 days stage.

3.6.4 Leaf area per plant

All leaves on the plants were graded into three grades *viz.* big, medium and small. The grade wise leaves were counted and maximum length and breadth of this representative leaf sample were measured and leaf area was calculated by using the following formula for each grade.

$A = L \times B \times F \times N$

Where,

A=leaf area (cm^2) under particular group

L=Maximum length of representative leaf (cm^2)

B=Maximum Breadth of representative leaf (cm^2)

N=Number of leaves in each grade

F= Correction factor (0.7117)

3.7. Dry matter studies

One representative plant from each net plot was selected randomly and uprooted carefully at each observation date for dry matter studies. Roots were discarded and plants were kept for sun drying in well labeled brown paper bags. Initially plant samples were sundried up to two days followed by oven drying at a constant temperature of $65^0 \pm 2^0C$ until constant dry weight was obtained.

3.8. Growth analysis

Data on growth parameters AGR, RGR, NAR and LAI was further analyzed for working out the growth functions.

3.8.1. Absolute growth rate (g / day)

Absolute growth rate (AGR) is the dry matter production per unit time (g /day) which was calculated by using formula given by Radford (1967).

$$AGR\ (g / day) = \frac{W_2 - W_1}{T_2 - T_1}$$

Where,

W_1 = Dry matter of the plant (g) at time t_1

W_2 = Dry matter of the plant (g) at time t_2

3.8.2. Relative growth rate (g/g/day)

Relative growth rate is the increase in plant dry matter per unit of time in relation to initial weight. It was calculated as per formula given by Blackman (1919) and expressed in g/g/day.

$$\text{RGR (g/g/day)} = \frac{\text{Loge}W_2 - \text{Loge } W_1}{T_2 - T_1}$$

Where,

W_1= Dry matter of the plant (g) at time T_1

W_2= Dry matter of the plant (g) at time T_2

3.8.3. Net assimilation rate (g/dm^2/day)

Net assimilation rate is expressed as increase in dry matter per unit leaf area per unit time. It is expressed in g/dm^2/day. The concept of NAR on the basis of leaf area was introduced by Gregory (1917).

$$\text{NAR (g/dm}^2\text{/day)} = \frac{W_2 - W_1}{T_2 - T_1} \times \frac{\text{Loge}L_2 - \text{Loge}L_1}{L_2 - L_1}$$

Where,

W_1 = dry weight taken at time T_1

W_2 = dry weight taken at time T_2

L_1 = Leaf area taken at time T_1

L_2 = Leaf area taken at time T_2

3.8.4. Crop growth rate (g /m^2/ day)

Crop growth rate (CGR) is the ratio of dry matter production per unit ground area per unit time, which was calculated by adopting the formula given by Watson (1956) and expressed as g/ m^2/day.

$$\text{CGR (g/m}^2\text{/day)} = \frac{W_2 - W_1}{T_2 - T_1} \times \frac{1}{A}$$

Where,

W_1 = Dry matter of the plant (g) at time T_1

W_2 = Dry matter of the plant (g) at time T_2

A = Unit land area occupied by the plant (m^2)

3.8.5. Leaf area index (LAI)

Since the crop yield is to be assessed per unit ground area instead of per plant, the leaf area existing on unit ground area was proposed by Watson D. J. (1947). Leaf area index is the ratio of leaf area to ground area occupied by crop plant. Leaf area index per plant was calculated by using the following formula.

$$\text{LAI} = \frac{\text{Leaf area / plant } (cm^2)}{\text{Ground area / plant } (cm^2)}$$

3.9. Post harvest studies

The plants selected for biometric observations were used for generating yield attribute *viz.* number of pods per plant, number of grain per plant, number of grains per pod, grain yield per plant, grain yield per hectare, harvest index and test weight.

3.9.1. Number of pods per plant

Numbers of pods from five selected plants were counted and an average number of pods per plant were worked out.

3.9.2. Number of grains per pod

Number of grains per pod was recorded from the randomly selected plant from each net plot at the time of harvesting and average is worked out.

3.9.3. Test weight (100 seed weight) (g)

Hundred seeds were counted from each net plot seed yield and its weight was recorded.

3.10. Yield:

3.10.1. Grain yield per plant

The observation plants threshed separately and cleaned grain produce was recorded as a grain yield per plant in grams.

3.10.2. Grain yield per plot

The plants from each net plot were harvested and seeds were separated by threshing. After sun drying seed yield obtained in each net plot were weighed in Kg and presented as Kg / plot.

3.10.3. Grain yield per hectare

The plants harvested from each net plot were threshed and weight of clean produce was recorded in kilograms per plot and converted into quintal per hectare.

3.10.4. Harvest index (%)

The harvest index was calculated by using formula

$$\text{Harvest index} = \frac{\text{Total seed yield (Kg / ha)}}{\text{Total biological yield (Kg / ha)}} \times 100$$

Where,

Biological yield = seed yield + straw yield

3.11. Chemical analysis studies

3.11.1. Chlorophyll content

Fresh leaves from five plants each net plot was collected at random for chlorophyll studies. The first sample was taken at 30 days after sowing and there after it was taken at 15 days interval up to 60 days.

Shoaf and Lium (1976) devised an improved method of extraction of chlorophyll by dimethyl sulphoxide (DMSO). The fresh leaves were gently washed in water to remove dirt and were blotted gently with tissue paper to remove water. The fresh leaf tissue was cut into small pieces avoiding midrib and thick veins, 100 mg was weighed and incubated in 7.0 ml of DMSO at 65ºC for 30 minutes. At the end of the incubation period, supernatant was decanted and leaf tissue was discarded. The volume was made up to 10.0 ml with DMSO. The absorbance of the extract was measured at 645 nm, 652 nm and 663 nm in spectrophotometer (Spectro UV-VIS dual beam UVS-2700, Labomed Inc., USA) using DMSO as a blank. The chlorophyll ‘a’, chlorophyll ‘b’ and total chlorophyll contents were calculated by using formulae as given below and expressed as mg/g fresh weight.

$$\text{Chlorophyll 'a'} = 12.7\,(A663) - 2.69\,(A645) \times \frac{V}{1000 \times W \times a}$$

$$\text{Chlorophyll 'b'} = 22.9\,(A645) - 4.68\,(A663) \times \frac{V}{1000 \times W \times a}$$

$$\text{Total Chlorophyll} = 22.9\,(A645) - 4.68\,(A663) \times \frac{V}{1000 \times W \times a}$$

Where,

A = Absorbance at specific wave length (645 and 663 nm)

V = Final volume of the chlorophyll extract (ml)

W= Fresh weight of the sample (g)

a = Path length of light (1 cm)

3.11.2. Protein content in seed (%)

The grains obtained from observation plants were used for determination of protein. Initially percent nitrogen was estimated by Micro Kjeldahal’s method (Jackson, 1967) and protein content was worked out as per the formula given below.

Protein percentage = Nitrogen percentage x F

Where,

F=6.25 for Green gram factor

3.12. Statistical analysis and interpretation of the data

The statistical analysis of the data was carried out by the standard statistical method 'Analysis of Variance' (Panse and Sukhatme, 1967). The null hypothesis was tested by F at significance in order to ascertain whether treatment effects were real or not. From the data, in which the treatment effects were significant, the appropriate standard error (SE) and critical difference (CD) at 5 per cent level of significance were worked out.

3.13. Correlation studies

Simple correlation coefficient (r) values were computed amongst the yield and yield attributing characters.

The value of (r) was computed from the error lines of corresponding co-variance table as follows.

$$r = \frac{\sum xy}{\sqrt{(\sum x2)(\sum y2)}}$$

Where,

r = Correlation coefficient

y = Dependent variable (yield)

xy = Correlation cross product of independent and dependent variables.

General view of plot

Results

CHAPTER IV

RESULTS

Result of experiment entitled "Physiological analysis of growth and yield of Green gram (*Vigna radiata* (L.) Wilczek) cultivars" conducted during *Kharif* 2019-20 are presented in this chapter. The experimental results are presented under the following heads.

4.1 Phenological studies

4.2 Growth observation studies

4.3 Growth analysis

4.4 Dry matter studies

4.5 Post harvest studies

4.6 Chemical analysis studies

4.7 Correlation studies

4.1. Phenological studies

4.1.1. Days to 50% flowering

The data on mean days to 50% flowering is presented in **Table 4** and shown in **Fig.2**.

Table 4: Days to 50% flowering

Varieties	**Days to 50% flowering**
BM-4	37.50
BM-2002-1	37.33
BM-2003-2	35.17
BPMR-145	41.23
PKV AKM-4	37.00
PKV Green Gold	40.84
VAIBHAV	37.65
S.E.±	1.08
C.D. at 5%	3.33
G.M.	38.10

The differences amongst the varieties were significant. Variety BM-2003-2 recorded early flowering over rest of the varieties. Whereas, it was at par with BM-2002-1 and PKV AKM-4 however, the varieties BPMR-145 recorded late flowering.

4.1.2. Days for physiological maturity

The data on mean days for physiological maturity is presented in **Table 5** and shown in **Fig.3.**

Table 5: Days for physiological maturity

Varieties	Days for physiological maturity
BM-4	60.58
BM-2002-1	61.35
BM-2003-2	58.92
BPMR-145	64.57
PKV AKM-4	62.06
PKV Green Gold	61.77
VAIBHAV	62.95
S.E.$\pm$	0.75
C.D. at 5%	2.32
G.M.	61.74

The differences amongst the varieties were significant. The variety BM-2003-2 (58.92 Days) recorded early physiological maturity over rest of the varieties and statistically at par with BM-4, BM-2002-1, and PKV Green Gold However, the variety BPMR-145 (64.57 Days) recorded late physiological maturity.

4.2. Growth observation studies

4.2.1. Germination count on field

The data of mean emergence count on field is presented in **Table 6** and shown in **Fig 4**. The mean emergence count was found to be non-significant indicating that the uniform emergence in all treatments. Amongst the varieties, BM-2003-2 and BM-4 recorded maximum and minimum germination count.

Fig.2: Days to 50% flowering

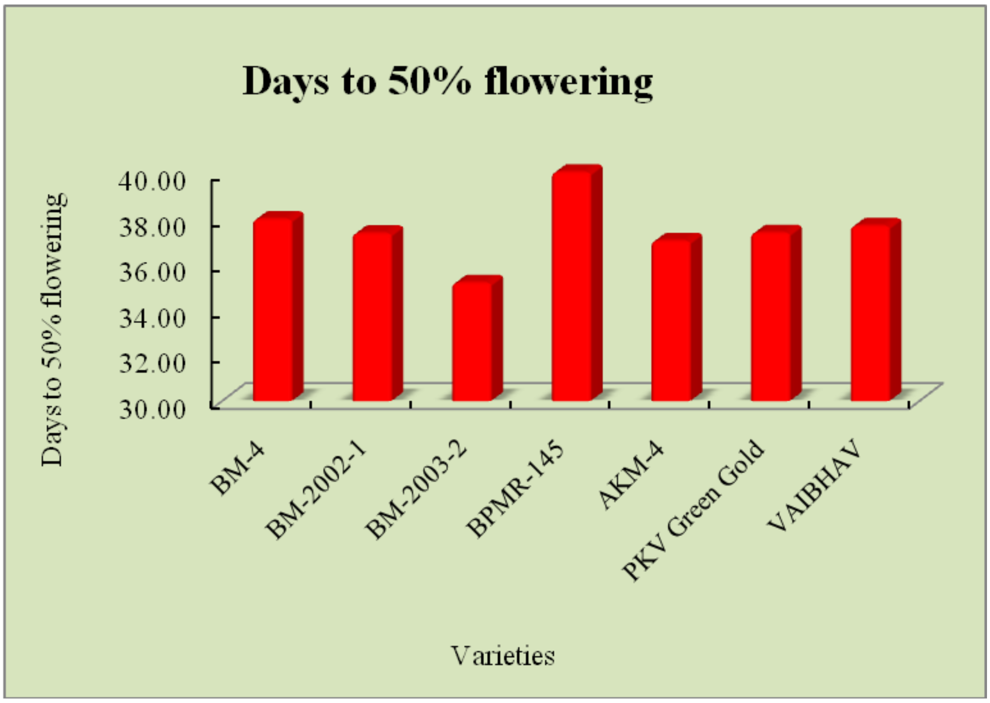


Fig.3: Days for physiological maturity

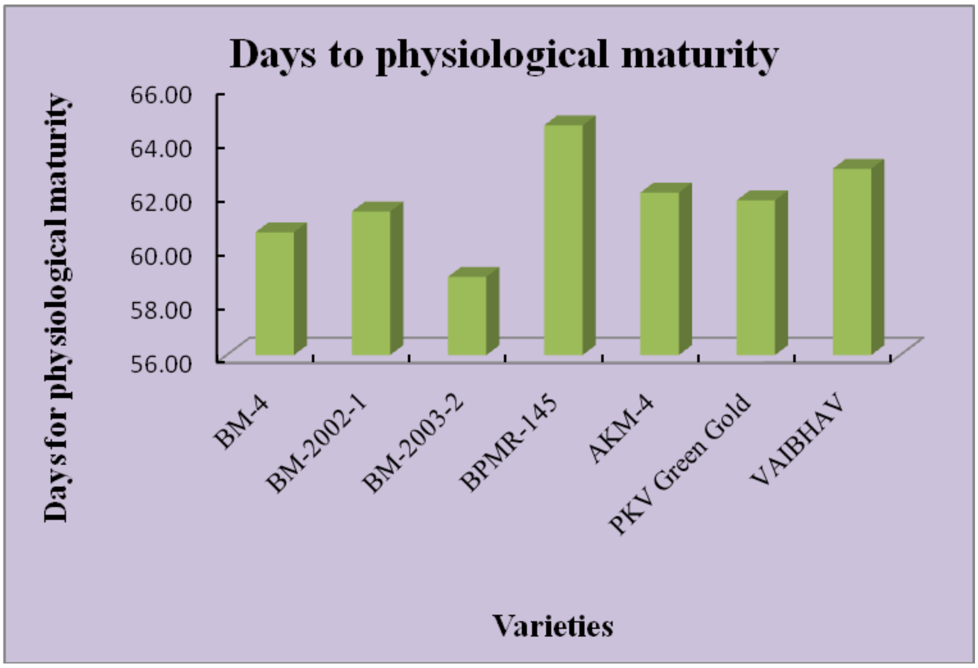


Table 6: Germination count on field

Varieties	Germination count on field
BM-4	83.62
BM-2002-1	86.45
BM-2003-2	87.42
BPMR-4	84.86
PKV AKM-4	83.88
PKV Green Gold	86.07
VAIBHAV	86.51
S.E.$\pm$	0.87
C.D. at 5%	NS
G.M.	85.54

4.2.2 Plant height (cm)

Data on mean plant height per plant recorded at various stages of crop growth are presented in **Table 7** and depicted in **Fig.5.**

Table 7: Plant height (cm) at various stages of crop growth

Varieties	Days after sowing			
	30 DAS	**45 DAS**	**60 DAS**	**At harvest**
BM-4	16.14	37.40	40.80	43.26
BM-2002-1	18.27	38.60	47.78	49.75
BM-2003-2	19.9	44.10	50.20	50.95
BPMR-145	13.1	30.29	34.45	39.77
PKV AKM-4	16.1	38.20	41.92	43.93
PKV Green Gold	17.07	32.10	40.96	42.54
VAIBHAV	16.27	37.62	41.50	44.07
S.E.$\pm$	1.13	2.51	2.53	2.20
C.D. at 5%	3.47	7.73	7.78	6.77
G.M.	16.69	36.90	42.52	44.90

The plant height was found to be increased continuously up to harvest. The increase in plant height was slow during initial stage up to 30 days. It was very fast during 30-60 days and again it was decreased with increasing order from 60 days onwards. The mean maximum plant height of 44.90 cm per plant was recorded at harvest.

Fig.4: Germination count on field

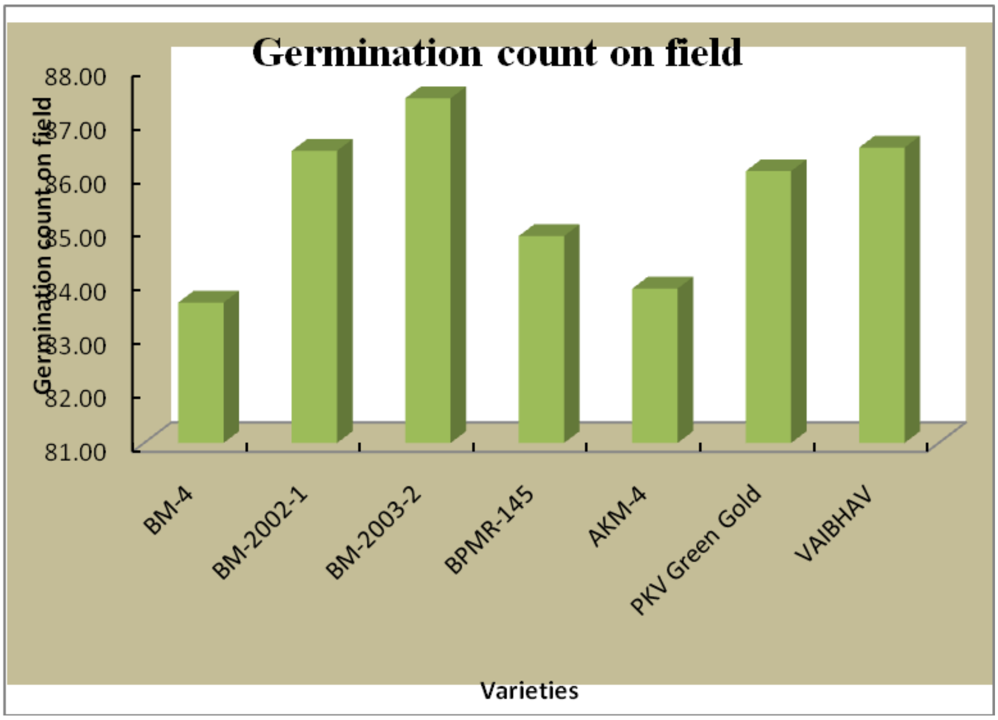
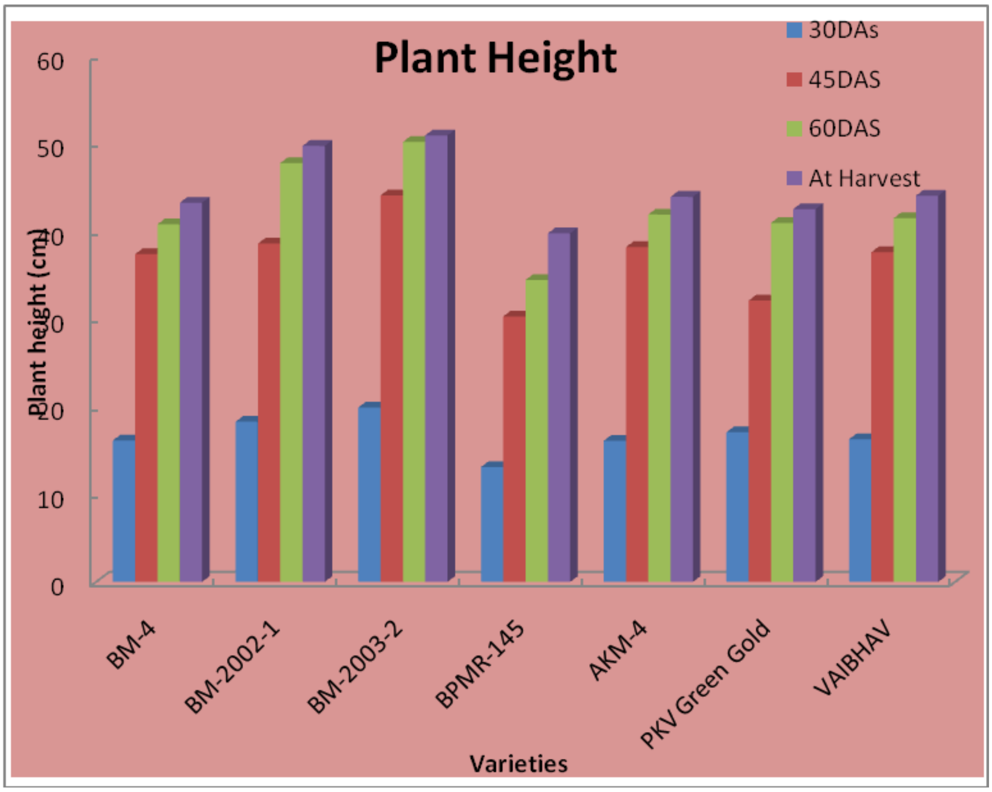


Fig.5: Height (cm) at various stages of crop growth



The differences amongst the varieties were significant at all the stages. The variety BM-2003-2 recorded significantly higher plant height than the rest of the varieties. whereas, it was at par with BM-2002-1.

4.2.3. Number of functional leaves per plant

The data on mean number of functional leaves per plant recorded at various stages of crop growth are presented in **Table 8** and shown in **Fig.6**.

The mean number of functional leaves per plant were 32.57, 50.34, 25.48 and 13.43 at 30, 45, 60 DAS and at harvest, respectively. The mean number of functional leaves was increased up to 45 DAS and then it was decreased due to leaf senescence. The mean number of functional leaves was found to be higher (50.34) at 45 DAS.

Table 8: Number of functional leaves per plant at various stages of plant growth

Varieties	Days after sowing			
	30 DAS	45 DAS	60 DAS	At harvest
BM-4	31.00	49.34	25.52	12.00
BM-2002-1	35.90	56.38	27.00	16.00
BM-2003-2	36.00	58.00	29.00	18.00
BPMR-145	26.39	42.68	20.98	11.00
PKV AKM-4	30.97	45.00	25.00	12.00
PKV Green Gold	34.9	51.14	25.56	13.00
VAIBHAV	32.82	49.84	25.30	12.00
S.E.±	1.75	2.24	1.32	0.96
C.D. at 5%	5.39	6.90	4.07	2.95
G.M.	32.57	50.34	25.48	13.43

Perusal of data presented in Table 8, revealed that the number of functional leaves per plant in variety BM-2003-2 found significantly superior over other varieties at 30, 45, 60 DAS and at harvest. whereas, it was at par with BM-2002-1 and PKV Green Gold.

4.2.4. Leaf area per plant (cm^2)

Data pertaining to mean leaf area per plant recorded at various growth stages of crop are presented in **Table 9** and shown in **Fig.7**.

Table 9: Mean of leaf area per plant in of different varieties at various stages of crop growth.

Varieties	Days after sowing			
	30 DAS	**45 DAS**	**60 DAS**	**At harvest**
BM-4	149.02	378.07	660.54	540.14
BM-2002-1	177.44	385.00	689.67	580.00
BM-2003-2	188.21	390.33	712.00	610.00
BPMR-145	140.47	342.08	630.00	520.20
PKV AKM-4	146.96	375.00	639.53	542.17
PKV Green Gold	173.54	379.42	691.81	590.00
VAIBHAV	170.23	378.45	685.67	570.23
S.E.$\pm$	07.84	05.07	04.42	5.20
C.D. at 5%	24.16	15.63	13.62	16.02
G.M.	163.70	375.48	672.75	564.68

The leaf area per plant was increased up to 60 DAS and later on it was decreased slowly due to leaf senescence. The mean leaf area was 163.70, 375.48, 672.75 and 564.68 cm^2 at 30, 45, 60 DAS and at harvest.

Data recorded amongst the varieties were significant at all the stages. The variety BM-2003-2 recorded significantly maximum leaf area over varieties BM-4, BPMR-145, PKV AKM-4, and VAIBHAV whereas, it was at par with BM-2002-1 and PKV Green Gold and VAIBHAV.

4.3. Dry matter studies

Observations are recorded at an interval of 15^{th} days in the field starting from 30 days after sowing.

4.3.1. Leaf dry weight per plant (g)

The data regarding mean dry weight of leaf production per plant as affected periodically by different genotypes are presented in **Table 10** and shown in **Fig.8**.

The mean dry weight of leaf per plant was 3.64, 6.52, and 6.01 gm per plant at 30, 45, DAS and at harvest respectively.

Fig.6: Number of functional leaves per plant at various stages of plant growth

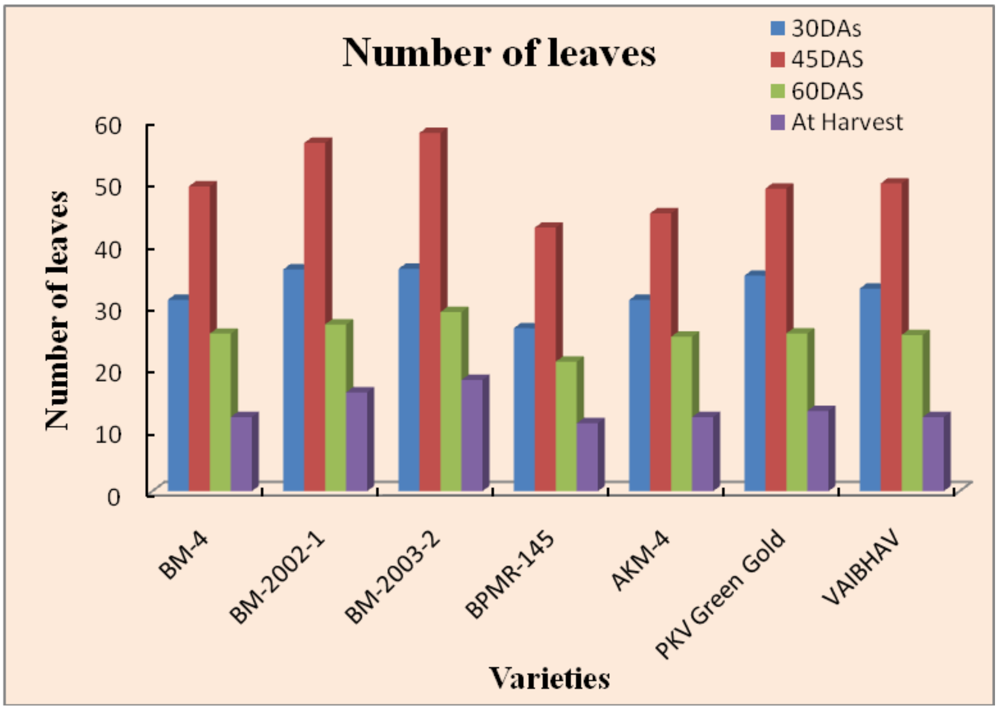


Fig.7: Mean of leaf area per plant in of different varieties at various stages of crop growth.

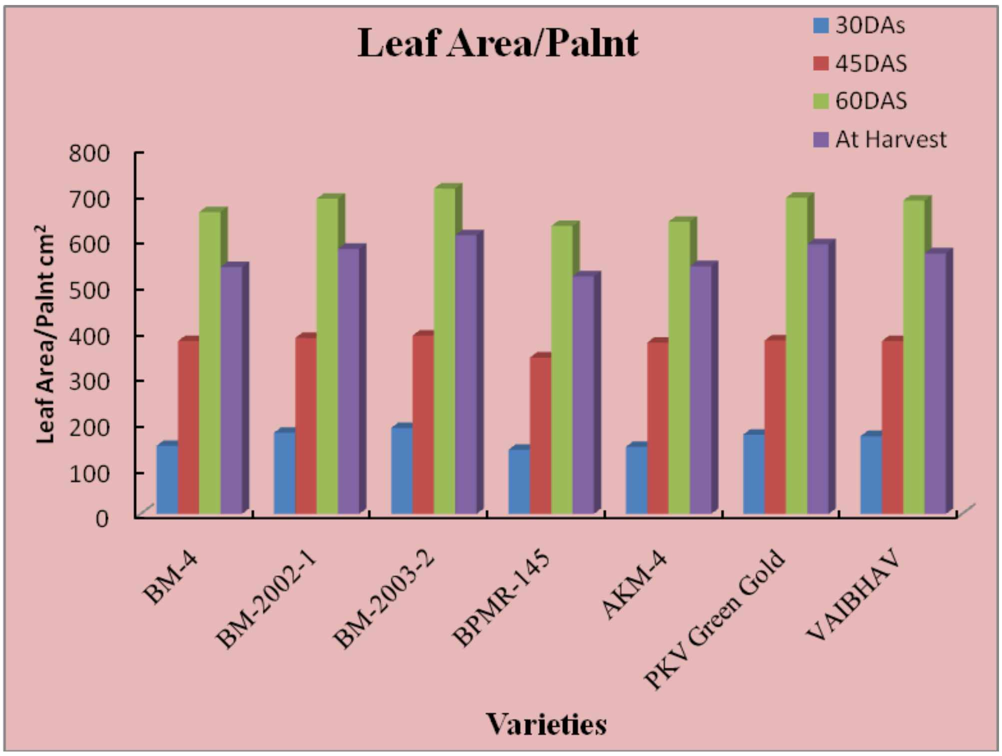


Table 10: Mean dry weight of leaf in g/plant of different varieties at various stages of crop growth

Varieties	30 DAS	45 DAS	At harvest
BM-4	3.09	5.93	5.83
BM-2002-1	3.92	7.05	6.12
BM-2003-2	5.5	8.5	7.50
BPMR-145	3.05	5.1	5.08
PKV AKM-4	3.01	5.60	5.40
PKV Green Gold	3.82	6.85	6.08
VAIBHAV	3.10	6.6	6.04
S.E.±	0.21	0.30	0.27
C.D. at 5%	0.64	0.91	0.82
G.M.	3.64	6.52	6.01

Data presented in Table 10 shows that, in all the varieties mean leaf dry weight increased upto 45 days and there after decreased. The variety BM-2003-2 recorded significantly high leaf dry weight as compared to BM-2002-1 and PKV Green Gold over rest of genotypes *i.e.* BM-4, BPMR-145 and PKV AKM-4 at all the growth stages. Whereas, it was at par with BM-2002-1 and PKV Green Gold.

4.3.2 .Stem dry weight per plant (g)

The data regarding mean dry weight of stem per plant as affected periodically by different genotypes are presented in **Table 11** and shown in **Fig.9**.

The mean dry weight of stem per plant was 1.56, 4.79, and 7.76 gm per plant at 30, 45, DAS and at harvest respectively.

Table 11: Mean dry weight of stem in g/plant of different varieties at various stages of crop growth.

Varieties	30 DAS	45 DAS	At harvest
BM-4	1.3	4.5	7.44
BM-2002-1	1.83	4.9	7.96
BM-2003-2	2.02	6	8.69
BPMR-145	0.9	4.2	6.68
PKV AKM-4	1.4	4.45	7.43
PKV Green Gold	1.8	4.8	8.1
VAIBHAV	1.70	4.7	7.99
S.E.±	0.11	0.33	0.33
C.D. at 5%	0.35	1.03	1.02
G.M.	1.56	4.79	7.76

Fig.8: Mean dry weight of leaf in g/plant of different varieties at various stages of crop growth

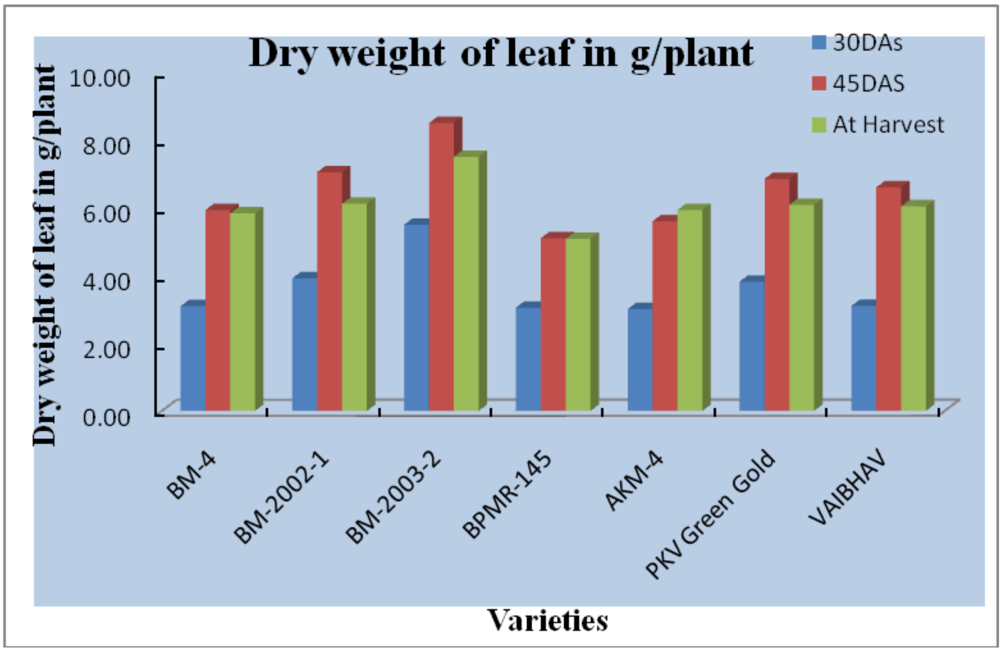
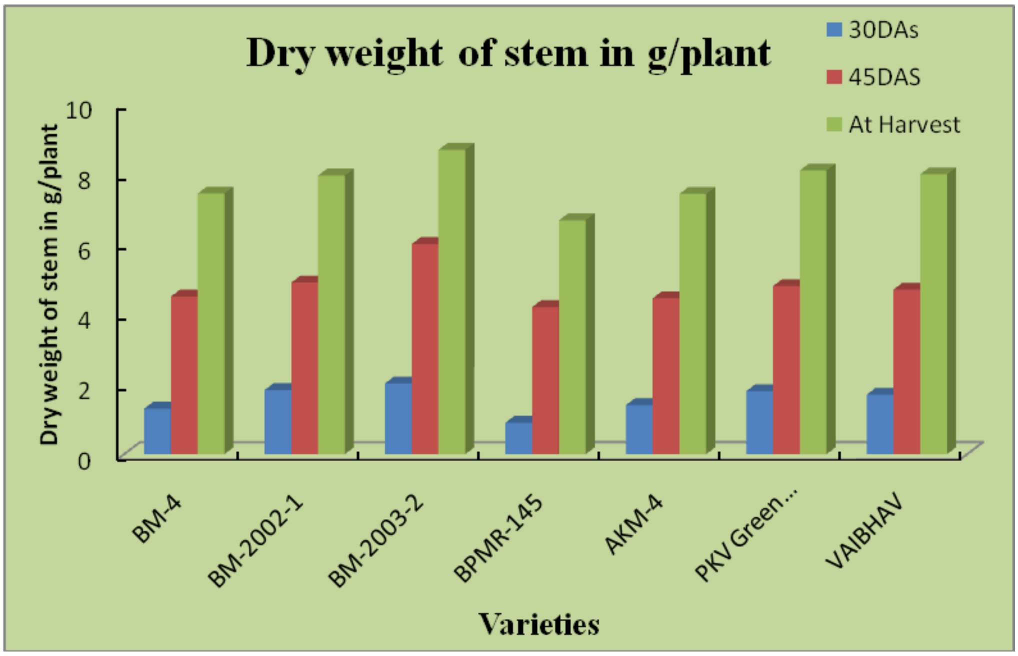


Fig.9: Mean dry weight of stem in g/plant of different varieties at various stages of crop growth.



Data presented in Table 11 revealed that, in the entire varieties mean stem dry weight increased upto 60 DAS thereafter, it decreased.

The differences amongst the varieties were significant at all the stages. The variety BM-2003-2 recorded significantly higher stem dry weight over rest of the cultivars. however, it was at par with BM-2002-1 and PKV Green Gold at harvest.

4.3.4. Total dry weight per plant (g)

The data regarding mean total dry weight production of per plant as affected periodically by different cultivars are presented in **Table 12** and depicted in **Fig.10**.

Table 12: Mean total dry weight in g/plant of different varieties at various stages of crop growth

Varieties	30 DAS	45 DAS	At harvest
BM-4	1.21	6.82	9.7
BM-2002-1	1.62	7.22	10.66
BM-2003-2	1.81	7.81	11.77
BPMR-145	1.12	6.64	9.25
PKV AKM-4	1.16	6.80	9.4
PKV Green Gold	1.59	7.15	10.48
VAIBHAV	1.56	6.98	10.26
S.E.$\pm$	0.08	0.11	0.36
C.D. at 5%	0.25	0.35	1.12
G.M.	1.44	7.06	10.22

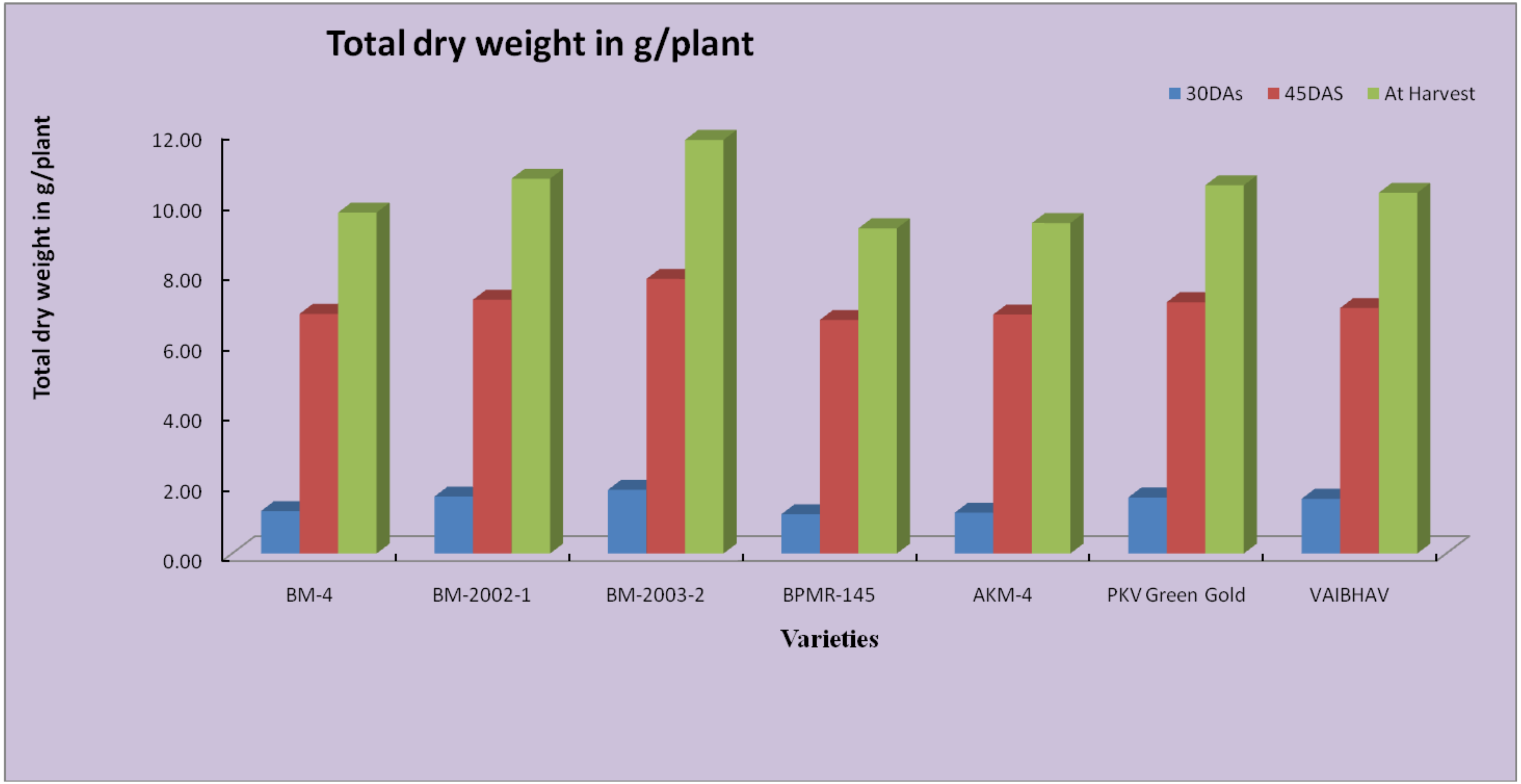
The mean total dry weight of per plant was 1.44, .7.06 and 10.22 gm per plant at 30, 45, DAS and at harvest respectively. Data presented in Table 12 showed that, the mean of total dry weight increased fast upto 60 DAS and there after decreases at harvest in all the varieties. The variety BM-2003-2 recorded significantly higher total dry weight than rest of the treatments. Whereas, it was at par with BM-2002-1 and PKV Green Gold.

4.4. Growth Analysis:

4.4.1. Absolute growth rate (AGR)

The data on absolute growth rate for plant height of different varieties recorded at various stages of crop growth are presented in **Table 13.1** and depicted in **Fig.11**.

Fig.10. Mean total dry weight in g/plant of different varieties at various stages of crop growth



The data presented in Table 13.1 reveal that, AGR for plant height in all the varieties AGR was less during 30 (0.22) DAS and at harvest stages (0.52) and higher in 45 (0.34) DAS and 60 (0.60) DAS.

Table 13.1: Mean of absolute growth rate in g/plant/day of different varieties at various stages of crop growth. (Plant height)

Varieties	Days after sowing			
	30 DAS	45 DAS	60 DAS	At harvest
BM-4	0.190	0.330	0.599	0.490
BM-2002-1	0.221	0.360	0.630	0.560
BM-2003-2	0.240	0.370	0.640	0.540
BPMR-145	0.215	0.310	0.561	0.520
PKV AKM-4	0.218	0.319	0.590	0.500
PKV Green Gold	0.220	0.350	0.607	0.530
VAIBHAV	0.210	0.340	0.604	0.520
S.E.±	0.01	0.01	0.011	0.035
C.D. at 5%	NS	0.03	0.034	NS
G.M.	0.22	0.34	0.604	0.523

The variety BM-2003-2 at 30, 45, 60 DAS stage and variety BM-2002-1 at harvest stage recorded more AGR for plant height as compared to other varieties.

Table.no.13.2. Mean of absolute growth rate in g/plant/day of different varieties at different growth stages (Dry matter)

Varieties	Days after sowing			
	30 DAS	45 DAS	60 DAS	At harvest
BM-4	0.072	0.0727	0.0611	0.0409
BM-2002-1	0.084	0.0824	0.0798	0.0528
BM-2003-2	0.086	0.0839	0.0989	0.0576
BPMR-145	0.065	0.0690	0.0500	0.0378
PKV AKM-4	0.074	0.0700	0.0500	0.0392
PKV Green Gold	0.080	0.0807	0.0800	0.0437
VAIBHAV	0.077	0.0800	0.0700	0.0428
S.E.±	0.01	0.003	0.007	0.008
C.D. at 5%	NS	0.010	0.021	NS
G.M.	0.08	0.0769	0.070	0.045

The data on absolute growth rate for dry matter of different varieties recorded at various stages of crop growth are presented in **Table 13.2** and depicted in **Fig.12**.

Fig.11: Mean of absolute growth rate in g/plant/day of different varieties at various stages of crop growth.(Plant height)

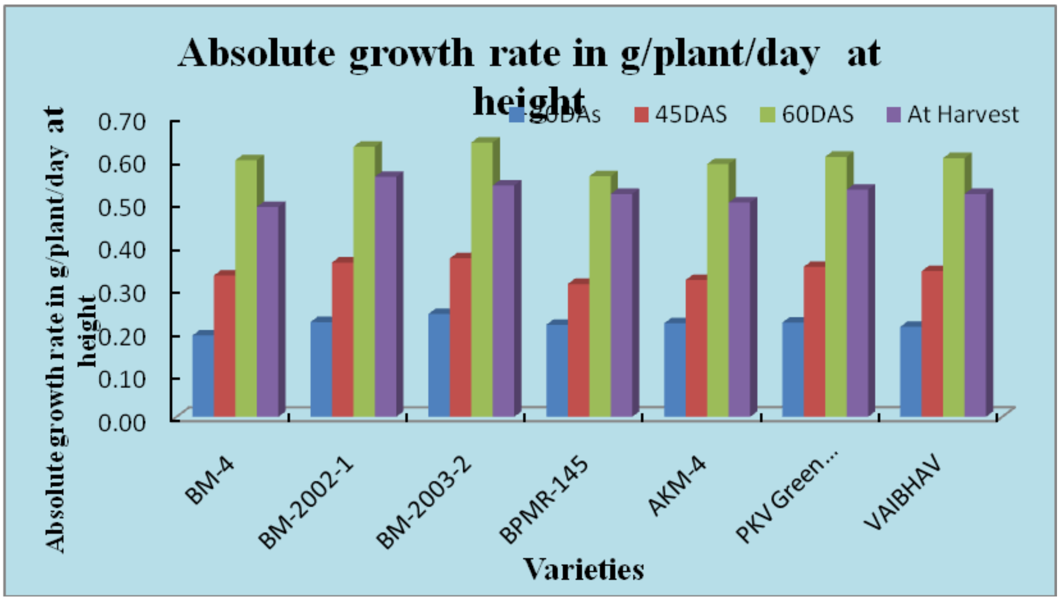
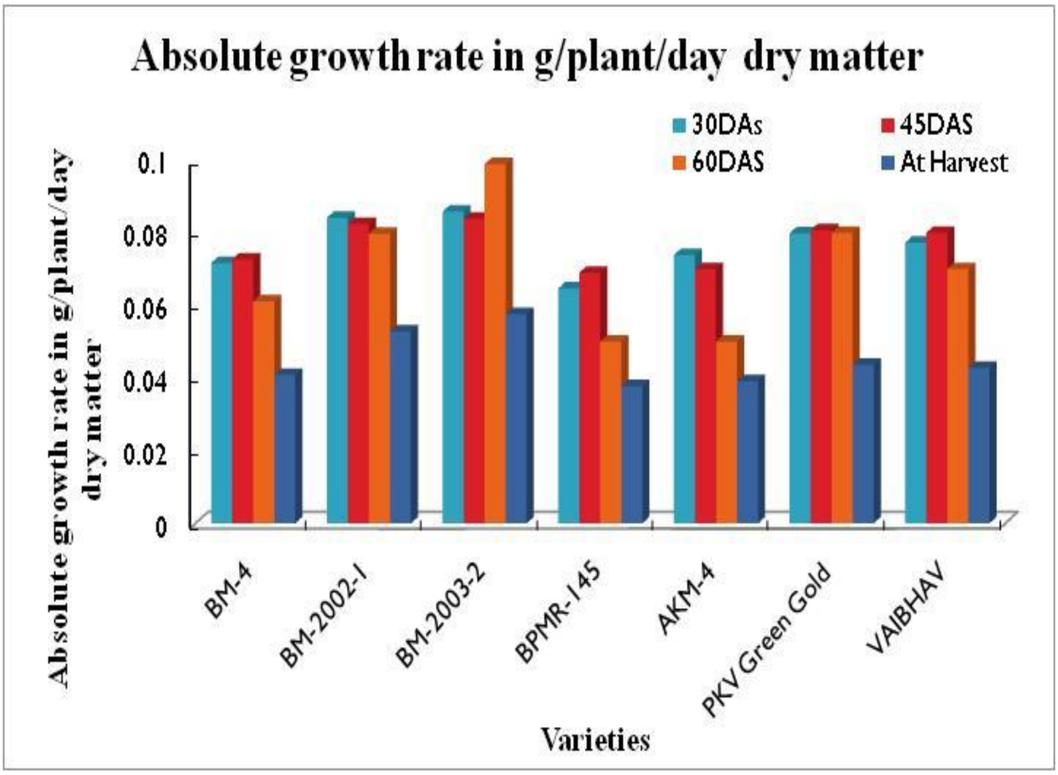


Fig:12: Mean of absolute growth rate in g/plant/day of different varieties at different growth stages (Dry matter)



The data presented in Table 13.2 reveal that, in all the varieties AGR was less during 30 (0.08) DAS and at harvest stages (0.045) and higher in 45 (0.076) DAS and 60 (0.070) DAS

The variety BM-2003-2 at 30, 45, 60, DAS stage and at harvest stage recorded more AGR as compared to other varieties.

4.4. Relative growth rate (RGR)

Data on relative growth rate of different varieties recorded at various stages of crop growth are presented in **Table 14** and shown in **Fig.13**.

Table 14. Mean of relative growth rate in g/g/day of different varieties at various stages of crop growth

Varieties	Days after sowing			
	30 DAS	45 DAS	60 DAS	At harvest
BM-4	0.43	1.770	2.110	2.090
BM-2002-1	0.53	1.809	2.200	2.150
BM-2003-2	0.63	1.850	2.220	2.200
BPMR-145	0.42	1.750	1.980	1.940
PKV AKM-4	0.36	1.760	2.090	2.000
PKV Green Gold	0.42	1.810	2.200	2.120
VAIBHAV	0.41	1.800	2.110	2.090
S.E.±	0.03	0.01	0.01	0.01
C.D. at 5%	0.10	0.03	0.03	0.04
G.M.	0.46	1.79	2.13	2.08

The data presented in Table 14 indicate that, the differences among varieties were significant at all the stages. All the varieties RGR was increased upto 30 DAS (0.46), and 45 DAS (1.79), 60 DAS (2.13) and thereafter it declined. The variety BM-2003-2 at 30 DAS, 45 DAS, 60 DAS and at harvest stage recorded higher relative growth rate as compared to other varieties. Whereas, it was at par with BM-2002-1, PKV Green Gold and VAIBHAV.

4.4.3. Net assimilation rate (NAR)

The data on net assimilation rate of different varieties recorded at various stages of crop growth are presented in **Table 15** and shown in **Fig.14**.

Table 15: Mean of net assimilation rate in g/dm²/day of different varieties at various stages of crop growth

Varieties	Days after sowing			
	30 DAS	45 DAS	60 DAS	At harvest
BM-4	0.051	0.550	0.599	0.387
BM-2002-1	0.062	0.580	0.630	0.455
BM-2003-2	0.071	0.590	0.640	0.462
BPMR-145	0.044	0.530	0.561	0.360
PKV AKM-4	0.052	0.540	0.590	0.369
PKV Green Gold	0.060	0.570	0.607	0.454
VAIBHAV	0.057	0.563	0.604	0.449
S.E.±	0.00	0.010	0.012	0.017
C.D. at 5%	0.01	0.031	0.036	0.052
G.M.	0.06	0.560	0.609	0.419

The data presented in Table 15 indicates that, the differences among the varieties were significant at all the stages. In all varieties NAR increased upto 60 DAS and there after it decreased. The variety BM-2003-2 at 30, 45, 60 DAS and at harvest stage recorded more NAR as compared to other varieties. Whereas, it was at par with BM-2002-1, PKV Green Gold and VAIBHAV.

4.4.4. Leaf area index (LAI)

The data on leaf area index of different varieties recorded at various stages of crop growth are presented in **Table 16** and depicted in **Fig.15**.

Table 16: Mean of leaf area index of different varieties at various stages of crop growth

Varieties	Days after sowing			
	30 DAS	45 DAS	60 DAS	At harvest
BM-4	0.199	1.32	1.490	1.360
BM-2002-1	0.208	1.42	1.560	1.390
BM-2003-2	0.227	1.46	1.600	1.410
BPMR-145	0.178	1.25	1.450	1.340
PKV AKM-4	0.189	1.32	1.460	1.350
PKV Green Gold	0.208	1.42	1.550	1.380
VAIBHAV	0.200	1.38	1.530	1.370
S.E.±	0.007	0.01	0.017	0.013
C.D. at 5%	0.023	0.04	0.052	0.041
G.M.	0.201	1.37	1.520	1.371

Fig.13: Mean of relative growth rate in g/g/day of different varieties at various stages of crop growth

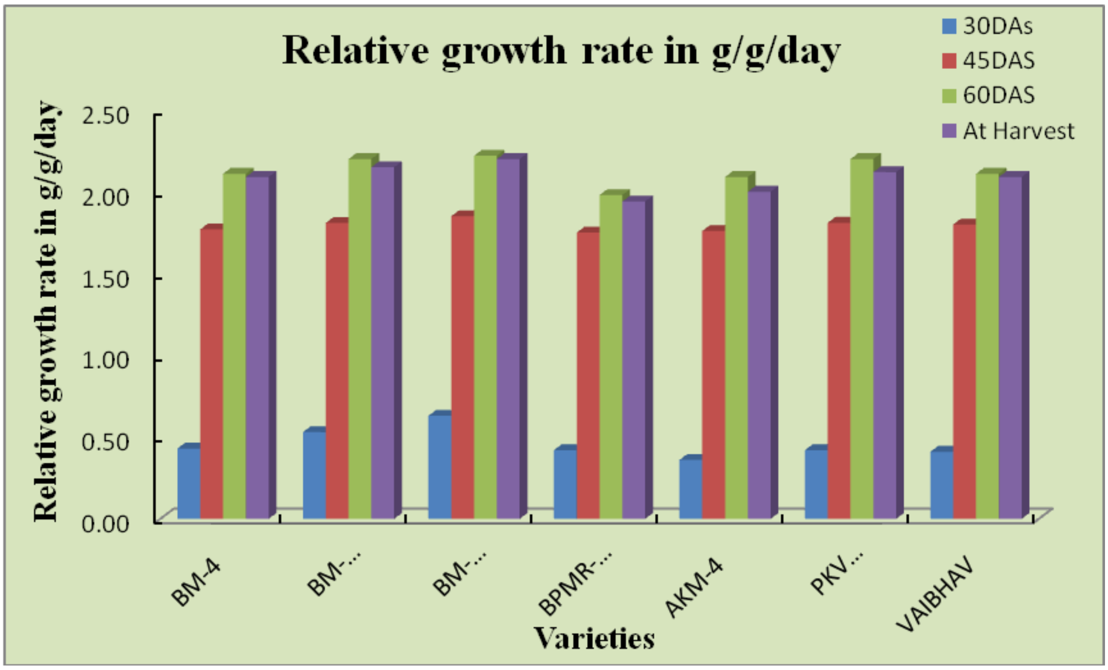
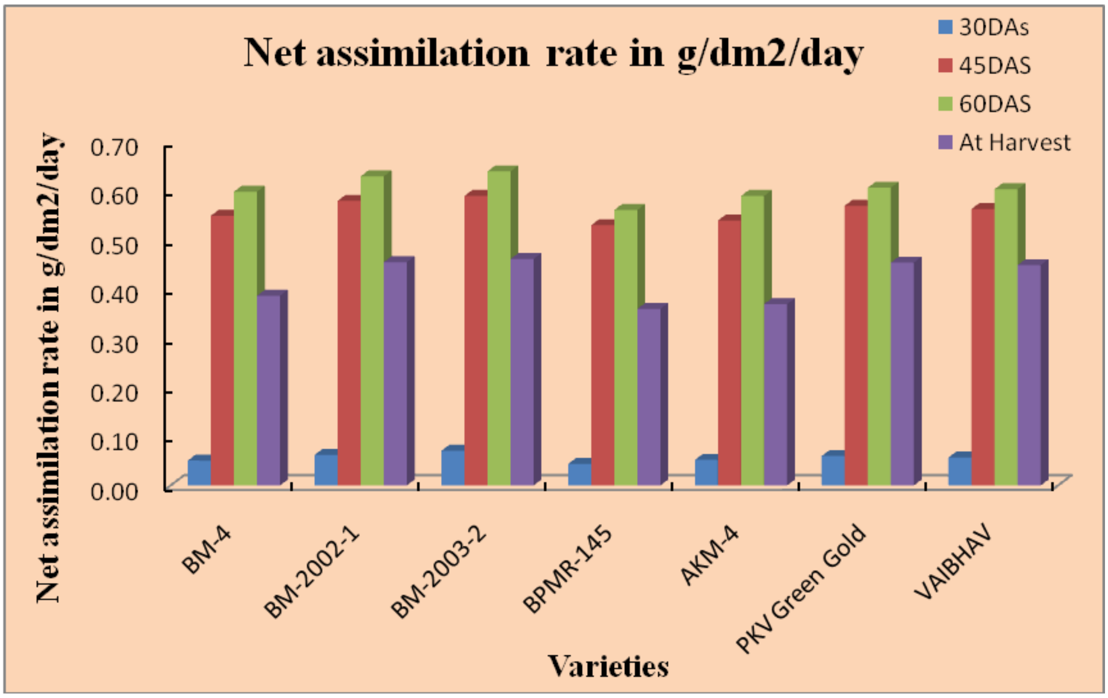


Fig.14: **Mean of net assimilation rate in g/dm^2/day of different varieties at various stages of crop growth**



The data presented in Table 16 reveal that, the differences among varieties were significant at all the stages. The entire varieties leaf area index was increased up to 30 to 60 DAS and thereafter it decreased. The variety BM-2003-2 at all stages recorded more leaf area index as compared to other varieties. The variety BPMR-145 recorded lower leaf area index in all stages. Whereas, it was at par with BM-2002-1, PKV Green Gold and VAIBHAV.

4.4.5. Crop growth rate (CGR)

The data on crop growth rate of different varieties recorded at various stages of crop growth are presented in **Table 17** and depicted in **Fig.16**.

Table 17: Mean of crop growth rate in $g/dm^2/day$ of different varieties at various stages of crop growth

Varieties	Days after sowing			
	30 DAS	**45 DAS**	**60 DAS**	**At harvest**
BM-4	0.033	0.113	0.759	0.349
BM-2002-1	0.036	0.130	0.799	0.370
BM-2003-2	0.041	0.139	0.823	0.377
BPMR-145	0.027	0.089	0.709	0.330
PKV AKM-4	0.032	0.101	0.745	0.346
PKV Green Gold	0.036	0.125	0.780	0.363
VAIBHAV	0.034	0.116	0.759	0.361
S.E.$\pm$	0.001	0.006	0.013	0.008
C.D. at 5%	0.004	0.019	0.040	0.024
G.M.	0.034	0.116	0.768	0.357

The data presented in Table 17 indicate that, the differences among all the varieties were significant at all stages. in all the varieties crop growth rate increased up to 60 days and there after it decreased. The variety BM-2003-2 at 30, 45, 60 DAS and at harvest stage recorded more crop growth rate as compared to other varieties. Whereas, it was at par with BM-2002-1, PKV Green Gold and VAIBHAV.

4.5. Post harvest studies

The data on mean number of grains per pod, number of pods per plant, grain yield per plant, test weight, recorded at harvest are presented in **Table 18** and shown in **Fig.17**.

Fig.15: Mean of leaf area index of different varieties at various stages of crop growth

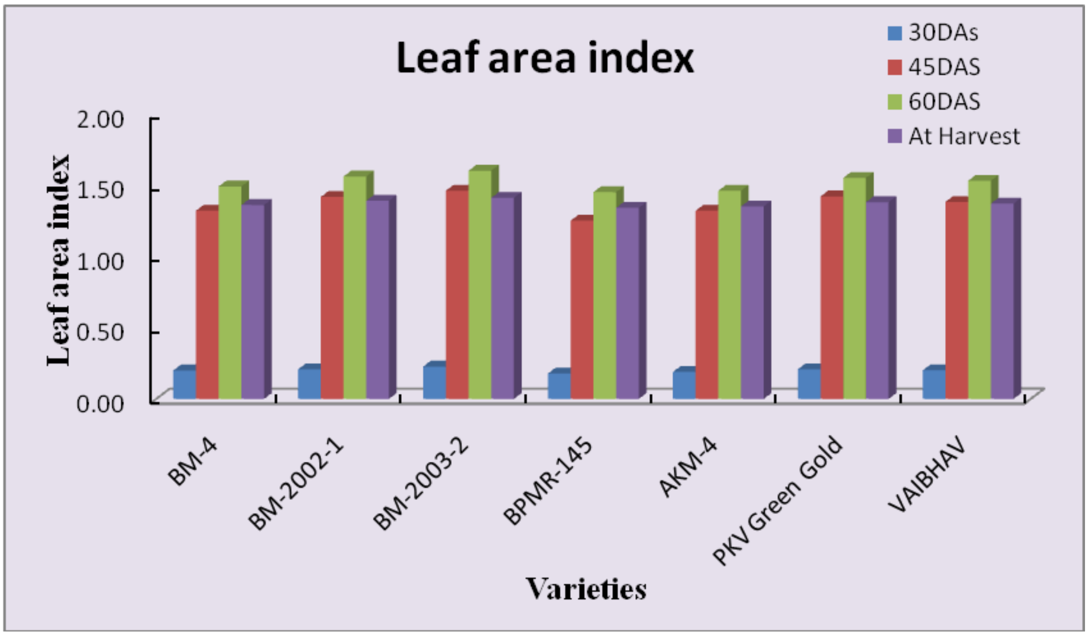


Fig.16: Mean of crop growth rate in $g/dm^2/day$ of different varieties at various stages of crop growth

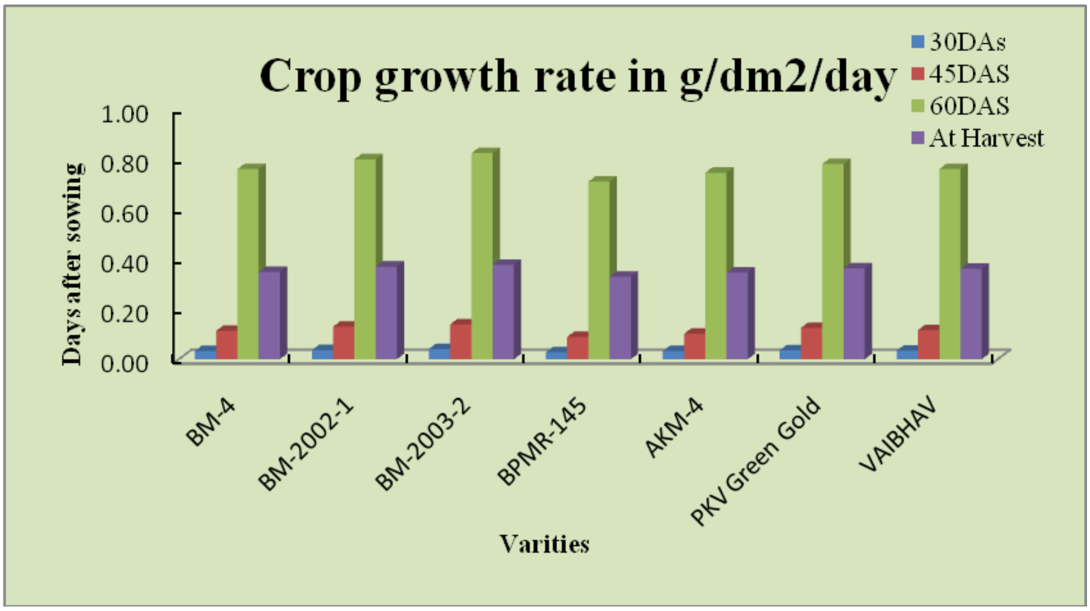


Table 18: Mean of yield component of different varieties.

Varieties	No. of grains/pod	No. of pods/plant	Grain yield/plant (g.)	Test wt. in (g)
BM-4	10.80	23.13	7.20	4.23
BM-2002-1	12.35	26.15	9.16	4.51
BM-2003-2	14.65	29.85	12.20	4.85
BPMR-145	10.72	20.04	6.75	4.33
PKV AKM-4	11.00	22.98	7.30	4.18
PKV Green Gold	12.11	26.43	8.10	4.20
VAIBHAV	11.50	25.02	7.99	4.10
S.E.±	0.78	1.40	0.61	0.15
C.D. at 5%	2.42	4.30	1.88	NS
G.M.	11.88	24.80	8.39	4.34

The data on mean grain yield per plot, grain yield per hectare and harvest index recorded at harvest are presented in **Table 19** and shown in **Fig.18**.

Table 19: Mean of grain yield kg/plot, gain yield qt/ha and harvest index of different varieties.

Varieties	Grain yield/plot(Kg.)	Grain yield/ha (qt/ha)	Harvest index in %
BM-4	0.95	8.79	31.50
BM-2002-1	1.03	10.27	31.75
BM-2003-2	1.28	11.85	31.76
BPMR-145	0.9	8.33	31.05
PKV AKM-4	0.97	8.98	31.41
PKV Green Gold	0.99	9.16	31.69
VAIBHAV	0.98	9.07	31.65
S.E.±	0.07	0.66	2.12
C.D. at 5%	0.22	2.03	NS
G.M.	1.01	9.49	31.54

4.5.1. Number of grains per pod

Data presented in **Table 18** indicate that, the differences amongst the varieties were significant. The variety BM-2003-2 recorded significantly higher number of grains per pod over rest of the varieties. Whereas, it was at par with BM-2002-1.

4.5.2. Number of pods per plant

Data presented in **Table 18** shows that, for number of pods per plant the differences amongst the varieties were significant. Variety BM-2003-2 recorded significantly higher number of pods per plant than other cultivars, and it was at par with BM-2002-1 and PKV Green Gold.

4.5.3. Grain yield per plant (g)

Data presented in **Table 18** indicate that, the differences amongst the varieties for grain yield per plant were significant. The variety BM-2003-2 recorded significantly higher grains yield per plant over rest of the varieties.

4.5.4. Test weight (100 grain weight)

Data presented in **Table 18** indicate that, there were no significant differences amongst the varieties. The variety BM-2003-2 recorded numerically more test weight as compared to other varieties.

4.5.5. Grain yield per plot (Kg)

Data presented in **Table 19** indicated that, the differences amongst the varieties were significant and the variety BM-2003-2 recorded significantly higher grain yield per plot as compared to other varieties.

4.5.6. Grain yield per hectare (qt/ha)

Data presented in **Table 19** and depicted in Fig. 17 indicate that, the differences amongst the varieties were significant and the variety BM-2003-2 recorded significantly higher grain yield per hectare than varieties BM-4, BPMR-145, PKV AKM-4, PKV Green Gold and VAIBHAV. whereas, it was at par with BM-2002-1.

4.5.7. Harvest index (%)

Data presented in **Table 19** showed that, non significantly difference amongst the varieties. The variety BM-2003-2 recorded significantly higher harvest index as compared to other varieties.

4.6. Chemical analysis studies

4.6.1. Chlorophyll content

Data recorded on chlorophyll a, b and total presented in **Table 20, 21** and **22** and depicted in **Fig. 19, 20,** and **21.**

Fig.17: Mean of yield component of different varieties

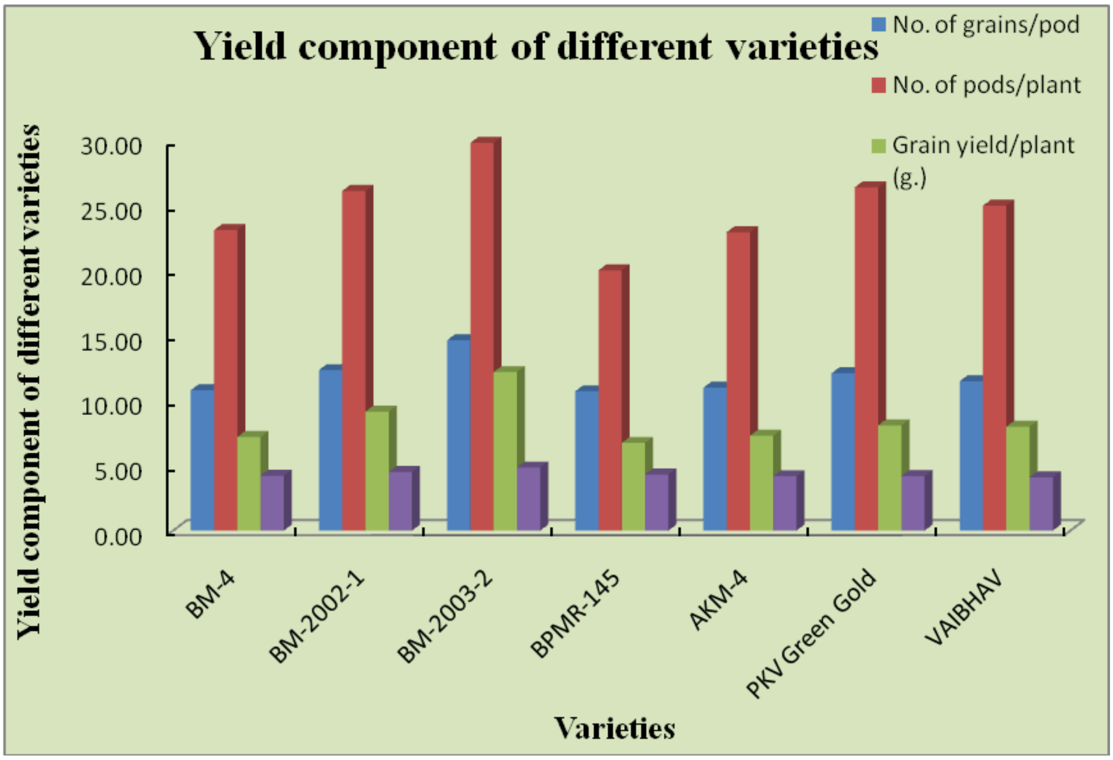
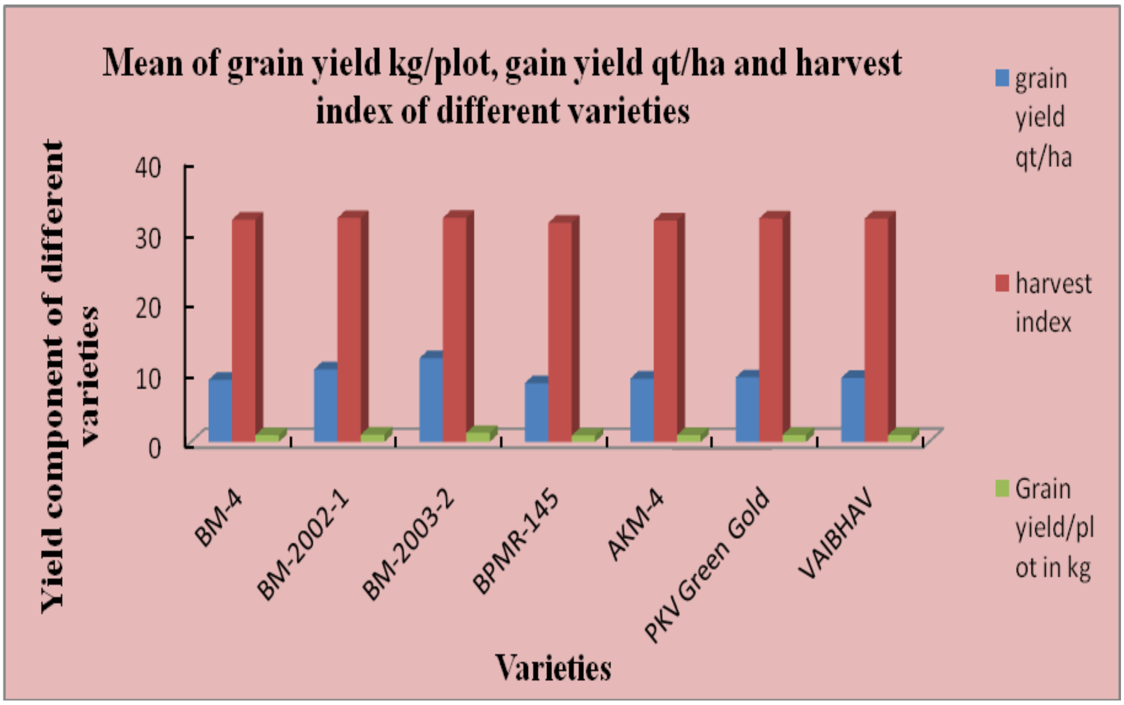


Fig.18: Mean of grain yield kg/plot, gain yield qt/ha and harvest index of different varieties



4.6.2. Chlorophyll “a”content

Data presented in **Table 20** and shown in **Fig.19** indicate that, the differences amongst the varieties were significant and the variety BM-2003-2 recorded significantly higher chlorophyll a over varieties BM-4, BPMR-145, PKV AKM-4 and VAIBHAV at 30,45 DAS ; whereas, it was at par with BM-4 and BPMR-145.

Table 20: Mean of Chlorophyll “a” content of different varieties.

Varieties	Days after sowing		
	30 DAS	45 DAS	60 DAS
BM-4	0.54	0.67	0.41
BM-2002-1	0.7	0.7	0.48
BM-2003-2	0.85	0.99	0.66
BPMR-145	0.48	0.66	0.38
PKV AKM-4	0.69	0.71	0.49
PKV Green Gold	0.6	0.83	0.61
VAIBHAV	0.58	0.75	0.56
S.E.±	0.04	0.05	0.04
C.D. at 1%	0.19	0.23	0.16
GM	0.63	0.76	0.51

4.6.3. Chlorophyll “b” content

Data presented in **Table 21** and shown in **Fig.20** indicate that, the differences amongst the varieties were significant and the variety BM-2003-2 recorded significantly higher chlorophyll b over varieties BM-4, BPMR-145, PKV AKM-4, and VAIBHAV, at 30,45 DAS whereas, it was at par with BM-4, BM-2002-1, BPMR-145 and PKV AKM-4.

Table 21: Mean of chlorophyll “b” content of different varieties.

Varieties	Days after sowing		
	30 DAS	45 DAS	60 DAS
BM-4	0.49	0.69	0.41
BM-2002-1	0.64	0.85	0.51
BM-2003-2	0.74	0.97	0.61
BPMR-145	0.39	0.6	0.36
PKVAKM-4	0.51	0.67	0.38
PKV Green Gold	0.6	0.84	0.68
VAIBHAV	0.56	0.79	0.67
S.E +	0.04	0.05	0.04
CD@1%	0.17	0.24	0.16
GM	0.56	0.77	0.52

Fig.19: Mean of Chlorophyll "a" content of different varieties

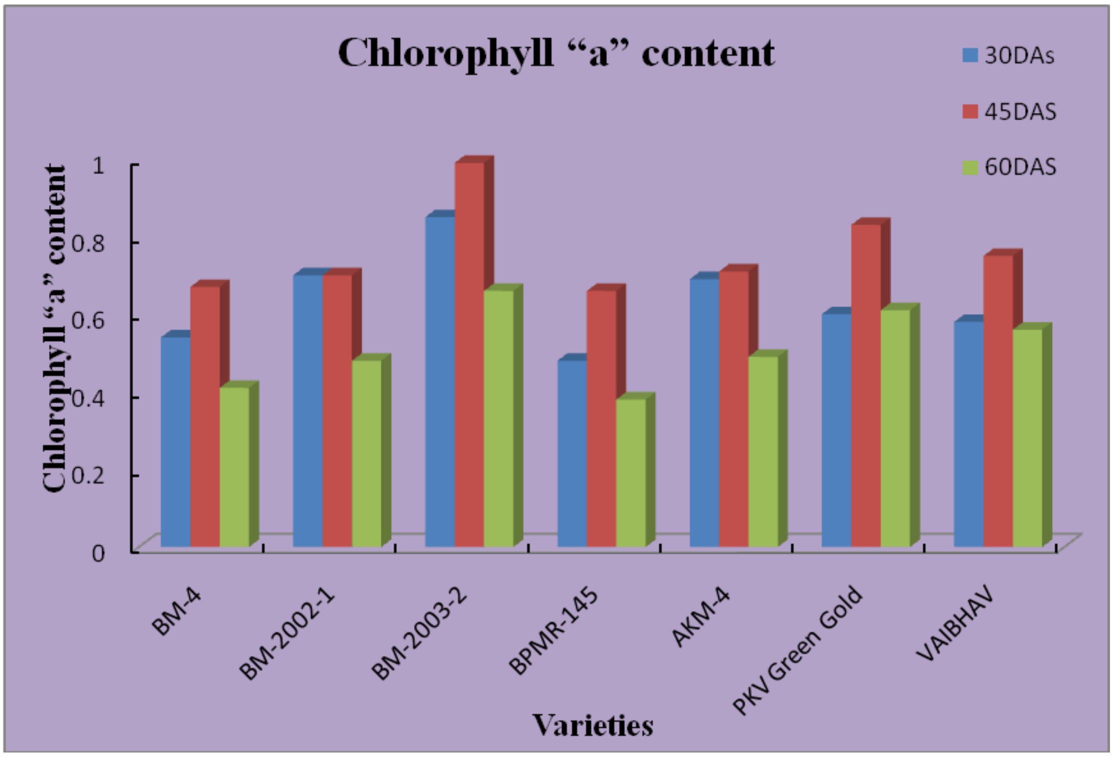
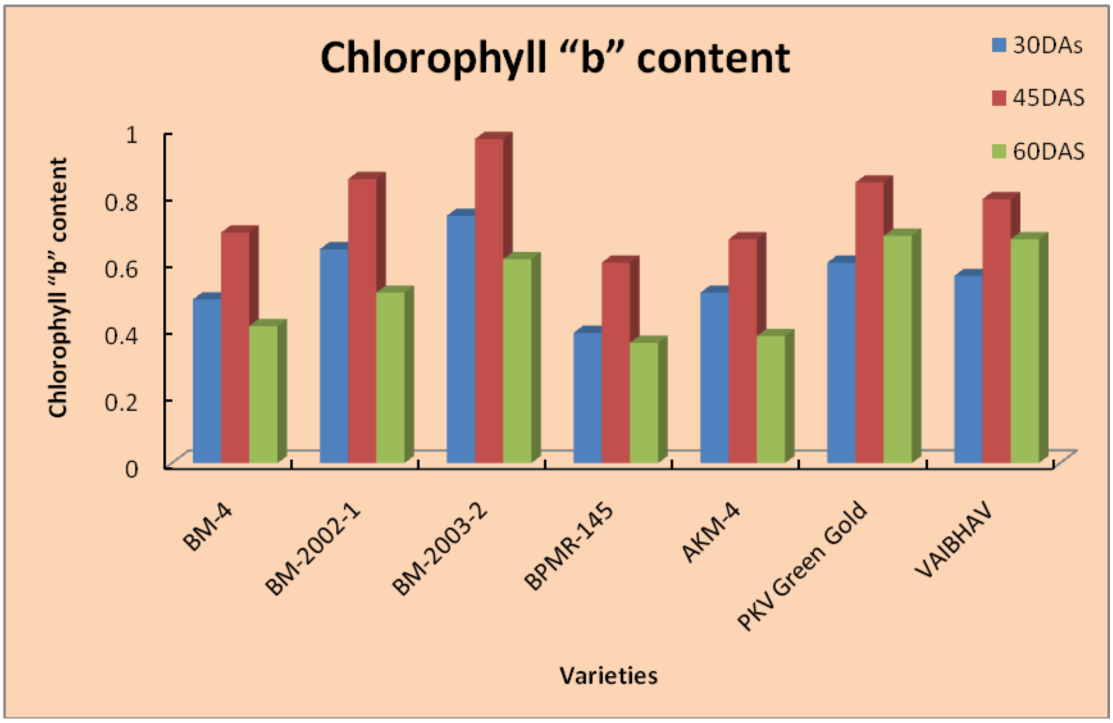


Fig.20: Mean of Chlorophyll "b" content of different varieties



4.6.4. Total chlorophyll content

Table 22: Mean of total chlorophyll content of different varieties.

Varieties	Days after sowing		
	30 DAS	45 DAS	60 DAS
BM-4	1.17	1.40	1.33
BM-2002-1	1.28	1.53	1.39
BM-2003-2	1.34	1.70	1.41
BPMR-145	1.08	1.40	1.30
PKV AKM-4	1.14	1.45	1.35
PKV Green Gold	1.20	1.50	1.36
VAIBHAV	1.12	1.46	1.34
S.E.±	0.04	0.05	0.02
C.D. at 1%	0.19	0.20	0.08
G.M.	1.19	1.49	1.36

Data presented in **Table 22** and shown in **Fig.21** showed that, the differences among the varieties were significant and the variety BM-2003-2 recorded significantly higher total chlorophyll at 30, 45,DAS as compared to other varieties and it was at par with varieties BM-4 and BPMR-145.

4.6.4. Protein content in grain

Data on protein content in grain for different varieties is presented in **Table 23** and shown in **Fig. 22**.

Table 23: Protein content in grain of different varieties.

Varieties	Protein percentage in grain (%)
BM-4	20.76
BM-2002-1	21.15
BM-2003-2	21.90
BPMR-145	20.27
PKV AKM-4	20.75
PKV Green Gold	20.90
VAIBHAV	20.54
SE(m)	1.41
CD@1%	6.08
General mean	20.90

Data presented in Table 23 revealed that, differences amongst the varieties were significant and the variety BM-2003-2 recorded significantly higher protein as compared with other varieties.

4.7. Correlation studies

The simple correlation coefficient (r) values were worked out between yield and yield attributing characters and the values are presented in **Table 24**.

The data presented in Table 24 reveals that, the yield was positively and significantly correlated with plant height, number of leaves per plant, leaf area per plant, number of grains per pod, number of pods per plant, grain yield per plant, total dry weight per plant, harvest index and test weight. Similarly significantly positive correlation between plant characters *i.e.* total dry weight with plant height, number of leaves per plant, leaf area per plant, number of grains per pod, number of pods per plant, grain yield per plant, harvest index with test weight was also observed.

Table 24: Simple correlation coefficient between different plant characters

Characters	Correlation (r) in with grain yield /plant (g)
Plant height (cm)	0.879
No. Of leaves/ plant	0.955
Leaf area (cm^2)	0.853
No of grains/pod	0.988
No of pods/plant	0.904
Test weight (g)	0.880
Total dry weight (g)	0.955
Harvest index (%)	0.675

Fig.21: Mean of total chlorophyll content of different varieties.

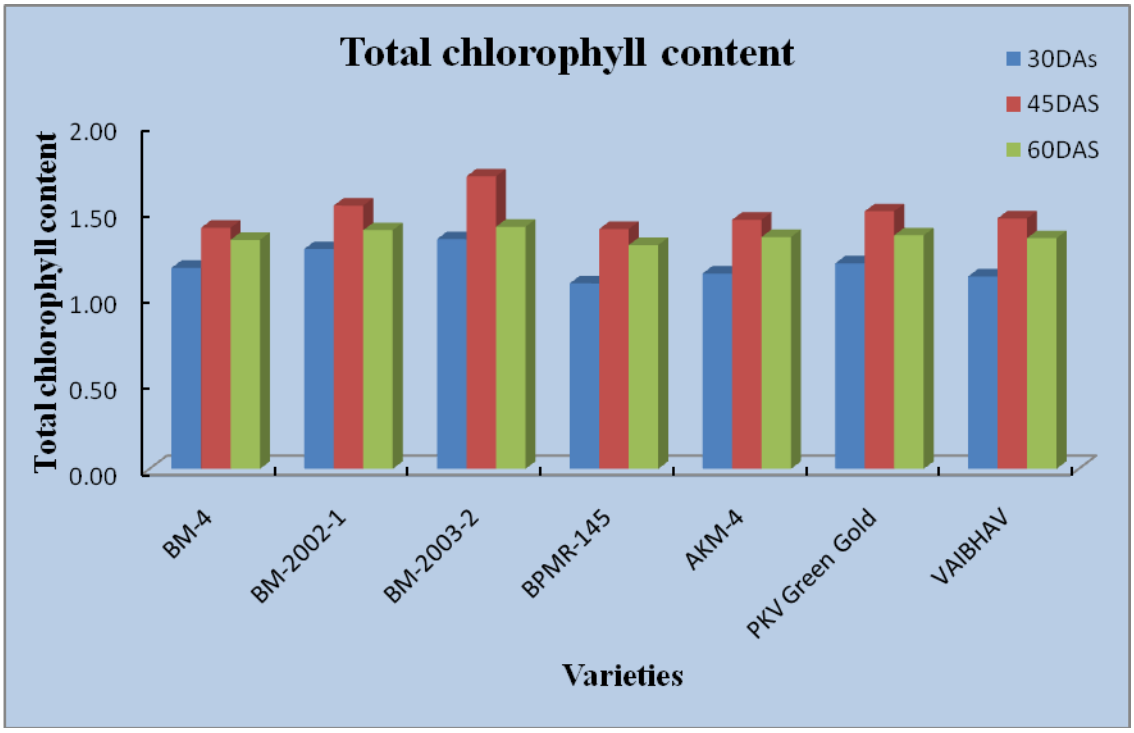
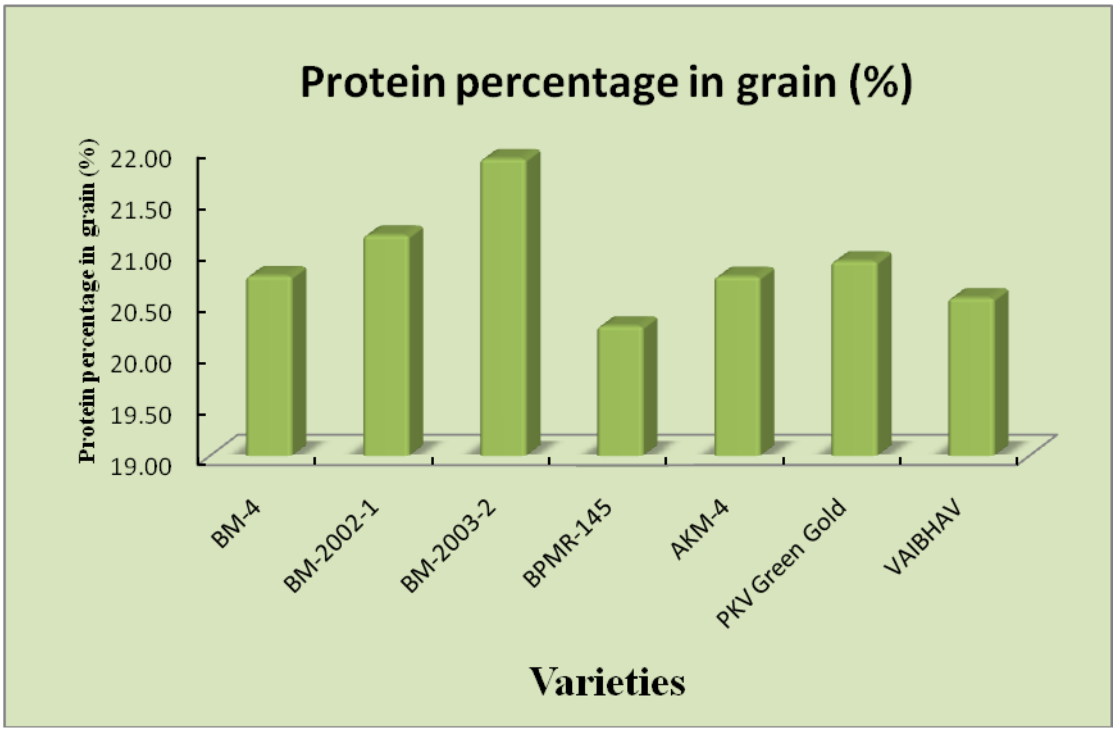


Fig.22: Protein content in grain



Discussion

CHAPTER-V

DISCUSSION

Knowledge of yield and yield contributing characters, their physiological reasoning's are important for selection manipulating ideotype of any crop. Therefore the physiological studies were under taken in Seven varieties of Green gram. The results of present investigation are discussed in this chapter.

Variety BM-2003-2 recorded significantly early flowering over rest of the varieties, however, the varieties BPMR-145 recorded late flowering. The results of investigation are in confirmation with the finding made by Ayyangouda *et al.* (2003), Rajesh *et al.* (2014) in green gram and Reni *et al.* (2013) in black gram.

The differences amongst the varieties for physiological maturity were significant. The variety BM-2003-2 recorded early physiological maturity (58.92 Days) over rest of the varieties, However, the variety BPMR-145 recorded late maturity (64.57 Days). The results of investigation are in confirmation with the finding made by Rajesh *et al.*(2014) in green gram and Reni *et al*. (2013) in black gram.

The emergence count was found to be non-significant indicating that the uniform emergence in all treatments. Amongst the varieties BM-2003-2 and BM-4 recorded maximum and minimum germination count respectively. The results of investigation are in confirmation with the findings made by Baskaran *et al.* (2009) in green gram and Vanaja *et al*. (2006) in black gram.

The plant height was found to be increased continuously up to harvest. The increase in plant height was slow during initial stage up to 30 days. It was very fast during 30-60 days and again was decreased with increasing order from 60 days onwards. The gross mean maximum plant height of 44.90 cm per plant was recorded at harvest. The differences amongst the varieties were significant at all the stages. The variety BM-2003-2 was significantly higher plant height than the rest of varieties, The varietal differences in respect of plant height were also reported by Yadahalli *et al.*

(2006), Reddy *et al.* (1991), and Nayak *et al.* (2014) in black gram and Ali *et al.* (2013) in soybean.

The mean number of functional leaves per plant were 32.57, 50.34, 25.48, and 13.43 at 30, 45, 60 DAS and at harvest, respectively. The mean numbers of functional leaves were increased up to 45 DAS and then it decreased due to leaf senescence. The mean numbers of functional leaves were produced by BM-2003-2 (58.00) at 45 DAS were maximum and also at other stages. The results of investigation are in confirmation with the finding made by Nayak *et al.* (2014), Rathore *et al.* (2010) in black gram.

The leaf area per plant increased up to 60 DAS and later on it decreased slowly due to leaf senescence. The mean leaf area was 163.70 cm^2, 375.48 cm^2, 672.75 cm^2 and 564.68 cm^2 at 30, 45, 60 DAS and at harvest. Data recorded amongst the varieties was significant at all the stages. The variety BM-2003-2 recorded significantly maximum leaf area over other varieties. The varietal differences in respect of leaf area per plant were also reported by Baroowa and Gogoi (2012) and Nayak *et al.* (2014) in black gram.

The mean dry weight of leaf per plant was 3.64, 6.52, and 6.01 gm per plant at 30, 45, DAS and at harvest respectively and in all the varieties mean leaf dry weight increased up to 45 days and there after decreased. The variety BM-2003-2 recorded significantly higher leaf dry weight as compared to variety BM-2002-1 and PKV Green Gold over rest of genotypes *i.e.* BM-4, BPMR-145, PKV AKM-4 and VAIBHAV at all the growth stages. The results of investigation are in confirmation with the finding made by Karim *et al.* (2001) in mung bean and Pandey and Gupta (2012) in black gram.

The mean dry weight of stem per plant was 1.56, 4.79 and 7.76 gm per plant at 30, 45, DAS and at harvest respectively and in all the varieties mean stem dry weight increased upto harvest. The differences amongst the varieties were significant at all the stages. The variety BM-2003-2 recorded significantly higher stem dry weight over rest of the genotypes. The varietal differences for stem dry weight were also reported by Karim *et al.* (2001) in mung bean and Pandey and Gupta (2012) in black gram

The mean total dry weight per plant was 1.44, 7.06 and 10.22 gm per plant at 30, 45 DAS and at harvest respectively. The mean total dry weight increased fast upto 60 Days and after decreased at harvest in all the varieties. The variety BM-2003-2recorded significantly higher total dry weight at all the stages. The varietal differences for stem dry weight were also reported by Abrahan and Lal (2004), Kulsum *et al.* (2007), Hossain *et al.* (2009) and Prabahar and Ganapathy (1996) in black gram.

The AGR in varieties was less during 30 (0.08) DAS and at harvest stages (0.045) and higher in 45 (0.076) DAS and 60 (0.070) DAS. The variety BM-2003-2 at 30, 45, 60 DAS stage and at harvest stage recorded more AGR as compared to other varieties. The results of investigation are in confirmation with the finding made by Biswas *et al.* (2002), and Singh *et al.* (1992) in black gram.

The RGR in varieties was increased up to 30 (0.46) and 45 (1.79) 60(2.13) DAS and increased and at harvest decreased upto (2.08). The variety BM-2003-2 at 30, 45, 60 DAS and at harvest stage recorded higher relative growth rate as compared to other varieties. The results of investigation are in confirmation with the finding made by Biswas *et al.* (2002) and Singh *et al.* (1992) in black gram.

NAR in different varieties increased upto 45 DAS and there after it decreased. The variety BM-2003-2 at 30, 45, 60, DAS and at harvest stage recorded more NAR as compared to other varieties. The result of investigation are in confirmation with the finding made by Biswas *et al.* (2002) and Singh *et al.* (1992) in black gram.

The varietal leaf area index increased up to 30 to 60 DAS and thereafter it decreased. The variety BM-2003-2 at all stage recorded more leaf area index as compared to other varieties. The verity BPMR-145 recorded leaf area index in all stages as compared to other varieties.

The varietal differences for leaf area index were also reported by Ayyangouda *et al.* (2003) in green gram and Patil *et al.* (2015), Patil and Salimath (2003) in black gram.

Crop growth rate in varieties was increased up to 60 days and there after it decreased. The variety BM-2003-2 at 30, 45 and 60 DAS and at harvest stage recorded more crop growth rate as compared to other varieties. The results of investigation are in confirmation with the finding made by Biswas *et al.* (2002) and Singh *et al.* (1992) in black gram.

The differences amongst the varieties were significant to number of grains per pod. The variety BM-2003-2 recorded significantly higher number of grains per pod as compared to BM-2002-1. The varietal differences for grains per pod were also reported by Mondal *et al.* (2011) in mung bean and Nayak *et al.* (2015) and Nag *et al.* (1998) in black gram.

The differences amongst the varieties were significant for number of pods per plant. Variety BM-2003-2 recorded significantly higher number of pods per plant over rest of cultivars; however, it was at par with BM-2002-1 and PKV Green Gold the results of investigation are in confirmation with the finding made by Marimuthu and Surendran (2015), Nag *et al.* (1998), Rahman *et al.* (1993) in black gram. The variety BM-2003-2 recorded significantly higher number of grains per plant than the rest of varieties. The results of investigation are confirmation with the finding made by Yadahalli et al. (2006) and Nag et al. (1998) in black gram and Baskaran et al. (2009) in Green gram.

In general BM-2003-2 has significantly higher grain yield per plant, per plot and per hectare over rest of the varieties and is in conformity with finding made by Mondal *et al.* (2011) in mung bean and Nag *et al*. (1998), Narasimhan *et al*. (2013) and Karande *et al.* (2013) in black gram and Patil *et al*. (1997) in urd bean.

The non significant differences amongst varieties for test weight. The variety BM-2003-2 recorded significantly higher test weight as compared to other varieties. The results of investigation are in confirmation with the finding made by Yadahalli *et al*. (2006) and Hariharasudhan and Kalaiarasu (2015) in black gram.

The non significant differences amongst the varieties for harvest index. The variety BM-2003-2 recorded significantly higher harvest index as compared to other varieties. The results of investigation are in confirmation with the finding made by Mondal *et al*. (2011) in mung bean.

In general observation BM-2003-2 has higher values for yield and yield contributing characters. These higher values are manifested might be due to higher values of chlorophyll a, chlorophyll b and total chlorophyll which are responsible for photosynthates. These photosynthates accumulated and dry matter production and more harvest index in BM-2003-2. Similar result observed by Djanaguiraman *et al.* (2005) and Baroowa and Gogoi (2012) and Islam *et al.* (2010) in black gram and patel *et al*. (1998) in soybean.

The differences amongst varieties were non significant for protein content and the variety BM-2003-2 recorded significantly higher protein over rest of the varieties. Whereas, it was at par with variety PKV Green Gold and VAIBHAV. The results of investigation are in confirmation with the finding made by Ramesh and Ramprasad (2013) in soybean and Sritharan *et al*. (2015) in black gram.

The yield was positively significantly correlated with plant height, number of leaves per plant, leaf area per plant, number of grains per pod, number of pods per plant, grain yield per plant, total dry weight per plant, harvest index and test weight. The results of investigation are in confirmation with the finding made by Prabahar and Ganapathy (1996), Patil *et al.* (1997), Parveen *et al.* (2011) and Mathivathana *et al.* (2015) in black gram.

Summary and Conclusion

CHAPTER-VI

SUMMARY AND CONCLUSIONS

Summary of present investigation entitled "Physiological analysis of growth and yield of Green gram (*Vigna radiata* (L.) Wilczek) cultivars" which was undertaken at VNMKV, Parbhani during the *Kharif* season of 2019-20 with a view of following objectives:

1) To study the varietal differences in growth, development and yield.
2) To study the physiological basis for yield differences among the Green gram varieties.
3) To study the accumulation of dry matter among different plant parts.

The field experiment was conducted with Seven varieties (BM-4, BM-2002-1, BM-2003-2, BPMR-145, PKV AKM-4, PKV Green Gold and VAIBHAV) and observations were taken at successive stages *i.e*. (30, 45, 60 DAS and at harvest) of crop growth. This experiment was conducted in Randomized Block Design during *Kharif* 2019-2020. Observations on days to 50 % flowering, days for physiological maturity, germination count, number of leaves per plant, leaf area per plant, absolute growth rate, relative growth rate, net assimilation rate, leaf area index, crop growth rate, stem dry weight per plant, leaf dry weight per plant, total dry weight per plant, number of pods per plant, number of grains per pod, number of grains per plant, test weight, harvest index, seed yield per hectare, chlorophyll content, protein content in seed, correlation studies, yield and yield components were recorded.

Variety BM-2003-2 recorded significantly early flowering over rest of the varieties, however, the variety BPMR-145 recorded late flowering. The variety BM-2003-2 (58.92 Days) recorded significantly early physiological maturity over rest of the varieties; however, the variety BPMR-145(64.57 Days) recorded late physiological maturity.

The emergence count on field of varieties were non significant. The varieties BM-2003-2 and BM-2002-1 and VAIBHAV had emergence more as compared to other varieties.

The varieties were significant in plant height. The variety BM-2003-2 recorded significantly higher plant height than the rest of varieties, whereas, it was at par with BM-2002-1and VAIBHAV.

The number of functional leaves per plant in variety BM-2003-2 were at par with BM-2002-1 and PKV Green Gold and found significantly superior over other varieties at 30, 45, 60 DAS at harvest.

The varieties were significant at all the stages for leaf area. The variety BM-2003-2 recorded significantly higher leaf area over varieties BM-4, BPMR-145, PKV AKM-4 and PKV Green Gold whereas; it was at par with BM-2002-1and VAIBHAV.

The variety BM-2002-3 recorded significantly higher leaf dry weight as compared to BM-2002-1 and PKV Green Gold over rest of cultivars *i.e*. BM-4, BPMR-145, PKV AKM-4and VAIBHAV at all the growth stages. The variety BM-2003-2 recorded significantly higher stem dry weight over rest of the cultivars, however, at par with BM-2002-1 and PKV Green Gold at all growth stages during the experiment.

The mean of total dry weight increased fast upto 60 DAS after decreased at harvest in all the varieties. The variety BM-2003-2 recorded significantly higher total dry weight at all the stages over rest of the varieties and it was at par with BM-2002-1.

The variety BM-2003-2 at 30, 45, 60 DAS and at harvest stage recorded more AGR as compared to other varieties. The variety BM-2003-2 at 30 and 45, 60 DAS and at harvest stage recorded higher relative growth rate as compared to other varieties. The variety BM-2003-2 at 30,45, 60 DAS and at harvest stage recorded more NAR as compared to other varieties. The variety BM-2003-2 at all stage recorded more leaf area index as compared to other varieties. The variety BPMR-145 recorded lower leaf area index in all stages as compare to other varieties. The variety BM-2003-2 recorded significantly higher CGR at 30, 45, 60 DAS at harvest stage as compared to other varieties.

The variety BM-2003-2 recorded significantly higher number of grains per pod and number of pods per plant over rest of the varieties. The variety BM-2003-2 recorded significantly higher grain yield per plant, per plot, per hectare than the rest of varieties.

The variety BM-2003-2 recorded higher test weight as compared to other varieties.

The variety BM-2003-2 recorded significantly higher grain yield per plot and grain yield per hectare over rest of varieties

The variety BM-2003-2 recorded higher harvest index as compared to other varieties.

The variety BM-2003-2 recorded significantly higher chlorophyll a, b and total chlorophyll over rest of the varieties.

The variety BM-2003-2 recorded significantly higher grain protein as compared to other varieties, whereas, it was as par with variety BM-2002-1and PKV Green Gold.

Simple correlation study revealed that, the yield was positively significantly correlated with plant height, number of leaves per plant, leaf area per plant, number of grains per pod, number of pods per plant, grain yield per plant, total dry weight per plant, harvest index and test weight.

CONCLUSION

It is seen from the results that the variety BM-2003-2 was superior in respect of growth attributes, yield attributes and seed yield, as compared with other genotypes tested.

The differences in yield are due to differences in percent translocation of total dry matter for grain development as well as the difference in capacity to accumulate the photosynthate. The variety BM-2003-2 is found significantly superior for total dry matter accumulation and due to its efficient translocation for pod development.

For selection of high yielding cultivars the desirable characters of variety BM-2003-2 should be taken in to accounts and further large number of genotypes should be screened for confirmation in future.

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in

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