MORPHO-PHYSIOLOGICAL CHARACTERIZATION OF SOYBEAN CULTIVARS FOR EFFICIENT PHOTO-ASSIMILATES PARTITIONING AND YIELD

M.Sc. (Ag) Thesis

By

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Thesis

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Dineshwar Singh Kanwar

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CERTIFICATE – I

This is to certify that the thesis entitled "**Morpho-physiological characterization of soybean cultivars for efficient photo-assimilates partitioning and yield**" submitted in partial fulfillment of the requirements for the degree of **Master of Science in Agriculture (Plant Physiology)** of the Indira Gandhi Krishi Vishwavidyalaya, Raipur, is a record of the bonafide research work carried out by **Shri Dineshwar Singh Kanwar** under my/our guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma or has been published/published part has been fully acknowledged. All the assistance and help received during the course of the investigations have been duly acknowledged by him.

P. Katiyar
Chairman

Date: 21.7.16

THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

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Member	(Dr. Sunil Kumar Nag)	
Member	(Dr. M.L. Lakhera)	22/7/2016

CERTIFICATE – II

This is to certify that the thesis entitled "**Morpho-physiological characterization of soybean cultivars for efficient photo-assimilates partitioning and yield**" submitted by **Shri Dineshwar Singh Kanwar** to the Indira Gandhi Krishi Vishwavidyalaya, Raipur, in partial fulfillment of the requirements for the degree of **Master of Science in Agriculture (Plant Physiology)** in the Department of Plant Physiology, Agricultural Biochemistry and Medicinal and Aromatic Plants has been approved by the external examiner and Student's Advisory Committee after oral examination.

AKtrivedi
23.08.2016

Signature External Examiner

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Date: 23.08.2016

Major Advisor P. Katiyar 23.8.16

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Approved/Not approved

Director of Instructions ________________

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LIST OF NOTATIONS/SYMBOLS

Symbol/ notations	Detail
%	Percent
^0C	Degree Celsius
CD	Critical difference
cm	Centimeter
cm^2	Square centimeter
cm^3	Cubic centimeter
$cm^2\ g^{-1}$	Square centimeter per gram
d^{-1}	Per day
$g\ cm^{-2}$	Gram per square centimeter
gm or g	Gram
ha^{-1}	Per hectare
Hrs	Hours
Kg	Kilogram
m	Meter
m^2	Square meter
Mg	Milligram
mg $g-^{1}$	Milligram per gram
mg g^{-1} FW	Milligram per gram fresh weight
Ppm	Part per million
unit g^{-1}	Unit per gram
unit H_2O_2 $min-^{1}$	Unit per H_2O_2 per minute
$\mu M\ g^{-1}$ FW	Micromole per gram fresh weight
$\mu M\ m^{-2}\ s^{-1}$	Micromole per meter per second
$mM\ m^{-2}\ s^{-1}$	Millimole per meter per second

LIST OF ABBREVIATIONS

Abbreviations	**Detail**
CHL	Chlorophyll
DAS	Day after sowing
DW	Dry weight
EC	Electrical conductivity
et al.	And coworkers / and others
i.e	That is
viz.	Namely
Fig.	Figure
FW	Fresh weight
ICAR	Indian Council of Agriculture Research
IISS	Indian Institute of Soil Science
IGKV	Indira Gandhi Krishi Vishwavidyalaya
LA	Leaf area
LAR	Leaf area ratio
NS	None significant
RWC	Relative water content
SLA	Specific leaf area
SLW	Specific leaf weight

THESIS ABSTRACT

a) Title of the Thesis:	"Morpho-physiological characterization of soybean cultivars for efficient photoassimilate partitioning and yield"
b) Full Name of the Student:	Dineshwar Singh Kanwar
c) Major Subject:	Plant Physiology
d) Name and Address of the Major Advisor	Dr. P. Katiyar, Professor Plant Physiology, Agricultural Biochemistry and Medicinal and Aromatic Plants.
e) Degree to be Awarded:	Master of Science in Agriculture (Plant Physiology)

Signature of the Student

Signature of Major Advisor

Date: 21.7.2016

Signature of Head of the Department 22/7/16

ABSTRACT

The present investigation entitled "Morpho-physiological characterization of Soybean cultivars for efficient photo assimilate partitioning and yield" was carried out during *kharif* season 2015 at Research cum instructional farm IGKV Raipur (C.G.) in the Department of Plant Physiology. The experiment was conducted to explicit out the morpho-physiological

markers and plant architecture, growth pattern for efficient partitioning of photo assimilates and high sink realization and yield via evaluating 44 cultivars of three groups *i.e*. early medium and long in randomized block design replicated thrice. The morpho-physiological growth and yield parameters were taken at various growth phase and time *i.e.* 40, 60, 90 days after sowing (DAS) and at physiological and physical maturity. The first flower initiating node was also calculated. The correlation studies indicated that the HI was highly positively correlated with test weight, seed yield and plant height.

Seed yield was also positively correlated with test weight, no. of pods plant^{-1}, no. of seed plant^{-1}. However BY (biological yield) was highly negatively correlated with physiological maturity, chlorophyll SPAD value. The no. of seeds pod^{-1} was highly negatively associated with days to flower initiation. No. of seed plant^{-1}, was positively correlated with no. of leaves plant^{-1}, no. of branches plant^{-1} and no. of pod plant^{-1}.

It was observed that the cultivars KDS 775 (E), RSC 10-30 (E), NRC 123 (M) and PS 1570 (L) have significant higher HI amongst their groups. KDS 775 have high test weight and low biological yield. The cultivars RVS 2010-1 (E), KDS 975 (E), RHC 10-04 (M), NRC 117 (M), JS 20-94 (M) and JS 95-52 (C) (L) and RSC 10-29 (L) have significantly higher seed yield amongst their groups of various duration *i.e*. 'E' early, 'M' medium, and 'L' long. These cultivars have less number of flower drop, more sink realization and efficient photo assimilates partitioning towards economic sink. These cultivars have significantly higher number of branches RHC 10-04 (M) JS 97-52 (c) (L), higher leaf area RHC 10-04 (M) RSV 2010-1 (E) and DSb 29 (L). These cultivars also having higher no. of pods plant^{-1} and cultivar JS 20-94 (M) have minimum no. of pod bearing node.

Cultivars VLB 202 (E), TS 72 (M), MACS 1480 (L) have significantly higher CGR. However, RVS 2010-1 (E), RHC 10-04 (M) and DSb 29 (L) have higher LAI. The average maximum NAR, RGR were observed in VLB 202 (E), TS 72 (M) and SL 1074 (L) cultivars of various groups.

शोध सारांश

अ) शोध शीर्षक — "सोयाबीन की आकरिकिय कार्यिकी गुणों का चित्रांकन पौधों में भोजन की सार्थक एकत्रीकरण एवं उत्पादन के लिए किया गया ।"

ब) छात्र का नाम — दिनेश्वर सिंह कँवर

स) मुख्य विषय — पादप कार्यिकी

द) मुख्या सलाहकार का नाम व पता — डॉ. पी कटियार , प्रोफेसर पादप कार्यिकी कृषि जैव रसायन ओषधिय एवं सुगन्धित पौधे , कृषि विश्वविध्यालय, इंदिरा गाँधी कृषि विश्वविध्यालय, रायपुर (छ.ग.)

इ) सम्मानित उपाधि — एम् .एस.सी (कृषि) पादप कार्यिकी

Skanwar

छात्र का हस्ताक्षर

P. Katiyar

प्रमुख सलाहकार के हस्ताक्षर

22/7/16

विभागाध्यक्ष के हस्ताक्षर

दिनांक 21.7.2016

सारांश

वर्तमान शोध शीर्षक सोयाबीन की आकरिकिय कार्यिकी गुणों का चित्रांकन पौधों में भोजन की सार्थक एकत्रीकरणएवं उत्पादन के लिए किया गया है " सत्र 2015-16 खरीफ ऋतू में इंदिरा गाँधी कृषि विश्वविध्यालय के अनुसंधान प्रक्षेत्र के पादप कार्यिकी विभाग में किया गया, इस अध्ययन के अन्तर्गत सोयाबीन की 44 किस्मो को जो की तीन वर्गों में थी, लघु

अवधि, माध्यम एवं दीर्घ अवधी की थी, को आर बी डी डिजाईन में तीन पुनरावृत्ति के साथ विश्लेषण किया गया है। यह शोध अकार्यिकी कार्यिकी मार्कर, पादप संरचना, वृद्धि नमूना, प्रकाश समावेश के कुल विभाजन एवं उच्च सिंक प्राप्ति के लिए किया गया।

सहसंबंध अधयन्न यह बताता है की हार्वेस्ट इंडेक्स का बीजो के वजन, बीजो की मात्रा, तथा पौधों की लम्बाई से काफी धनात्मक सम्बन्ध है , जबकि जैविक उत्पादकता का ऋणात्मक सम्बन्ध पौधों की परिपक्वता की अवधि से है, कार्यिकी एवं उपज मापदंड को विभिन्न वृद्धि नमूना लक्षण 40, 60 एवं 90 दिनों के अन्तराल में किया गया। प्रथम पुष्पन के समय पुष्प के साथ साथ नोड को गिना गया , यह देखा गया की KDS775 (लघु), RSC10-30 (लघु), NRC123(मध्यम), और PS1570 (दीर्घ) किस्मो का फसल सूचकांक, अन्य किस्मो की अपेक्षा अधिक पाया गया, KDS775 अत्यधिक मूल्यांकन भार एवं कम जैविक उपज RBS2010-1 (लाघु), KDS975(लघु), RHC10-04(मध्यम), JS97-52(C)(दीर्घ) और RSC10-29 (दीर्घ) का अन्य क्सिमो की अपेक्षा तीनो समूहों जैसे लघु, माध्यम तथा दीर्घ अवधि में अत्यधिक बिज उत्पादन पाया गया, इन जीन प्रारूपो में कम पुष्प झडन, उच्च सिंक प्राप्ति तथा कुशल प्रकाश समावेश विभाजन जो की उसके आर्थिक सिंक को बढाता है साथ ही साथ अधिक शाखाओं RHC10-04, JS97-52(C)(दीर्घ), और पत्ती परिक्षेत्र के लिए यह किस्मे RHC10-04, RSB2010-01 और DSB29 सार्थक पाया गया। यह किस्मे फलियों की संख्या प्रति पौधों के लिए उच्च और किस्म JS20-94(मध्यम) में फलियाना कम पाया गया, किस्मे VLB202, TS72 और SL1074(दीर्घ), उच्च एन ऐ आर, और सी जी आर 40 से 60 और 60 से 90 के लिए सार्थक पाया गया है NRC119(लघु), VLB200(लघु), TS72 (मध्यम), MACS1480 (दीर्घ) उच्च CGR के लिए जबकि RVS2010-1(लघु), RHC10-04(मध्यम), DSB29(दीर्घ), एल ऐ आई के लिए सार्थक पाया गया है।

CHAPTER - I

INTRODUCTION

Legumes are the major source of high quality, low cost protein having major role in providing balanced protein component in the diet of human and animals. The legume/ pulses contain three time protein as compared to cereals and also having essential amino acid. Apart from genetic makeup, the major physiological constraints limiting its production are flower drop and fruit drop. Climate change is the major factor of the environment conditioning the regional and seasonal adaptation and yield of the crop plant.

Soybean (*Glycine max L. Merrill*) is an important pulse as well as oilseed crop. It has become wonder crop of twentieth century and is often designated as Golden bean. Three soybean species have bean identified are as *Glycine ussuriensis* (wild) *Glycine max* (cultivated) *Glycine gracillis* (intermediate) out of these *Glycine max* is cultivated all over the world (Desai *et al*., 1997). Soybean is one of the most important oilseed crop in the world in terms of total production and international trade. It is considered as "**wonder crop**" of 20 th century being an excellent source of both protein (40-44%) and oil (18- 20%) as protein is rich in valuable amino acid, lysine (5%) in which most of the cereal are deficient. In addition, it also contain a good amount of minerals (4.5%), salt and vitamins (thiamine and riboflavin). Its milk is comparable to cows milk. Now it is being used for manufacture of nutritional product for human being. The cake flours are extensively used as animal feed. Soybean is used for preparation of milk, curd, cheese etc. and can be afforded by poor class people also. The crop also helps in increasing the fertility level of soil through symbiotic nitrogen fixation. It is thus, a multipurpose crop with many advantages.

As an autogamous crop belonging to family leguminosae, sub family papilionaceae, the genus Glycine comprises of 1200 species. The plant is normally diploid with 2n=40 chromosomes. Soybean originated in the temperate northern plains of China and was domesticated in about 1100 BC. It spread to Europe, USA and other countries in South America and south East Asia and has undergone expansion in cultivation from temperate to tropical and sub tropical region.

Cultivation of soybean in India was reliable in 1970's picked up during last two decades. In 1993-94, the was cultivated in 4.5 million hectares and production reached 4.3 million tones, while in 1998-99, the area and production further increased to 6.3 million hectare and 6.7 million tones with productivity 1.083 kg/ ha. In India major soybean producing states are Madhya Pradesh, Maharashtra, Rajasthan and Uttaranchal. Madhya Pradesh accounts for about 75% of total soybean produced in India. While Chhattisgarh stand with 1.5 lakh hectare area. In recent past, cultivation of soybean has been gaining in Chhattisgarh. Soybean is only oilseed crop than can be grown successfully during kharif season in Chhattisgarh.

In Chhattisgarh, the average productivity of soybean is very poor in comparison to Worlds productivity. The area under soybean crop during 2013-14 was 156590 hectares and production was 1070 kg/ha (Krishi darshika 2015). In Chhattisgarh, among all districts maximum area and production of soybean comes under Rajnandgoan followed by Durg and Kabirdham.

The climate of the state is also very congenial to soybean cultivation during Rabi. Soybean can be grown as contingent soybean seed production programme in Rabi, when the main crop of soybean seed production fails during *Kharif* season. Although the country has witnessed phenomenal growth in area under soybean the national productivity is still low, about one half of the world average. To enhance and stabilize yield levels of soybean in the country emphasis has been laid on the development of high yielding cultivars having short duration long seed filling period, good seed longevities, resistance to pod shatter, resistance to biotic and abiotic stress and value added characters.

Unfortunately there has been no significant increase in productivity of soybean in India (1008 kg ha^{-1}) as compared to the productivity of world (2148 kg ha^{-1}). Its yield is a very complex character being depends upon a number of genetic and physiological factors interacting with the environment. Due to certain constraints of productivity like lower sink demand is inviting the wide gap in critical yield status, resulting in stagnant genetic yield potential. In view of the fast shrinkage of agriculture resources, it is urgently needed to identify the possible key and physiological variables, which are the physiological determinant and associated with the seed yield of the crop. This could only be the ray of hope in order to select the most suitable cultivars for Chhattisgarh region and to understand the dynamics of yield variation associated with the phenology of the crop.

Soybean creates alkalinity after digestion, whereas, cereals creates acidity in the body after digestion. Seed size play an important role an deciding the quality and viability of soybean, larger seed contains more food material but are subjected to severe field weathering and mechanical injuries during harvesting, processing and handling. Physiological as well as genetic factor 4 both influence the size of seed (Gupta, 1976), large seed deteriorated faster than small seed. Many times the germination was affected by seed size (Vanangamudi, 1988). It is legume crop, often referred as a golden bean, as it is easy for cultivation with less inputs of fertilizers and plant protection seed is a basis of agriculture and agriculture is foundation of economy of India.

One of the major constraints in soybean production in lack of suitable location specific cultivars to particular reason. Major physiological constraints limiting its production are flower drop and fruit drop. Leaf area development in very slow during initial growth period and that influenced dry matter partitioning and seed yield. That can be enhanced by maintaining C:N ratio, date of sowing during different season, symbiotic nitrogen fixation and meiotic cell division an very sensitive to temperature extremes, pollen formation is highly sensitive to both high and low temperature. In Soybean and Vigna species cool high temperature which reduce the reproductive sink through gemetogenesis can substantially reduce HI.

Efficiency of conversion of incident radiation plays important role in photo assimilate production and its efficient partitioning depend on photo thermal sensitivity. Thus manipulation of photo thermal sensitivity offer most powerful tool for improving HI. Therefore present investigation entitled “Morpho-physiological characterization of soybean cultivars for efficient photo-assimilates partitioning and yield” was under taken to find out the morpho-physiological markers architecture and growth pattern for efficient partitioning of photo-assimilates toward economic sink, with the following objectives:

1. To study the morpho-physiological markers for plant architecture and growth pattern in Soybean.
2. To assess the morpho-physiological traits related to efficient partitioning of photo- assimilates.
3. Correlation of morpho-physiological traits with flower abortion, sink realization and yield.

CHAPTER - II

REVIEW OF LITERATURE

In India, soybean cultivation is rapidly spreading to occupy third place in national production of oilseed and edible oil, but still we have to import new technology from developed countries for the productivity and very few attempts have been made on physiological parameters, which govern the growth, development and yield of soybean.

An attempt has been made to review the available literature related to physiological basic of seed yield variation and its determining traits in soybean (*Glycine max (L) Merrill*) under following suitable sub-heads:

(1) Morpho-physiological & growth parameter

(2) Yield parameters.

(3) Sink realization.

2.1 Morpho-Physiological parameters

Buttery (1970) investigated that growth parameters and observed *viz.* RGR and NAR increased with the increasing density while mean CGR and LAR decreased. The NAR of soybean plant is nearly half that of maize and thus the crop growth lower efficiency of soybean and lower productivity as compared to maize.

Egli and Leggett (1971) reported that the rate of accumulation of dry matter in the pods and seed was greater for determinate than indeterminate varieties. The length of effective filling period *i.e.*, the grain yield divided by the rate of grain filling was longer and was positively associated with grain yields.

Pawar (1978) studied growth parameters in soybean varieties and observed that RGR increased up to 30 days and later on it decreased while, LAI was less of seedling stage but increased continuously up to 60 days and there after it decreased.

Marcos Filho, (1977-1978) observed that the development and seed maturation of soybean studied in field experiments. The seeds were harvested times/yr and after each harvest the m. c., dry wt., integument and hilum color, germination and vigor of seeds were measured. The absence of yellow-green seeds with the same color hilum and the loss of green color from the pods were useful and acceptable indicators of physiological maturity. Maximum soybean seed dry weight was found to be insufficient by itself to characterize physiological maturity.

Momen *et al*. (1979) stated that limited soil moisture influenced the field crop performance of soybean by reducing the plant height, the size of the assimilating leaf area and reduction in dry matter.

Shrivastva *et al*. (1982) studied the growth analysis in soybean in relation to productivity and observed that the maximum yield was noticed in 30 mg cobalt seed treatment. The increase in productivity was attributed to increase in LAR, CGR, RGR & NAR.

Nirmala Kumari and Balasubramanian (1989) observed that the dry matter production and CGR increased slowly up to 60 DAS and decreased later up to harvest while, LAI increased sharply up to 60 DAS and decreased till harvest in soybean.

Egli, *et al*. (1990) reported that the seed size had no effect on specific growth rate or NAR. Seed vigour had no effect on SGR, NAR or seedling weight at 20 DAE. In a 2nd set of experiments, individual seed conductivity of seeds from high and low vigour seed lots and related to seedling DW accumulatein. The data indicated that seed vigour has no effecton the ability of the seedling to accumulate DW if there is no injury to the cotyledons.

Sincliar *et. al.* (1991) observed that the greatest mean nodule weight also had the greatest positive response to favorable environment and also noticed that root and shoot weight had moderately positive correlation with nodule number and its weight.

Jones *et al.* (1991) reported that the soybean development model SOYGRO is described, and four other soybean phenology models reviewed. SOYGRO is a crop growth model which includes a development model designed to predict the duration of growth phase in soybean cultivars growing in various climates, using cultivar response to photoperiod and temperature. Average errors in predicted flowering date were 1-9 d, but when the crop was planted late and maturity occurred during cool late autumn weather the predicted maturity date was up to 19 d late.

Verma and Gupta (1985) observed that seed size plays important role in deciding the quality of soybean seed. The maximum percent of germination was observed in bold seeded cultivars (78.53%). The germination percentage was decreased further as the size of seed reduced. The higher germination of bold seeded cultivars may be attributed to higher starch content which may facilitate early sprouting of radical and plumule.

Chandel *et al*. (1987) observed the yield components in general decreased with increase in plant population. The interaction effects of varieties and plant population for grain yield was significant. Increasing plant population decreased the protein content in soybean.

Kumari and Balasubramanian (1989) observed that the dry matter production and CGR increased slowly up to 60 DAS and decreased later up to harvest while, LAI increased sharply up to 60 DAS and decreased till harvest in soybean.

Egli *et al.* (1990) reported that the seed size had no effect on specific growth rate or NAR. Seed vigour had no effect on SGR, NAR or seedling weight at 20 DAE. In a 2nd set of experiments, individual seed conductivity of seeds from high and low vigour seed lots and related to seedling DW accumulation. The data indicated that seed vigour has no effecton the ability of the seedling to accumulate DW if there is no injury to the cotyledons.

Charajan and Tarar (1991) observed that in soybean, first count of germination percentage, plumule length, speed of germination, radical length, dry matter production and seed vigour index were increased with seed size.

Sincliar *et al.* (1991) observed that the greatest mean nodule weight also had the greatest positive response to favorable environment and also noticed that root and shoot weight had moderately positive correlation with nodule number and its weight.

Jones *et al*. (1991) reported that the soybean development model SOYGRO is described, and four other soybean phenology models reviewed. SOYGRO is a crop growth model which includes a development model designed to predict the duration of growth phase in soybean cultivars growing in various climates, using cultivar response to photoperiod and temperature. Average errors in predicted flowering date were 1-9 d, but when the crop was planted late and maturity occurred during cool late autumn weather the predicted maturity date was up to 19 day late.

Sharma and Sharma (1992) studied the varietal response in soybean on plant varietal response on plant height and branches per plant and concluded that it was significant but its response on dry weight was not found significant and physiological growth parameters like LAI, CGR and NAR were significant to varietal response.

Abbas *et al.* (1992) reported that erect plant type in soybean was superior than spreading type for almost all the growth and physiological parameters, *viz*., fresh weight, number of root nodule, LAI, NAR and CGR significantly increased with 0 to 80 kg P205 ha^{-1}.

Miao *et al.* (1993) reported that field-grown soybeans leaves and pods were removed daily during reproductive growth. Specific leaf weight increased more in the treated plants than in the untreated controls. During early reproductive growth rates of photosynthesis and N contents were lower in the treated plants, but both became higher than in the controls at later growth stages. At the late stages depodding also increased photorespiration and the CO_2 compensation point.

Toledo *et al*. (1993) observed that the Soybean is a short day plant highly influenced by photoperiod. Response to day length is determined by the cultivars, and the genetic control of flowering and growth is distinct and independent for long and short day conditions. Parental final plant height, days to flowering, trifoliolate leaf number and average length of the internodes and the genetic mechanisms controlling photoperiodic response of these traits in the 6 crosses were studied.

Wells *et al.* (1993) observed that the altered canopy light environments created by plant architectural changes may increase plant productivity. Two morphological traits in soybean, brachytic stems, and lanceolate leaflets, could be used for genetic manipulation of canopy structure.

Taware *et al.* (1994) reported that the mean square verities and seasons were highly significant for days to flowering, days to maturity, plant height, pods per plant, 100 seed weight, oil content and seed yield.

Bholia *et al.* (1995) evaluated 27 divergent soybean cultivars at two reproductive growth stages and reported that the specific leaf weight was significantly and positively associated with leaf and palisade thickness.

Jain *et al*. **(**1996) observed that in soybean LAI, CGR and RGR were increased with age and decreased at ripening, whereas, NAR declined with increase in age. The LAI, CGR and NAR declined significantly due to number of branches plant^{-1} and number of pod plant^{-1} under delayed sowing.

Pantalone *et al*. (1996) reported that the to related visual root scores to other measurable root characteristics in order to provide breeders with a means for rapid phenotypic evaluation of soybean roots. Root score, root surface, and root dry weight were measured at three soybean stages of development in 1992 and 1993. Nodule number and nodule dry weight were also measured during the second year. PI416937 had higher root score, root surface, nodule number and nodule dry weight than Lee 74. Root score was positively correlated with root surface, nodule number and nodule dry weight. Phenotypic root scores could be utilized effectively in selection programmers to rapidly evaluate large numbers of progeny in order to identify those with extensive fibrous root systems.

Bhatia *et al*. (1996) reported that the field trial, 27 divergent soybean (*Glycine max*) cultivars were evaluated for leaf photosynthesis (Pn), specific leaf weight (SLW), and leaf and palisade thickness at two reproductive growth stages *i.e.* R1 (appearance of first flower) and R5 (commencement of seed filling). A wide range of genotypic variability was observed for all the characters studied. At R5, Pn had a strong and positive genotypic correlation with SLW, leaf thickness and palisade thickness. SLW was in turn significantly and positively associated with leaf for PN. Donors for desirable physiological and anatomical characters were identified for use in and palisade thickness at this growth stage. A strong positive association was also observed between SLW at R5 and grain yield. Owing to a high proportion of genetic variance and a high degree of positive association, SLW at R5 is recommended as a simple selection criterion for evaluation of a large number of cultivars breeding programmes.

Kundu *et al*. (1997) observed that the crop had maximum nodule dry weight (1.88 g plot^{-1}) between 55 to 65 DAS.

Luquez *et al*.(1997) compared wild type soybean variety (cv. clark) and chlorophyll deficient line homozygous for the recessive allel Y9 under watered or water stress condition and found that matured leaves of Y9 had a 65 per cent lower chlorophyll content than wild type. However net photosynthetic rate (PN) of Y9 leaves was only 20 per cent lower than wild type. Transpiration rate (E) were significantly higher in the leaves of Y9, compared to wild type, the higher E of Y9 correlated with increase in stomatal conductance.

Gontia and Awasthi (1998) observed that bold seed proved superiority over small and medium seed for almost all seed vigour traits, growth parameters and recorded 55.67 per cent higher seed yield over small seed.

Koti and Chetti (1998) noticed that in soybean cultivars all the morph physiological characters differed significantly in different season. The cultivars were found to be superior in Kharif followed by summer and least in Rabi. Similar trend was also noticed for seed yield also.

Koesmaryono *et al*. (1998) investigated diurnal variation of net photosynthetic rate (PN) and transpiration rate (E) in six week old soybean (cv. Fukuyutaka) under condition of 100,50 or 25 per cent of full sun irradiance (I-100,I-50,I-25 plants) and found that in morning photosynthetic rate and transpiration rate in plant at irradiances, grew. However during afternoon all plants were tested under full irradiance. At low level of irradiance, low PN and E was observed. Stomatal conductance was considerably lower in I 25 plants only.

Rajput and Shrivastava (1999) studies the effect of sowing dates, varieties and seed rate on growth, physiological parameters and yield of soybean. Sowing of 11th July was significantly superior to 21st July and 31st July for growth and yield parameters. All physiological growth parameters *i.e*., LAI, LAR, RGR, CGR and AGR were different significantly and growth parameters were found to be maximum with the sowing of 4th July, which decreased continuously with late sowing.

Bacanamwo and Purcell (1999) noticed that the two experiments evaluated morphological and anatomical changes induced by flooding for plants relying on N_2 fixation or supplemented with nitrate.

Nakano, *et al.* (2001) suggested that a higher yield was obtained by the square planting compared to rectangular planting as a result of the higher numbers of branches and branch nodes and higher podding efficiency in the lower nodes of the main stem due to reduced matual shading.

Agrawal *et al.* (2002) observed that the pattern of dry matter accumulation in soybean pod and its relationship with pod shattering was studied using ten soybean cultivars that differed in the extent of pod shattering during three different seasons. Dry matter accumulation in pod and seed increased continuously up to physiological maturity, whereas dry matter of pod shell increased up to 40 days after anthesis and reduced afterwards. Dry matter accumulation in pod and seeds was negatively correlated with pod shattering.

Khan *et al.* (2003) observed that the determinate and indeterminate soybean types have different growth habits. Number of days to emergence, unifoliate and 6th trifoliate leaf formation were reduced in both cultivars with delay in sowing. Highest plant density of 60 plants m-2 attained maximum plant height as compared with the lowest plant densities. The number of days to maturity declined with each successive planting date for both cultivars.

Veerbhadrappa and Yeldhalli, (2005) reported that the morphological parameters like number of leaves per plant provides base for physiological functioning of plant. The physiological process like photosynthesis, carbohydrates, protein, far metabolism etc. are located in leaves, thus provide substrates for most of the metabolism required for growth, development and storage.

Sonawane *et al.* (2005) reported that the cultivars was found to be superior in respect of growth characters like plant height, number of fully opened leaves, number of primary branches, leaf area of green leaves, phenological stages such as days required for initiation of flowering, days required for 50% flowering and days required for physiological maturity.

Liu Xiao Bing, (2005) observed that the pod and seed number are the most important yield components of soybean. Leaf area index (LAI), leaf area duration (LAD) and dry matter accumulation during the reproductive period strongly influence yield components. Dry matter accumulation, LAI, and LAD were measured at R2, R4, R5, and R6 stages. Yield components and harvest index were determined at maturity. Significant variations were found for LAI, LAD and dry matter within each maturity group. Higher accumulation of dry matter, higher LAI and LAD during reproductive stages were found to be closely related to high-yield cultivars in each group.

Mazahero, Daroish., *et al.* (2005) reported that the grain yield increased by 38% with increasing plant density from 20 to 60 plants/m^2. The maximum grain yield was obtained at 60 plants/m^2. High total dry matter resulted in high seed yield if the total dry matter was produced prior to the seed filling period. High dry matter accumulation during under the highest plant density resulted from high leaf area index during the period from early emergence to early seed filling, and high net assimilation rate during early reproductive stage.

Kausale *et al.* (2006) studied the effect of sowing dates on growth, physiological parameters and yield of soybean verities at Parbhani (Maharashtra). The sowing of soybean on 15th September was significantly superior over 30th September, 15th and 30th October in respect of growth and yield parameters. They mentioned that the physiological parameters *i.e.* means absolute growth rate, dry matter and RGR were reduced with successive delay in sowing time.

Li,WenXia. *et al*. (2006) observed that the seed size is one of the important factors of soybean [*Glycine max (L.) Merrill*] yield. There have been lots of reports about genetic effects and physiology-ecological researches on seed size, but the genetic behaviours of genes during seeds development were rarely discussed. The phenotypic means of FSS and DSS in soybean at eight stages among three generations reached the highest value at 9/6 and 9/13, respectively. The means of FSS decreased dramatically after 9/6, but the means of DSS maintained relatively stable tendency at corresponding periods.

Heerden, (2007) observed that the effects of growth media on shoot physiology were assessed by measurement of plastochron index, chlorophyll content and assimilation rates, nodule numbers, nitrogenase activity and nodule ureide content were also determined. Although similar source-sink relationships were maintained in plants cultured in the various growth media, large effects on nodule numbers were observed. Shoot phenotype and physiology did not provide any insight into these belowground effects.

Mihajlov, (2007) observed that the average number of the pods in the all seedtimes and for all varieties for the three year period is 96, and it is 33.6% less than the average number of formed flowers. The average number of pods per plant for the three year period in the seedtime is 10% bigger. The variety with longer vegetation during the three year period forms, the biggest number of pods per plant, but the variety with shorter vegetation forms the smallest number of pods per plant.

Uddin, *et al*. (2007) reported that the some morphological structure, and root and shoot biomass production in soybean cultivars. The plant height, stem base diameter, seed dry weight per plant were significantly greater in the late planting crops but number of branches per plant, number of leaves plant^{-1}, leaves dry weight plant^{-1}, shoots dry weight plant^{-1}, roots dry weight plant^{-1}, total dry matter plant^{-1} were significantly greater in November planting. Highest plant height, branches plant^{-1} and leaves plant^{-1}, shoot dry weight plant^{-1} and total dry matter were found in soybean cultivars.

Tandale, *et al.* studied the effect of leaf area and leaf shedding (%) on seed yield of different soybean varieties. It is observed from the pooled mean data of leaf area and leaf shedding% at 30 DAS and 90 DAS and seed yield (q/ha) that there were significantly differences observed among all varieties studied. There was positive correlation of leaf area with seed yield at 30, 60 AND 90 DAS.

Rajkumar-Ramteke and Husain (2008) observed that the soybean cultivars with superior agronomic traits important for adaptation, to assess the presence and nature of the G x E interactions for plant height, nodes per plant, branches per plant, pods per plant, seeds per plant, 100-seed weight, seed yield and days to 50% flowering and to determine the yield stability of 30 cultivars over 3 years. Mean squares for cultivars, linear components of environments and interactions of cultivars x environment were significant for all characters. The cultivars stable for yield and other characters can be used as parents in future breeding programmes for the development of suitable cultivars for cultivation under diverse environments.

Setiyono, *et al.* (2008) studied that the rate of change in expanding leaf area was simulated using the first derivative of a logistic function accounting for plant population density, air temperature, and water deficit. The rate of change in senescing leaf area was also simulated using the first derivative of a logistic function, assuming monocarpic senescence that began at the flowering stage. Phenology was simulated as a function of temperature and photoperiod. Interactions between leaf growth and source-driven processes can be incorporated in the future, while maintaining the basic physiological assumptions underlining leaf expansion and senescence.

Deokar, *et al*. (2009) observed that the cultivars MACS-1314 showed maximum plant height among all other cultivars and recorded more number of leaves as well as leaf area index. Cultivars, Kuber recorded highest total dry weight, absolute growth rate, relative growth rate and net assimilation rate. In yield attributing characters cultivars Kuber recorded highest number of seed per pod and 100 seed weight while cultivars JS-335 showed highest harvest index.

Feng NaiJie, *et al.* (2009) observed that the Morphological and physioogical regulations responding to plant growth substances could effectively control lodging, increase leaf area index, promote photosynthesis, reduce productive abscission and improve yield and quality in soybean production. The results indicated that the plant growth substances caused the changes of both anatomical structure of leaf and photosynthetic characteristics.

Mertz, *et al.* (2009) studied that evaluate the physiological quality of seeds from cultivars and TP (black coat, semi-permeable and resistant to deterioration and identify structural differences between the coats of these cultivars. The physiological quality of the seeds was obtained by germination tests and vigour. To evaluate structural differences, soybean seeds were collected at different development stages. According to the results cultivars TP presented higher physiological quality in relation to cultivars. Structural differences were observed between the coats of the two cultivars which may be related to physiological quality of seeds.

Najar, *et al.* (2011) reported that the increasing levels of sulphur significantly increased growth, nodulation, yield, uptake and quality of soybean up to the application of 30 kg S/ ha but maximum growth nodulation, yield and quality of soybean was recorded under 40 kg S/ ha which was at par with 30 kg S/ha. Stover and grain yield of soybean increased in the tune of 66 and 53.4%.

Anil Kumar, *et al.* observed that the three date of sowing with four levels of spacing based on Growing Degree Days (GDD), Heliothermal units (HTU) Photo thermal units (PTU) obtained for prediction of phenopheses, growth and yield of Soybean. Three dates of sowing, leaf area development, plant height, number of pods per plant, number of seed per pod, dry matter accumulation, stover yield and grain yield were correlated with GDD, HTU and PTU of agro climatic indices were observed for early sown soybean. The highest HUE of 0.83 g m^{-2} per °C day for Stover and 0.78 g m^{-2} per °C day for grain yield are recorded and GDD directly reflected in dry matter accumulation to soybean as well as Stover yield.

Patil, (1989) observed the varietal difference for plant height, number of leaves, leaf area, dry matter accumulation, number of pods per plant, number of grain per pods, test weight and yield in soybean.

Nirmala Kumari and Balasubramanian, (1989) observed that the dry matter production and CGR increased slowly up to 60 DAS and decreased later up to harvest while, LAI increased sharply up to 60 DAS and decreased till harvest in soybean.

Sharma and Sharma, (1992) studied the varietal response in soybean on plant verietal response on plant height and branches per plant and concluded that it was significant but its response on dry weight was not found significant and physiological growth parameters like LAI, CGR and NAR were significant to varietal response.

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2.2 Yield and its attributing characters

Saxena and Pandey, (1970) were reported that grain yield of soybean varieties was significantly associated with the number of pods plant^{-1} 100 grain weight and days taken from planting to maturity.

Maley and Sharm, (1973) reported that planting soybean on 15th June yielded 40 per cent more as compared to 25th June planting. Delayed planting reduced the yield tremendously.

Perraju, *et al*.(1982) studied 107 diverse cultivars of soybean and reported that yield plant^{-1} was positively associated with number of pods, number of nodes, number of branches, harvest index, number of seed pod^{-1}, 100 seed weight and plant height.

Syder, *et al*. (1982) reported that in late maturity cultivars of soybean water stress caused seed yield reduction by 12 per cent while in early maturing cultivars there was 18 per cent reduction due to soil water stress on pod abortion.

Singh, *et.al*.(1983) examined the phenological yield components viz., number of days to maturity, plant height (cm), number of primary branches, number of pod bearing node, pod plant^{-1}, seed pod^{-1}, 100 seed weight and seed yield plant^{-1} in 28 strains of soybean. At the phenotypic level the yield was positively correlated with plant height, primary branches and the number of pod plant^{-1}. The remaining characters ware positively associated with one another. The path analysis revealed that the number of pod bearing nodes number of primary branches and 100 seed weight directly and the number of pod plant^{-1}, plant height, maturity and primary branches via the number of pod bearing nodes plant^{-1} exerted the greatest influence on seed yield.

Pookpakdi *et al*. (1990) concluded that water deficit reduced the yield, dry matter production, pods plant^{-1} and seed size without any change in seed number pod^{-1} in soybean.

Baisakh and Dash, (1991) found that variety x year interaction was also significant in the influencing the characters viz., plant height, pod plant^{-1}, seeds pod^{-1}, 100 seed weight, days to flowering and yield in soybean crop and indicated significantly different response of varieties to environment.

Deshmukh *et.al***. (**1991) showed that number of branches plant^{-1} and number of pod plant^{-1} are significantly associated with seed yield. The path analysis revealed the plant height exerted highest positive direct effect on seed yield followed by 100 seed weight, number of branches plant^{-1}, dry matter accumulation, oil content and number of pod plant^{-1}.

Ghatge and Kadu, (1992) studied the genetic diversity for sixteen characters of soybean have been worked out by mahalanobis D2 statistics. Sixteen characters *viz*., day to 50% flowing maturing, plant height, plant spread, plant index, leaf length, leaf breath, harvest index, number of branches on main stem, number of pods plant^{-1}, number of seed pod^{-1}, 100 seed weight, biological weight and seed yield.

Jasani, (1993) observed that soybean plant performance was batter under earlier planting with lower seed rate expect in case of plant height grain and straw yield, which was highest with the highest seed rate.

Deka and Talukdar, (1994) noticed the significant interaction between cultivars X environment in almost all the character like 100 seed weight and yield plant^{-1} only linear components contributed significantly towards GE interaction variance.

Isler, *et al.* (1997) studied that the some important characteristics of ten soybean cultivars, such as plant height, first pod height, branch number per plant, pod number per plant, pod length, seed number per pod, 100 seed weight, seed yield per plant and per hectare. The cultivars showed differences in the investigated characteristics, except for pod length and seed number per pod.

Rani, *et al.* (1998) to study the response of early maturing soybean variety to different row spacing. Plant population and nitrogen level, in the black soil of Krishna- Godavari zone. Planting the early maturing soybean at 6.0 lakh plant population per ha gave significantly higher seed yield and was on par with population of 5.0 lakh plant/ha. Seed yield.

Maske *et al.* (1998) observed that significant variation in yield contributing parameters such as pods plant^{-1} , number of seed pod^{-1} , seed yield pod^{-1} and harvest index ware recorded in various concentration of GA_3 & NAA in soybean crop.

Pramila Rani and Ramaiah, (1999) suggested that plant height number of pod plant^{-1}, 100 seed weight, day to harvest and grain yield decreased in with delay in sowing.

Billore, *et al*.(1999) suggest that delayed sowing from normal time (25th June) resulted in significant alternation in yield attributes like branches plant^{-1}, pod and seed plant^{-1},seed pod^{-1}, seed pod^{-1} and seed index. The pooled data for two years showed a decrease in all the attributers. The average soybean yield reduction was 181.77 kg ha^{-1} for five day delay in sowing.

Reddy *et al.* (2001) reported variation in morpho-physiological and yield contributing characters determine the productivity of crop. There are some cultivars specific characters which are responsible for higher productivity. The effect or stress on seed yield depends on many factors including its severity, duration, and the stage of plant development during which it occurs.

Chandel *et al*. (2004) reported that the during *Kharif season* to assess the effect of various fertilizer and manurial treatment on soybean (*Glycin max L. Merrill.).* Integrated use of recommended fertilizers increased the yield attributes and yield highest yield attributes (pod / plant, and 100 seed weight) harvest index, grain yield was recorded.

Karad, *et al*. (2005) observed that the genotypic and phenotypic variability for days to 50% flowering, days to maturity, plant height, branches per plant, pods per plant, seeds per pod and yield per plot were assessed in 16 soybean cultivars during *kharif* 2003. The phenotypic coefficients of variation were higher than the genotypic coefficients of variation for all traits. Plant height indicating the effect of the environment on their and pods per plant, and moderate for seeds per pod and branches per plant, indicating that these traits have scope for improvement through selection.

Sumit chaturvedi and Chandel, A. S. (2005) observed that the highest yield attributes (pod/ plant, and 100 seed weight), harvest index, grain yield as well as NPK uptake was recorded with the application of 100% recommended does of NPK + FYM @ 10 tonnes/ ha. Use of organic sources helped in maintaining soil fertility in terms of available nutrients.

Gulluoglu, *et al.* (2006) resulted that the positive effects of PGRs on shattering rate and yield losses were decreased with the increasing delay of harvest. The results of the current study showed that seed yield losses of main-cropped soybean could be alleviated by the application of PGRs. However application of PGRs was not suggested for double-cropped soybean if the scope was to reduce yield losses caused by pod shattering.

Kim SeokHyeon, *et al*. (2006) concluded that the soybean seeds of various sizes showing different seed hardness for water absorption and seed viability under adverse storage conditions. Soybean cultivars showing high hard seed coat were slow in water absorption and low in the electroconductivity of seed leachate in distilled water. The higher storing ability of both collections was confirmed by electroconductivity test for leachate. This cultivars was considered as to having a poor storing ability based on the difference of electroconductivity before and after artificial aging. Water absorption property of seed is strongly related to the hardness that is directly related to the seed viability and storing ability in soybean seed.

Liu, X., *et al.* (2006) observed that the seeds are the primary sinks for photosynthates during reproductive growth. Variation in light intercepted during and after seed initiation has been found a major environmental determinant of soybean [*Glycine max (L.) Merrill*] seed size. Higher rates of seed growth, greater seed dry weight, and higher cotyledon cell number were all observed with light enrichment. The level of ABA in cotyledon during seed development was significantly correlated with seed growth rates only under shade treatments. Both the growth rates and seed filling duration were influenced by variation in light interception by the soybean canopy.

Yadav, (2007) resulted that the seed yield and quality attributes using path analysis during the *kharif* season. Ten characteristics were included days to 50% flowering, days to maturity, plant height, pod bearing length, pod number plant^{-1}, seed number/plant, 100-seed weight, protein percentage, oil percentage and genetic correlation for seed yield. Results indicated that seed yield was significantly correlated with plant height, pod bearing length, pod number plant^{-1} and seed number plant^{-1}.

Shinde, *et al.* (2007) resulted that the, seed yield of soybean could be increased by application of 45 kg N ha^{-1}. Besal dose of N ha^{-1} application significantly increased 100 seed weight, number of pods plant^{-1}. Significantly varietal differences were noted in respect of oil content, days to 50% flowering, number of pods plant^{-1}, 100 seed weight, seed yield plant^{-1}, biological yield plant^{-1} and harvest index.

Zhang-Wei. *et al.* (2007) resulted that the morphological and physiological characteristics of super-high-yielding soybean, Comparative analysis of plant type characteristics were carried out through multi-year experiments with super-high yielding soybean variety and common soybean variety. High yielding varieties of soybean exhibited high photosynthetic rate and chlorophyll content after full podding and the photosynthetic rate of upper and lower leaves layer were different. High yield was better canopy structure, maintained higher LAI and photosynthetic potential and had higher photosynthetic productivity.

Kalyankar, *et al*. (2008) resulted that the GA_3 and NAA were applied to the foliage at 30 days after sowing, whereas CCC was applied at 40 days after sowing. MAUS 61-2 recorded the highest number of pods per plant, number of grains per pod, grain yield, biological yield and harvest index. Among the growth regulators, NAA at 100 ppm, and CCC at 200 and 250 ppm resulted in the highest grain yields. The highest biological yield was obtained with 100 ppm NAA and 50 ppm NAA.

Gayatri Kakad *et al.* (2008) studies that the effect of different pre sowing seed soaking treatment on seed protein, oil, yield contributing characters and yield in soybean seed. The results revealed that seed lots treated with various chemicals increases the oil%, protein%, yield and yield attributing characters $plant^{-1}$.

Abayomi, (2008) significant differences were obtained between the early and late maturity groups in all growth parameters, yield components and grain yield measured. Leaf production, branching, plant height, dry matter production, crop growth rate and relative growth rate were higher in late than in the early maturity group. The decreases were greater with stress occurring at the vegetative and flowering growth stages. Grain yield was significantly reduced by soil moisture stress, especially when it occurred at the vegetative and flowering growth stages, by reducing number of pods produced per plant, shelling percentage, harvest index and increasing floral and pod abortion.

Kosala, Ranathunge. *et al.* (2010) observed that the seed is permeable or non-permeable is governed by a number of quantitative trait loci further influenced by environmental factors. In soybean seeds, water loss is controlled by a thin, inconspicuous outer cuticle. When intact, the outer cuticle constitutes a barrier to water passage; however, the presence of minute cracks in the cuticle results in the ready passage of water. Cutin deposition occurred early in the development and ceased just prior to the final stage of rapid seed expansion. Cracks in the cuticle appeared after cutin synthesis ceased while the seed continued to grow. In permeable seeds the resistance of the cuticle to water passage increased steadily during development until seed expansion was maximal and cracks appeared in the cuticle.

Tony Ngalamu *et al*. (2012) reported the years showed significant differences among the cultivars and sowing dates for all the measured traits, with the exception of number of seeds per pod in both years. The highest seed yield was obtained from a sowing dates in 2010. The strongest and positive relationship was detected between productive pods and number of branches per plant whereas the weakest relationship was noticed between yield and first pod height. The highest yielding soybean cultivars was in 2009 and in 2010. The medium yielders were Soja and the lowest yielder in both years. These agronomic traits, number of pods per plant, number of seeds per pod, leaf area and number of branches per plant contributed to the yield performance.

Marcos *et al.* Soybeans harvested in the growth stages R7 and R8 commercial harvesting time and at two other subsequent times to compare their physiological and technological characteristics. Seeds were stored at two moisture levels, 12% and 15%, for 6 months. Germination and vigor (accelerated aging, electrical conductivity), oil and free fatty acids, peroxide and iodine values were evaluated periodically. As expected, the time of harvesting and seed moisture content affected seed performance, while oil content did not correlate to physiological quality as acidity, peroxide value and iodine number.

2.3 Sink realization.

Makie Kokubun, *et al. (2007)* reported that the fail to grow pods and abort during development. Many studies indicated primitive effects of exogenously applied cytokinin on pod setting, but the effects of auxin application on pod set are ambiguous. The changes in the concentrations of endogenous auxin and cytokinin in racemes and the effects of application of the two hormones on pod setting to clarify the role of auxin and cytokinin in soybean pod setting. The long raceme soybean cultivars IX93-100 was grown in pots and in the field. The auxin (IAA, indole acetic acid) concentration in racemes was high for a long period from pre-anthesis to 9 days after anthesis (DAA) of the first flower on a raceme, but the cytokinin concentration was high for a short period, with a peak at 9 DAA. The IAA concentration was higher in distal portions of racemes, but the cytokinin concentration was higher in basal portions of racemes. In pot-grown plants, IAA applied to racemes tended to reduce the number of flowers and pods. In contrast, 6-benzylaminopurine (BA) applied to racemes before anthesis tended to reduce the number of flowers and pods, and that applied around 7 DAA significantly increased the pod-set percentage. However, these effects of IAA and BA application were slight in field-grown plants. These results indicate that the concentration of endogenous auxin and cytokinin in racemes changes in a different manner, and that cytokinins have a positive, and auxin a negative effect on pod setting when respective hormones are applied to racemes after the anthesis stage.

Shibles *et al.,* (1975) Observed that the individual seed weight. The seed number depends upon the number of floral buds that initiate pods and attain maturity. Generally, soybean plants produce an abundance of floral buds, but a large proportion of them abort during development. Indeed, rates of flower and pod abscission/abortion were estimated to reach 80%. Alleviation of this abortion rate should increase pod and seed number, and thereby increase yield.

Kato & Sakaguchi, (1954) Observed that the studies conducted in the 1950s and 1960s, Kato and his group examined abscised/aborted buds, flowers, and pods, and classified them according to their developmental stage. The greatest rate of abscission/abortion took place after fertilization, particularly during early stages of embryo development (Table 1). Based on this observation, they concluded that most critical stage causing flower abortion was at proembryo development after fertilization.

Kokubun, (1988) Subsequent studies conducted in the 1970s and 1980s suggested that soybean abortion is primarily caused by deficiency in or competition for photo assimilates and nutrients among growing organs (Brevedan *et al.*, 1978; Brun & Betts, 1984; Antos & Wiebold, 1984). Shading treatment imposed at different reproductive growth stages clearly showed that reduced solar radiation significantly decreased the number of pods and seeds, and thereby grain yield. The yield reduction was particularly marked when the shading treatment was imposed during the period from flowering to early grain development, due to a decrease in dry matter production and/or dry matter partitioning to reproductive organs. The yield reduction was particularly marked when the shading treatment was imposed during the period from flowering to early grain development, due to a decrease in dry matter production and/or dry matter partitioning to reproductive organs

Raper & Kramer (1987) Reported by water deficit during reproductive development was shown to be a dominant environmental factor accelerating the rate of abortion (Kato, 1964; Westgate & Peterson, 1993). Based on these findings, concluded that water stress imposed during flower development reduces photosynthesis and the amount of photo assimilates allocated to reproductive tissues, thereby accelerating the rate of abortion.

Oberholster *et al.,* (1991) Reported the critical role of phytohormones in the formation and abortion of reproductive organs in soybean was clearly recognized when Huff & Dybing (1980) observed that extracts from flowers and young pods applied to growing flowers accelerated flower abortion. They then applied a lanolin paste containing either indole acetic acid (IAA), giberellin (GA) or 6- benzylaminopurine (BA) to the growing raceme, and found that IAA enhanced the abortion rate, as did the extract, whereas GA and BA did not. These results indicated that IAA plays a crucial role in increasing the abortion rate, although there was a conflicting report indicating that IAA delays the abortion.

Heindle *et al.,* (1982), observed that the another possible physiological factor affecting flower abortion in soybean is the availability of plant hormones. There are a number of reports showing that the application of 6-benzylaminopurine (BA) to racemes reduced the rate of abortion and thereby increased pod set. Analysis of endogenous cytokinins revealed that cytokinins detected in root pressure exudates showed a maximum concentration during a period from 0 to 9 days after initial flowering, when most flowers are destined to either initiate pods or abort.

Carlson *et al.* (1987) Among phytohormones, cytokinins are considered to play a vital role in floral development in soybean. There have been numerous reports showing that the application of BA to racemes reduced seed abortion and increased pod number.

Sitton *et al.* (1967) A limited number of reports support the notion that cytokinins are produced by the root system and transported to the shoot, where they are involved in the regulation of shoot development.

Heindle *et al.* (1982) To examine the hypothesis that cytokinins produced in the root system are transported to the shoot, collected root pressure exudates from detopped roots, and analyzed the forms and quantities of cytokinins in these exudates. Using high-performance liquid chromatography, they isolated and quantitated several forms of cytokinins: zeatin, zeatin riboside, and their dihydro derivatives, dihydrozeatin and dihydrozeatin riboside.

Heindl *et al.* (1982) Their results indicated that cytokinin fluxes were independent of exudate flux, and that the ribosides accounted for the majority of the observed transport. In a later study, they also found a peak in cytokinin concentration during the period from the beginning of anthesis until 9 days after initial anthesis. This period corresponds to a stage in which most flowers are destined to either initiate or abort floral structure. Based on these findings, they concluded that cytokinins exported from the root may function in the regulation of reproductive growth in soybean.

Yashima *et al.* (2005) The clear evidence that cytokinin plays a prompting role in flower development raised the following question. Does cytokinin accelerate flower development independently or synergistically with photo assimilate supply? To address this question, we examined the combined effects of these two physiological circumstances by manipulating source-sink Soybean ratios at specific nodes in soybean plants. As the source-sink ratio increased, the number of pods per node on manipulated plants increased curvilin early, reaching a plateau at high source/sink ratios.

Kato, 1964; Westgate & Peterson, (1993) Deficient water supply during reproductive development is a major environmental factor that increases the rate of pod abortion in soybean.

Shaw & Laing, 1966; Sionit & Kramer, (1977) While the effect on yield of increased pod abortion at one stage can be offset an increase in pod set at another stage of development, or by an increase in seed mass, frequent or long-term water deficit during reproductive development reduces the yield of soybean.

Raper & Kramer, (1987) In fact, the rate of abortion substantially increases when soybean plants are subjected to water deficient conditions during reproductive development, particularly during later flowering stages. Water stress imposed during flowering and early pod development reduces photosynthesis and the amount of photosynthetic assimilates allocated to floral structures, which is likely to increase the rate of abortion.

Lie *et al.* (2003) they are reports on the involvement of phytohormones in regulation of abortion under water-stressed conditions found that reduced pod-set percentages induced by water deficit were associated with an increase in the ABA content of reproductive structures during a period from 3 to 5 days after anthesis. Because cytokinins play such a pivotal role in flower development, clarifying the interacting roles of cytokinins and other phytohormones, including ABA.

Kokubun *et al.* 2001; Kokubun, (2004) They are reported on conducted experiments to clarify a) whether water deficit imposed on a soybean plant prior to flowering caused abortion of the basal flowers on the rachis, which are very likely to develop seed-bearing pods under favorable conditions, and b) whether the abortion, if occurred, was due to the impairment of stamen (pollen) or pistil (ovule) function

CHAPTER - III

MATERIALS AND METHODS

This chapter deals with the description of the material used and various techniques or methods adopted throughout the course of investigation entitled **"Morpho-physiological characterization of soybean cultivars for efficient photo-assimilates partitioning and yield"** Experiment was conducted at the Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Krishak Nagar Raipur (C.G.). during Kharif 2015.

3.1 Location of experimental site

The field experiment was layout at the experimental area of department of Genetics & Plant Breeding at Research cum Instructional Farm, Indira Gandhi Krishi Viswavidyalaya, Raipur, during kharif 2015. Chhattisgarh state is located in south eastern part of India and positioned between N latitudes 17˚ 46′ to 24˚ 05′ and E longitude 80˚15′ and 84˚20′ encompassing a geographic area of 137.9 lakh hectare. Raipur is situated at 210 16' N latitude, 810 30' E longitude and altitude of 289.60 mt above the mean sea level.

3.2 Weather conditions during crop period

The weather data recorded at meteorological observatory, IGKV, Raipur during life span of crop given in Appendix -I and depicted through Fig. 3.1 and Fig. 3.2. During crop periods, the total rainfall 1100.2 mm was received in kharif, 2015. The maximum temperature during crop growth period varied from 31.2^{0}C in first week of July to 33.4^{0}C in third week of October, while minimum temperature varied from 22.8^{o}C in third week of October to 25.2^{o}C in last week of July. Relative humidity throughout the crop season varied between 37 to 96 per cent. The maximum relative humidity for different weeks varied from 88 to 96 per cent, while, weekly minimum relative humidity varied between 45 to 90 per cent. The open pan evaporation mean values ranged from 3.8 to 4.6 mm day^{-1}, whereas, sunshine hours varied from 4.6 to 8.7 hours day^{-1}.

3.3 Experimental details and Technical Programme of work:

Field experiment was carried out in the year 2015-2016 at the Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.).

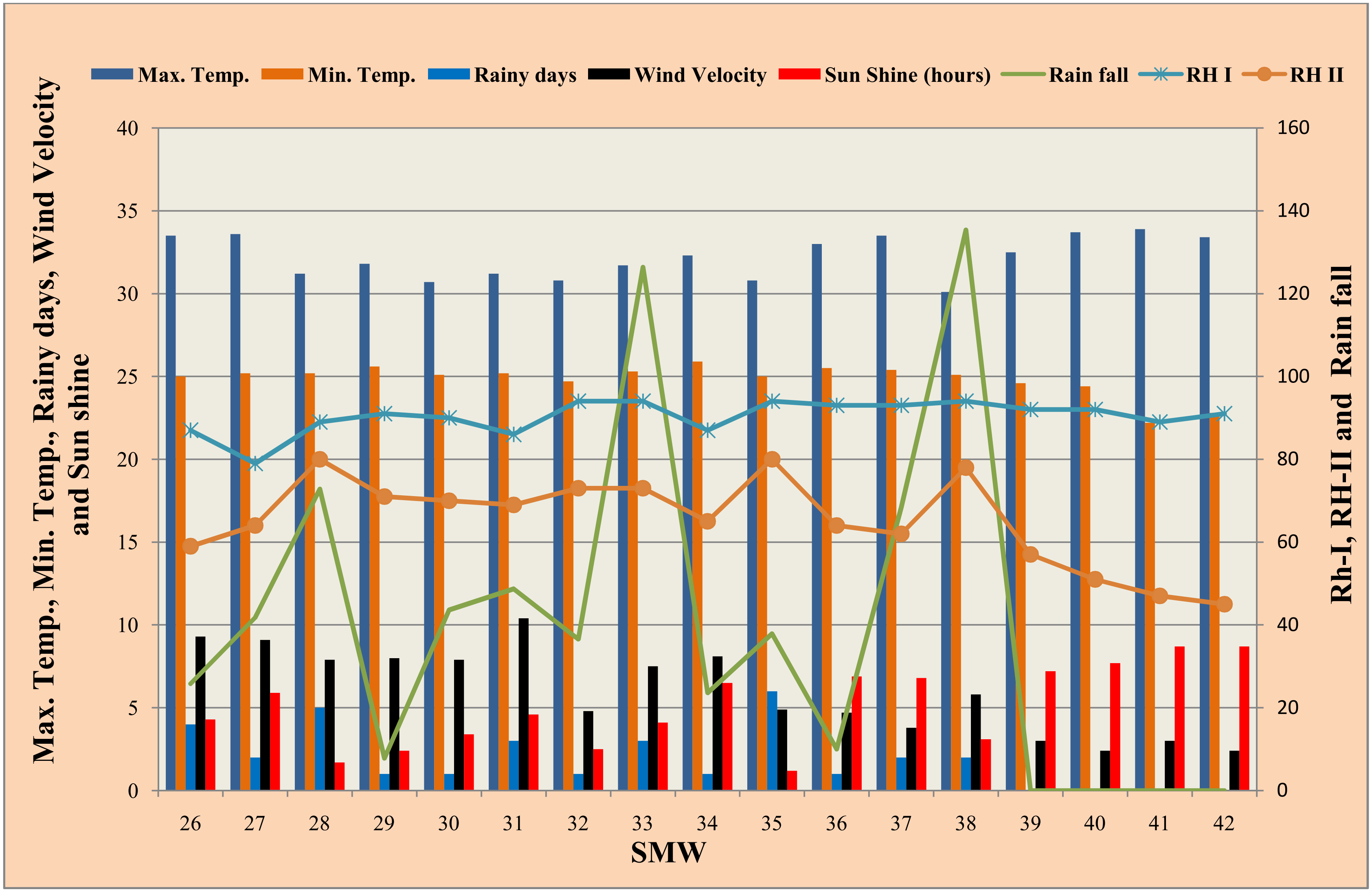
Experimental details:

The experiment was laid out in RBD with three replications and three duration , early, medium and long duration cultivars , total forty four cultivars were taken for field experiment purpose given below:

Treatment details and layout-

R1		R2		R3	
RVS 2010-1	AMS 100-1	MACS 1480	VLB 202	RSC 10-04	KDS 775
NRC 117	NRC 120	RVS 2010-2	NRC 121	RKS 18	Himso 1686
KDS 975	DS 3103	NRC 123	PS 1570	JS 97-52	SL 1074
JS 20-116	PS 1572	NRC 118	BAUS 72	JS 335	MAUS 740
RSC 10-30	KBS 24-2014	AMS 1001	VLS 90	NRC 122	DS 3104
JS 20-94	MACS 1491	KDS 754	DSb 29	TS 69	MACS 1488
NRC 119	TS 72	MACS 1488	TS 69	DSb 29	KDS 754
MAUS 710	PS 1569	DS 3104	NRC 122	VLS 90	AMS 1001
AMS 115	DSb 30-2	MAUS 740	JS 335	BAUS 72	NRC 118
RSC 10-29	VLS 91	SL 1074	JS 97-52	PS 1570	NRC 123
MACS 1480	VLB 202	Himso 1686	RKS 18	NRC 121	RVS 2010-2
RVS 2010-2	NRC 121	KDS 775	RSC 10-04	VLB 202	MACS 1480
NRC 123	PS 1570	AMS 100-1	RVS 2010-1	VLS 91	RSC 10-29
NRC 118	BAUS 72	NRC 120	NRC 117	DSb 30-2	AMS 115
AMS 1001	VLS 90	DS 3103	KDS 975	PS 1569	MAUS 710
KDS 754	DSb 29	PS 1572	JS 20-116	TS 72	NRC 119
MACS 1488	TS 69	KBS 24-2014	RSC 10-30	MACS 1491	JS 20-94
DS 3104	NRC 122	MACS 1491	JS 20-94	KBS 24-2014	RSC 10-30
MAUS 740	JS 335	TS 72	NRC 119	PS 1572	JS 20-116
SL 1074	JS 97-52	PS 1569	MAUS 710	DS 3103	KDS 975
Himso 1686	RKS 18	DSb 30-2	AMS 115	NRC 120	NRC 117
KDS 775	RSC 10-04	VLS 91	RSC 10-29	AMS 100-1	RVS 2010-1

Field layout plan of experiment



Max. Temp.
Min. Temp.
Rainy days
Wind Velocity
Sun Shine (hours)
Rain fall
RH I
RH II
Max. Temp., Min. Temp., Rainy days, Wind Velocity and Sun shine
Rh-I, RH-II and Rain fall
SMW
0
5
10
15
20
25
30
35
40
0
20
40
60
80
100
120
140
160
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42

Technical program of work-

Location: Research cum Instructional farm, IGKV, Raipur

Season : Kharif 2015

Crop : Soybean

Design : RBD

No. of Replications : 3

Plot size : 1.35x3m

1. Date of Sowing : 24-06-2015
2. Date of harvesting : 11-10-2015
3. No. of cultivars : 44
4. Spacing : 45 cm (row to row)
5. No. of plants : 60 /m^2

3.4 Cultural practices

3.4.1 Field preparation:

The final preparation was done by two criss-cross tractor, then ploughing followed by harrowing. The soil surface was leveled and the field was divided into blocks.

3.4.2 Fertilizers application:

The fertilizers were applied as per the recommended doses 30:60:40 kg ha^{-1} N: P: K were added to the soil by thoroughly mixing into the soil. Urea, Single Super phosphate (SSP) and Muriate of Potash (MOP) respectively, as basal dose applied in sowing time.

3.4.3 Weed management

One hand weeding at thirty days was done by *khurpi* in the plot to keep them weed free and also helped in breaking the surface crust and provides better aeration.

3.4.4 Gap filling and thinning

Very rare gaps were observed in few plots, population of cultivars was maintained through gap filling and thinning were completed each plot after sowing.

3.4.5 Plant protection measures:

Plant protection measures were adopted when required during the crop growth period.

3.4.6 Water management:

The soil was kept saturated until seedlings were get established. The irrigation was not provided until maturity.

3.4.7 Harvesting:

The crop was harvested on 11 October at leaf senescence and litter fall stage. The date varies according to the season. The harvested material was left for a week to dry completely then weighed. Seed were separated by hand, seed were weighed for seed yield with the help of electronic weighing machine.

3.4.8 Threshing :

The plot wise harvested produce was separately stocked and scattered on threshing floor for proper drying. When the produce was dried completely, the bundle weight was taken plot- wise and then it was threshed. After threshing seed yield was recorded plot wise. Stover yield was worked out after subtracting the seed yield from bundle weight.

3.4.9 Winnowing:

The threshed seeds were cleaned by removing pieces of stover and winnowed in fan wind. The seeds were collected for storage.

3.5 Observation schedule:

The plants were grown under various morphological, physiological, water relations and yield attributing observation. Three plants were selected from each treatment for observation after completion of various treatments at different critical stages.

1. Vegetative stage – 30 -40 DAS
2. Flowering stage – 60 DAS
3. Grain filling sate – 90 DAS
4. At harvesting stage- Physical maturity

Observations recorded

3.5.1 Morpho-pysiological & growth parameter

3.5.2 Crop Growth Rate (g m^{-2} day^{-1})

The average daily increment of shoot biomass (W_2-W_1) unit^{-1}, ground area (p) unit^{-1}, time interval (t_2-t_1) provided the rate of dry matter production of the crop stand (Potter and Jones, 1977).

$$\textbf{CGR} = \frac{W_2 - W_1}{P\,(t_2 - t_1)}$$

Where,

W_2- W1 = total dry weight of the plant at the time t_2 and t_1 respectively and P is ground area.

3.5.3 Net assimilation rate (mg. cm^{-2} day^{-1})

It is expressed as increase in dry matter per unit leaf area unit^{-1} time. It is expressed in mg dry matter accumulation cm^{-2} leaf area per unit time . The concept of NAR on the basis of leaf area was introduced by Gregory (1917).

$$\textbf{Net assimilation rate} = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{\ln A_2 - \ln A_1}{A_2 - A_1}$$

Where,

W_2 = total dry weight of plant at time 't_2'

W_1 = total dry weight of plant at time 't_1'

t_1 = initial time of observation

t_2 = final time of observations

A_1 = leaf area/ plant at time 't_1'

A_2 = leaf area / plant at time 't_2'

3.5.4 Relative Growth Rate (RGR):

The term was coined by Williams (1946). Relative Growth Rate (RGR) expresses the total plant dry weight increase in a time interval in relation to the initial weight or dry matter increment per unit biomass per unit time or grams of dry weight increase per gram of dry weight and expressed as unit dry weight / unit dry weight / unit time (g g^{-1}day^{-1}).

$$\text{Relative Growth Rate } (g\ g^{-1} plant^{-1} day^{-1}) = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1}$$

Where,

W1 and W2 are whole plant dry weight at t1 and t2 respectively

t1 and t2 are time interval in days

3.5.5 Leaf size and shape:

The leaves of different experimental cultivars were measured by graph methods. The leaves were small, narrow and broad. The structure of leaves were maintain the plant architecture and play an important role in light interception and photo assimilate partitioning. Leaf area was measured by graph method.

3.6 Phenological traits:

The phonological observations were recorded via taking the observations on days to first flower initiation, 50% flowering, days to pod initiation, days to physiological maturity and days to physical maturity.

3.6.1 Days to Flower initiation

It was observed on the basis of visual score when flowers appeared in the experimental plot and was considered as flowering stage.

3.6.2 Days to 50% flowering

It was observed on the basis of visual score when 50 percent of flowers appeared in the experimental plot and was considered as 50 percent flowering stage.

3.6.3 Days to maturity

The maturity stage was determined when the stamen of spikelet were completely yellow and dried. This stage was also determined by grain hardiness and by decreased moisture percentage.

3.7 Morpho-physiological & yield parameters.

3.7.1 Leaf area and leaf area index (LAI):

Leaf area was recorded manually at 60 and 90 DAS. Leaf area of the plant was measured through leaf area meter and graph method. The leaf area index was calculated with the following formula (Watson, 1947):

Leaf area = Length x Width x Correction factor (K)x no. of leaves per plant x no of plants per m^2

$$\text{Leaf area index (LAI)} = \frac{\text{Leaf area}}{\text{Ground area}}$$

3.7.2 Leaf dry weight:

The dry weight of leaves per plant was recorded by separating all the leaves from plant and drying them in oven at 60^0C till constant weight was obtained. The leaf weight was recorded in gram at flowering stage (60 DAS), grain filling stage (90 DAS), and at harvesting stage.

3.7.3 Plant height (cm):

Plant height was recorded at 60, 90 DAS and at harvest from five randomly selected tagged plants. The height was measured from ground level to the apex of the shoot and expressed in centimeter (cm). The average height was worked out by dividing the summation with five.

3.7.4 Number of leaves per plant^{-1}:

Number of leaves of randomly selected five plants from each cultivars recorded at 60 and 90 DAS.

3.7.5 Number of branch per plant^{-1}:

Number of branches of selected experimental plants, from each plot were recorded. The first observation was recorded at flowering stage (60 DAS) and second were recorded at grain filling stage (90 DAS).

3.7.6 Plant dry weight at different growth stages:

The dry weight of stem plant^{-1} was recorded until constant weight was obtained after dry matter per plant at 60^0C in oven. The stem dry weight was recorded in gram at flowering stage (60DAS), grain filling stage (90 DAS), at harvesting stage.

3.7.7 Number of pods per plant:

The numbers of pods per plants were recorded individually counted, then average number of pods plant^{-1} was worked out.

3.7.8 Number of pods on primary secondary and tertiary branches

The number of pods on primary secondary and tertiary branch were recorded at flowering stage (60DAS), grain filling stage (90DAS), at harvest stage and then average number of pods plant^{-1} was worked out.

3.7.9 Pod weight per plant

The pod dry weight was recorded at flowering stage (60DAS), grain filling stage (90 DAS), at harvest stage and expressed in gram.

3.7.10 Number of seeds per plant

The pods of observation plants were harvested separately and average number of seeds plant^{-1} was worked out.

3.7.11 Test weight

The test weight was recorded by weighing 100 healthy seed from each treatment on an electronic weighing machine and expressed in g.

3.7.12 Biological yield g/m^2

Biological yield Seed yield of the net plot was noted down after threshing, winnowing and drying. Seed yield then calculated in g/m^{-2} with appropriate multiplication factor.

3.8 Sink realization

3.8.1 Pod bearing node

Pod bearing nodes were noted down at the interval of 60 and 90 days.

3.8.2 Days to flower initiation

It was observed on the basis of visual score when flowers appeared in the experimental plot and was considered as flowering stage.

3.8.3 Total number of pods per plant

The numbers of pods per plants were recorded individually counted, then average number of pods plant^{-1} was worked out.

3.8.4 Flower abortion

The total number of flowers initiated per plant and the total number of pods sustained on plants at maturity. The difference in these parameters known as flower abortion and sink realization.

3.9 Biochemical parameters

3.9.1 Chlorophyll value (SPAD value):

SPAD value of middle fully expanded leaf (5^{th}) from the top were taken from five randomly selected tagged plants at 30 and 60 DAS with the help of chlorophyll meter. The average SPAD value was worked out by dividing the summation with five.

3.9.2 Harvest index (HI):

The ratio of economic product (seed) to the total above ground biomass at harvest (Synder and Carlson, 1984) was calculated by following formula.

$$\text{Harvest index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Where,

Economic yield - grain yield

Biological yield - grain yield + straw yield (above ground biomass)

3.10 Statistical analysis:

The experiment was laid out in complete randomize block design. The data obtained on various characters under study were analyzed statistically by using the method of analysis of variance for complete randomize block design and significance was tested by 'F' test (Gomez and Gomez, 1984). Correlation coefficient was obtained for combination of some of the traits under study.

3.10.1 Descriptive analysis:

Descriptive analysis (mean, range, standard deviation and coefficient of variance) of morphological, phenological, physiological and biochemical and yield attributing traits under rainfed conditions.

3.10.2 Correlation analysis:

The correlation between grain yield and different traits like morphological, phenological, physiological, biochemical and yield attributing traits under rainfed conditions.

CHAPTER – IV

RESULTS AND DISCUSSION

The present chapter deals with the experimental findings and discussion obtained during the course of investigation entitled "Morpho-physiological characterization of Soybean cultivars for efficient photo-assimilates partitioning and yield". The field experiment was conducted during *kharif* season (July to October, 2015) at Instructional Cum Research Farm, Indira Gandhi Krishi Vishwavidyalaya,in the Department of Plant Physiology, Raipur (C.G.). The observations recorded on various aspects of study and revealed some interesting facts, which are briefly discussed in this chapter. The experimental findings are statistically analyzed and are presented in appropriate tables, graphs and few are also depicted through figures. The experimental findings of present work have been grouped under the following heads.

4.1 Morphological and growth parameters

The morphological parameters were taken for plant height (cm), number of leaves plant^{-1}, number of branches plant^{-1} and leaf area.

4.1.1 Plant height (cm)

Plant height was measured at flowering stage and grain filling stages. The significantly higher plant height was observed in medium duration cultivars in between 60 DAS in followed by early and then long duration cultivars. However, the plant height was maximum at 90 DAS in medium duration cultivars followed by early and then long duration cultivars. The average maximum plant height was achieved by RVS 2010-1 (82.63) followed by DSB 30-2 (82.43)in early group of cultivars. The significant lowest plant height was observed in MAUS 710 (49.73) followed by PS 1569 (53.10).

In medium duration cultivars MACS 1491 having significantly maximum plant height (90.20) followed by MACS 1488 (87.35), JS 20-94 (85.25). The significantly minimum plant height was observed RSC 10-04 (51.93) followed by KDS 754 (63.82).

Table 4.1 Variation in plant height (cm) of soybean cultivars at various growth phases.

Early Treatment	flowering stage 60 (DAS)	Grain filling stage 90 (DAS)	Mean	Medium Treatment	flowering stage 60 (DAS)	Grain filling stage 90 (DAS)	Mean	Late Treatment	flowering stage 60 (DAS)	Grain filling stage 90 (DAS)	Mean
PS 1569	48.80	57.40	53.10	MACS 1491	99.67	80.73	90.20	DS 3103	63.3	67.50	65.4
RVS 2010-1	102.73	62.53	82.63	JS 20-94	85.73	84.77	85.25	PS 1572	58.7	48.30	53.5
DSb 30-2	73.17	91.70	82.43	NRC 117	62.67	68.80	65.73	MACS 1480	58.4	55.33	56.9
RSC 10-30	73.47	86.63	80.05	AMS 115	75.67	60.83	68.25	DSb 29	69.8	75.00	72.4
KDS 975	73.17	63.33	68.25	TS 72	73.17	66.73	69.95	PS 1570	55.3	73.13	64.2
VLS 91	48.23	64.40	56.32	AMS 100-1	81.60	69.63	75.62	DS 3104	64.3	43.67	54.0
MAUS 710	64.63	34.83	49.73	Himso 1686	66.30	87.30	76.80	SL 1074	72.2	55.03	63.6
NRC 118	59.33	63.37	61.35	MACS 1488	87.33	87.37	87.35	TS 69	64.1	49.07	56.6
KDS 775	73.80	78.43	76.12	KDS 754	80.57	47.07	63.82	BAUS 72	87.1	66.97	77.0
VLS 90	63.13	93.30	78.22	RVS 2010-2	63.60	66.07	64.83	NRC 121	94.1	37.37	65.7
NRC 119	71.77	54.53	63.15	AMS 1001	67.30	71.30	69.30	RSC 10-29	63.7	60.10	61.9
NRC 120	64.70	62.70	63.70	NRC 123	76.67	82.53	79.60	MAUS 740	47.0	66.23	56.6
VLB 202	45.73	80.37	63.05	JS 335 (c)	78.00	82.73	80.37	NRC 122	47.5	48.00	47.8
JS 20-116	74.70	78.57	76.63	RSC 10-04	49.60	54.27	51.93	KBS 24-2014	45.8	50.40	48.1
RKS 18 (c)	80.83	80.83	80.83	-	-	-	-	JS 97-52 (c)	44.2	56.86	50.5
Mean	**67.88**	**70.196**		**Mean**	**74.85**	**72.15**		**Mean**	**62.382**	**56.86**	
SEm±	**8.215**	**9.04**		**SEm±**	**5.751**	**6.69**		**SEm±**	**6.753**	**16.068**	
C.D. (5%)	**23.798**	**26.19**		**C.D. (5%)**	**16.719**	**19.46**		**C.D. (5%)**	**19.562**	**6.693**	
	NS				NS				NS	NS	

In long duration cultivars BAUS 72 have significantly higher plant height (77.0) followed by DSb 29 (72.4). The significantly minimum plant height was observed in cultivars NRC 122 (47.8) followed by KBS 24-2014 (48.1)
(Table 4.1 fig 4.1).

Momen et al., (1979) also stated that soil status also influenced the plant height, leaf area and dry matter partitioning.

Baisakh and Dash (1991) also observed significant variation in plant height, pods plant^{-1}, seed pod^{-1}, 100 seed weight and days to flowering in soybean genotypes in relation to environment. Similarly, Singh and Singh (1996) also reported non significant negative correlation of plant height with grain yield in soybean.

4.1.2 Number of leaves plant^{-1}

The number of leaves were non significantly varied in between duration as well as cultivars, measured at flowering and grain filing stages. The highest number of leaves per plant were observed in long duration cultivars at 60 DAS and followed by early and then medium duration cultivars. However, the number of leaves per plant were maximum at 60 DAS in long duration cultivars followed by early cultivars and then medium duration cultivars.

In early duration cultivars the maximum number of leaves per plant were observed in PS 1569 (81.66) followed by RKS 18 (54.33). The minimum number of leaves per plant was observed in RSC 10-30 (19.83) followed by NRC 119 (20.33).

In medium duration cultivars AMS 100-1 having maximum number of leaves per plant (58.83) followed by AMS 1001 (51.16). The minimum number of leaves per plant were observed by JS 20-94 (24.66) followed by MACS 1491 (27.00).

In long duration cultivars PS 1574 having maximum (114.83) no of leaves followed by NRC 122 (57.83). The non significantly minimum number of leaves per plant were observed in TS 69 (27.66) followed by DS 3103 (28.00).

(Table 4.2 fig. 4.2).

Veerbhadrappa and Yeldhalli (2005) also reported the morphological parameters like number of leaves per plant provides base for physiological.

Table 4.20 Variation in flower color and leaf shape and cultivars

COLOR					
Voilate	White	Broad leaves	Nerrow leaves	Small leaves	4-5 leaf lets
DSb 30-2	PS 1569	RVS 2010-1	PS 1569	JS 20-94	MACS 1491
KDS 975	RVS 2010-1	DSb 30-2	AMS 115	KDS 975	KDS 975
MAUS 710	RSC 10-30	RSC 10-30	JS 20-94	SL 1074	KDS 775
KDS 775	VLS 91	MACS 1491	NRC 117	JS 97-52 (c)	NRC 122
RKS 18 (c)	NRC 118	NRC 117	AMS 115		
MACS 1491	VLS 90	TS 72	Himso 1686		
JS 20-94	NRC 119	DS 3103	PS 1570		
NRC 117	NRC 120	MACS 1480	DS 3104		
AMS 115	VLB 202	AMS 100-1	SL 1074		
TS 72	JS 20-116	KDS 775	NRC 120		
MACS 1488	AMS 100-1	NRC 119	VLB 202		
RVS 2010-2	Himso 1686	DSb 29	NRC 122		
AMS 1001	KDS 754	DS 3104			

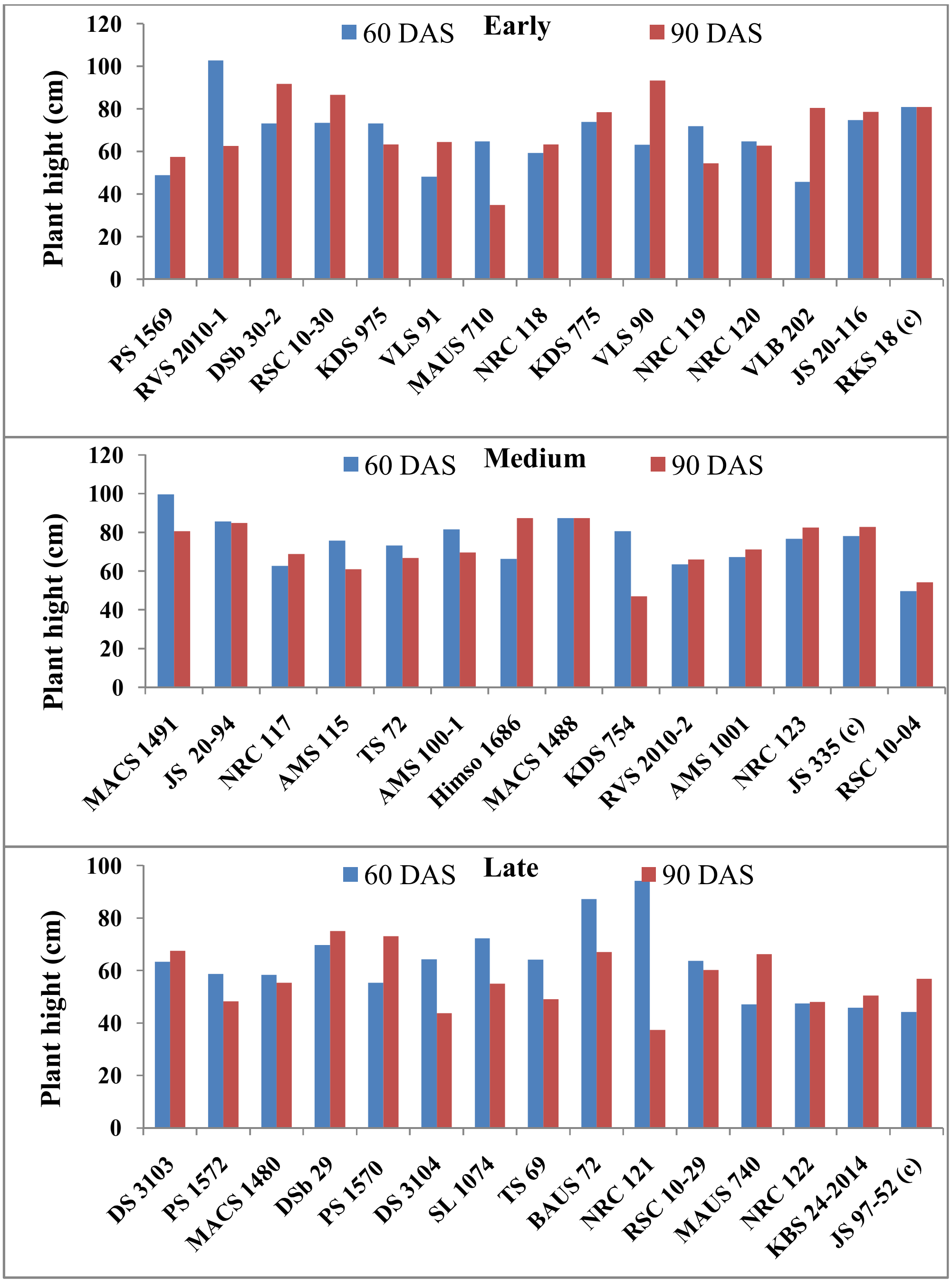


Fig 4.1 Variation in Plant height (cm) in soybean cultivars at various growth phases.

Table 4.2 Variation in number of leaves per plant in soybean cultivars at various.

Early Treatment	flowering stage 60 (DAS)	Grain filling stage 90 (DAS)	Mean	Medium Treatment	stage 60 (DAS)	Grain filling stage 90 (DAS)	Mean	Late Treatment	flowering stage 60 (DAS)	Grain filling stage 90 (DAS)	Mean
PS 1569	82.67	80.67	81.67	MACS 1491	27.00	27.67	27.33	DS 3103	28.67	27.33	28.00
RVS 2010-1	51.00	50.00	50.50	JS 20-94	25.67	23.67	24.67	PS 1572	35.67	33.33	34.50
DSb 30-2	34.00	33.00	33.50	NRC 117	31.67	29.67	30.67	MACS 1480	37.33	35.67	36.50
RSC 10-30	19.33	20.33	19.83	AMS 115	39.33	37.33	38.33	DSb 29	31.33	29.00	30.17
KDS 975	46.00	43.33	44.67	TS 72	42.33	40.00	41.17	PS 1570	116.00	113.67	114.83
VLS 91	37.67	35.67	36.67	AMS 100-1	59.67	58.00	58.83	DS 3104	49.00	46.67	47.83
MAUS 710	40.67	39.00	39.83	Himso 1686	41.33	40.00	40.67	SL 1074	29.00	28.33	28.67
NRC 118	41.00	39.33	40.17	MACS 1488	33.00	31.33	32.17	TS 69	28.00	27.33	27.67
KDS 775	38.33	41.00	39.67	KDS 754	40.00	37.33	38.67	BAUS 72	37.00	35.00	36.00
VLS 90	33.67	33.00	33.33	RVS 2010-2	38.33	35.67	37.00	NRC 121	42.33	40.33	41.33
NRC 119	19.33	21.33	20.33	AMS 1001	52.33	50.00	51.17	RSC 10-29	43.67	42.00	42.83
NRC 120	41.00	38.33	39.67	NRC 123	42.67	40.00	41.33	MAUS 740	46.33	44.67	45.50
VLB 202	42.33	40.67	41.50	JS 335 (c)	36.00	33.67	34.83	NRC 122	59.33	56.33	57.83
JS 20-116	45.00	42.67	43.83	RSC 10-04	36.00	33.00	34.50	KBS 24-2014	46.00	44.33	45.17
RKS 18 (c)	55.67	53.00	54.33	-	-	-	-	JS 97-52 (c)	48.00	46.00	47.00
Mean	**41.84**	**40.76**		**Mean**	**38.95**	**36.95**		**Mean**	**45.18**	**43.33**	
SEm±	**51.87**	**11.35**		**SEm±**	**4.33**	**3.69**		**SEm±**	**7.41**	**6.97**	
C.D. (5%)	**36.30**	**32.87**		**C.D. (5%)**	**12.60**	**10.74**		**C.D. (5%)**	**21.46**	**20.18**	
	NS	**NS**			**NS**	**NS**			**NS**	**NS**	

functioning of plant. The physiological process like photosynthesis, carbohydrates, protein, fat metabolism etc. are take place in leaves, thus provide substrates for most of the metabolism required for growth, development and storage.

4.1.3 Number of branches plant^{-1}

The number of branches were non significantly varied in between cultivars. The no. of branches per plant were measured at 60 and 90 DAS. The no. of branches were higher at grain filling stage 90 day after sowing in all three duration cultivars.

In early duration cultivars PS1569 having maximum (4.60) branches followed by RKS 18(c) (4.2). While minimum no of branches was observed in VLB 202 (2.60) followed by KDS 975 (2.46). In medium duration cultivars RSC 10-04 (4.30) having maximum branches followed by MACS 1491 (3.96). While, minimum no of branches were observed in NRC 123 (2.26) followed by AMS 100-1 (2.80).

In long duration cultivars JS 97-52 (c) having highest no. of branches (4.66) followed by MACS 1480(3.76). Whereas, minimum no. of branches were observed in DSb 29 (2.53) followed by NRC 121 (2.60) (Table 4.3 fig. 4.3).

Nakano, *et al.* (2001) mentioned the higher yield was obtained by the square planting compared to rectangular planting as a result of the higher numbers of branches and branch nodes and higher podding efficiency in the lower nodes of the main stem due to reduced natural shading. Deshmukh *et al*. (1991) reported that number of branches plant^{-1}, number of pod plant^{-1}, were significant association with seed yield.

4.1.4 Leaf area cm^{-2}

The leaf area was measured at 60 and 90 DAS. It was observed that the leaf area was more in medium duration cultivars followed by long duration and then leaf area were measured in early duration cultivars. However, at 90 DAS the average leaf area was maximum in (406.11) early duration cultivars.

In early group RVS 2010-1 have significantly maximum leaf area (625.72) followed by NRC 120 (563.91). The minimum leaf area exhibited in PS 1569 (168.41) and followed by VLS 90 (271.82).

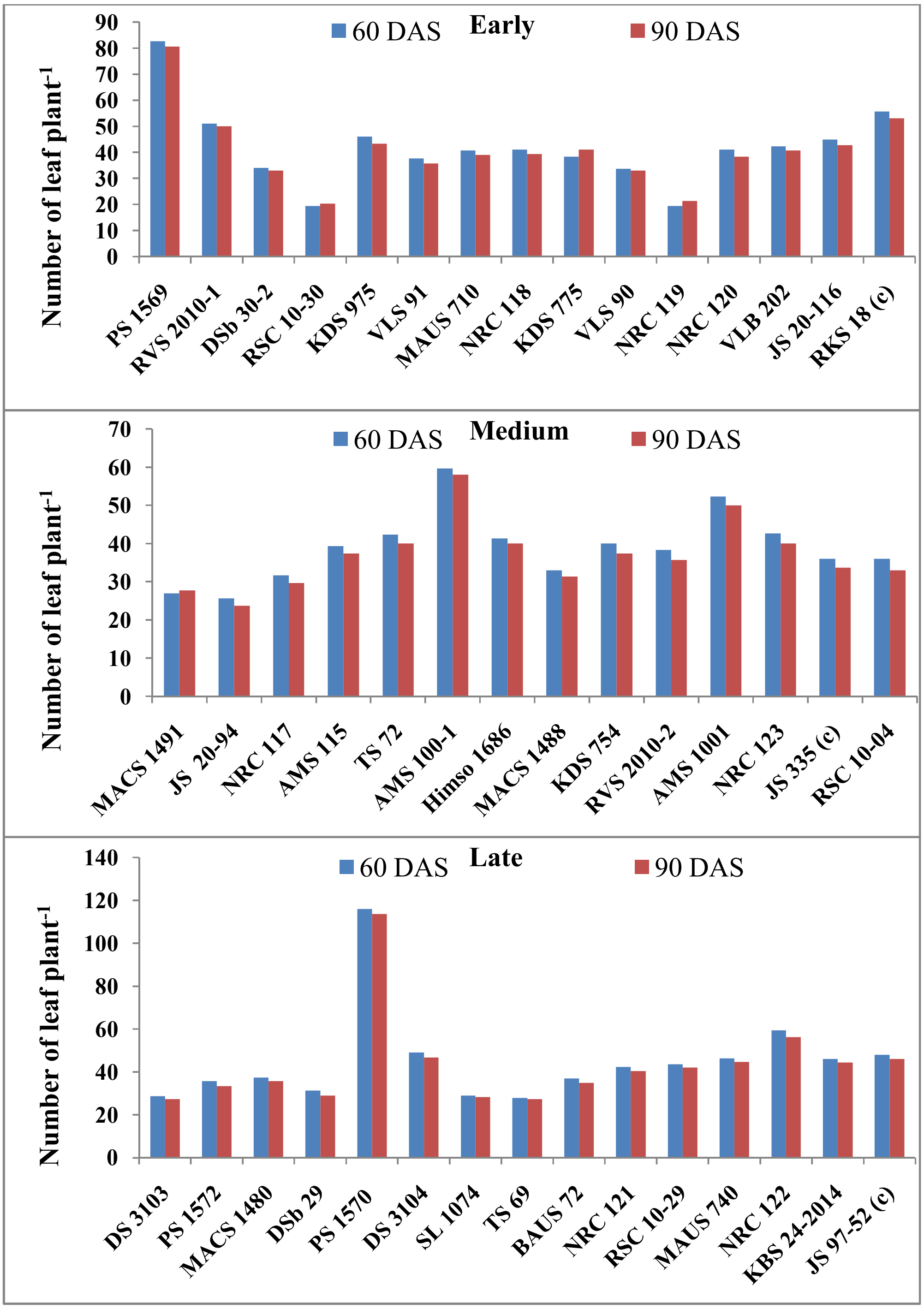


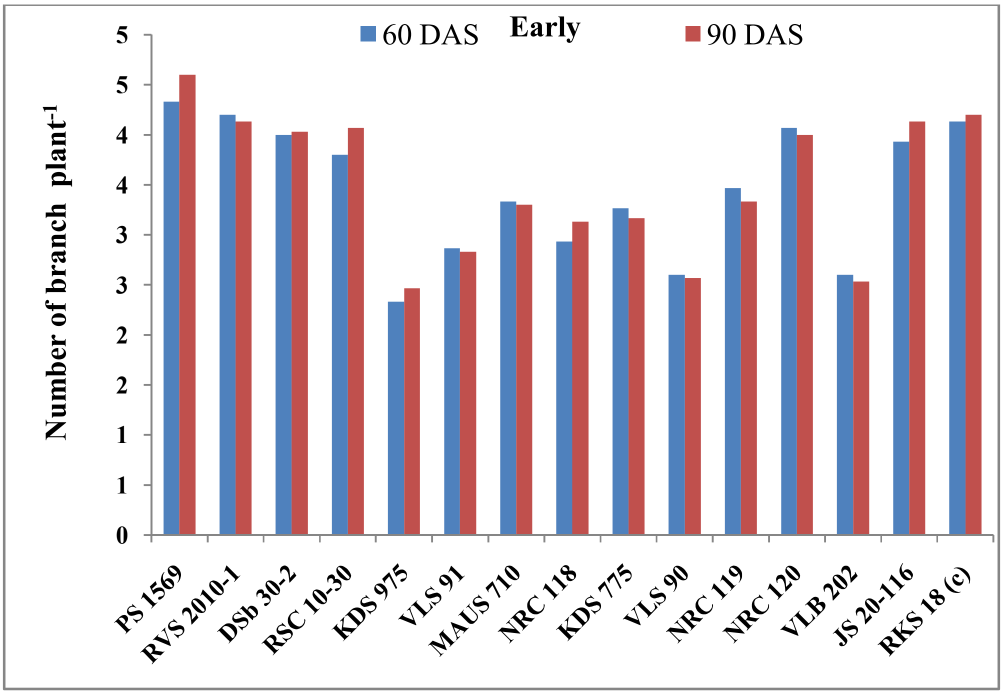
Fig 4.2 Variation in Number of leaves plant^{-1} in soybean cultivars at various growth phases.

Table 4.3 Variation in number of branches per plant in soybean cultivars at various growth phases.

Early Treatment	flowering stage 60 (DAS)	Grain filling stage 90 (DAS)	Mean	Medium Treatment	flowering stage 60 (DAS)	Grain filling stage 90 (DAS)	Mean	Late Treatment	flowering stage 60 (DAS)	Grain filling stage 90 (DAS)	Mean
PS 1569	4.33	4.60	4.47	MACS 1491	3.87	3.97	3.92	DS 3103	4.60	3.57	4.08
RVS 2010-1	4.20	4.13	4.17	JS 20-94	2.93	3.10	3.02	PS 1572	4.13	3.33	3.73
DSb 30-2	4.00	4.03	4.02	NRC 117	3.67	3.57	3.62	MACS 1480	4.03	3.77	3.90
RSC 10-30	3.80	4.07	3.93	AMS 115	3.33	3.20	3.27	DSb 29	4.07	2.53	3.30
KDS 975	2.33	2.47	2.40	TS 72	3.53	3.37	3.45	PS 1570	2.47	3.37	2.92
VLS 91	2.87	2.83	2.85	AMS 100-1	3.13	2.80	2.97	DS 3104	2.83	3.63	3.23
MAUS 710	3.33	3.30	3.32	Himso 1686	3.53	3.60	3.57	SL 1074	3.30	3.63	3.47
NRC 118	2.93	3.13	3.03	MACS 1488	3.13	2.90	3.02	TS 69	3.13	3.43	3.28
KDS 775	3.27	3.17	3.22	KDS 754	3.47	3.43	3.45	BAUS 72	3.17	2.93	3.05
VLS 90	2.60	2.57	2.58	RVS 2010-2	3.00	3.17	3.08	NRC 121	2.57	2.60	2.58
NRC 119	3.47	3.33	3.40	AMS 1001	3.07	3.27	3.17	RSC 10-29	3.33	3.50	3.42
NRC 120	4.07	4.00	4.03	NRC 123	3.40	2.27	2.83	MAUS 740	4.00	3.03	3.52
VLB 202	2.60	2.53	2.57	JS 335 (c)	3.93	3.80	3.87	NRC 122	2.53	3.57	3.05
JS 20-116	3.93	4.13	4.03	RSC 10-04	4.73	4.30	4.52	KBS 24-2014	4.13	3.27	3.70
RKS 18 (c)	4.13	4.20	4.17	-	-	-	-	JS 97-52 (c)	4.20	4.67	4.43
Mean	**3.46**	**3.50**		**Mean**	**3.48**	**3.34**		**Mean**	**3.50**	**3.39**	
SEm±	**0.22**	**0.23**		**SEm±**	**0.28**	**0.31**		**SEm±**	**0.23**	**0.15**	
C.D. (5%)	**0.63**	**0.67**		**C.D. (5%)**	**0.81**	**0.90**		**C.D. (5%)**	**0.67**	**0.42**	
	NS	NS							NS	NS	

Table 4.4: Variation in Leaf area of soybean genotypes at various growth phases

Early Treatment	flowering stage 60 (DAS)	Grain filling Stage 90 (DAS)	Mean	Medium Treatment	flowering stage 60 (DAS)	Grain filling stage Stage 90 (DAS)	Mean	Late Treatment	flowering stage 60 (DAS)	Grain filling Stage 90 (DAS)	Mean
				Leaf area cm^{-2}							
PS 1569	166.25	170.58	168.41	MACS 1491	550.40	556.45	553.43	DS 3103	208.14	244.55	226.35
RVS 2010-1	621.16	630.29	625.72	JS 20-94	471.05	475.91	473.48	PS 1572	232.62	244.98	238.80
DSb 30-2	432.96	438.06	435.51	NRC 117	260.86	271.02	265.94	MACS 1480	403.32	409.51	406.41
RSC 10-30	386.91	391.26	389.09	AMS 115	367.25	372.51	369.88	DSb 29	650.83	654.77	652.80
KDS 975	255.49	260.93	258.21	TS 72	536.78	545.81	541.29	PS 1570	265.54	419.56	342.55
VLS 91	511.35	517.28	514.32	AMS 100-1	450.66	455.33	452.99	DS 3104	329.45	333.10	331.28
MAUS 710	306.67	311.31	308.99	Himso 1686	417.25	428.64	422.95	SL 1074	519.80	524.11	521.96
NRC 118	310.22	321.28	315.75	MACS 1488	544.90	549.93	547.42	TS 69	443.82	447.49	445.65
KDS 775	462.96	468.93	465.94	KDS 754	479.63	484.92	482.28	BAUS 72	414.20	419.56	416.88
VLS 90	270.30	275.33	272.82	RVS 2010-2	269.78	275.63	272.70	NRC 121	171.27	180.29	175.78
NRC 119	515.90	521.39	518.65	AMS 1001	281.12	287.05	284.09	RSC 10-29	251.84	256.32	254.08
NRC 120	561.89	565.93	563.91	NRC 123	340.87	345.62	343.24	MAUS 740	269.46	276.99	273.23
VLB 202	494.79	504.15	499.47	JS 335 (c)	433.10	437.62	435.36	NRC 122	313.46	379.76	346.61
JS 20-116	336.13	346.10	341.11	RSC 10-04	802.49	808.21	805.35	KBS 24-2014	318.34	325.01	321.67
RKS 18 (c)	363.80	368.85	366.33	-	-	-		JS 97-52 (c)	210.40	216.72	213.56
Mean	**399.79**	**406.11**		**Mean**	**443.30**	**449.62**		**Mean**	**333.50**	**355.51**	
SEm±	**90.61**	**65.47**		**SEm±**	**94.62**	**66.76**		**SEm±**	**4756.99**	**61.01**	
C.D. (5%)	**64.07**	**189.65**		**C.D. (5%)**	**66.91**	**194.05**		**C.D. (5%)**	**3363.70**	**176.73**	



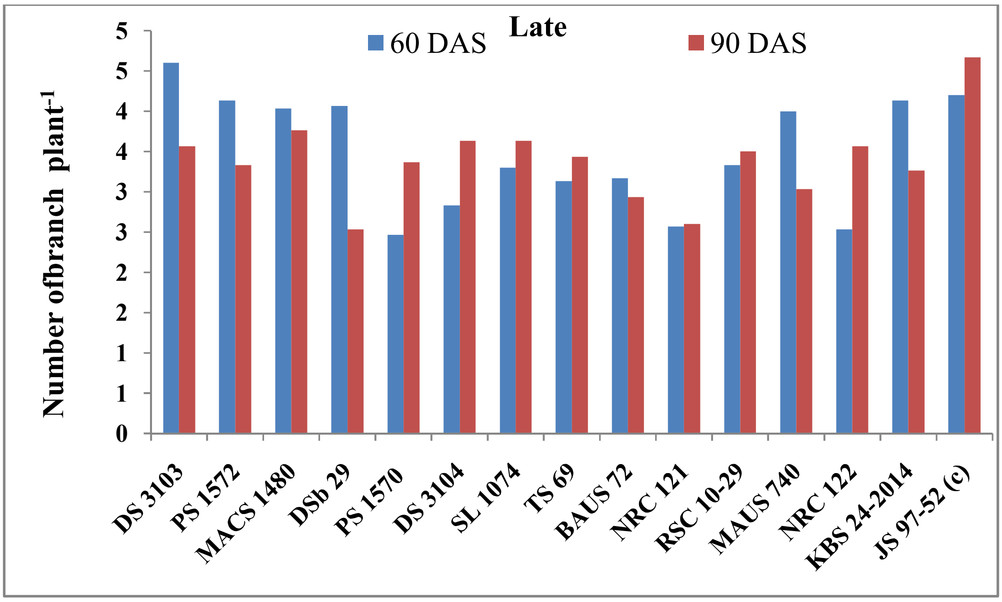


Fig 4.3 Variation in Number of branches plant^{-1}in soybean cultivars at various growth phases

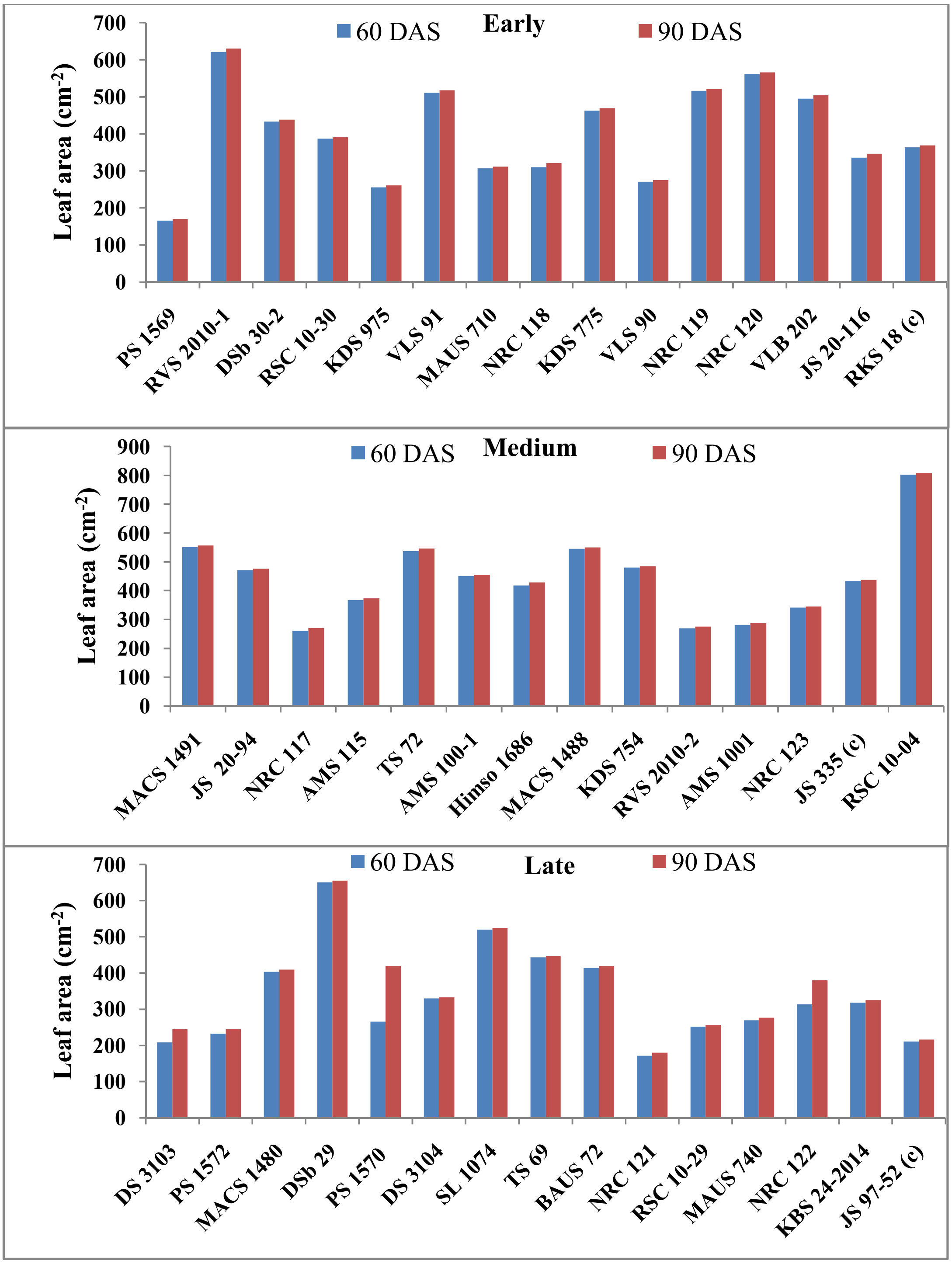


Fig 4.4 Variation in leaf area cm^{-2} in soybean cultivars at various growth phases

In medium duration group RSC 10-04 have significantly higher LA (803.35) followed by MACS 1491 (553.43). The minimum leaf area was observed in NRC 117 (265.94) followed by AMS 1001 (284.09).

In long duration cultivars DSb 29 having maximum (652.80) leaf area followed by SL 1074 (521.96). Whereas, minimum LA was obtained by NRC 121 (175.78) followed by JS 97-52 (c) (213.56) (Table 4.4 fig. 4.4).

Khargakharate, *et al*. (1992) also reported the suitable equation for estimating leaf area in soybean from linear measurement was calculated to be leaf area = maximum length x maximum width x 0.68. Chatterjee *et al.* (1985) also reported the similar finding of increases in leaf area up to 50-70 DAS.

4.2 Phenological Parameters

The phenological parameters includes days to flower initiation, days to 50% flowering, days to physiological maturity.

4.2.1 Days to flower initiation:

It was observed that the soybean cultivars exhibited non significant difference in days to flower initiation. The maximum days to flower initiation was observed in soybean cultivars early group NRC 118 (27.0) followed by RSC 10-30 (25.67). While the minimum days to flower initiation was observed in DSb 30-2 (18.0) and VLS 90 (18.33) followed by NRC 120 (19.0).

Medium duration cultivars MACS 1491 (24.67) having significantly higher yield followed by TS 72 (24.33) and RSC 10-04 (24.0). Whereas significantly lowest yield was obtained in NRC 123 (18.67) followed by Himso 1686 (18.67).

In long duration cultivars TS 69 having significantly higher day to flower initiation (33.00) followed by JS 97-52 (c) (30.00) and DSb 29 (29.33). Whereas significantly lowest yield was obtained in NRC 121 (19.00) followed by MACS 1480 (21.00) and MAUS 740 (23.00) (Table 4.5 fig. 4.5).

Sonawane *et al.* (2005) also reported the cultivars was found to be superior in respect of growth characters like phenological stages such as days required for initiation of flowering, days required for 50% flowering and days required for physiological maturity.

4.2.2 Days to 50 % flowering:

It was observed that soybean cultivars exhibited non significant difference in days to 50% flowering. The average days to 50% flowering of all varieties of soybean cultivars was recorded in maximum day long cultivars (43.29) followed by medium (42.98) and early (42.04).

Early cultivars PS 1569 having non significantly maximum day to 50 % flowering (53.00) followed by KDS 975 (46.00). However VLB 202 having minimum day to 50 % flowering (34.00) followed by NRC 120 (37.00).

In medium duration cultivars AMS 1001 having maximum day to 50 % flowering (47.00) followed by MACS 1491 (46.33). While average minimum day to 50 % flowering was achieved by KDS 754 (36.33) followed by Himso 1686 (38.33).

In long duration cultivars TS 69 and JS 97-52 (c) having highest day to 50 % flowering (49.67) followed by DSb 29 (47.33). The minimum day to 50 % flowering was obtained in NRC 212 (33.67) followed by NRC 122 (38.00).

Jagtap and Choudhary (1992) days to 50% flowering, number of seed plant^{-1}, number of branches and day to maturity. The characeters, which showed significant positive correlation with seed yield were also positively associated among themselves except day to maturity.

4.2.3 Days to physiological maturity

The soybean cultivars exhibited non significantly difference in days to physiological maturity. The average days to physiological maturity of in long duration soybean cultivars was recorded in (108.923) followed by medium duration cultivars (10.67) then early (99.1).

In early duration cultivars KDS 775, DSb 30-2 having non significantly maximum (100.00) days to physiological maturity was observed followed by followed by NRC 118 (99.67), while the minimum was observed in RKS 18 (c) (98.00) followed by VLS 90 (98.33).

In medium duration cultivars RSC 10-04 (108.67) days to physiological maturity was obtained followed by KDS 975 (105.33), and minimum was obtained by RVS 2010-1,RSC 10-30 and MAUS 710 (101.0).

Table 4.5 Variation in phenological observation in soybean cultivars in variation growth phases.

Early Treatment	Day to initiation of flowering	Day to 50 % of flowering	Mean	Medium Treatment	Day to initiation of flowering	Day to 50 % of flowering	Mean	Late Treatment	Day to initiation of flowering	Day to 50 % of flowering	Mean
PS 1569	22.33	53.00	37.67	MACS 1491	24.67	46.33	35.50	DS 3103	25.00	43.33	34.17
RVS 2010-1	20.33	43.33	31.83	JS 20-94	23.67	43.33	33.50	PS 1572	27.00	43.67	35.33
DSb 30-2	18.00	45.00	31.50	NRC 117	20.33	42.00	31.17	MACS 1480	21.00	38.33	29.67
RSC 10-30	25.67	45.00	35.33	AMS 115	23.67	39.67	31.67	DSb 29	29.33	47.33	38.33
KDS 975	23.33	46.00	34.67	TS 72	24.33	45.33	34.83	PS 1570	26.33	45.33	35.83
VLS 91	25.67	39.00	32.33	AMS 100-1	20.33	43.67	32.00	DS 3104	26.00	41.67	33.83
MAUS 710	21.00	38.33	29.67	Himso 1686	18.67	38.33	28.50	SL 1074	28.00	45.00	36.50
NRC 118	27.00	39.00	33.00	MACS 1488	22.33	46.00	34.17	TS 69	33.00	49.67	41.33
KDS 775	21.33	45.00	33.17	KDS 754	21.00	36.33	28.67	BAUS 72	26.33	45.00	35.67
VLS 90	18.33	39.33	28.83	RVS 2010-2	21.67	41.33	31.50	NRC 121	19.00	33.67	26.33
NRC 119	22.00	39.00	30.50	AMS 1001	23.33	47.00	35.17	RSC 10-29	29.33	45.00	37.17
NRC 120	19.00	37.00	28.00	NRC 123	18.67	45.00	31.83	MAUS 740	23.00	40.00	31.50
VLB 202	20.33	34.00	27.17	JS 335 (c)	19.00	42.33	30.67	NRC 122	23.00	38.00	30.50
JS 20-116	22.00	45.00	33.50	RSC 10-04	24.00	45.00	34.50	KBS 24-2014	25.00	43.67	34.33
RKS 18 (c)	19.33	42.67	32.27	-	-	-	-	JS 97-52 (c)	30.00	49.67	39.83
Mean	**21.71**	**42.04**		**Mean**	**21.83**	**42.98**		**Mean**	**26.09**	**43.29**	
SEm±	**1.148**	**0.206**		**SEm±**	**1.153**	**1.148**		**SEm±**	**1.143**	**0.2751**	
C.D. (5%)	**3.336**	**0.596**		**C.D. (5%)**	**3.339**	**3.351**		**C.D. (5%)**	**3.310**	**0.7968**	
	NS				**NS**				**NS**		

Table 4.6 Variation in day to physiological maturity in soybean cultivars at various growth phases

Day to physiological maturity					
Early Treatment	**Mean**	**Medium Treatment**	**Mean**	**Late Treatment**	**Mean**
PS 1569	99.0	MACS 1491	103.00	DS 3103	109.33
RVS 2010-1	99.0	JS 20-94	101.00	PS 1572	118.00
DSb 30-2	100.0	NRC 117	105.00	MACS 1480	106.00
RSC 10-30	99.0	AMS 115	101.00	PS 1570	108.00
KDS 975	99.0	TS 72	105.33	DS 3104	108.00
MAUS 710	99.0	AMS 100-1	101.00	SL 1074	109.00
NRC 118	99.7	Himso 1686	105.00	BAUS 72	110.33
KDS 775	100.0	MACS 1488	105.00	NRC 121	108.00
VLS 90	98.3	KDS 754	103.00	RSC 10-29	108.33
NRC 119	99.0	RVS 2010-2	104.33	MAUS 740	109.67
NRC 120	99.0	AMS 1001	101.00	NRC 122	107.67
VLB 202	99.0	NRC 123	101.00	KBS 24-2014	107.67
JS 20-116	99.0	JS 335 (c)	103.00	JS 97-52 (c)	106.00
RKS 18 (c)	98.0	RSC 10-04	108.67	-	-
Mean	**99.1**	**Mean**	**103.4**	**Mean**	**108.923**
SEm±	**0.124**	**SEm±**	**0.217**	**SEm±**	**0.572**
C.D. (5%)	**0.359**	**C.D. (5%)**	**0.630**	**C.D. (5%)**	**1.669**
	NS		NS		NS

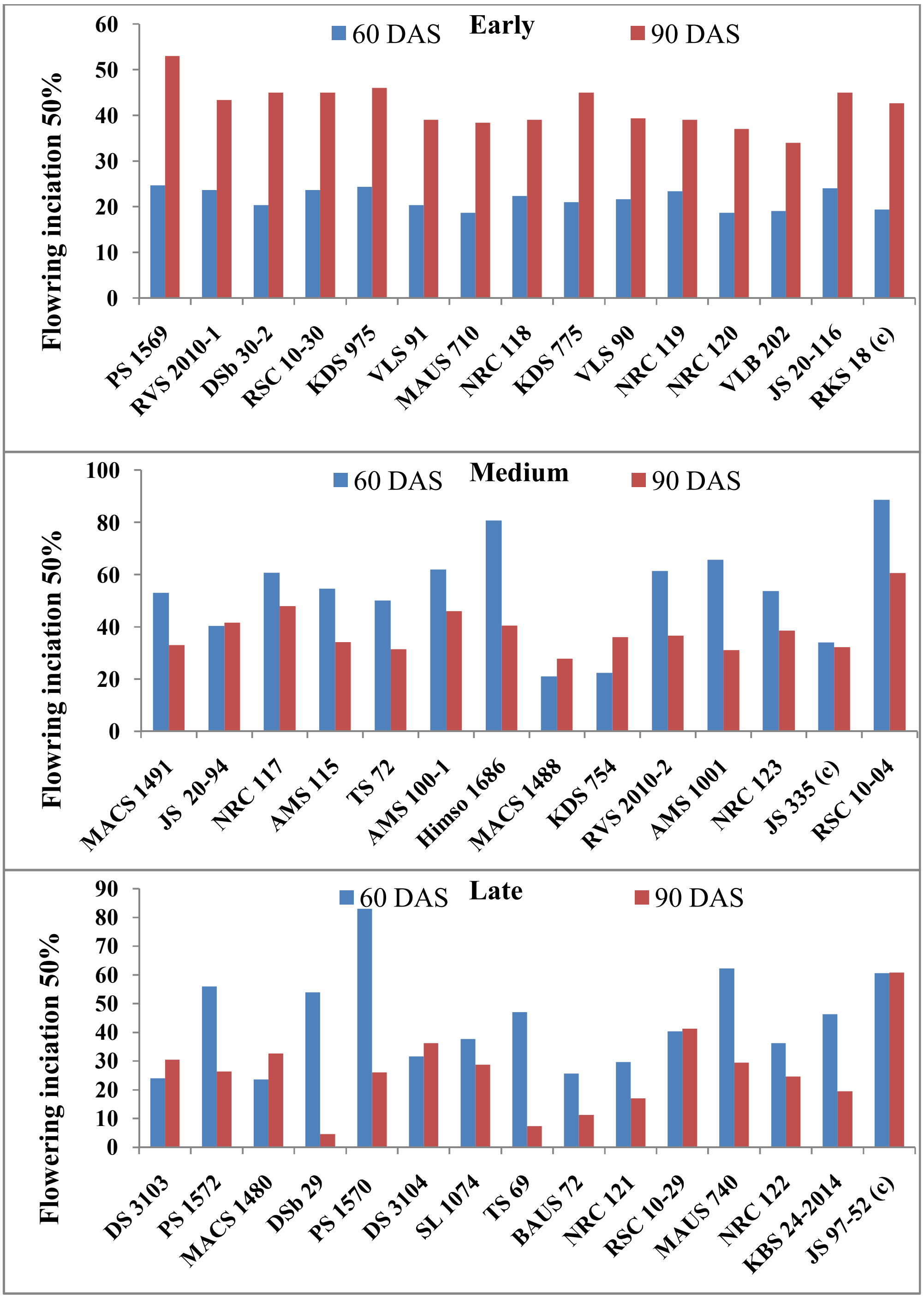


Fig 4.5 Variation in flowering initiation 50% in soybean cultivars at various growth phases.

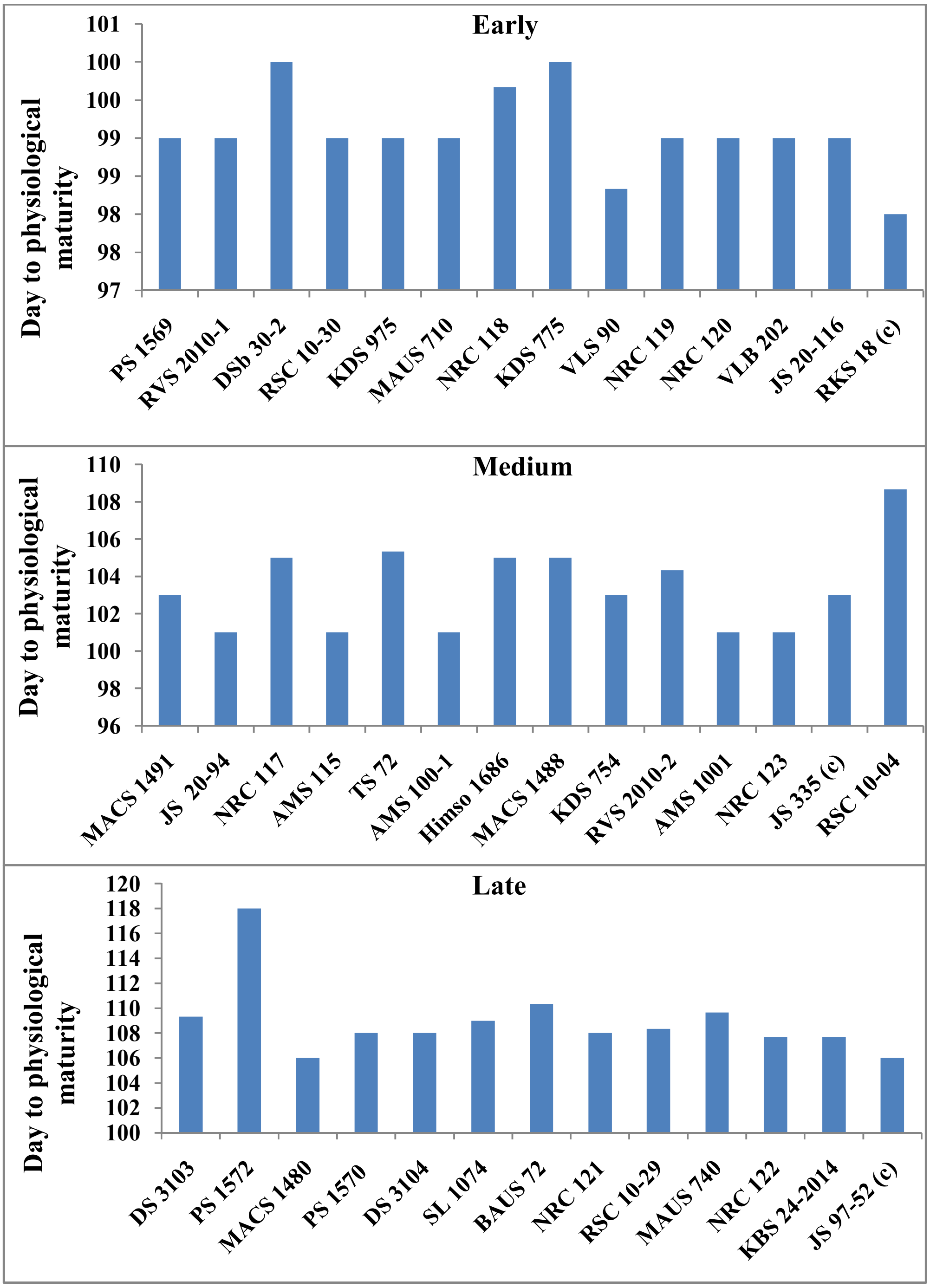


Fig 4.6 Variation in day to physiological maturity in soybean cultivars.

In long duration cultivars PS 1572 have non significantly higher (118.00) days to physiological maturity followed by MAUS 740 (109.67), While minimum days to physiological maturity was recorded by MACS 1480 (106.00), JS 97-52 (106.00) followed by NRC 122 (107.67). (Table 4.6 fig. 4.6).

Singh *et al.* (1983) also reported the phenological yield components *i.e.* days to maturity, plant height, number of pods plant^{-1}, seeds pod^{-1} and test weight, number of primary branches were positively correlated with seed yield. Similarly**,** Shaikh *et al.* (2003) also reported the cultivars of soybean (*Glycine max L. Merrill*) for different characters. The observations were recorded on days to 50 percent flowering, days to maturity, plant height (cm), number of primary branches per plant, number of pods per plant.

4.3 Growth parameters

The growth parameters includes leaf area per pant, leaf area index, crop growth rate, relative growth rate, net assimilation rate.

4.3.1 Leaf area index (LAI)

The Leaf area index was calculated at 60 and 90 days after sowing. It was observed that the LAI was maximum at 60 and 90 DAS in medium duration (1.97, 2.00) cultivars followed by early (1.78, 1.80) and then long duration cultivars (1.50, 1.58).

In early duration cultivars RVS 2010-1 (2.78) having significantly higher LAI followed by NRC 120 (2.51) Whereas, PS 1569 exhibited significantly minimum (0.75) LAI followed by KDS 975 (1.15).

In medium duration cultivars RSC 10-04 having maximum LAI (3.58) followed by MACS 1491 (2.46) and minimum LAI observed in NRC 117 (1.18) followed by RVS 2010-2 (1.21).

In long duration cultivars maximum LAI (2.90) was observed in DSb 29 followed by SL 1074 (2.32) while minimum was observed in NRC 121 (0.78) followed by JS 97-52 (c) (0.95) in long group of cultivars. (Table 4.7 fig. 4.7).

Pawar (1978) also observed the increased LAI up to 60 days and decreased thereafter in soybean.

Table 4.7 Variation in leaf area index in soybean cultivars at various growth phases

Early Treatment	flowering stage 60 (DAS)	Grain filling Stage 90 (DAS)	Mean	Medium Treatment	flowering stage 60 (DAS)	Grain filling Stage 90 (DAS)	Mean	Late Treatment	flowering stage 60 (DAS)	Grain filling Stage 90 (DAS)	Mean
PS 1569	0.74	0.76	0.75	MACS 1491	2.44	2.47	2.46	DS 3103	0.92	1.09	1.00
RVS 2010-1	2.76	2.80	2.78	JS 20-94	2.09	2.12	2.10	PS 1572	1.03	1.09	1.06
DSb 30-2	1.92	1.95	1.93	NRC 117	1.16	1.20	1.18	MACS 1480	1.79	1.82	1.81
RSC 10-30	1.72	1.74	1.73	AMS 115	1.63	1.66	1.64	DSb 29	2.89	2.91	2.90
KDS 975	1.14	1.16	1.15	TS 72	2.39	2.43	2.41	PS 1570	1.18	1.86	1.52
VLS 91	2.27	2.30	2.28	AMS 100-1	2.00	2.02	2.01	DS 3104	1.46	1.48	1.47
MAUS 710	1.36	1.38	1.37	Himso 1686	1.85	1.91	1.88	SL 1074	2.31	2.33	2.32
NRC 118	1.38	1.43	1.40	MACS 1488	2.42	2.44	2.43	TS 69	1.97	1.99	1.98
KDS 775	2.06	2.08	2.07	KDS 754	2.13	2.16	2.14	BAUS 72	1.84	1.86	1.85
VLS 90	1.20	1.22	1.21	RVS 2010-2	1.20	1.23	1.21	NRC 121	0.76	0.80	0.78
NRC 119	2.29	2.32	2.31	AMS 1001	1.25	1.28	1.26	RSC 10-29	1.12	1.14	1.13
NRC 120	2.50	2.52	2.51	NRC 123	1.52	1.54	1.53	MAUS 740	1.20	1.23	1.22
VLB 202	2.20	2.24	2.22	JS 335 (c)	1.92	1.94	1.93	NRC 122	1.66	1.69	1.67
JS 20-116	1.49	1.54	1.52	RSC 10-04	3.57	3.59	3.58	KBS 24-2014	1.42	1.44	1.43
RKS 18 (c)	1.62	1.64	1.63	-	-	-	-	JS 97-52 (c)	0.93	0.96	0.95
Mean	**1.78**	1.80		**Mean**	**1.97**	**2.00**		**Mean**	**1.50**	**1.58**	
SEm±	**0.29**	**2.52**		**SEm±**	**0.30**	**2.21**		**SEm±**	**14.95**	**1.14**	
C.D. (5%)	**0.83**	**0.82**		**C.D. (5%)**	**0.87**	**25.72**		**C.D. (5%)**	**0.80** NS	**0.79** NS	

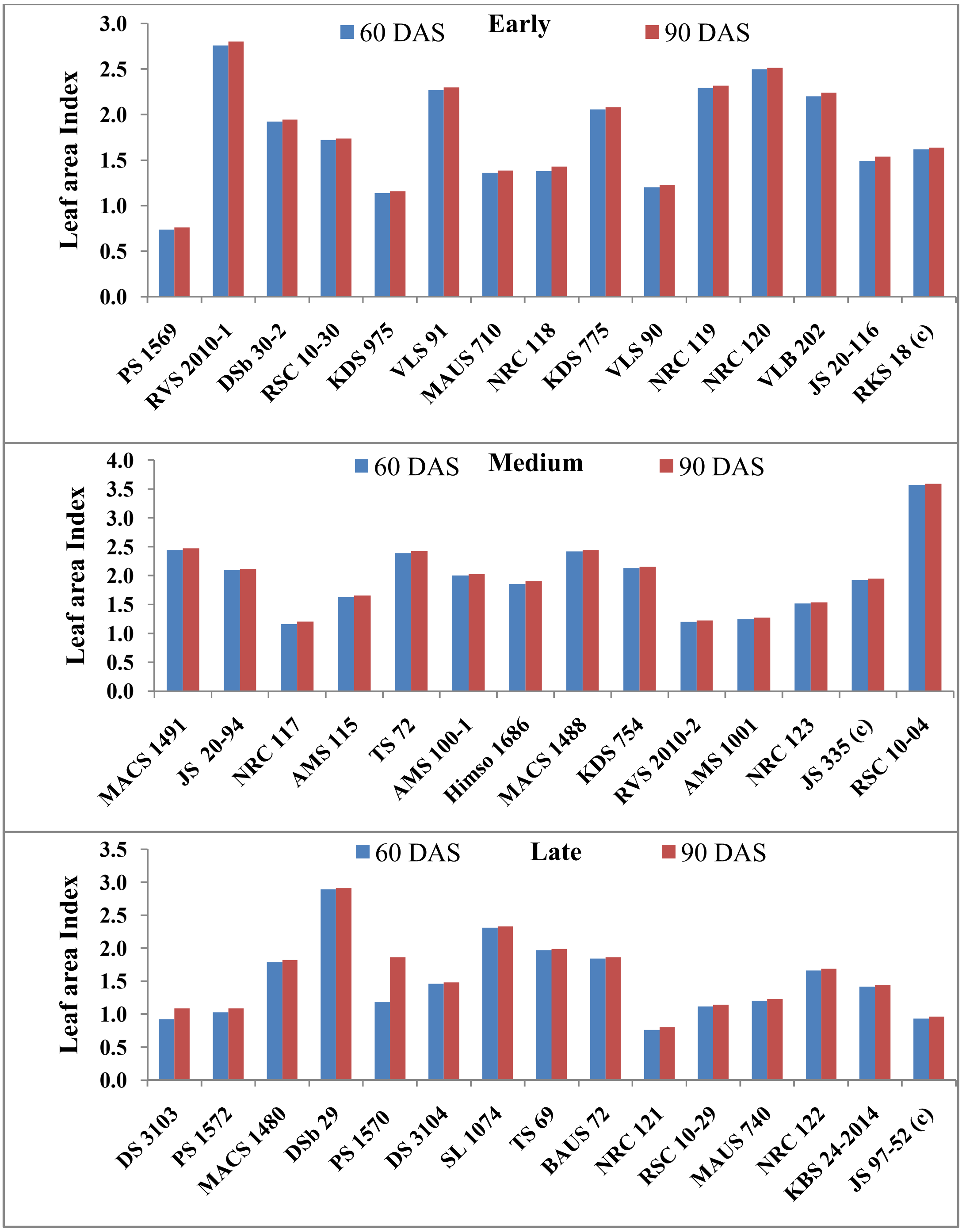


Fig 4.7 Variation in leaf area index plant^{-1} in soybean cultivars at various growth phases.

4.3.2 Crop growth rate (g $m^{-2}day^{-1}$)

The Crop growth rate was calculated from vegetative to grain filling stage (40, 60, 90) days after sowing. It was observed that the average crop growth rate was higher between 40-60 DAS in all group of cultivars *i.e.* early, medium and long. The average crop growth rate was higher and early cultivars (1.60) followed by medium (1.47) and long duration (1.01) during their growth stages. However, during the 60-90 DAS the average maximum growth rate was observed in long duration cultivars (0.105) followed by medium (0.085) and then early (0.084).

Early cultivars NRC-119 having significantly maximum CGR (3.72) followed by VLB-202 (2.63). However, JS 20-116 having minimum CGR (0.34) followed by RKS 18 (c) (0.49).

In medium duration cultivars TS 72 having maximum CGR (1.91) followed by JS 20-94 (1.05). While average minimum CGR was achieved by AMS 1001 (0.34) followed by KDS 754 (0.41).

In long duration cultivars MACS 1480 having highest CGR (1.41) followed by JS97-52 (c) (0.67). The minimum CGR was obtained in TS 69 (0.24) followed by (0.33) (Table 4.8 fig 4.8).

Nirmala Kumari and Balasubramanian (1989) also observed the similar observation of dry matter production increased slowly up to 60 DAS and decreased later up to harvest in soybean.

4.3.3 Net assimilation rate (NAR) (g (crop) m^{-2} day^{-1})

NAR was calculated since vegetative to grain filling stage. The significantly higher NAR was observed in early duration cultivars in between 40-60 DAS in followed by medium and then long duration cultivars. However, the NAR was maximum in between 60-90 DAS in long duration cultivars followed by medium and then early duration cultivars.

The average maximum NAR was achieved by VLB 202 (0.1023) followed by VLS 90 (0.1000). The significant lowest rate of NAR was observed in KDS 775 (0.0193) followed by JS 20-116 (0.0232).

In medium duration cultivars TS 72 having significantly maximum NAR (0.1267) followed by JS20 (0.0713), RVS 2010-2 (0.0712). The significantly

Table 4.8 Variation in crop growth rate in soybean cultivars at various growth phases (g m^{-2} day^{-1})

Early	Vegetative	Flowering		Medium	Vegetative	Flowering		Late	Vegetative	Flowering	Mean
Treatment	Flowering stage	Grain filling stage	Mean	Treatment	Flowering stage	Grain filling stage	Mean	Treatment	Flowering stage	Grain filling stage	Mean
PS 1569	1.75	0.08	0.92	MACS 1491	1.45	0.07	0.76	DS 3103	0.98	0.08	0.53
RVS 2010-1	1.96	0.05	1.00	JS 20-94	1.50	0.13	0.81	PS 1572	1.01	0.09	0.55
DSb 30-2	1.54	0.10	0.82	NRC 117	1.27	0.10	0.69	MACS 1480	2.50	0.32	1.41
RSC 10-30	1.50	0.09	0.79	AMS 115	1.50	0.08	0.79	DSb 29	0.73	0.07	0.40
KDS 975	1.64	0.12	0.88	TS 72	3.75	0.07	1.91	PS 1570	0.70	0.18	0.44
VLS 91	1.20	0.09	0.65	AMS 100-1	1.76	0.09	0.93	DS 3104	0.50	0.12	0.31
MAUS 710	1.14	0.06	0.60	Himso 1686	1.98	0.14	1.06	SL 1074	0.74	0.12	0.43
NRC 118	1.96	0.08	1.02	MACS 1488	0.81	0.04	0.43	TS 69	0.41	0.09	0.25
KDS 775	0.30	0.14	0.22	KDS 754	0.68	0.16	0.42	BAUS 72	0.57	0.10	0.33
VLS 90	2.05	0.08	1.07	RVS 2010-2	1.41	0.07	0.74	NRC 121	1.22	0.05	0.64
NRC 119	3.73	0.15	1.94	AMS 1001	0.64	0.05	0.35	RSC 10-29	1.31	0.05	0.68
NRC 120	1.03	0.06	0.55	NRC 123	1.19	0.01	0.60	MAUS 740	1.31	0.10	0.71
VLB 202	2.63	0.05	1.34	JS 335 (c)	1.28	0.06	0.67	NRC 122	1.05	0.06	0.55
JS 20-116	0.65	0.04	0.34	RSC 10-04	1.41	0.14	0.78	KBS 24-2014	1.08	0.01	0.54
RKS 18 (c)	0.92	0.08	0.50	-	-	-	-	JS 97-52 (c)	1.20	0.14	0.67
Mean	**1.60**	**0.08**		**Mean**	**1.47**	**0.09**		**Mean**	**1.02**	**0.11**	
SEm±	**0.04**	**0.03**		**SEm±**	**0.06**	**0.04**		**SEm±**	**0.07**	**0.07**	
C.D. (5%)	**0.11**	**0.09**		**C.D. (5%)**	**0.18**	**0.11**		**C.D. (5%)**	**0.20**	**0.22**	

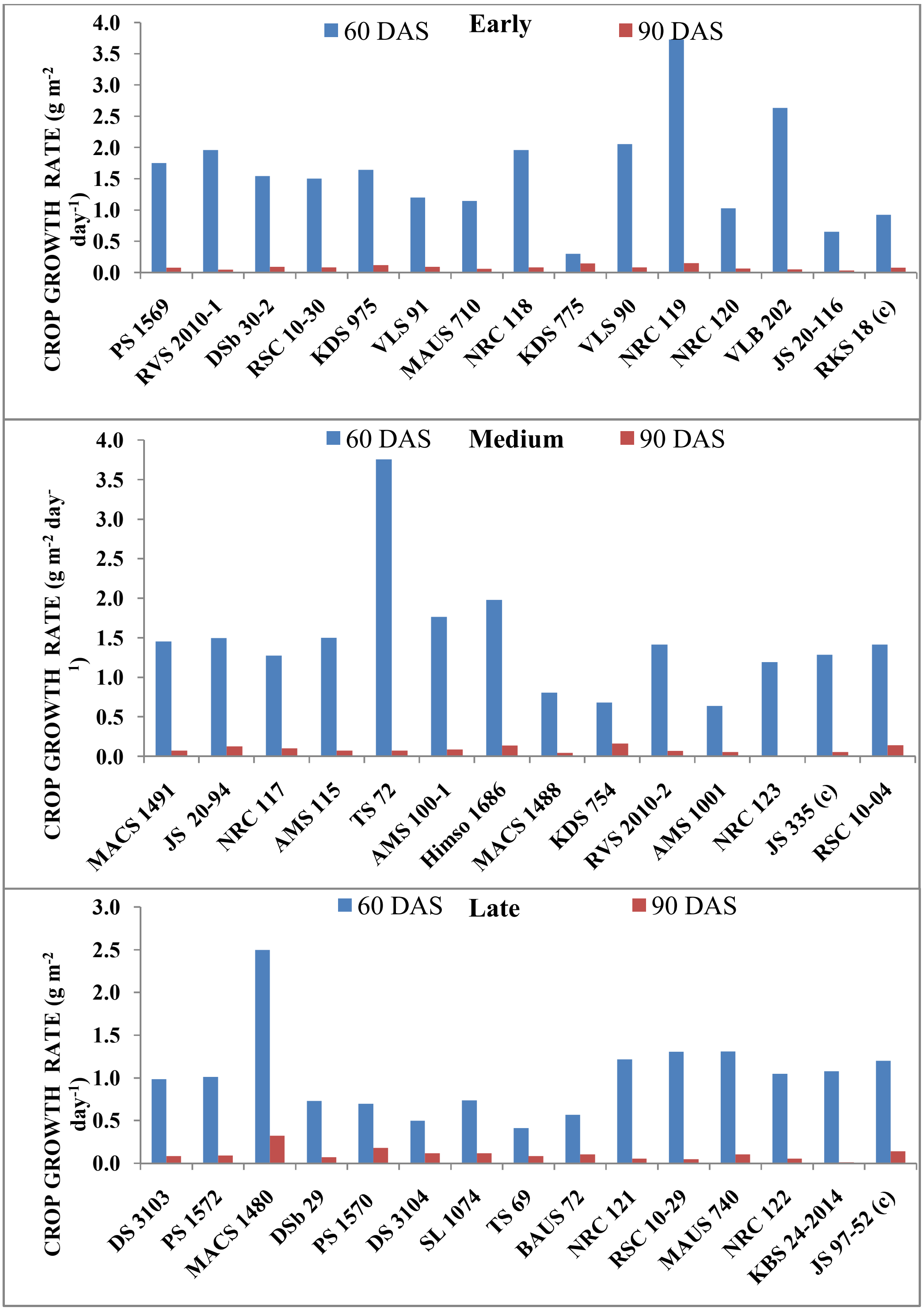


Fig 4.8 Variation in Crop growth rate (gm^{2}day^{-1}) in soybean cultivars at various growth phases.

Table 4.9 Variation in net assimilation rate (mg. cm^{-2} day^{-1}) in soybean cultivars at various growth phases

Early Treatment	Vegetative Flowering stage	Flowering Grain filling stage	Mean	Medium Treatment	Vegetative Flowering stage	Flowering Grain filling stage	Mean	Late Treatment	Vegetative Flowering stage	Flowering Grain filling stage	Mean
PS 1569	0.190	0.003	0.097	MACS 1491	0.128	0.003	0.066	DS 3103	0.130	0.006	0.068
RVS 2010-1	0.098	0.001	0.050	JS 20-94	0.137	0.006	0.071	PS 1572	0.128	0.006	0.067
DSb 30-2	0.118	0.004	0.061	NRC 117	0.108	0.005	0.056	MACS 1480	0.141	0.009	0.075
RSC 10-30	0.131	0.004	0.068	AMS 115	0.109	0.003	0.056	DSb 29	0.075	0.005	0.040
KDS 975	0.119	0.005	0.062	TS 72	0.252	0.002	0.127	PS 1570	0.115	0.016	0.065
VLS 91	0.086	0.004	0.045	AMS 100-1	0.109	0.003	0.056	DS 3104	0.071	0.012	0.041
MAUS 710	0.097	0.003	0.050	Himso 1686	0.120	0.004	0.062	SL 1074	0.147	0.011	0.079
NRC 118	0.138	0.003	0.070	MACS 1488	0.095	0.003	0.049	TS 69	0.041	0.007	0.024
KDS 775	0.028	0.011	0.019	KDS 754	0.088	0.013	0.051	BAUS 72	0.100	0.010	0.055
VLS 90	0.197	0.003	0.100	RVS 2010-2	0.139	0.003	0.071	NRC 121	0.136	0.003	0.070
NRC 119	0.162	0.003	0.083	AMS 1001	0.064	0.004	0.034	RSC 10-29	0.119	0.002	0.061
NRC 120	0.136	0.004	0.070	NRC 123	0.123	0.001	0.062	MAUS 740	0.109	0.005	0.057
VLB 202	0.203	0.002	0.102	JS 335 (c)	0.101	0.003	0.052	NRC 122	0.082	0.003	0.043
JS 20-116	0.045	0.002	0.023	RSC 10-04	0.084	0.005	0.045	KBS 24-2014	0.124	0.001	0.062
RKS 18 (c)	0.083	0.004	0.044	-	-	-	-	JS 97-52 (c)	0.087	0.006	0.046
Mean	**0.122**	**0.004**		**Mean**	**0.118**	**0.004**		**Mean**	**0.107**	**0.007**	
SEm±	**0.008**	**0.001**		**SEm±**	**0.010**	**0.002**		**SEm±**	**0.013**	**0.003**	
C.D. (5%)	**0.022**	**0.004**		**C.D. (5%)**	**0.029** NS	**0.006** NS		**C.D.(5%)**	**0.037**	**0.009**	

minimum NAR was observed in AMS 1001 (0.0337) followed by MACS 1488 (0.0492).

In long duration cultivars SL 1074 have significantly higher NAR (0.0793) followed by MACS 1480 (0.0754). The significantly minimum NAR was observed in cultivars TS 69 (0.0240) followed by NRC 122 (0.0425). (Table 4.9 fig 4.9).

Jain *et al*. **(**1996) mentioned that in soybean LAI, CGR and RGR were increased with age and decreased at grain filling stage. Whereas NAR declined with increase in age. The NAR declined significantly due to formation of number of branches plant^{-1} and number of pod plant^{-1} under delayed sowing and formation of two sink at the same time due to indeterminate type of growth.

4.3.4 Relative growth rate (g g^{-1}day^{-1})

The RGR was also calculated in between 40-60 and 60-90 DAS in all the their groups of cultivars the average RGR was maximum in early types followed by medium and then long duration cultivars in between 40-60 DAS this was become of their duration. However, the trend was reversed in between 60-90 DAS.

In early duration cultivars VLB 202 have significantly higher RGR(0.058) followed by VLS 90 (0.055) and significantly minimum RGR was observed by KDS 775 (0.008) followed by JS 20-116 (0.013).

In medium duration cultivars TS 72 (0.072) having highest RGR followed by RVS 2010-2 (0.040), JS 20-94 (0.039) and MACS 1491 (0.037). While AMS 1001 (0.018) having minimum RGR and followed by RSC 10-04 (0.024).

In long duration cultivars SL 1074 having significantly higher RGR (0.042) followed by MACS 1480 (0.041). Whereas, TS 69 having significantly lowest RGR (0.012) followed by DS 3104 (0.020) and DSb 29 (0.022). (Table 4.11 fig 4.11).

Pawar (1978) mentioned some contradictory information regarding RGR and he observed increased RGR up to 30 DAS and decreased rate in latter phase of growth. Similarly Buttery (1970) mentioned growth parameters and observed that mean RGR increased with the increasing density while mean CGR and LAR decreased. Rajput and Shrivastava (1999) also mentioned that the sowing dates also influenced the growth parameters *ie.,* LAI, LAR,,RGR ,CGR and AGR.Sowing date July was found better for better growth in Soybean. However,

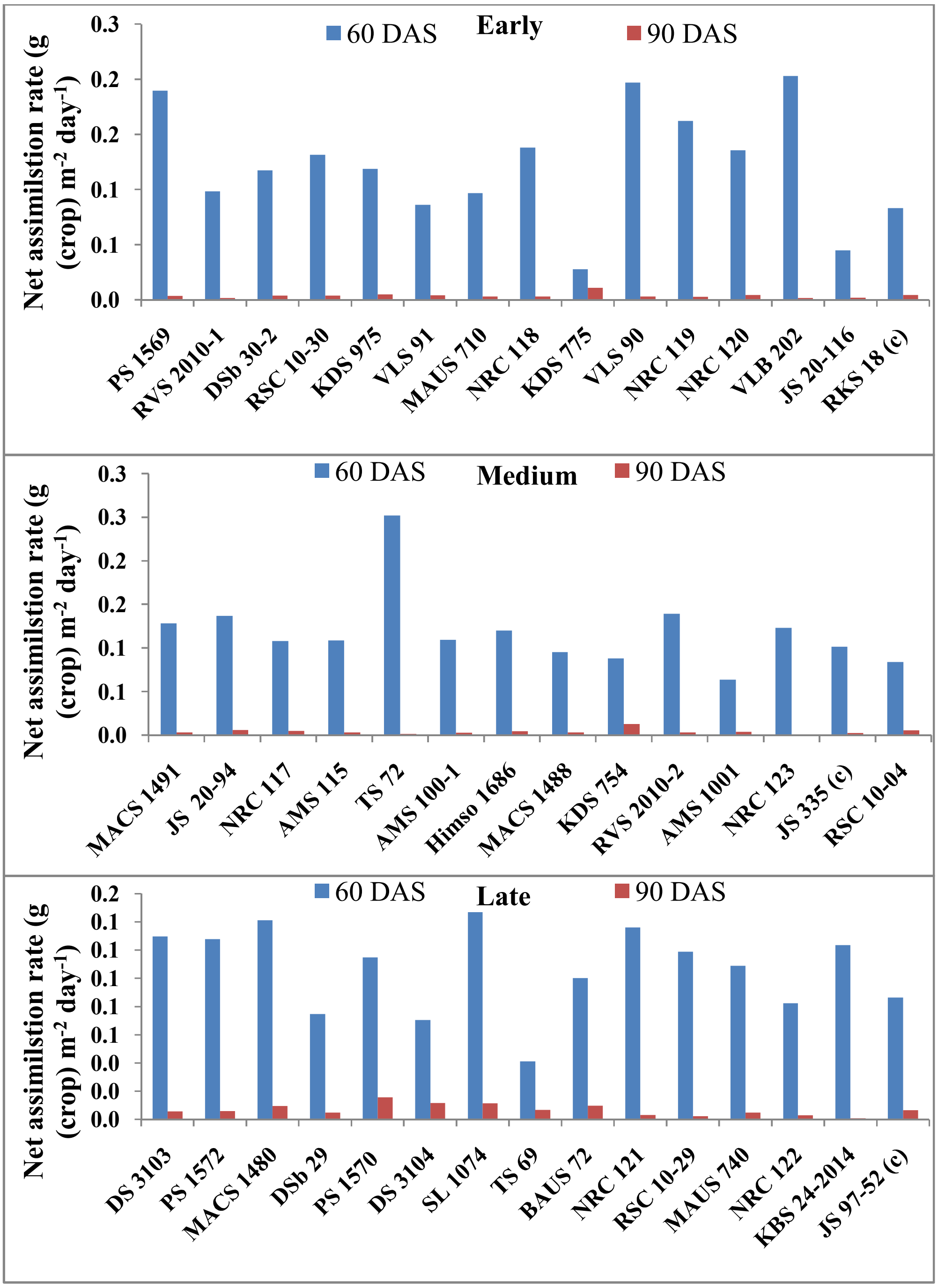


Fig 4.9 Variation in Net assimilation rate (g (crop) m^{-2} day^{-1}) in soybean cultivars at various growth phases.

Table 4.10 Variation in relative growth rate (g g $^{-1}$ plant $^{-1}$ day $^{-1}$) in soybean cultivars at various growth phases.

Early Treatment	Vegetative Flowering stage	Flowering Grain filling stage	Mean	Medium Treatment	Vegetative - Flowering stage	Flowering Grain filling stage	Mean	Late Treatment	Vegetative Flowering stage	Flowering Grain filling stage	Mean
PS 1569	0.107	0.002	0.054	MACS 1491	0.072	0.001	0.037	DS 3103	0.073	0.001	0.037
RVS 2010-1	0.055	0.001	0.028	JS 20-94	0.077	0.000	0.039	PS 1572	0.072	0.001	0.036
DSb 30-2	0.066	0.001	0.033	NRC 117	0.061	0.001	0.031	MACS 1480	0.079	0.002	0.041
RSC 10-30	0.074	0.002	0.038	AMS 115	0.061	0.001	0.031	DSb 29	0.042	0.001	0.022
KDS 975	0.067	0.001	0.034	TS 72	0.142	0.002	0.072	PS 1570	0.065	0.001	0.033
VLS 91	0.048	0.000	0.024	AMS 100-1	0.062	0.001	0.031	DS 3104	0.040	0.001	0.020
MAUS 710	0.054	0.001	0.028	Himso 1686	0.068	0.001	0.034	SL 1074	0.083	0.002	0.042
NRC 118	0.078	0.001	0.039	MACS 1488	0.054	0.001	0.027	TS 69	0.023	0.001	0.012
KDS 775	0.016	0.001	0.008	KDS 754	0.050	0.003	0.026	BAUS 72	0.056	0.005	0.030
VLS 90	0.111	0.000	0.055	RVS 2010-2	0.078	0.001	0.040	NRC 121	0.077	0.001	0.039
NRC 119	0.091	0.002	0.047	AMS 1001	0.036	0.001	0.018	RSC 10-29	0.067	0.001	0.034
NRC 120	0.076	0.000	0.038	NRC 123	0.069	0.001	0.035	MAUS 740	0.061	0.000	0.031
VLB 202	0.114	0.002	0.058	JS 335 (c)	0.057	0.000	0.029	NRC 122	0.046	0.001	0.024
JS 20-116	0.025	0.001	0.013	RSC 10-04	0.047	0.001	0.024	KBS 24-2014	0.070	0.002	0.036
RKS 18 (c)	0.047	0.001	0.024	-	-	-	-	JS 97-52 (c)	0.049	0.002	0.025
Mean	**0.069**	**0.001**		**Mean**	**0.067**	**0.001**		**Mean**	**0.060**	**0.001**	
SEm±	**0.004**	**0.000**		**SEm±**	**0.006**	**0.000**		**SEm±**	**0.007**	**0.001**	
C.D.(5%)	**0.012**	**0.001**		**C.D.(5%)**	**0.016**	**0.001**		**C.D.(5%)**	**0.021**	**0.002**	

the late sowing show decreased in these parameters.

4.4 Biochemical parameters

4.4.1 Chlorophyll value (SPAD value)

The total chlorophyll content was measured at vegetative stage (30 DAS) and flowering (60 DAS) and grain filling stage of crop growth of soybean plant. It was observed that the chlorophyll content varied non significant in soybean cultivars. Growth also possessed non significantly impact on chlorophyll content. The maximum chlorophyll SPAD value was observed at flowering stage as compared to grain filling stage and decreased gradually with the later phase of growth.

The average maximum chlorophyll content was found in long duration soybean cultivars (38.72) vegetative stage followed by medium soybean cultivars (38.36), whereas minimum was observed in early soybean cultivars (37.65). The average chlorophyll of flowering stage maximum chlorophyll recorded in early cultivars (34.00) followed by long cultivars (33.48). However, medium cultivars (33.58) having minimum chlorophyll at flowering stage (60 DAS).

Early cultivars vegetative stage NRC-120 having significantly maximum chlorophyll (42.71) followed by RSC 10-30 (42.12). However, VLB 202 having minimum chlorophyll (33.77) followed by PS 1569 (34.59).

In medium duration cultivars MACS 1488 having maximum chlorophyll (43.65) followed by RVS 2010-2 (40.12). While average minimum chlorophyll was achieved by AMS 100-1 (35.25) followed by TS 72 (35.47).

In long duration cultivars RSC 10-29 having highest chlorophyll (42.36) followed by PS 1570 (40.95). The minimum chlorophyll was obtained in DSb 29 (36.71) followed by TS 69 (36.91).

Early cultivars flowering stage NRC-18 having significantly maximum chlorophyll (36.24) followed by DSb 30-2 (35.76). However, VLB 202 having minimum chlorophyll (30.55) followed by VLS 90 (35.91).

Medium duration cultivars RVS 2010-2 having maximum chlorophyll (40.12) followed by JS 20-94 (35.95). While average minimum chlorophyll was achieved by NRC 117 (31.53) followed by JS 335 (c) (31.72).

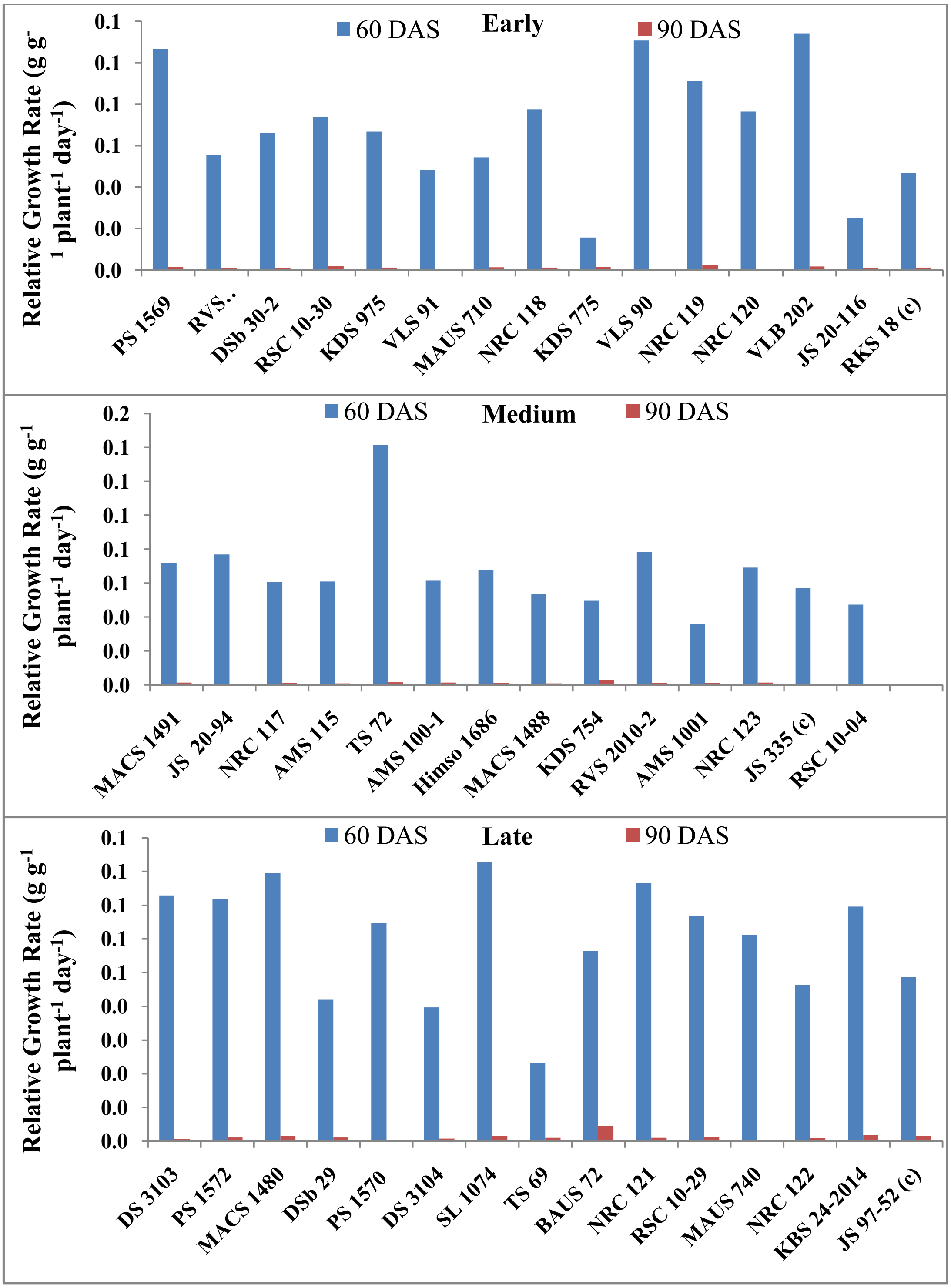


Fig 4.10 Variation in Relative growth rate ($gg^{-1}plant^{-1}day^{-1}$) in soybean cultivars at various growth phases.

Table 4.11 Variation in chlorophyll content (SPAD value) in soybean cultivars at various growth phases

Early Treatment	Vegetative stage 30 (DAS)	flowering stage 60 (DAS)	Mean	Medium Treatment	Vegetative stage 30 (DAS)	flowering stage 60 (DAS)	Mean	Late Treatment	Vegetative stage 30 (DAS)	flowering stage 60 (DAS)	Mean
PS 1569	34.59	32.83	33.71	MACS 1491	37.15	33.98	35.57	DS 3103	39.05	32.94	35.99
RVS 2010-1	35.61	34.20	34.91	JS 20-94	37.29	35.95	36.62	PS 1572	39.79	34.85	37.32
DSb 30-2	39.47	35.76	37.61	NRC 117	38.96	31.53	35.25	MACS 1480	38.61	31.58	35.10
RSC 10-30	42.12	32.67	37.40	AMS 115	39.65	32.05	35.85	DSb 29	36.71	32.09	34.40
KDS 975	37.78	34.64	36.21	TS 72	35.47	33.25	34.36	PS 1570	40.95	36.24	38.59
VLS 91	36.75	33.63	35.19	AMS 100-1	35.25	32.67	33.96	DS 3104	37.25	35.30	36.28
MAUS 710	36.80	34.90	35.85	Himso 1686	38.50	35.23	36.87	SL 1074	37.05	33.88	35.47
NRC 118	38.97	36.24	37.61	MACS 1488	43.65	31.93	37.79	TS 69	36.91	34.52	35.72
KDS 775	39.92	34.76	37.34	KDS 754	39.31	33.16	36.24	BAUS 72	40.59	29.60	35.09
VLS 90	35.91	32.52	34.22	RVS 2010-2	40.12	40.12	40.12	NRC 121	38.17	35.97	37.07
NRC 119	34.94	33.04	33.99	AMS 1001	39.53	32.45	35.99	RSC 10-29	42.36	34.23	38.29
NRC 120	42.71	34.57	38.64	NRC 123	38.89	32.16	35.53	MAUS 740	37.00	31.40	34.20
VLB 202	33.77	30.55	32.16	JS 335 (c)	37.53	31.72	34.63	NRC 122	39.45	35.78	37.62
JS 20-116	35.15	35.15	35.15	RSC 10-04	35.80	33.86	34.83	KBS 24-2014	37.86	32.04	34.95
RKS 18 (c)	40.28	34.60	37.44	-	-	-	-	JS 97-52 (c)	38.99	31.78	35.38
Mean	**37.65**	**34.00**		**Mean**	**38.36**	**33.58**		**Mean**	**38.72**	**33.48**	
SEm±	**1.957**	**1.210**		**SEm±**	**1.893**	**1.711**		**SEm±**	**1.432**	**1.533**	
C.D. (5%)	**5.669**	**3.504**		**C.D. (5%)**	**5.502**	**4.973**		**C.D. (5%)**	**4.147**	**4.441**	
	NS	**NS**			**NS**	**NS**			**NS**	**NS**	

Long cultivars flowering stage PS 1570 having highest chlorophyll (36.24) followed by NRC 121 (35.97). However, minimum chlorophyll was obtained in BAUS 72 (29.60) followed by MAUS 740 (31.40). (Table 4.12 fig 4.12)

Basuchaudhuri and Munda (1987) also reported that chlorophyll concentration was higher in the upper portion of 60-70 cm then decreased sharply along the canopy. The maximum and minimum concentrations of chlorophyll in leaves of soybean were 3.00 and 0.77mg /g fw respectively. Vishwakarma *et al***.** (1998) also observed that elemental sulphur produced the highest chlorophyll content (a, b and total) in soybean leaves at 60 DAS.

4.5 Yield attributes

Yield attributes such as number of pod plant^{-1}, number of seed pod^{-1}, number of seed plant^{-1}, 100 seed weight (g), seed yield (g/m^{-2}) and biological yield (g/m^{-2}), pod bearing nods were measured at harvest.

4.5.1 Number of pod plant^{-1}

The number of pod per plant was counted at grain filling and harvest stage. The soybean cultivars have non significant difference in number of pods per plant at grain filling and harvest stage. The average maximum number of pods per plant was found in medium duration cultivars of grain filling stage 60 DAS (53.42) followed by early (46.18) and long (43.89). However, during the harvest stage 90 DAS the average maximum in long cultivars (38.38) followed by early (33.04) and long (26.46).

In early cultivars RVS 2010-1 having highest (100.66) pod per plant followed by RKS 18 (c) (69.00) whereas minimum was observed in MAUS 710 (16.33) followed by NRC 120 (27.66) at grain filling stage.

In medium duration cultivars RSC 10-4 having maximum (88.66) number of pod per plant followed by Himso 1686 (80.66). However, MACS 1488 having minimum pod per plant (21.00) followed by KDS 754 (22.33).

In long duration cultivars PS 1570 having highest (83.00) number of pod per plant followed by MAUS 740 (62.33), the minimum number of pod per plant was obtained in MACS 1480 (23.66) followed by DS 3103 (24.00) at grain filling stage.

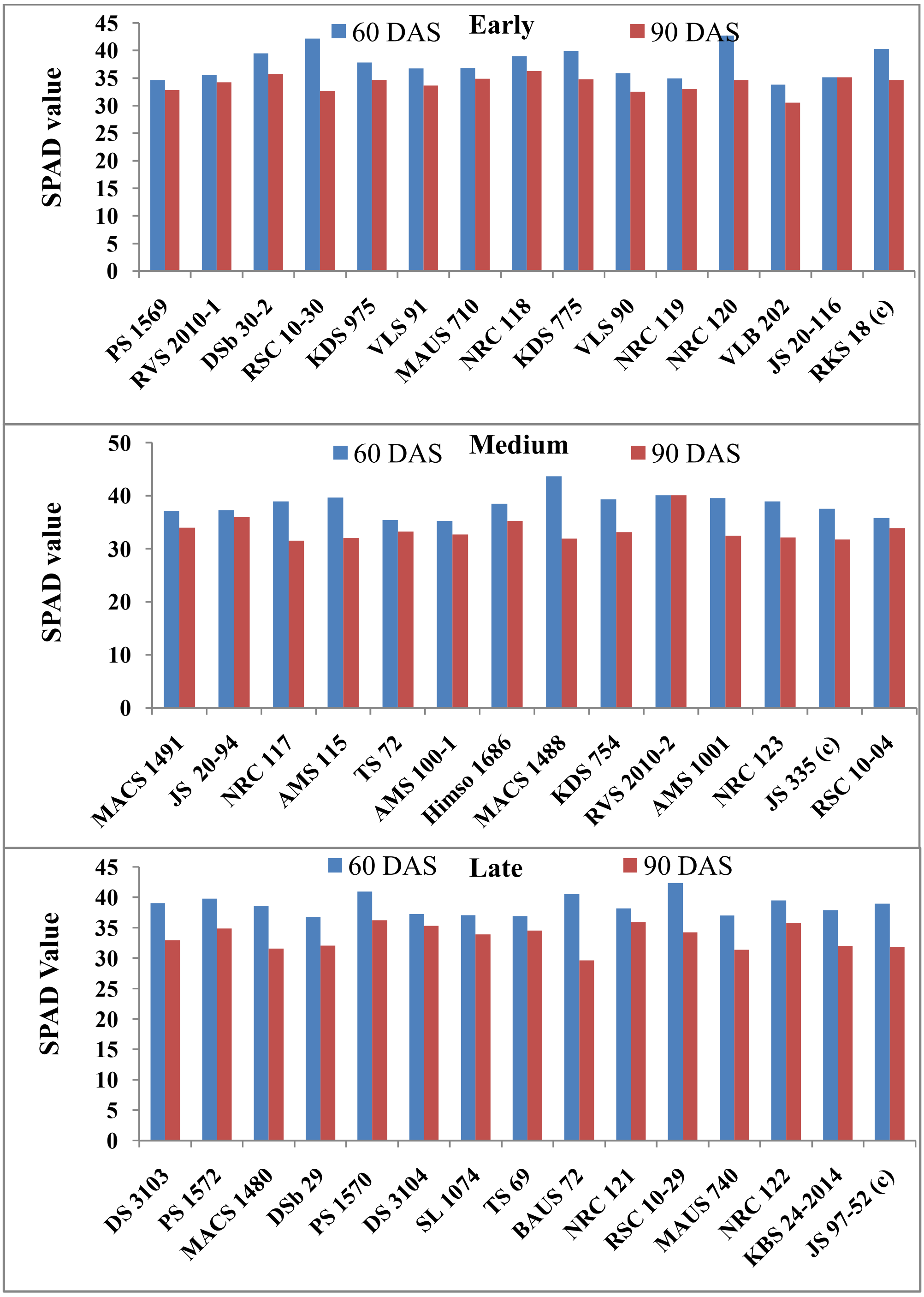


Fig 4.11 Variation in Chlorophyll SPAD Value in soybean cultivars at various growth phases.

Table 4.12 Variation in Number of pod plant^{-1} in soybean cultivars at various growth phases.

Early Treatment	Grain filling stage (60 DAS)	At Harvest stage (90 DAS)	Mean	Medium Treatment	Grain filling stage (60 DAS)	At Harvest stage (90 DAS)	Mean	Late Treatment	Grain filling stage (60 DAS)	At Harvest stage (90 DAS)	Mean
PS 1569	51.00	31.47	41.23	MACS 1491	53.00	32.93	42.97	DS 3103	24.00	30.53	27.27
RVS 2010-1	100.67	71.67	86.17	JS 20-94	40.33	41.60	40.97	PS 1572	56.00	26.33	41.17
DSb 30-2	56.00	13.13	34.57	NRC 117	60.67	47.93	54.30	MACS 1480	23.67	32.67	28.17
RSC 10-30	48.67	58.93	53.80	AMS 115	54.67	34.13	44.40	DSb 29	54.00	4.67	29.33
KDS 975	36.00	29.67	32.83	TS 72	50.00	31.47	40.73	PS 1570	83.00	26.07	54.53
VLS 91	48.00	12.60	30.30	AMS 100-1	62.00	46.07	54.03	DS 3104	31.67	36.33	34.00
MAUS 710	16.33	27.80	22.07	Himso 1686	80.67	40.47	60.57	SL 1074	37.67	28.80	33.23
NRC 118	37.33	28.67	33.00	MACS 1488	21.00	27.87	24.43	TS 69	47.00	7.40	27.20
KDS 775	49.67	37.20	43.43	KDS 754	22.33	36.00	29.17	BAUS 72	25.67	11.27	18.47
VLS 90	51.67	12.33	32.00	RVS 2010-2	61.33	36.60	48.97	NRC 121	29.67	17.13	23.40
NRC 119	28.67	41.87	35.27	AMS 1001	65.67	31.00	48.33	RSC 10-29	40.33	41.33	40.83
NRC 120	27.67	44.00	35.83	NRC 123	53.67	38.53	46.10	MAUS 740	62.33	29.47	45.90
VLB 202	33.33	11.80	22.57	JS 335 (c)	34.00	32.23	33.12	NRC 122	36.33	24.60	30.47
JS 20-116	38.67	41.60	40.13	RSC 10-04	88.67	60.53	74.60	KBS 24-2014	46.33	19.53	32.93
RKS 18 (c)	69.00	33.00	51.00	-	-	-	-	JS 97-52 (c)	60.67	60.87	60.77
Mean	**46.18**	**33.05**		**Mean**	**53.43**	**38.38**		**Mean**	**43.89**	**26.47**	
SEm±	**11.57**	**5.24**		**SEm±**	**10.51**	**12.91**		**SEm±**	**9.93**	**13.17**	
C.D. (5%)	**33.52**	**1.81**		**C.D. (5%)**	**30.56**	**4.44**		**C.D. (5%)**	**28.86**	**4.55**	
	NS	**NS**			**NS**	**NS**			**NS**	**NS**	

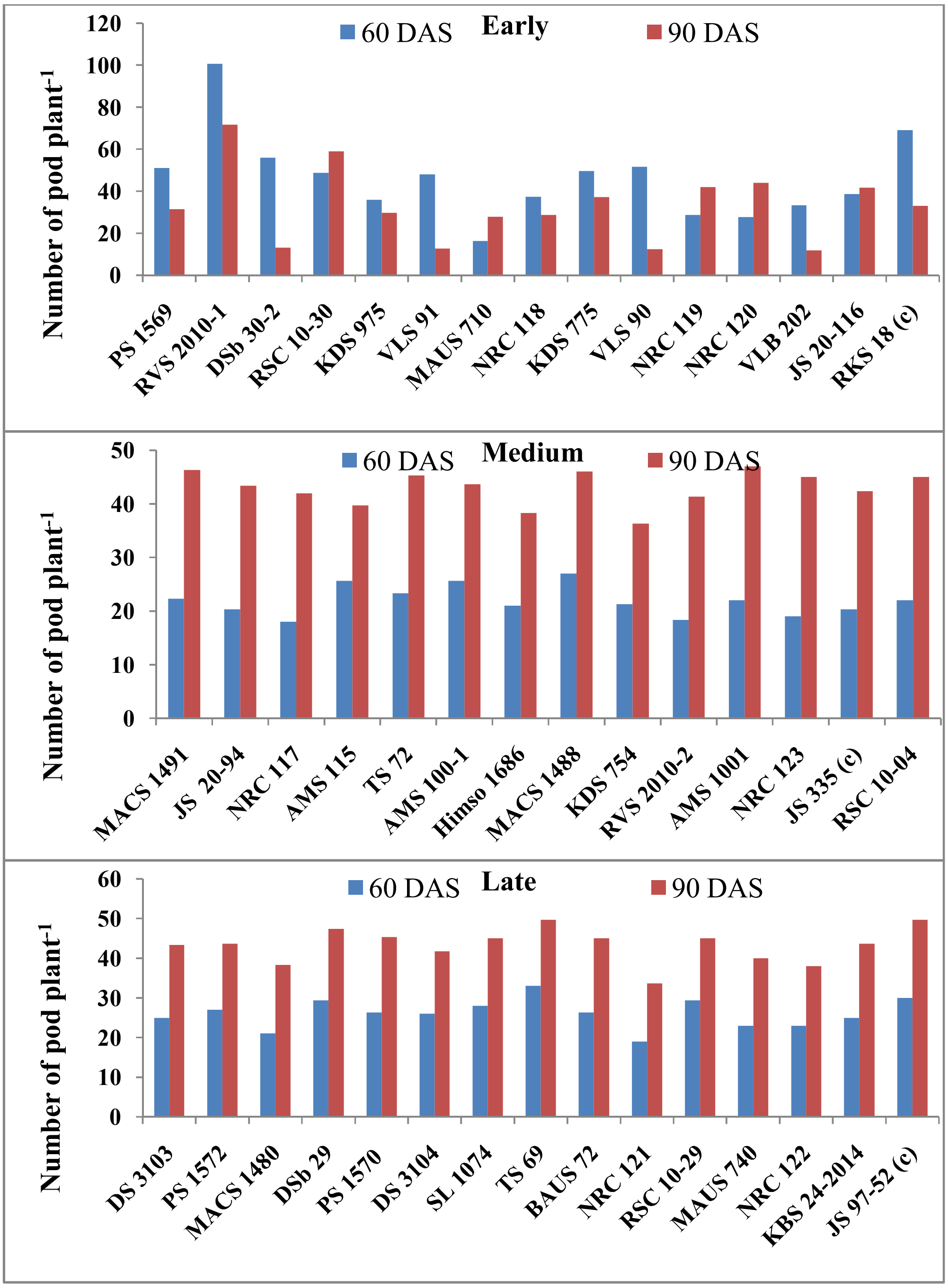


Fig 4.12 Variation in Number of pod plant^{-1} in soybean cultivars at various growth phases.

At harvest stage early cultivars the maximum number of pods was observed in RVS 2010-1 (71.66) followed by RSC 1030 (58.93), while minimum was observed in VLS 90 (12.33) followed by VLS 91 (12.60).

In medium cultivars RHC 10-4 having highest (60.53) number of pods per plant at harvest stage followed by NRC 117 (47.93), whereas the minimum pods was observed in MACS 1488 (27.86) followed by AMS 1001 (31.00).

In long cultivars the numbers of pods were high in JS 97-52 (c) (60.86) followed by RSC 10- 29 (41.33), however the minimum number of pods in DSb 29 (4.66) followed by TS 69 (7.40) at harvest stage. (Table 4.12 fig 4.12).

Pramila Rani and Ramaiah (1999) also suggested that plant height number of pod plant^{-1}, 100 seed weight, day to harvest and grain yield decreased in with delay in sowing.

4.5.2 Number of Seed plant^{-1}

The number of seed per plant was calculated in between 60-90 DAS in all the their groups of cultivars the average number of seed per plant medium duration cultivars 147.52 was maximum followed by early and then long duration cultivars. However, the minimum number of seed per plant was recorded in early duration cultivars (94.52), followed by medium then late duration cultivars.

In early duration cultivars RVS 2010-1 have significantly higher number of seed per plant (201.06) followed by RSC10-30 (143.47) and non significantly minimum number of seed per plant was observed by MAUS 710 (63.48) followed by VLS 90 (67.70).

In medium duration cultivars RHC10-04 (198.93) having highest number of seed per plant followed by Himso1668 (181.70) and while KDS 775 (68.06) having minimum number of seed per plant and followed by MACS 4418 (73.30).

In long duration cultivars PS 15-70 having non significantly higher number of seed per plant (163.60) followed by DSb 29 (131.44). Whereas, NRC 121 having non significantly lowest number of seed per plant (52.51) followed by BAUS 72 (55.40). Chandel *et al.,* showed that the recommended dose of fertilizer increased the yield attributes , pod /plant, 100 seed weight, harvest index and grain yield. (Table 4.13fig 4.13).

Table 4. 13 Variation in number of seed per plant in soybean cultivars at various growth phases.

Early Treatment	Grain filling stage 60 (DAS)	At Harvest stage (90 DAS)	Mean	Medium Treatment	Grain filling stage 60 (DAS)	At Harvest stage (90 DAS)	Mean	Late Treatment	Grain filling stage 60 (DAS)	At Harvest stage (90 DAS)	Mean
PS 1569	170.00	104.89	137.44	MACS 1491	159.00	98.80	128.90	DS 3103	64.00	81.42	72.71
RVS 2010-1	234.89	167.22	201.06	JS 20-94	121.00	124.80	122.90	PS 1572	168.00	79.00	123.50
DSb 30-2	168.00	39.40	103.70	NRC 117	161.78	143.80	152.79	MACS 1480	71.00	98.00	84.50
RSC 10-30	129.78	157.16	143.47	AMS 115	164.00	102.40	133.20	DSb 29	162.00	12.44	87.22
KDS 975	96.00	89.00	92.50	TS 72	133.33	94.40	113.87	PS 1570	249.00	78.20	163.60
VLS 91	128.00	33.60	80.80	AMS 100-1	165.33	122.84	144.09	DS 3104	63.33	84.78	74.06
MAUS 710	43.56	83.40	63.48	Himso 1686	242.00	121.40	181.70	SL 1074	113.00	86.40	99.70
NRC 118	112.00	86.00	99.00	MACS 1488	63.00	83.60	73.30	TS 69	94.00	17.27	55.63
KDS 775	149.00	111.60	130.30	KDS 754	52.11	84.00	68.06	BAUS 72	77.00	33.80	55.40
VLS 90	120.56	28.78	74.67	RVS 2010-2	143.11	97.60	120.36	NRC 121	59.33	45.69	52.51
NRC 119	76.44	125.60	101.02	AMS 1001	197.00	93.00	145.00	RSC 10-29	80.67	96.44	88.56
NRC 120	83.00	132.00	107.50	NRC 123	125.22	89.91	107.57	MAUS 740	124.67	68.76	96.71
VLB 202	100.00	35.40	67.70	JS 335 (c)	102.00	96.70	99.35	NRC 122	109.00	73.80	91.40
JS 20-116	116.00	124.80	120.40	RSC 10-04	236.44	161.42	198.93	KBS 24-2014	139.00	58.60	98.80
RKS 18 (c)	184.00	99.00	141.50	-	-	-	-	JS 97-52 (c)	121.33	141.56	131.44
Mean	**127.41**	**94.52**		**Mean**	**147.52**	**108.19**		**Mean**	**113.02**	**70.41**	
SEm±	**0.194**	**0.267**		**SEm±**	**0.196**	**0.236**		**SEm±**	**0.245**	**0.264**	
C.D. (5%)	**0.561 NS**	**0.774 NS**		**C.D. (5%)**	**0.570 NS**	**0.685 NS**		**C.D. (5%)**	**0.708 NS**	**0.766 NS**	

4.5.3 Number of Seed pod^{-1}

The number of seed per pod was calculated in between grain filling stage 90 DAS and harvest stage in all the their groups of cultivars the average number of seed per pod medium duration cultivars (3.167) was observed in maximum followed by early (3.156) and then long (3.067) duration cultivars in harvest stage. The average maximum early duration cultivars (2.867) number of seed per pod grain filing stage was recorded, followed by medium (2.833) then late (2.756).

In early duration cultivars PS 69 have significantly higher number of seed per plant (3.33) followed by NRC 120 (3.167) and JS 20-116 (3.16). However, the significantly minimum number of seed per pod was observed by RVS 2010-1 (2.833) followed by DSb 30-2 (3.000).

In medium duration cultivars JS 20-94 (3.167) having highest number of seed per pod followed by MACS 1491 (3.000) and while JDS 754 (2.333) having minimum number of seed per pod followed by NRC 123 (2.833).

In long duration cultivars MACS 1480 having non significantly higher number of seed per plant (3.333) followed by DS 3103 (3.000). Whereas, TS 69 having non significantly lowest number of seed per pod (2.333) followed by DSb 29 (2.667). (Table 4.14 fig 4.14)

Isler, *et al.* (1997) also reported the plant height after first pod length, pod number per plant, pod length, seed number per pod, 100-seed weight, seed yield per plant and per hectare. The cultivars showed differences in the investigated characteristics, except for pod length and seed number per pod.

4.5.4 Pod bearing node plant^{-1}

Pod bearing node was calculated at flower initiation. The non significantly higher Pod bearing nod per plant was observed in medium duration cultivars at flowering stage 60 DAS in followed by late and then early duration cultivars. However, the pod bearing node per plant was maximum in grain filing stage 90 DAS in medium duration cultivars followed by long and then early duration cultivars.

The average maximum pod bearing node per plant was achieved by VLB 202 (3.83) followed by RKS 18 (c) (3.72). The non significant lowest pod bearing

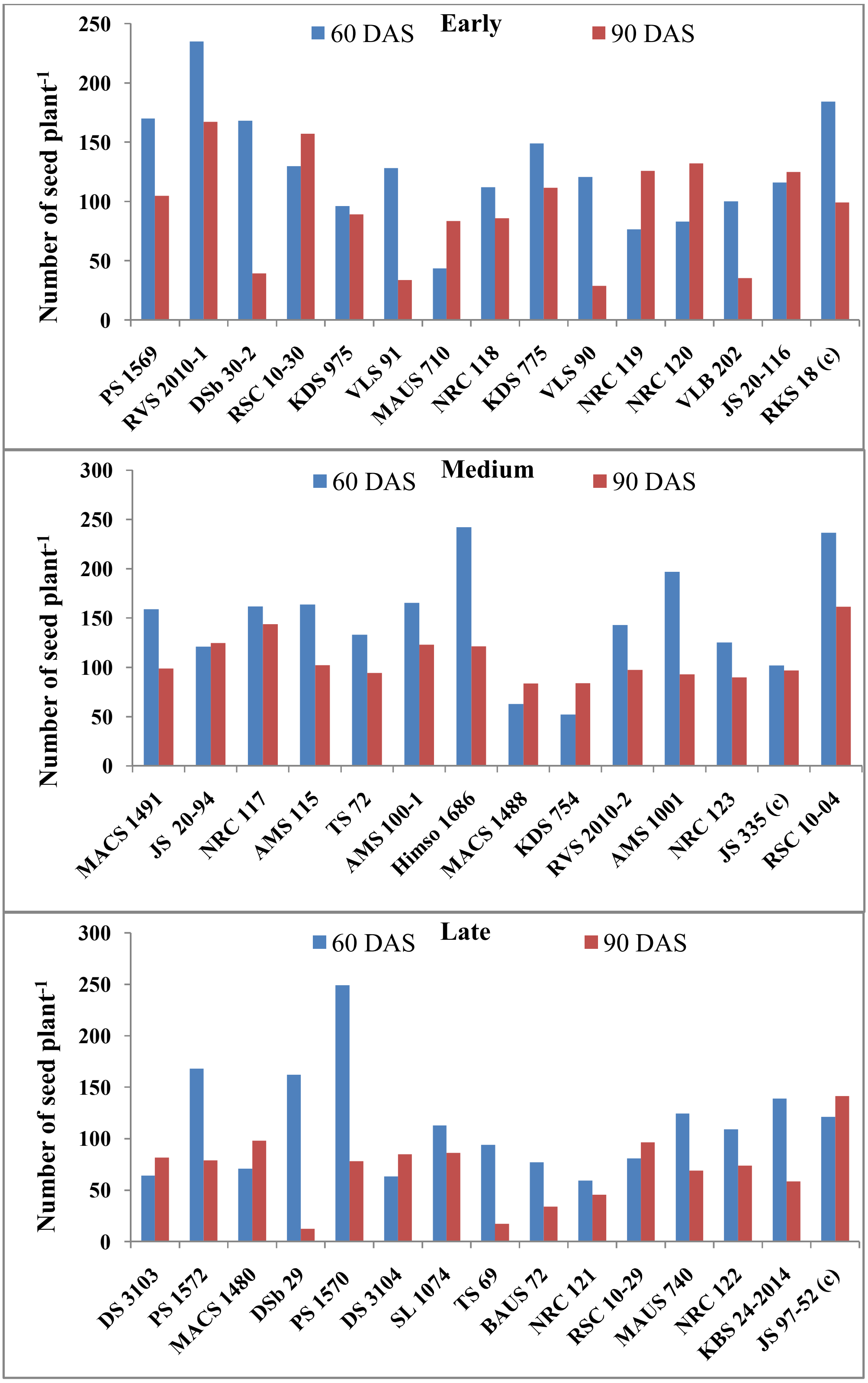


Fig 4.13 Variation in Number of seed plant^{-1} in soybean cultivars at harvest.

Table 4.14 Variation in no. of seed per pod in soybean cultivars at various growth phases.

Early				Medium				Late			
Treatment	Grain filling stage	Harvesting stage	Mean	Treatment	Grain filling stage	Harvesting stage	Mean	Treatment	Grain filling stage	Harvesting stage	Mean
PS 1569	3.33	3.33	3.33	MACS 1491	3.00	3.00	3.00	DS 3103	3.00	3.00	3.00
RVS 2010-1	2.33	3.33	2.83	JS 20-94	3.00	3.33	3.17	PS 1572	3.00	3.00	3.00
DSb 30-2	3.00	3.00	3.00	NRC 117	3.00	3.33	3.17	MACS 1480	2.67	3.33	3.00
RSC 10-30	2.67	3.33	3.00	AMS 115	3.00	3.00	3.00	DSb 29	2.67	2.67	2.67
KDS 975	3.00	3.00	3.00	TS 72	3.00	3.00	3.00	PS 1570	3.00	3.00	3.00
VLS 91	2.67	3.00	2.83	AMS 100-1	2.67	3.33	3.00	DS 3104	2.33	3.00	2.67
MAUS 710	3.00	3.00	3.00	Himso 1686	3.00	3.33	3.17	SL 1074	3.00	3.00	3.00
NRC 118	2.67	3.33	3.00	MACS 1488	3.00	3.00	3.00	TS 69	2.33	3.00	2.67
KDS 775	3.00	3.00	3.00	KDS 754	2.33	3.33	2.83	BAUS 72	3.00	3.00	3.00
VLS 90	2.33	3.33	2.83	RVS 2010-2	2.67	3.33	3.00	NRC 121	2.67	3.33	3.00
NRC 119	3.00	3.00	3.00	AMS 1001	3.00	3.00	3.00	RSC 10-29	2.33	3.00	2.67
NRC 120	3.00	3.33	3.17	NRC 123	2.33	3.33	2.83	MAUS 740	2.67	3.33	3.00
VLB 202	3.00	3.00	3.00	JS 335 (c)	3.00	3.00	3.00	NRC 122	3.00	3.00	3.00
JS 20-116	3.00	3.33	3.17	RSC 10-04	2.67	3.00	2.83	KBS 24-2014	3.00	3.00	3.00
RKS 18 (c)	3.00	3.00	3.00	-	-	-	-	JS 97-52 (c)	2.67	3.33	3.00
Mean	**2.87**	**3.16**		**Mean**	**2.83**	**3.17**		**Mean**	**2.76**	**3.07**	
SEm±	**0.21455**	**0.22771**		**SEm±**	**0.196116**	**0.243349**		**SEm±**	**0.237936**	**0.248807**	
C.D. (5%)	**0.621527**	**0.65965**		**C.D. (5%)**	**0.570101**	**0.707404**		**C.D. (5%)**	**0.689275**	**0.720764**	

Table 4.15 Variation in number of pod bearing node per plant in soybean cultivars at various growth phases.

Early Treatment	flowering stage 60 (DAS)	Grain filling stage 90 (DAS)	Mean	Medium Treatment	flowering stage 60 (DAS)	Grain filling stage 90 (DAS)	Mean	Late Treatment	flowering stage 60 (DAS)	Grain filling stage 90 (DAS)	Mean
PS 1569	3.33	3.66	3.50	MACS 1491	4.33	4.55	4.44	DS 3103	3.00	2.33	2.66
RVS 2010-1	2.44	2.67	2.55	JS 20-94	2.22	2.22	2.22	PS 1572	2.77	2.88	2.83
DSb 30-2	3.33	3.66	3.50	NRC 117	4.11	4.66	4.39	MACS 1480	3.33	2.22	2.78
RSC 10-30	3.11	3.55	3.33	AMS 115	2.55	2.89	2.72	DSb 29	2.89	3.11	3.00
KDS 975	2.44	2.78	2.61	TS 72	4.33	4.66	4.50	PS 1570	3.22	2.78	3.00
VLS 91	2.11	2.22	2.17	AMS 100-1	2.44	2.11	2.28	DS 3104	3.55	2.78	3.17
MAUS 710	2.89	3.22	3.05	Himso 1686	4.77	3.67	4.22	SL 1074	3.55	3.55	3.55
NRC 118	2.11	2.22	2.17	MACS 1488	2.55	3.55	3.05	TS 69	2.88	3.44	3.16
KDS 775	2.55	2.22	2.39	KDS 754	4.22	2.33	3.28	BAUS 72	4.44	4.89	4.66
VLS 90	2.55	2.55	2.55	RVS 2010-2	2.44	2.22	2.33	NRC 121	2.77	2.22	2.50
NRC 119	3.22	2.89	3.05	AMS 1001	3.55	2.88	3.22	RSC 10-29	3.55	2.33	2.94
NRC 120	4.00	2.88	3.44	NRC 123	4.00	3.22	3.61	MAUS 740	2.66	2.66	2.66
VLB 202	4.00	3.66	3.83	JS 335 (c)	2.44	2.77	2.61	NRC 122	3.33	3.55	3.44
JS 20-116	2.78	4.44	3.61	RSC 10-04	3.55	3.55	3.55	KBS 24-2014	3.11	3.22	3.16
RKS 18 (c)	4.44	3.00	3.72	-	-	-		JS 97-52 (c)	3.55	3.55	3.55
Mean	**3.02**	**3.04**		**Mean**	**3.39**	**3.23**		**Mean**	**3.24**	**3.03**	
SEm±	**0.467**	**0.484**		**SEm±**	**0.513**	**0.508**		**SEm±**	**0.440**	**0.447**	
C.D. (5%)	**1.352**	**1.402**		**C.D. (5%)**	**1.490**	**1.476**		**C.D. (5%)**	**1.276**	**1.296**	

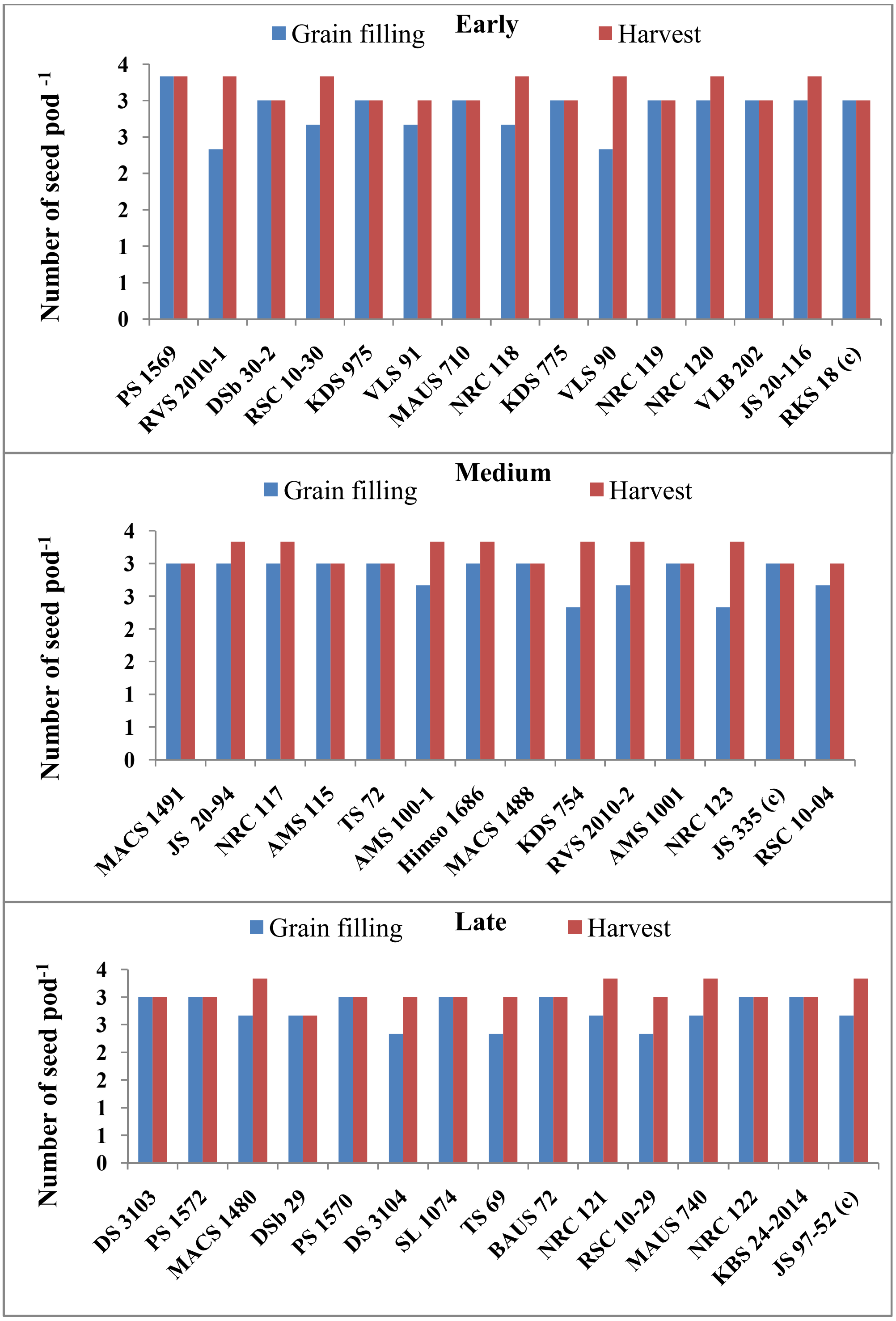


Fig 4.14 Variation in Number of seed pod^{-1} in soybean cultivars at various growth phases.

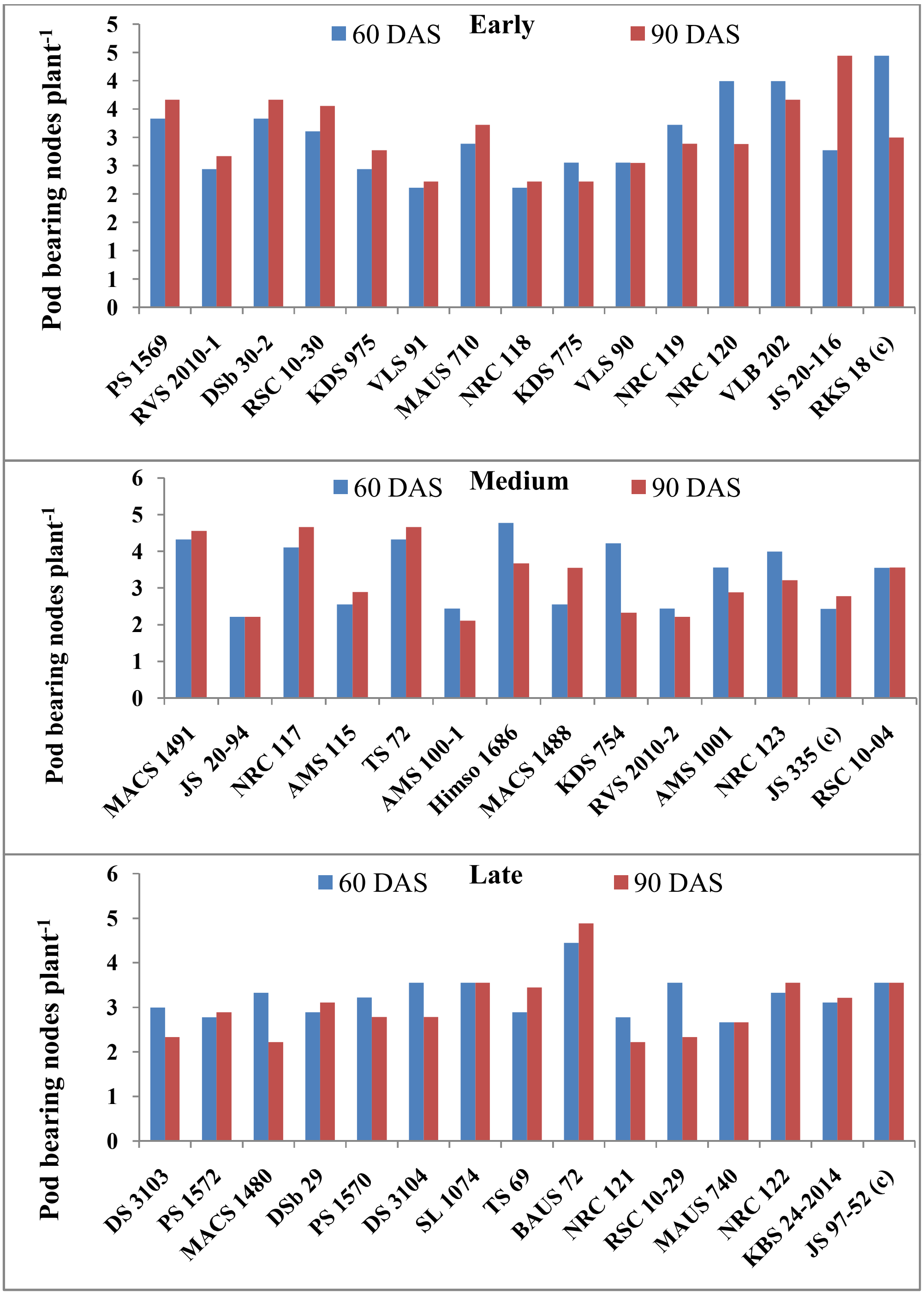


Fig 4.15 Variation in first Pod bearing nodes plant^{-1} in soybean cultivars at various growth phases.

node per plant was observed in VLS 91 (2.17) and NRC 118 (2.17) followed by KDS 775 (2.39).

In medium duration cultivars TS 72 having non significantly maximum pod bearing node (4.50) followed by MACS 1491 (4.44). The minimum pod bearing node per plant was observed in JS 20-94 (2.22) followed by AMS 100-1 (2.28).

In long duration cultivars BAUS 72 have higher pod bearing node per plant (4.66) followed by SL 1074 (3.55). The non significantly minimum pod bearing node per plant was observed in cultivars NRC 121 (2.50) followed by DS 3103 (2.66). (Table 4.15 fig 4.16).

4.5.5 Total dry weight plant^{-1}

The total dry weight was calculated from vegetative to grain filling stage and harvest stage (30, 60, 90) days after sowing. It was observed that the average total dry weight was higher in long duration cultivars at harvest stage in all group of cultivars *i.e.* early, medium and long. The average total dry weight per plant was higher and long duration cultivars (24.215) followed by early (21.954) and late (21.021) during their stages. However, during the 60-90 DAS the average minimum total dry weight per plant was observed in early duration cultivars (0.393) followed by medium (0.396) and then late (0.426).

Early duration cultivars JS 20-116 having non significantly maximum total dry weight per plant (21.993) followed by RVS 2010-1 (21.928). However, NRC 120 (6.796) having minimum total dry weight per plant followed by VLS 91 (789.4).

In medium duration cultivars TS 72 having significantly maximum total dry weight per plant (31.648) followed by Himso 1686 (20.257). While average minimum total dry weight per plant was achieved by NRC 123 (9.467) followed by MACS 1488 (9.486).

In long duration cultivars DSb 29 having highest total dry weight per plant (33.38) followed by MACS 1480 (25.07). The minimum total dry weight per plant was obtained in SL 1074 (6.79) followed by PS 1570 (7.79). (Table 4.17 fig 4.17). Mazahero, Daroish., *et al.* (2005) also reported The maximum grain yield was obtained at 60 plants/m^2. High total dry matter resulted in high seed yield if the total dry matter was produced prior to the seed filling period. High dry matter

Table 4.16 Variation in total dry weight plant in soybean cultivars at various growth phases.

Early Treatment	flowering stage 60(DAS)	Grain filling stage 60 (DAS)	At Harvest stage 90 (DAS)	Mean	Medium Treatment	flowering stage 60(DAS)	Grain filling stage 60 (DAS)	At Harvest stage 90 (DAS)	Mean	Late Treatment	flowering stage 60(DAS)	Grain filling stage 60 (DAS)	At Harvest stage 90 (DAS)	Mean
PS 1569	0.38	21.34	22.97	14.90	MACS 1491	0.33	21.72	24.18	15.41	DS 3103	0.16	14.21	15.97	10.11
RVS 2010-1	0.46	31.87	33.45	21.93	JS 20-94	0.38	19.78	22.10	14.09	PS 1572	0.31	15.63	16.83	10.92
DSb 30-2	0.33	22.86	24.13	15.77	NRC 117	0.23	20.43	22.90	14.52	MACS 1480	0.31	36.71	38.22	25.08
RSC 10-30	0.28	20.66	22.61	14.52	AMS 115	0.32	21.84	24.97	15.71	DSb 29	0.47	49.05	50.64	33.39
KDS 975	0.60	23.41	25.93	16.65	TS 72	0.36	46.51	48.08	31.65	PS 1570	0.26	10.62	12.50	7.79
VLS 91	0.28	10.67	12.73	7.89	AMS 100-1	0.33	26.55	28.66	18.51	DS 3104	0.30	13.53	15.28	9.70
MAUS 710	0.23	20.94	22.20	14.46	Himso 1686	0.32	29.35	31.10	20.26	SL 1074	0.66	8.81	10.93	6.80
NRC 118	0.25	17.80	20.21	12.75	MACS 1488	0.55	12.95	14.96	9.49	TS 69	0.61	13.41	15.56	9.86
KDS 775	0.43	26.69	28.74	18.62	KDS 754	0.53	12.97	15.08	9.53	BAUS 72	0.55	11.83	15.02	9.13
VLS 90	0.34	11.01	13.47	8.27	RVS 2010-2	0.30	19.95	21.97	14.07	NRC 121	0.51	17.30	19.33	12.38
NRC 119	0.66	25.46	26.91	17.68	AMS 1001	0.43	17.13	19.63	12.40	RSC 10-29	0.36	19.75	22.01	14.04
NRC 120	0.61	8.85	10.92	6.80	NRC 123	0.63	13.15	14.62	9.47	MAUS 740	0.41	19.68	21.90	13.99
VLB 202	0.43	11.49	12.92	8.28	JS 335 (c)	0.48	20.77	23.13	14.80	NRC 122	0.53	18.32	20.05	12.97
JS 20-116	0.29	32.14	33.55	21.99	RSC 10-04	0.34	25.83	27.63	17.93	KBS 24-2014	0.53	14.86	16.66	10.68
RKS 18 (c)	0.32	16.80	18.55	11.89	-	-	-	-	-	JS 97-52 (c)	0.45	21.78	24.42	15.55
Mean	**0.39**	**20.13**	**21.95**		**Mean**	**0.40**	**22.07**	**24.22**		**Mean**	**0.43**	**19.03**	**21.02**	
SEm±	**0.04**	**0.32**	**0.44**		**SEm±**	**0.02**	**0.47**	**0.54**		**SEm±**	**0.03**	**0.49**	**0.68**	
C.D. (5%)	**0.11 NS**	**0.93**	**0.11**		**C.D. (5%)**	**0.07 NS**	**1.37**	**1.56**		**C.D. (5%)**	**0.07 NS**	**1.43**	**1.98**	

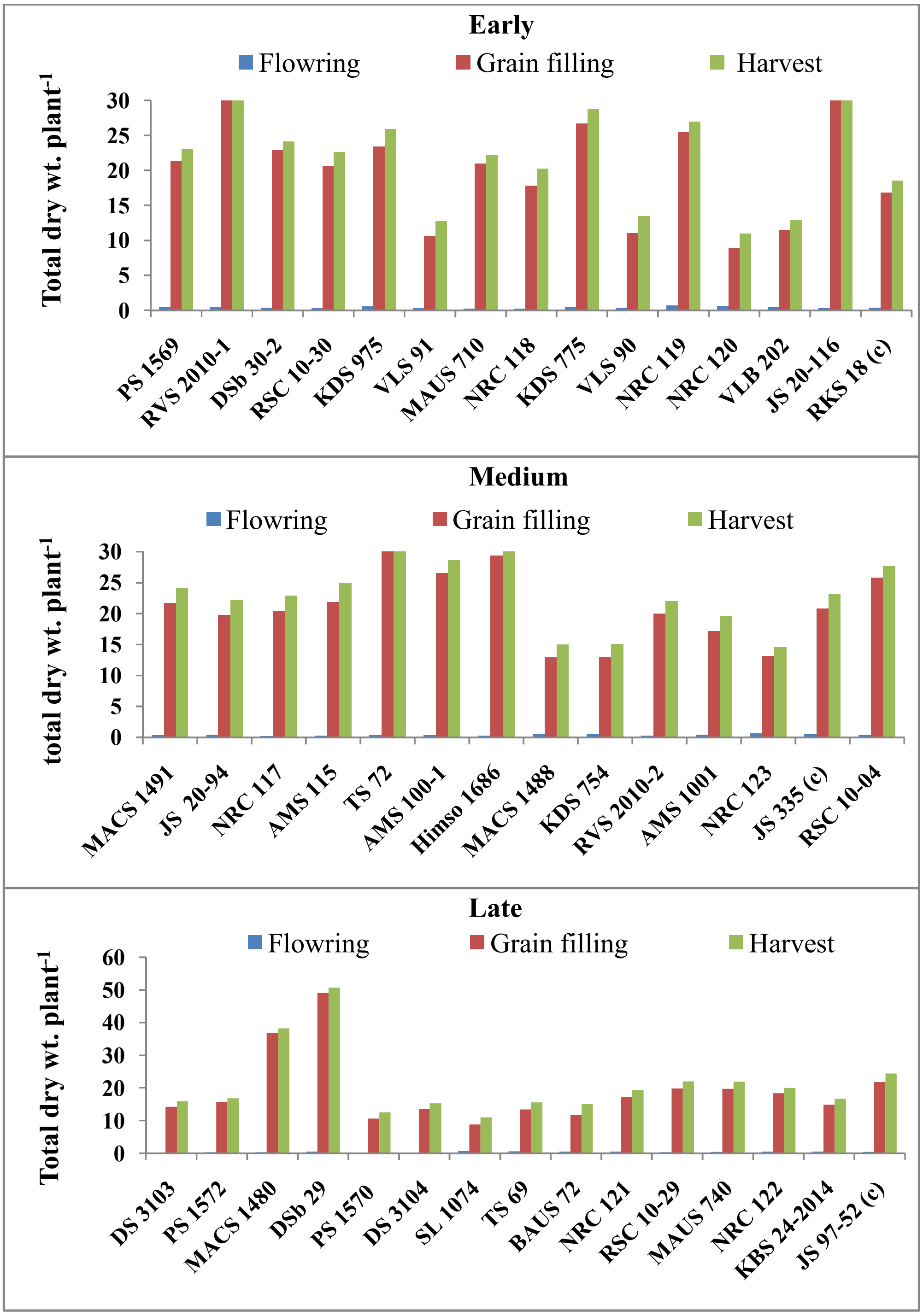


Fig 4.16 Variation in total dry wt. plant^{-1} in soybean cultivars at various growth phases.

accumulation during under the highest plant density resulted from high leaf area index during the period from early emergence to early seed filling.

4.5.6 Seed yield (g/m^{-2})

Seed yield was measured at physical maturity in all the three duration cultivars. Early cultivars have taken 90 days and medium duration cultivars have taken 90-100 days for maturity and long duration cultivars have taken 101-115 days for maturity. The average yield was highest in medium duration cultivars (149.32) followed by early (133.33) and long duration (90.67)

In early cultivars RVS 2010-1 having high yield (358.02) followed by KDS 975 (242.80) whereas, VLS 90 having lowest yield 28.81 followed by VLB 202 (41.15), VLS 91 (45.27).

Medium duration cultivars RSC 10-04 (378.60) having significantly higher yield followed by NRC 117 (255.14) and JS 20-94 (205.76). While MACS 1491 having significantly lowest yield (57.61) and TS 72 (57.61) followed by AMS 100-1 (76.13) and himso1686 (78.17).

In long duration cultivars JS 97-52 (c) having significantly higher seed yield (189.30) followed by RSC 10-29 (162.55) and MACS 1480 (162.14). Whereas significantly lowest yield was obtained in BAUS 72 (32.92) followed by PS 1570 (37.04), NRC 121 (41.15), KBS24-2014 (61.73) (Table 4.18 fig 4.18).

Saxena and Pandey (1970) reported that seed yield of soybean in highly association with number of pod plant^{-1}, 100 seed weight (test weight) and days taken from planting to maturity (duration of variety in soybean). Perraju *et al.* (1982), Singh *et al.* (1983) also reported the positive association of seed yield plant^{-1}, number of pods plant^{-1}. Number of nodes, number of branches, harvest index, number of seed pod^{-1}, plant height.

4.5.7 Biological yield (g /m^2)

The biological yields were observed in soybean cultivars at harvest and have significant variation. The average biological yield was highest in early duration cultivars (1508.45) followed by (1393.57) then (1045.30).

In early cultivars NRC 119 having significantly highest biological yield (3069.00) followed by VLS 202 (2008.40) whereas, KDS 775 having lowest yield (824.80) followed by NRC 120 (919.60).

Table 4.17 Variation in Seed yield g/m^2 in soybean cultivars at various growth phases.

Early Treatment	yield	Medium Treatment	yield	Late Treatment	yield
PS 1569	51.44	MACS 1491	57.61	DS 3103	69.96
RVS 2010-1	358.02	JS 20-94	205.76	PS 1572	61.73
DSb 30-2	49.38	NRC 117	255.14	MACS 1480	162.14
RSC 10-30	213.99	AMS 115	168.72	PS 1570	37.04
KDS 975	242.80	TS 72	57.61	DS 3104	94.65
VLS 91	45.27	AMS 100-1	76.13	SL 1074	82.30
MAUS 710	172.84	Himso 1686	78.19	BAUS 72	32.92
NRC 118	156.38	MACS 1488	127.57	NRC 121	41.15
KDS 775	78.19	KDS 754	144.03	RSC 10-29	162.55
VLS 90	28.81	RVS 2010-2	160.49	MAUS 740	92.59
NRC 119	197.53	AMS 1001	154.32	KBS 24-2014	61.73
NRC 120	74.07	NRC 123	160.49	JS 97-52 (c)	189.30
VLB 202	41.15	JS 335 (c)	65.84	-	-
JS 20-116	232.51	RSC 10-04	378.60	-	-
RKS 18 (c)	57.61	-	-	-	-
Mean	**133.33**	**Mean**	**149.32**	**Mean**	**90.67**
SE(m)±	**8.387**	**SE(m)±**	**11.823**	**SE(m)±**	**7.912**
C.D. (5%)	**24.296**	**C.D. (5%)**	**34.369**	**C.D. (5%)**	**23.205**
	NS				NS

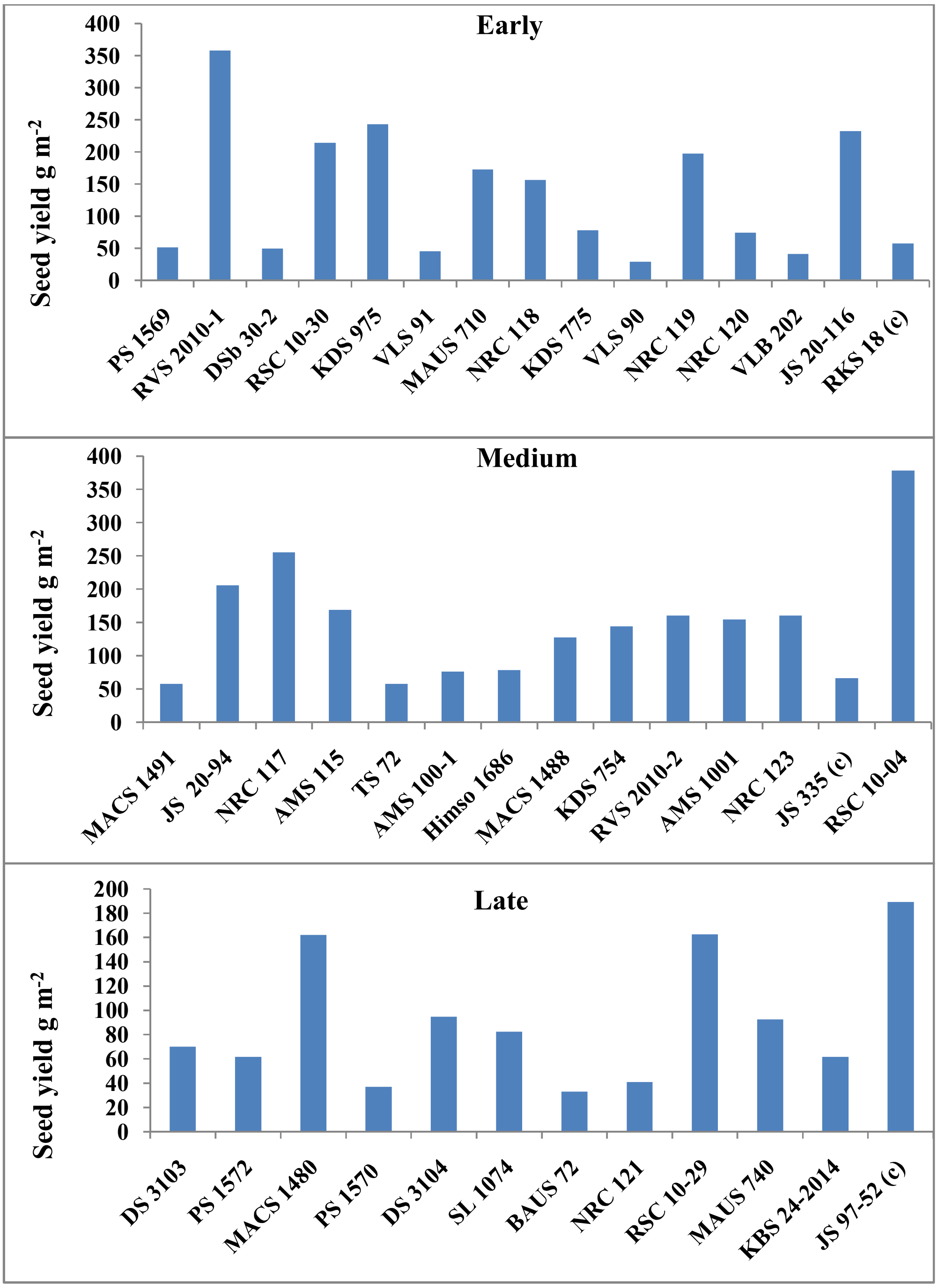


Fig 4.17 Variation in Seed yield gm^{-2} in soybean cultivars at various growth phases.

Table 4.18 Variation in biological yield (g/m^2) in soybean cultivars at various growth phases.

Early Treatment	Yield	Medium Treatment	Yield	Late Treatment	Yield
PS 1569	1379.80	MACS 1491	1318.40	DS 3103	905.40
RVS 2010-1	1996.60	JS 20-94	1345.00	PS 1572	933.60
DSb 30-2	1465.20	NRC 117	1268.80	MACS 1480	2265.80
RSC 10-30	1356.20	AMS 115	1469.60	DSb 29	913.60
KDS 975	1559.80	TS 72	2724.60	PS 1570	748.40
VLS 91	1347.60	AMS 100-1	1722.20	DS 3104	666.20
MAUS 710	1191.40	Himso 1686	1865.80	SL 1074	668.80
NRC 118	1714.60	MACS 1488	861.80	TS 69	784.80
KDS 775	824.80	KDS 754	803.40	BAUS 72	644.80
VLS 90	1592.60	RVS 2010-2	1255.20	NRC 121	1076.40
NRC 119	3069.00	AMS 1001	871.80	RSC 10-29	1227.00
NRC 120	919.60	NRC 123	1082.20	MAUS 740	1299.80
VLB 202	2008.40	JS 335 (c)	1299.80	NRC 122	1199.00
JS 20-116	1143.60	RSC 10-04	1621.40	KBS 24-2014	973.40
RKS 18 (c)	1057.60	-	-	JS 97-52 (c)	1372.60
Mean	**1508.45**	**Mean**	**1393.57**	**Mean**	**1045.31**
SEm±	**0.90**	**SEm±**	**1.07**	**SEm±**	**1.46**
C.D. (5%)	**2.74**	**C.D. (5%)**	**3.26**	**C.D. (5%)**	**4.45**

Medium duration cultivars TS 72 (2724.60) having significantly higher biological yield followed by Himso 1686 (1865.80). While KDS 754 having significantly lowest biological yield (803.40) followed by MACS 1488 (861.80).

In long duration cultivars MACS 1480 having significantly higher biological yield (2265.80) followed by JS 97-52 (C) (1372.60). Whereas significantly lowest biological yield was obtained in BAUS 740 (644.80) followed by DS 3104 (666.20). (Table 4.19 fig 4.19)

4.5.8 Test weight (g)

The weight of 100 seed is also an important attribute of yield. The 100 seed weight was measured at harvest. It was observed that soybean cultivars have non significant difference in 100 seed weight. The average 100 seed weight of long duration cultivars of soybean was recorded 10.60 g. followed by medium then late.

In early duration cultivars KDS 775 having non significantly maximum test weight was (16.15) followed by NRC 119 (15.98). Whereas lowest yield was obtained in PS1569 (7.26) followed by MAUS 710 (7.51).

In medium duration cultivars RVS2010-2 having non significantly maximum test weight was (13.90) observed followed by KDS754 (12.43). Whereas lowest yield was obtained in PS1569 (7.26) followed by MAUS 710 (7.51).

In long duration cultivars NRC 121 having non significantly maximum test weight obtained in (19.08) followed by KDS 2014 (12.87). While lowest yield was observed in SL1074 (7.76) (Table 4.20 fig 4.20).

Taware *et al.* (1994) also reported the mean square verities and seasons were highly significant for days to flowering, days to maturity, plant height, pods per plant, 100 seed weight, oil content and seed yield. Jagtap and Choudhary (1992) reported positive correlation and significant of seed yield with 100 seed weight. Mahajan *et al.* (1993) also reported the grain yield plant^{-1} was positively correlation with grain plant^{-1}, pods plant^{-1}, branches plant^{-1}, days to 50% flowering, days to maturity and plant height were most important yield attributing characters.

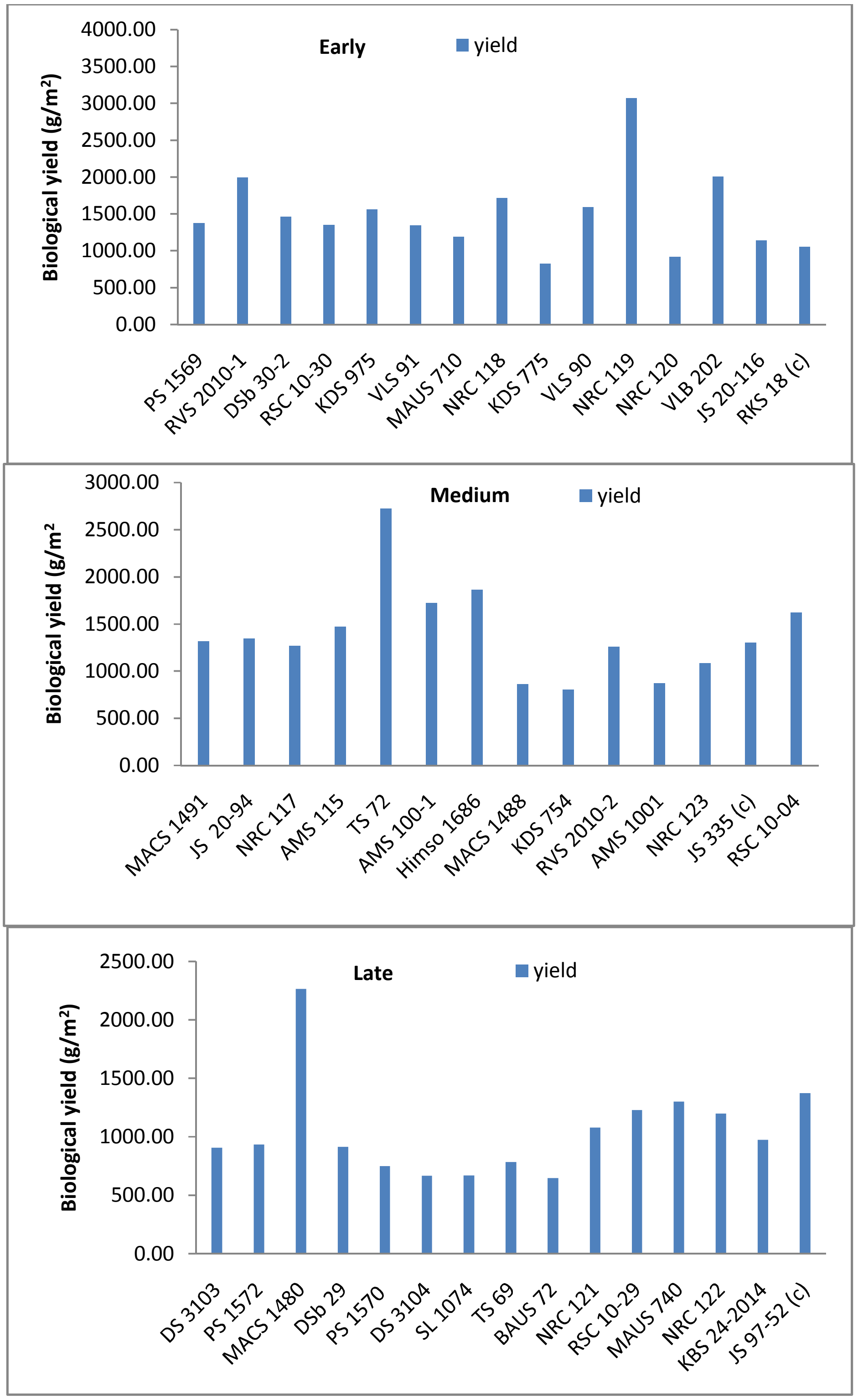


fig 4.18 Variation in biological yield (g/m²) in soybean cultivars

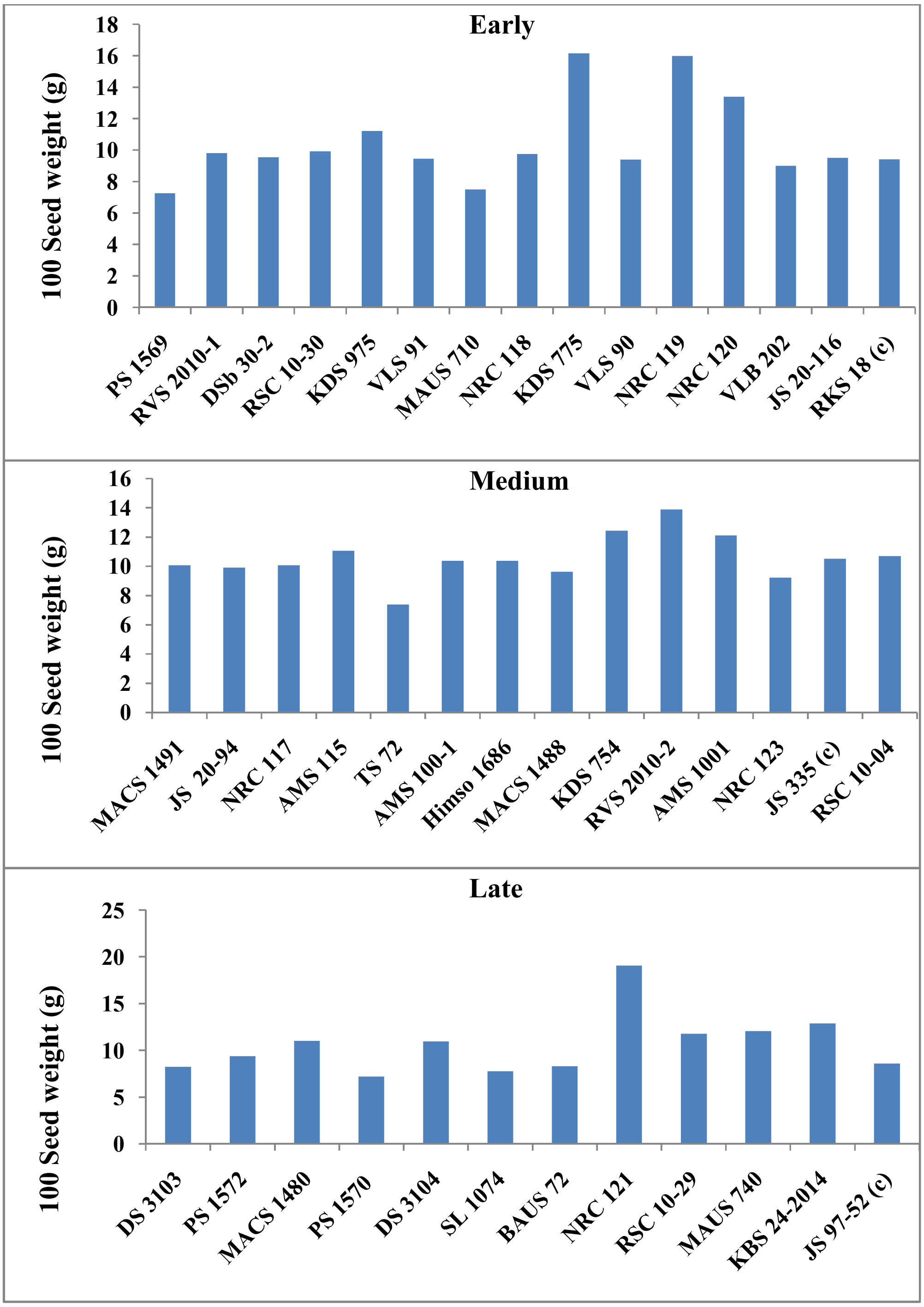


Fig 4.19 Variation in 100 Seed weight (g) in soybean cultivars at various growth phases.

4.5.9 Harvest index (%)

Harvest index was calculated via taking the economic yield over biological yield at physical maturity. HI was higher in long duration (38.80) cultivars followed by medium (37.14) and minimum HI was observed in early group of cultivars (36.76).

In early group KDS 775 exhibited significantly maximum HI (44.82) followed by RSC 10-30 (43.96). The minimum HI was obtained in RVS 10-1 (29.49) followed by VLB 202 (26.91).

In medium group NRC 123 having significantly higher HI (51.32) and TS 72 have significantly minimum HI (32.88).

However, in long duration cultivars PS 1570 have highest HI (38.14) followed by JS 97-52 (c) (37.46). Whereas, minimum HI was observed in MACS 1480 (29.17) followed by DS 3103 (32.35). (Table 4.21 fig 4.21).

Nirmala Kumari and Balasubramanian (1991) mentioned that harvest index has high significant positive correlation with seed yield plant$_{-1}$ followed by number of primary branches plant^{-1}. The results indicated that harvest index influenced by sink capacity. It might be possible to isolate the cultivars with high dry matter production and harvest index for further improvement in grain yield. Similarly, Chandel *et al.* (2004) also reported the effect of various fertilizer and manorial treatment on soybean Integrated use of recommended fertilizers increased the yield attributes and harvest index, grain yield was recorded.

Higher per cent of harvest index is directly related to ratio of grain and biological yield. Similar findings were also reported by Chandel *et al*. (2004).

Correlation study

The correlation studies indicated that the HI was highly positively correlated with test weight, seed yield and plant height. Seed yield was also positively correlated with test weight, no. of pods plant^{-1}, no. of seed plant^{-1}. However BY (biological yield) was highly negatively correlated with physiological maturity, chlorophyll SPAD value. The no. of seeds pod^{-1} was highly negatively associated with days to flower initiation. No. of seed plant^{-1}, was positively correlated with no. of leaves plant^{-1}, no. of branches plant^{-1} and no. of pod plant^{-1}.
Singh *et al.* (1983) examined the phenological yield components viz., no of days to maturity, plant height (cm), no. of primary branches, no. of pod bearing

Table 4.19: Variation in harvest index (%) in soybean cultivars at various growth phases

Early		Medium		Late	
Treatment	**Mean**	**Treatment**	**Mean**	**Treatment**	**Mean**
PS 1569	31.56	MACS 1491	37.29	DS 3103	32.35
RVS 2010-1	29.49	JS 20-94	37.83	PS 1572	36.54
DSb 30-2	39.13	NRC 117	33.71	MACS 1480	29.17
RSC 10-30	43.96	AMS 115	38.25	PS 1570	38.14
KDS 975	43.15	TS 72	32.88	DS 3104	35.88
VLS 91	42.14	AMS 100-1	36.16	SL 1074	34.57
MAUS 710	37.98	Himso 1686	33.47	BAUS 72	32.97
NRC 118	34.16	MACS 1488	35.46	NRC 121	34.39
KDS 775	44.82	KDS 754	35.1	RSC 10-29	33.78
VLS 90	35.42	RVS 2010-2	36.37	MAUS 740	35.56
NRC 119	31.25	AMS 1001	36.19	KBS 24-2014	36.74
NRC 120	35.75	NRC 123	51.32	JS 97-52 (c)	37.46
VLB 202	26.91	JS 335 (c)	36.29	-	-
JS 20-116	37.7	RSC 10-04	39.65	-	-
RKS 18 (c)	38.02	-	-	-	-
Mean	**36.76**	**Mean**	**37.14**	**Mean**	**34.80**
SEm±	**2.13**	**SEm±**	**3.52**	**SEm±**	**3.00**
C.D. (5%)	**6.17**	**C.D.(5%)**	**10.24**	**C.D.(5%)**	**8.79**
	NS		NS		**NS**

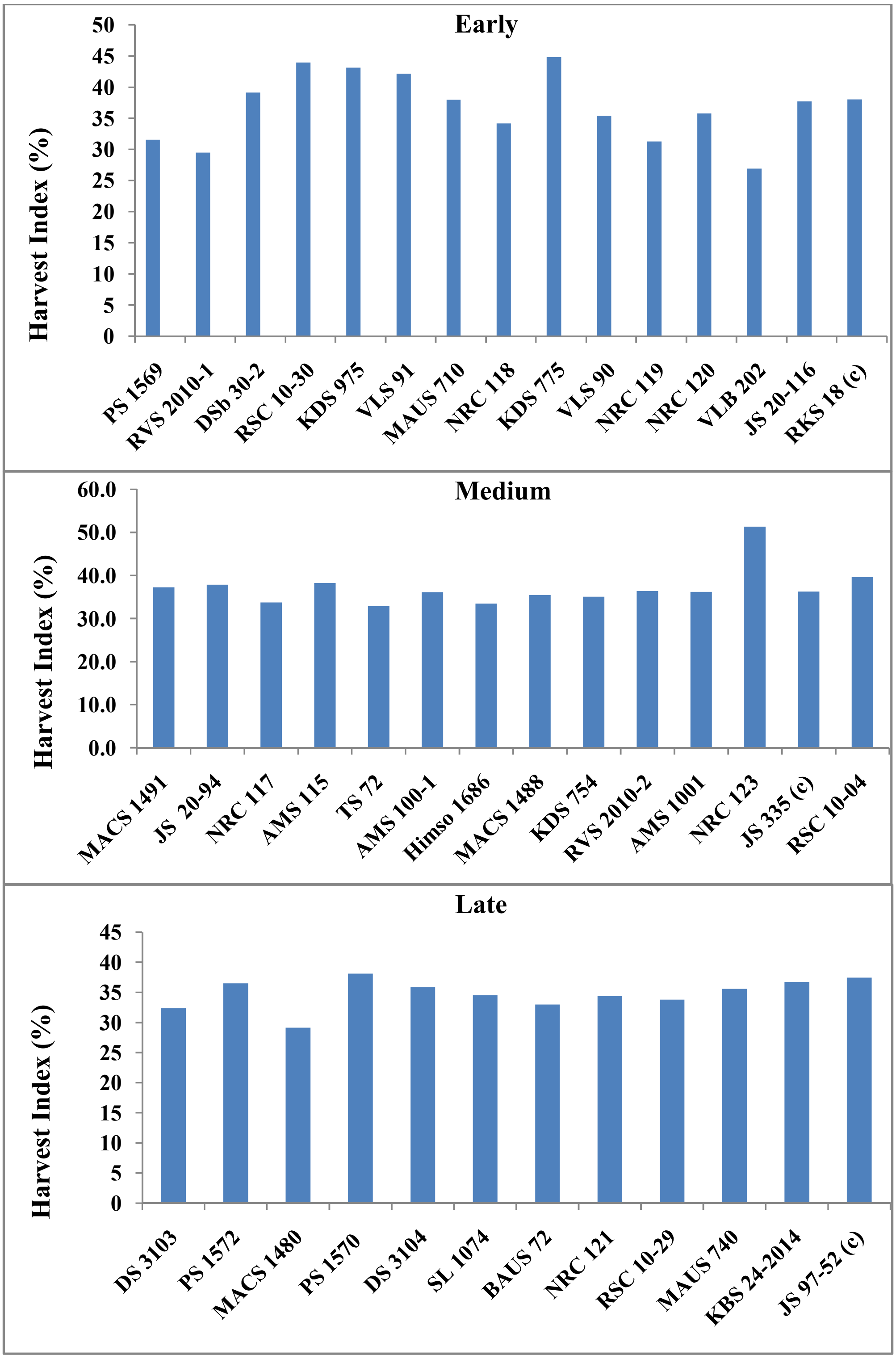


Fig 4.20 Variation in Harvest index (%) in soybean cultivars at various growth phases.

node, pod per plant, seed per pod, 100 seed weight and seed yield per plant in 28 strains of soybean. At the phenotypic level the yield was positivity correlated with plant height, primary branches and the no. of pod per plant. The remaining characters were positively associated with one another. The path analysis revealed that the no of pod bearing nodes no. of primary branches and 100 seed weight directly and the no of pod per plant, plant height, maturity and primary branches *via.,* the no. pod bearing nodes per plant exerted the greatest influence on seed yield.

Table 4.21: Correlation study of soybean cultivars of morpho-physiological & growth parameter with yield parameters.

	PH	NL	NB	LA	DFI	DTF	PM	CHL	NPP^{-1}	$NSPL^{-1}$	$Nspod-^{1}$	PBN	TDW	SY	BY	TW	HI
PH	1																
NL	-0.223	1															
NB	-0.078	-0.035	1														
LA	0.282	-0.280	0.144	1													
DFI	-0.188	0.088	0.086	-0.008	1												
DTF	0.142	0.167	0.351*	-0.011	0.587**	1											
PM	-0.353*	-0.018	0.026	-0.086	0.427**	0.064	1										
CHL	0.075	0.103	-0.051	-0.203	-0.077	-0.051	0.134	1									
NPP^{-1}	0.145	0.246	0.445**	0.182	-0.030	0.269	-0.126	0.051	1								
$NSPL^{-1}$	0.197	0.297*	0.462**	0.223	-0.102	0.289	-0.159	0.068	0.931**	1							
$Nspod^{-1}$	0.104	0.176	0.230	-0.251	-0.389**	-0.029	-0.269	0.025	0.068	0.294	1						
PBN	0.100	-0.023	0.304*	0.161	0.000	0.192	0.096	-0.187	0.057	0.132	0.203	1					
TDW	0.158	-0.100	0.248	0.291	0.067	0.194	-0.082	-0.254	0.267	0.301*	-0.004	0.077	1				
SY	0.157	-0.137	0.117	0.233	-0.247	-0.039	-0.184	-0.041	0.463**	0.417**	0.067	-0.071	0.213	1			
BY	0.035	-0.144	0.054	0.219	-0.230	-0.235	-0.346*	-0.400**	0.214	0.220	0.154	0.020	0.517**	0.238	1		
TW	0.302*	-0.209	-0.197	0.197	-0.092	-0.071	-0.111	0.193	-0.030	-0.028	-0.141	-0.176	-0.054	0.305*	0.036	1	
HI	0.484**	-0.173	-0.195	0.172	-0.247	0.032	-0.170	0.118	0.023	0.053	-0.116	-0.150	0.030	0.370*	-0.072	0.690**	1

= Singnificant at 5% df** *= Significant at 1% df**

PH = Plant height , NL = No. of leaves, NB = No. of branches, LA = Leaf area, DFI = Days to flower initiation, DTF = Days to 50% flowering, PM = Physiological maturity, CHL = Chlorophyll value (SPAD), NPP^{-1} = No. of pod per plant, NSP^{-1} = No. of seed per plant, $NSPod^{-1}$ = No. of seed per pod, TDW = Total dry weight, SY = Seed yield, BY = Biological yield, TW = Test weight, HI = Harvest index.

Table: Correlation of growth parameters from (40-60 DAS) with yield parameters (early group of soybean cultivars).

	LA	LAI	CGR	RGR	NAR	BY	SY	TW	HI
LA	1								
LAI	**0.999999****	1							
CGR	0.132202	0.132676	1						
RGR	-0.2015	-0.20104	**0.736069****	1					
NAR	-0.20518	-0.20471	**0.722411****	**0.999194****	1				
BY	0.246511	0.246903	**0.957103****	**0.522212***	**0.503317***	1			
SY	0.166985	0.167094	0.124764	-0.27887	-0.30352	0.310752	1		
TW	**0.474636***	**0.475006***	0.129311	-0.23222	-0.21868	0.203525	0.076165	1	
HI	-0.18549	-0.18567	**-0.63388****	**-0.61493****	**-0.59721****	**-0.59365****	-0.04028	0.192415	1

Early :- *= Significant at 5% df 0.441 **= Significant at 1% df 0.592

LA = Leaf area, LAI = Leaf area index, CGR = Crop growth rate, RGR = Relative growth rate, NAR = Net assimilation rate, BY = Biological yield, SY = Seed yield, TW = Test weight, HI = Harvest index.

Table: Correlation of growth parameters from (40-60 DAS) with yield parameters (medium group of soybean cultivars).

	LA	LAI	CGR	RGR	NAR	BY	SY	TW	HI
LA	1								
LAI	**0.999999****	1							
CGR	0.231218	0.23174	1						
RGR	0.071236	0.071823	**0.897321****	1					
NAR	0.071236	0.071823	**0.897321****	1	1				
BY	0.294877	0.295367	**0.975099****	**0.781862****	**0.781862****	1			
SY	0.244937	0.245351	-0.29029	-0.3747	-0.3747	-0.20962	1		
TW	-0.34294	-0.34328	**-0.59514****	**-0.56362***	**-0.56362***	**-0.56413***	0.2034	1	
HI	-0.03138	-0.03094	-0.28504	-0.15554	-0.15554	-0.28651	0.240376	-0.0975	1

Medium :- *= Significant at 5% df 0.441 **= Significant at 1% df 0.592

LA = Leaf area, LAI = Leaf area index, CGR = Crop growth rate, RGR = Relative growth rate, NAR = Net assimilation rate, BY = Biological yield, SY = Seed yield, TW = Test weight, HI = Harvest index.

Table: Correlation of growth parameters from (40-60 DAS) with yield parameters (long group of soybean cultivars).

	LA	LAI	CGR	RGR	NAR	BY	SY	TW	HI
LA	1								
LAI	**0.99817****	1							
CGR	-0.21964	-0.21992	1						
RGR	-0.28195	-0.29481	**0.511296***	1					
NAR	-0.25469	-0.26938	**0.496408***	**0.990089****	1				
BY	-0.18103	-0.1746	**0.959918****	0.271062	0.246164	1			
SY	-0.06981	-0.08937	0.359263	0.257305	0.290841	0.262716	1		
TW	0.133123	0.105549	-0.08567	-0.06188	-0.02261	-0.12568	**0.488933***	1	
HI	0.195991	0.163434	-0.12224	0.104919	0.161725	-0.23054	**0.591529***	**0.816651****	1

Late :- *= Significant at 5% df 0.441 **= Significant at 1% df 0.592

LA = Leaf area, LAI = Leaf area index, CGR = Crop growth rate, RGR = Relative growth rate, NAR = Net assimilation rate, BY = Biological yield, SY = Seed yield, TW = Test weight, HI = Harvest index.

CHAPTER –V

SUMMARY AND CONCLUSIONS

5.1 SUMMARY

Soybean yield is determined by the number of pods (seeds) produced per unit area and individual seed weight. The seed number depends upon the number of floral buds that initiate pods and attain maturity. Generally, soybean plants produce an abundance of floral buds, but a large proportion of them abort during development. Indeed, rates of flower and pod abscission/abortion were estimated to reach 80% (Shibles *et al.,* 1975). Alleviation of this abortion rate should increase pod and seed number, and thereby increase yield.

Hence the study on ”Morpho-physiological characterization of soybean cultivars for efficient photo-assimilates partitioning and yield” was calculated to find out the morpho-physiological markers for plant architecture and growth pattern related to efficient partitioning of photo-assimilates to achieve high sink realization and yield. For the experimentation, we have selected three groups of cultivars of early, medium and long duration, sown at same time in kharif 2015-16 at instructional cum research farm of IGKV, Raipur (C.G.). The salient findings of the experimentation are summarized below:

The morpho-physiological markers were studied in term of plant height, number of leaves per plant, number of branches per plant and leaf area.

1. The average plant height was maximum in medium duration cultivars followed by early and then long duration cultivars. In early group RVS 2010-1 (82.63) and DSb 30-2 (82.43) were significantly superior and MAUS 710 (49.73) and PS 1569 (53.10) were significantly inferior in plant height. In medium group MACS 1491 (Medium), MACS 1488 (Medium) were having maximum plant height and RSC 10-04 and KDS 754 were having minimum plant height. While long duration cultivar BAUS 72 having significantly high plant height and NRC 122 having minimum plant height. However, there were no correlation in plant height and number of leaves.

2. The early cultivars. PS 1569 having significantly more foliage (no. of leaves) and PS 10-30 having minimum no. of leaves. Whereas in medium duration cultivars AMS 100-1 having maximum leaves and JS 20-94 having minimum leaves. In long duration cultivars PS 1574 having maximum and TS 69 having minimum leaves.
3. The cultivars MACS 1491 cultivars, KDS975, KDS775 and NRC122 having 4-5 leaf lets. Whereas, JS20-94, KDS 975, SL1074, JS97-52(c) having small leaf. The cultivars having narrow leaves *ie.,*PS1569, AMS115, JS20-94, NRC117. Were PS1569, AMS115, JS20-94, NRC117, AMS115, Himso 1686. PS 1570, DS3104, SL1074, NRC 120 ,VLB 202, NRC 122. The cultivars having broad leaves.
4. The number of branches were not associated with plant height and number of leaves it was found individual genotypic character. However, in early group of cultivars having maximum branches in PS 1569 (4.60) and KDS 975 having minimum (2.46). In medium duration cultivars RSC 10-04 exhibited significantly maximum branches (4.30) and NRC 123 have minimum (2.26). Long duration cultivars JS 97-52 (c) having highest no. of branches (4.66) and minimum was observed in DSb 29 (2.53).
5. The leaf area was measured by graph method and medium duration cultivars having maximum leaf area followed by early group at 90 DAS and then long duration cultivars. Maximum LA was obtained in RVS 2010-1 early, RSC 10-04 medium and DSb 29 (L). Whereas, significantly minimum LA was obtained in PS 1569 early, NRC 177 medium and NRC 121 long.
6. Phenological parameters indicated that there was no significant variation in days to flower initiation. Cultivars MAUS 710 (18.67) early and NRC 120 early, NRC 117 (18.0) medium, RVS 2010-2 (18.33) medium and NRC 121 (19.0) long and MACS 1480 (21.0) long required was days to flower initiation. Whereas, PS 1569 (24.67) early, MACS 1488 (27.00) medium and TS 69 (33.00) long required maximum days to flower initiation.

The physiological maturity was also significantly different amongst the three group of cultivars RKS 18 (c) (98.00) early, MAUS 710 (101.00) medium, MACS 1480 (106.00) long required minimum days to physiological maturity.

Whereas, KDS 775 (100.00) early, RSC 10-04 (108.67) medium and PS 1572 (118.00) have maximum days to physiological maturity.

7. Growth parameter, i.e. LAI, CGR, NAR, RGR were calculated at various growth phases *i.e.,* 40-60, 60-90 DAS, in all three groups of cultivars. However, significantly maximum LAI was obtained in RVS 2010-1 (2.78) early RSC 10-04 (3.58) medium and DSb 29 (2.90) long were obtained maximum LAI in their respective graphs. While PS 1569 (0.75) early NRC 117 (1.18) medium and NRC 121 (0.78) long were exhibited minimum LAI in their respective group.
8. The LAI was calculated at 60 and 90 DAS and average maximum LAI was high in medium duration cultivars followed by early and then long duration cultivars. The maximum LAI was observed RVS 2010-1 early RSC 10-04 medium and DSb 29 long duration. While minimum LAI was observed in PS 1569 early NRC 117 medium and NRC 121 long.
9. CGR is an important growth parameter pay significant contribution in photo assimilates production and partitioning. It was calculated between 40-60, 60-90 DAS. The early cultivars were exhibited higher rate of crop growth followed by medium and then long duration. NRC-119 (E), TS 72(M) and MACS 1480(l) exhibited maximum CGR in their replication group, while JS20-116(e), AMS 1001 (M) and TS 69(L0 were having minimum CGR amongst them respective groups.
10. The NAR was higher in early group as compared to medium and long duration at initial phase of growth 40-60 DAS. However, NAR was higher at 60-90 in long duration cultivars. The average maximum NAR was observed in VLB 2029 (E), TS 72 (M) and SL 1074 (L). Whereas, minimum NAR exhibited in KDS 775(E), AMS 1001 (M)and TS 69 (L).
11. RGR was also measured between 40-60 and 60-90 DAS and early group exhibited more RGR than medium group and long duration cultivars at 40-60 DAS. Whereas, reversed trend was observed at 60-90 DAS long duration cultivars having maximum RGR and early group having minimum. The cultivars VLB 202 early, TS 72 medium and SL 1074 long have maximum

RGR amongst their respective group. Cultivar KDS 775 (E), AMS 1001 (M) and TS 69 (L) have minimum RGR.

12. The chlorophyll SPAD value was measured at 30 DAS and 60 DAS. The value was higher at flowering stage. Long duration cultivars have shown higher value followed by medium and then early cultivars. Cultivars NRC-120 (Early), MACS 1488(Medium), RSC 10-29 (Long duration) have maximum SPAD value amongst their respective groups. Whereas, VLB 202(Early), AMS 100-1 (Medium), and DSb 29 (Long duration) have minimum SPAD value amongst their respective groups.
13. Yield component having, number of pod per plant, number of seed per pod, 100 seed weight, seed yield, biological yield, pod bearing node were taken at maturity. The average number of pod per plant were maximum in medium duration cultivars followed by early and then long duration. Cultivars, RVS 2010-1 (E), RHC-10-4(M), PS 1570 (L) were exhibit maximum number of pods per plant amongst their respective groups. While NAUS 710 (E), MACS 1488 (M) and MACS 1480 (L) were having minimum number of pods per plant amongst their groups.
14. The average biological yield was greater in NRC 119 (early)), followed by VLB 202 (E), TS 72 (medium) have maximum biological yield followed by Himso 1686 (1865.80). MACS 1480 (Long) have maximum biological yield (2265.80) followed by JS 9752 (c) While, minimum biological yield was obtained by KDS 775 (E) followed by NRC 120 (E).The medium duration cultivars TS 72 have maximum biological yield followed by Himso 1686. Whereas, cultivars BAUS 72 (L) have minimum biological yield followed by DS 3104 (L).
15. Seed yield was measured at physical maturity. The cultivars was having more number of pod per plant *i.e.*, RVS 2010-1 (c) (L) having higher yield amongst their respective group. Whereas, VLS 90 (E), MACS 1491 (M), BAUS 72 have significantly low yield amongst their respective group.

16 The test weight (100 seed weight) exhibited non significant variation amongst cultivars and duration group. KDS 775 (E), RVS 2010-2 (M) and NRC 120 (L) were possessed maximum test weight amongst their group. However, PS

1569 (E), TS 72 (M), PS 1570 (L) were exhibited significantly lowest test weight amongst their group.

17 The first pod bearing node was minimum in early cultivars (3.03) followed by long duration (3.13) then medium duration (3.31). The cultivars NRC 118 (2.11) and VLS 91 (2.11) (Early) having minimum pod bearing node and RKS 18(c) (4.44)(E) having maximum pod bearing node followed by VLB 202 (4.00)(E) and NRC 120 (4.00) (E).While, in medium group JS20-94 (2.22) medium, having minimum pod bearing node and Himso 1686 (4.77) having maximum pod bearing node. However, in long duration cultivars MAVS 740 (2.66) having minimum pod bearing node and BAUS 72 (4.44) having maximum pod bearing node.

18. The HI was higher in long duration cultivars (38.80) followed by medium (37.14) and then early (36.76) group of cultivars. The cultivars KDS 775 (early) (44.82) NRC 123 (medium) (51.32) and PS 1570 (38.14) (long duration) have significantly maximum HI amongst their respective group. However, cultivars RVS 2010-1 (29.49) (early), TS 72 (32.88) (medium) and MACS 1480 (29.17) (long duration) have significantly minimum HI amongst their respective group.

Therefore the cultivars KDS 775 (early), RSC 10-30 (early) NRC 123 (medium) and PS 1570 (long) have higher HI amongst their group KDS 775 also have high test weight. The cultivars RVS 2010-1 (early), KDS 975 (early), RSC 10-04 (medium), NRC 117 (medium), JS 20-94 (medium) and JS 97-52(c) (long) and RSC 10 29 (long) have significantly higher seed yield amongst their group. These cultivars have less flower drop, more sink realization and efficient photo assimilate partitioning towards economic sink.

Correlation studies:

The correlation studies indicated that the HI was highly and positively correlated with test weight, seed yield and plant height. Seed yield was also positively correlated with test weight, no. of pods plant^{-1}, no. of seed plant^{-1}. However BY (biological yield) was highly negatively correlated with physiological maturity, chlorophyll SPAD value. The no. of seeds pod^{-1} was highly negatively associated with days to flower initiation. No. of seed plant^{-1}, was positively correlated with no. of leaves plant^{-1}, no. of branches plant^{-1} and no. of pod plant^{-1}.

The LAI was highly significant and positively correlated with LA, CGR of early group cultivars was highly significant and positively correlated with RGR (0.736), NAR (0.722), BY (0.957) and negatively correlated with HI (-0.633). However, HI was negatively correlated with CGR, RGR, NAR and BY. Biological yield was positively associated with CGR, RGR and NAR.

The LAI was highly significant and positively correlated with LA (0.999), CGR of medium group cultivars was highly significant and positively correlated with RGR (0.897), NAR (0.897) BY (0.975) and negatively correlated with TW (-0.595). However, BY was highly significant and positively correlated with CGR (0.975), RGR (0.781) and NAR (0.781). TW was negatively correlated with CGR, RGR, NAR and BY.

The Leaf area was highly significant and positively correlated with leaf area (0.998), CGR of long group cultivars was significant and positively correlated with RGR (0.511), NAR (0.496) highly significant and positively correlated with BY (0.959) and NAR was significant and positively correlated with CGR (0.496) RGR (0.990) and TW was correlated with SY (0.488). However, HI was found highly significant and positively correlated with SY(0.591) and TW (0.816).

5.2 CONCLUSIONS

Apart from genetic makeup, the major physiological constraints limiting its production is flower drop and fruit drop. Improvement in climatic adaptation is fundamental to the processes of crop improvement. The manipulation both cultivars and environments to respectively maximize genetic potential and minimize environmental constraints to the expression of the potential. The economic yield can be expressed as the product

Ye = (Q) x (i) x (Ec) x (P)

Where, Ye = Economic yield, Q Cumulative radiation incident on the crop, i = Proportion intercepted by the crop. Ec = Conservation efficiency to total dry matter, P = partitioning efficiency to economic yield.

An examination of the four compounds, of the above relationship help to illustrate the potential role of various physiological and environmental factors in contributing to variation in crop performance and thus to identify when an opportunity exist for improvement.

1. The cumulative incident radiation is one of the main determinants falling on the crop is duration of crop growth. Cultivar KDS 775 (E) have broad leaves with 4-5, more leaflets have shown high HI and economic yield. However, NRC 123 (medium) having medium sized leaves, and PS1570 (Long duration) having narrow leaves. They have shown high HI, and high seed yield.
2. The second main determinants of cumulative incident radiation is level of insolation *i.e.,* difference in irradiation induced by cloudiness between rainy and dry seasons which could result 50% higher potential for dry season.
3. Leaf area development play a significant role in pulses that is very slow during initial growth period that influenced the dry matter partitioning and seed yield.
4. Radiation interception is also an important determinant for photosynthetic efficiency, characteristic of canopy *i.e.,* orientation angle, size and dispersion of leaves.
5. LAI plays significant role an interception of radiation. Critical leaf area index depends partly on the level and nature of irradiance and extinction coefficient for that crop.
6. Endogenous hormones (cytokinin and auxin) play an important role in pod setting. Cytokinin have a positive and auxin have a negative effect on pod set.
7. Efficiency of conversion depends upon the photosynthetic surface and the rate per unit area, minus respiration and photorespiration.
8. HI depends on relative duration of vegetative and reproductive phase, proportion of dry matter assimilate remobilization from vegetative to reproductive organs.

9. The manipulation of photo-thermal sensitively offers the most powerful tool for improving harvest index.

SUGGESTIONS FOR FUTURE RESEARCH WORK

1. The study should be repeated at least three years in different time intervals in different agro-ecological conditions.

2. The growth habit and photo-thermal sensitively should be tested to find out the appropriate cultivars for the region.

3. The manipulation in incident radiation for photosynthesis efficiency, the partitioning efficiency and economic yield can be improved in soybean.

REFERENCES

Abbas Mohd., Singh, M.P., Nigam, K.B. and Kandalkar, V.S. 1992.Effect of plant densities and plant types on different growth and physiological parameters of soybean. Indian J. Agron. 39(2):246-248.

Abayomi, Y.A. 2008. Comparative growth and grain yield responses of early and late soybean maturity groups to induced soil moisture stress at different growth stages. World Journal of Agricultural Sciences. 4(1): 71-78.

Agrawal, P.K. and V yas , O. P. 1970. Note on the effect of temperature on oil and potein content on the seed of clark 63' soybean (Glycine max (L.) Merrill). Indian J. Agril. Sci 41 (12):1122-1123.

Agrawal, A.P., Patil,S.A., Salimath,, P.M.2002. Dry matter accumulation pattern in soybean pod and its relationship with pod shattering. : Indian Journal of Plant- Physiology. V. 7(1) p. 48-51.

Ali, A., Khan S.A., Khan, E., Ali, I.H. Fayaz A., 2015. Genetic studies among diverse soybean (*Glycine max* L. Merrill) cultivars for variability and correlation at Swat, International Journal of Biosciences. 6 (4): 165-169.

Amarnath, K. C. N., Vishwanath , S.R. and Chennakeshwa, B.C. 1990. Phenotypic and genotypic correlation coefficient of some quantitative characters in soybean. Maysore J. Agril. Sci. 42(4): 445-449.

Anil Kumar, V. Pandey, 2A.M. Shekh and 1Manoj Kumar Growth and Yield Response of Soybean (Glycine max L.) In Relation to Temperature, Photoperiod and Sunshine Duration at Anand, Gujarat, India Birla Institute of Technology, Mesra, Ranchi – 835215.

Baisakh, B. and Dash, G.B. 1991. Performance of promising cultivars of soybean (Glycine max (L.) Merrill) in hilly regions of Orissa. Indian J. Agril. Sci. 62 (5): 335-336.

Baisakh, V.S.,Tiwari, S. P. and Josh. 1995. Interrelationship of leaf photosynthesis, specific leaf weight and leaf anatomical characters in soybean. Indian J. plant physiology. 1(1):6-9.

Bacanamwo, M. and Purcell, L.C. 1999.Soybean root morphological and anatomical traits association with acclimation to flooding. Crop Science. 39: (1), 143-149.

Basuchaudhari, P. and Munda, G.S. 1987. Characterizing active physiological region in soybean (Glycine max (L.) Merrill) at pod formation stage. Legume Res. 10 (1): 27-28.

Beadle, C.L.1982. Plant growth analysis in the techniques in bioproductivity and photosynthesis. Pergamor Press Ltd. England. Cdt. Coombs and Hall: 21-25.

Bengal, U. S. and Gupta, D. N. 1998. Nutritive value of promising cultures of soybean under konkan agro – climatic condition. J. Maharashtra Agril. University. 23: 2.

Billore, S. D., Joshi, O.P. and Ramesh, A. 1999. Performance of soybean (Glycine max (L.) Merrill) cultivars on different sowing dates and row specing in vertisols. Indian J. Agril. Sci. 70 (9): 577-580.

Buttery, B.R. 1970. Effect of variation in leaf area index on growth of soybean and Maize. Crop Sci. (10): 9-10.

Carlson, J. B. & Lesten, N. R. (1987). Reproductive morphology, in Wilcox, J.R. (ed.) soybeans: improvement, production, and uses (2nd ed.), ASA, CSSA, SSSA, Madison, WI, pp.95-134.

Campbell, P.K. E., Middleton, E.M., Corp, L.A., Kim, M.S.2008.Contribution of chlorophyll fluorescence to the apparent vegetation reflectance. Science of the Total Environment. 404(2/3): 433-439.

Chandrakar, P. K., Shrivastava, R., Agrawal, S. K. and Rao, S.S. 1998. Stability analysis of soybean (Glycine max (L.) Merrill) varieties in rice zone of Madhya Pradesh. J. oilseed Res. 15 (2): 247-249.

Chandel, A. S., Bisht, J. K. and Saxena S.C. 1987. Influence of cultivars and plant densities on grain yield and quality of soybean crop improve 14(1): 60-63.

Charjan, S.K. U. and Tarar, J.L. 1991. Influence of seed size on germination and seedling vigour in soybean varieties. Bioved . 1(2): 165-168.

Cober, E.R., Morrison, M.J. 2010. Regulation of seed yield and agronomic characters by photoperiod sensitivity and growth habit genes in soybean.

Crosby, K. E., Aung, L. H. and Buss, G. R. (1981). Influence of 6-benzylaminopurine on fruit-set and seed development in two soybean, (Glycine max (L.) Merrill) Cultivars, Plant Physiology 68:985-988.

Desai, B.B., P.M. Kotecha and D.K. Salunkhe, 1997. Seed handbook biology, production, processing and storage. Publisher Dekker, Ine, New Yark. Pp. 199-205.

Deshmukh, D. T., Dhumale, D. R., Khorgade, P.W. and Kshirsagar, A. R. 1991. Inter- relationship and path analysis of yield and its componenets in soybean Ann. Plant physiol. 6(1): 139-141.

Deokar, P.A., Arti, Guhey., Patil, S. G. 2009. Physiological basis of seed yield variation in soybean [Glycine max (L.) Merrill]. International Journal of Plant Sciences Muzaffarnagar. 4(2): 596-598

Dornbos, D.L. and Mullen, R. E. 1989. Influence of stress during soybean seed fill on seed weight, germination and seedling growth rate. Fld. Crop Abstr. 44(12):1144.

Eastern Cereal and Oilseed Research Center, Agriculture and Agri-Food Canada. Deka, S. D. and Talukdar, P. 1994. Stability behavior of some soybean (Glycine max (L.) Merrill) cultivars under environmental variability. Indian J. Genet. 57 (1): 36-39.

Egli, D. B. and Leggett, J.E. 1971. Dry matter accumulation patterns in determinate and indeterminate soybean crop Sci. 13: 21-23.

Egli, D. B., TeKrony, D. M., Wiralaga, R. A. 1990. Effect of seed vigour and size on seedling growth. Journal of seed technology. 14: 1, 1-12; 27.

Feng, NaiJie. Zheng, DianFeng., Zhao, JiuXiang., Zu, Wei., Du JiDao., Zhang, YuXian., Liang, XiLong. 2009. Effect of plant growth substances on morphological and anatomical structure of leaf and photosynthetic characteristics in soybean. Acta Agronomica Sinica. 35(9): 1691-1697.

Fritschi, F.B., and Ray, J.D.2007. Soybean leaf nitrogen, chlorophyll content, and chlorophyll a/b ratio. Photosynthetica; 45(1): 92-98

Gaikwad, S. R., Bangar, N.D., Chavan, B.H. 2007. Correlation and path coefficient analysis in soybean. Journal of Maharashtra Agricultural Universities. 32(2): 276-277.

Gayatri Kakad, T. H., Rathod, R.P., Khedekar, and sapna Joshi 2008. Effect of growth regulators and ore sowing seed treatment on oil, protein, yield and yield attributing of soybean. Ann. Plant physiol. 22(2): 172.175.

Ghatge, R. D. and Kadu, R. N. 1992. Genetic diversity in soybean Ann. Agril. Res. 14(2): 143- 148.

Gontia, A. S. and Awasthi, M.K. 1998. Effect of seed size on various seed vigour attributes morphological characters and seed yield in soybean cultivars Seed Res. 27(1): 25-30.

Goswami, B. K. and shrivastava, G. C. 1989. Benzyl adenine on nitrate reductas in sunflower (Helianthus annus L.). Indian J. Plant physiol. 32(4):325-329.

Gulluoglu, L., Arioglu, H., Arslan, M. 2006. Effects of some Plant Growth Regulators and nutrient complexes on pod shattering and yield losses of soybean under hot and dry conditions. Asian Journal of Plant Sciences. 5(2): 368-372.

Gupta, P.C. 1976. Effect of seed size on variability and vigour of soybean. Seed Res. 4 (1): 138-141.

Haplusterts of Madhya Pradesh J. Indian Soc. Soil Sci 45(2):247-279. Kumar, M.S., Diwan, Singh. 2007. Agroclimatic models for growth and yield of soybean [Glycine max (L.) Merr.]. Annals of Biology. 23(2): 173-176.

Harer, P.N. and Deshmukh, R. B. 1998. Genetic variability, correlation and path coefficient analysis in soybean (Glycine max (L.) Merrill). J. oilseed res. 9(1): 65-71.

Hansen, W.R. & Shibles, R. (1978). Seasonal log of the flowering and podding activity of field- grown soybeans, Agronomy Journal 70:47-50.

Heerden, P. D. R.van., Beer, M.de., Mellet, D.J., Maphike, H.S., Foit, W.2007.Growth media effects on shoot physiology, nodule numbers and symbiotic nitrogen fixation in soybean. South African Journal of Botany. 73(4): 600-605.

Heindl, J.C., Carlson, D.R., Brun, W.A. & Brenner, M.L. (1982). Ontogenetic variation of four
cytokinins in soybean root pressure exudates. Plant Physiology 70: 1619-1625.

Heindl, J. C., Carlson, D. R., Brun, W. A. & Brenner, M. L. (1982). Ontogenetic variation of four cytokinins in soybean roots pressure exudates. Plant Physiology 70:1619-1625.

Huff, A. & Dybing, C. D. (1980). Factor affecting of shading of flowers in soybean (Glycine max (L.) Merrill), Journal of Experimental Botany 31:751-76.

Iqbal, S., Mahmood, T., Tahira Ali, M., Anwar, M., Sarwar, M. 2003. Path coefficient analysis in different cultivars of soybean (Glycine max (L) Merril). Pakistan J. of Biological Sci. v. 6(12) p. 1085-1087.

Isler, N., Sogut, T., Calskan, M.E.1997. Determination of important agricultural and morphological characteristics of some soybean cultivars (Glycine max (L.) Merr.) under second crop conditions. Ziraat Fakultesi-Dergisi, Mustafa Kemal Universitesi. 1997; 2(2): 81-90.

Jagtap, D.R. and Choudhary, P.N. 1992. Correlation studies in soybean (Glycine max (L.) Merrill). Ann Agril. Res. 14(2): 154-158.

Jain, H. C., Tiwari, J. P. and Jain, K.K. 1996. Effect of spacing seed rate and weed control measuring on physiological parameters of soybean world weed.3: 157-163.

Jansani, K.P., Patel, M.P. and Patel, H.S. 1993. Growth and yield of soybean (Glycine max (L.) Merrill) as influenced by sowing. Indian J. Agron. 38(4): 670-672.

Kalyankar, S. V., Kadam, G.R., Hudge, B.V., Deshmukh, D.D., Borgaonkar, S.B. 2008. Effect of foliar application of growth regulators on seed yield and yield components of soybean. Annals of Plant Physiology. 22(2): 293-294

Karad, S.R., Harer, P.N., Kadam, D.D., Shinde, R.B. 2005. Genotypic and phenotypic variability in soybean (Glycine max (L.) Merrill). J. Of Maharashtra Agricultural-Universities. 30(3): 365-367

Kausale, S.P., Ekshine, B.S., Kote, G.M., Gadade, G.D., Lomte, D. M. 2006. Effect of sowing dates on physiology parameters and seed yield of soybean. Annals of plant physiology. 20(2): 208-211.

Kato, I. & Sakaguchi, S. (1954). Studies on the mechanism of occurrence of abortive grains and their prevention in soybeans, Glycine max M., Tokai-Kinki National Agricultural Experiment Station Bulletin 1: 115-132.

Khan, A.Z., Shah,-P., Khalil, S.K., Taj. F.H. 2003. Influence of planting date and plant density on morphological traits of determinate and indeterminate soybean cultivars under temperate environment. Pakistan Journal of Agronomy. V. 2(3) p. 146-152.

Kim SeokHyeon., Kim-JiNa., Chung-JongIl., Shim-SangIn. 2006. Differences of water absorption property and seed viability according to morphological characters in soybean cultivars. Korean Journal of Crop Science. 51(1): 59-65.

Krishi darshikn (2015). IGKV Publication pp. 4

Koesmaryono, Y., Sugimoto, H., Ito, D., Haseba, T. 1998. Photosynthetic an transpiration rate of soybean as affected by different irradiances during growth. Photosynthetica 35(4): 573-578.

Kokubun, M. (1988). Design and evaluation of soybean ideotypes, Bulletin of Tohoku National Agricultural Experiment Station 77: 77-142.

Kokubun, M., Shimada, S. & Takahashi, M. (2001). Flower abortion caused by preanthesis water deficit is not attributed to impairment of pollen in soybean, Crop Science 41:1517-1521.

Koti, R.V. and Chetti, M.B. 1998. Influence of season on plant morphology and its relationship with seed yield in soybean cultivars. Kanataka J. Agril. Sci. 12(1-4): 26-31.

Kothule,V. G.,Bhalerao, R. K., and Rathod T. H. 2003. Effect of growth regulators on yield attributes, yield and correlation coefficient in soybean. Ann. Plant physiol. 17 (2):140-142.

Kosala, Ranathunge., Shao,SuQin., Qutob, D., Gijzen, M., Peterson, C. A.,Bernards, M.A. 2010.Properties of the soybean seed coat cuticle change during development. Planta.231 (5): 1171-1188.

Kundu, S., Singh, M., Tripathi, A.K., Manna, M. C., Takkar, P. N. and Singh, M. 1997. Time course of dinitrogen fixation in soybean grown on typic.

Lal, M.S., Mehta, S.K., Deodhar, A.D. and Sharma Y.K. 1972. Protein and oil content, their correlations and phenotypic stability in soybean as influence by different environments in Madhya Pradesh Indian J. Agril.Sci. 43(1):14-17.

Li, WenXia., Ning, HaiLong., Li,WenBin., LuWenHe. 2006. Developmental genetic analysis of seed size in soybean (Glycine max). Acta Genetica Sinica. 33(8): 746-756.

Liu, Z.X., Tang, R.Y., Liu, Y. Q, and Wang, Q.M. 1994. Black soybean variety Luheidoul crop Genetic Resources 4:56.

Liu XiaoBing, Jin Jian, Herbert, S.J., Zhang Qiu Ying, Wang GuangHua.2005. Yield components, dry matter, LAI and LAD of soybeans in Northeast China. Field Crops Res. 93(1): 85-93.

Liu, X., Herbert, S.J., Baath, K., Hashemi, A.M. 2006. Soybean (Glycine max) seed growth characteristics in response to light enrichment and shading. Plant, Soil and Environment.52 (4): 178-185.

Luquez, V. M., Guiamet, J.J.and Motaldi, E.R. 1997. Net photosynthetic and transpiration rate in a chlorophyll deficient isoline of soybean under well wanted and drought condition photosynthetica. 34(1): 125-131.

Mahajan, C.R. Mehetre, S.S. and Patil, P.A. 1993. Association of morphological traits with yield in soybean Ann. Plant Physiol. 7(1): 131-133.

Maley, S.R. and Sharma, S.R. 1973. Effect of date of sowing and varieties on growth and yield of soybean. JNKVV Res.J. 7(3): 115-117.

Malik, M.F.A., Muhammad, Ashraf-Qureshi, A.S., Abdul Ghafoor.2007 Assessment of genetic variability, correlation and path analyses for yield and its components in soybean. Pakistan Journal of Botany. 39(2): 405-413.

Maske, V.G., Deotate, R.D., Sorte, N.V. and Goramnagar, H. B. 1998. Influence of GA3 and NAA on growth and yield contributing parameters of soybean. J. Soil and crops. 8(1): 222.

Mannan, M.A., Karim, M. A., Khaliq, Q. A., Haque, M. M., Mian, M.A. K. Ahmed, J.U. (2009). Proline accumulation, water status and chlorophyll content in leaf in relation to salt tolerance in soybean.Indian Journal of Plant-Physiology. 14(2): 130-134

Marcos Filho, J. 1977-1978 Physiological maturity of soybean seeds. Pesquisa Agropecuaria Brasileira 1980 Vol. 15 No. 4 pp. 447-460.

Marcos-filho, J., Chamma, H.M.C.P., Casagrande, J.R. R ,Marcos, E.A.effect of harvesting time on seed physiological quality, chemical composition and storability of soybeans.Departamento de Ciência e Tecnologia Agroindustrial ESALQ/USP, C.P. 9, CEP: 13418-900 - Piracicaba,SP.

Mazahero, Daroish., Zeinali ,Hassan., Madani, Ahad .2005. Influence of planting dates and plant densities on photosynthesis capacity, grain and biological yield of soybean [Glycine max (L.) Merr.] . Journal of Agronomy. 2005; 4(3): 230-237.

Mcblain, B.A. and D.J. Hume, 1980. Physiological studies of higher yield in new early maturing soybean cultivars. Can. J. Pl. Sci. 60:1315-1326.

Mertz, L.M., Henning, F.A., Cruz, H. L.,da, Meneghello, G. E., Ferrari, C.dos S., Zimmer, P.D. 2009.Structural differences between soybean seeds coat with contrasting permeability. Revista-Brasileira de Sementes. 31(1): 23-29.

Mihajlov,-L. 2007. The seedtime and the maturity groups influencing the number of pods per plant on soybean. Sofia, Bulgaria: National Centre for Agrarian Sciences in Bulgaria.

Momen, N.M., Shae, R.E. and Arjamand, O.1979. Moisture stress effect on the components of two soybean cultivars. Agron. J.17 (1): 86-87.

Muhammad Arshad., Naazar, Ali. Abdul, Ghafoor. 2006 .Character correlation and path coefficient in soybean (Glycine max (L.) Merrill). Pakistan Journal of Botany. 38(1): 121-130.

Najar, G. R., Singh, S. R., Akhtar, F., and Hakeem, S.A.2011. Influence of sulphur level on yield, uptake and quality of soybean under temperate condition. Indian journal of Agricultural Sciences 81 (4): 340-3.

Nakano, H., Komoto, K., Ishida, K. 2001. Effect of planting on development and growth of the branch from, each node on the main stem in soybean plants. Japanese Journal of crop science. 70(1) p. 40-46.

Nirmal Kumari, A. and Balasubramanian, M. 1989. Physiological analysis of growth in soybean. India J. Plant Physiol. 33(3): 248- 252.

Nirmal Kumari, A. and Balasubramanian, M. 1991 variability in harvest index of soybean and it's associated with yield components. Ann. Plant Physiol 5(2):256-258.

Oberholster, S.D., Peterson, C.M. & Dute, R.R. (1991). Pedicel abscission of soybean: cytological and ultrastructural changes induced by auxine and ethephon, Canadian Journal of Botany 69: 2177- 2186.

Oberholster, S.D., Peterson, C.M. & Dute, R.R. (1991). Pedicel abscission of soybean: cytological and ultrastructural changes induced by auxine and ethephon, Canadian Journal of Botany 69: 2177-2186.

Ookawa, T., Nishiyama, M., Takahiro, J., Ishihara, K., Hirasawa, T. 2001. Analysis of the factors causing differences in the leaf senescence pattern between two soybean [Glycine max] cultivars, Comparison of root lengt and exudation rate among grafted plants. Plant Production Science. V. 4(1) p. 3-8.

Patil, V.R. 1989. Effect of varying photosynthesizing surface on growth, development and yield in black gram (Vigna mungo L.) M.Sc. Thesis submitted to M.A.U., Parbhani. 159

Pawar, V.P. 1978. Response of soybean (Glycine max (L.) Merrill) varieties to graded level of nitrogen and phosphorus M.Sc. thesis submitted to M.A.U. Parbhani.

Perraju, P., Mishra, Y., Sharma, S. M. and Tawar, M. L. 1982. Corelated response in soybean. JNKVV Res. J. 16 (2): 105-111.

Pirdashti, H., Motaghian, A., Bahmanyar, M.A. 2010. Effects of organic amendments application on grain yield, leaf chlorophyll content and some morphological characteristics in soybean cultivars. Journal of Plant Nutrition. 33(4): 485-495.

Pookpakdi, A. K., Thiravirojana, K., Saerades, I. and Chaikaew, S. 1990. Response of new soybean accessions to water stress during reproductive phase. Fld. Crop Abstr. 45 (9): 796.

Pramila Rani, B. and Ramaiah, K. 1999. Response of some soybean varieties to different sowing dates under rainfed condition Nagarjuna sagar project area of Andhra Pradesh Ann. Agril. Res. 20 (2): 325-237.

Raper, C.D. Jr. & Kramer, P.J. (1987). Stress physiology, in Wilcox, J.R. (ed.), Soybeans:
improvement, production, and uses (2nd ed.), ASA, CSSA, SSSA, Madison, WI, pp.589- 641.

Rajkumar-Ramteke., Husain, S.M. 2008. Evaluation of soybean (Glycine max) varieties for stability of yield and its components. Indian Journal of Agricultural-Sciences. 78(7): 625-628.

Rajput, L. and Shrivastava, V. K. 1999. Influence of varieties, sowing date and seed rate on physiological parameters and seed yield of soybean (Glycine max (L.) Merrill). Legume Res. 22(2): 117-120.

Ramana, M.V., Pramila Rani, B. and Satyanarayana, A. 1998. Genetic variability, correlation and path analysis in soybean. J. Oilseeds Res. 17(1): 23-35.

Rathod, T. H. Sakhare, R. S., Chaudhari, R. V., Paralwar, N.D. and Thakur, K.G. 1994. Correlation and path coefficient studies in black gram (Vigna mungo L.) Ann. Plant Physiol. 8(2): 188-191.

Sarkar, R. K. 1990. Correlation and path analysis of certain morpho- physiological characters in soybean. Indian J. Plant physiol. 33(1): 83-84.

Saxena, M. C. and Pandey, R. K. 1970. Characteristics and performance of some promising varieties of soybean (Glycine max (L.) Merrill) at pantnagar. Indian J. Agril. Sci. 41 (4): 355-360.

Setiyono, T D., Weiss, A., Specht, J-E., Cassman, K. G., Dobermann, A. 2008. Leaf area index simulation in soybean grown under near optimal conditions. Field Crops Research.108 (1): 82-92.

Sharma, J.P. and Sharma, S.P. 1992.influence of cultivars and plant densities on physiological parameters grain yield and quality of soybean. Indian J. Agron. 38 (2): 311-313.

Shinde, S. M., Rathod, T.H., Thakare, S. V., and Neelam Deva. 2007. Effect of nitrogen nutrition on yield and its attributes in soybean. Ann. Plant physiol. 21 (1): 38-41.

Shibles, R.M., Anderson, I.C. and Gibson, A.H. (1975). Soybean, in Evans, L.T. (ed.) Cropphysiology, Cambridge University Press, London. pp. 151-189

Shrivastava, S.K. Ratnam, N.V. and Agrawal, V. K. 1982. Growth analytical studies on soybean in relation to productivity as influenced by micronutrient. JNKV Res. J. 16 (3): 187-189.

Sinclair, T. R., Soffes, A.R., Hinsion, K., Albrecht, S.L. and Pfahler, P.L. 1991. Genotypic variation in soybean nodule number and height. Crop Sci. 31:301-304.

Singh, I. and Singh, B. 1998. Genetic variability and correlation studies in soybean (Glycine max (L.) Merrill) J. oilseed Res. 16 (1): 118-120.

Singh, K. D. and Singh, N.P. 1992. Yield and quality of soybean (Glycine max (L.) Merrill) as influenced by excess soil water at different stages of growth. Ann. Agril. Res. 14 (1): 95-99.

Singh, S.P. and Bansal, K.N. 1999. Response of soybean (Glycine max (L.) Merrill) to nitrogen its application time nd sulphur. Indian J. Agril. Sci 70 (1): 34-36.

Singh, S.P. Rao, S.K. and Sharma, S. M. 1983. Yield components in soybean (Glycine max (L.) Merrill). JNKVV Res. J. 17 (1-2): 46-50.

Sonawane, J. K., Kashid, N.V., Kamble, M.S., Kardak, V.N. 2005 Growth and development pattern of soybean cultivars. Annals of Agricultural-Res. 26(1): 21-26.

Sumit chaturvedi and chandel, H.S.2005.Influence of organic and inorganic fertilization on soil fertility and productivity of soybean (Glycine max.L. Merrill) Indian Journal of Agronomy 50 (4): 311-313.

Synder, R. L. Carlson, R.E. and Shaw, C. R. H. 1982. Yield of interminate soybean in response to multiple period of soil water stress during reproduction. Agron. J. 74 (5): 855-856.

Takahashi, M.2007.Development of a supernodulating soybean cultivar and studies on its physiological and agronomic properties. Bulletin of the National Institute of Crop-Science. (8): 49-108.

Taware, S. D., Raut, V. M., Halvankar, G.B. and Patil, V. 1994. Phenotypic stability analysis of soybean varieties in kharif and summer season. J. oilseed res. 11 (2): 237-241.

Tiwari, S.D. Joshi, H. J. 1988. Correlation and path analysis of seed quality characters in soybean. J. Oilseeds Res. 6: 51-57.

Toledo, JFF de., Oliveira, MF de., Tsutida, AC., Kiihl, RAS., De Toledo , JFF., De Oliveira, MF. 1993. Genetic analysis of growth of determinate soybean cultivars under three photoperiods. Revista Brasileira de Genetica.. 16: 3, 713-748.

Tony Ngalamu, Silvestro, Meseka., and Mohammed, Ashraf. 2012. Performance of soybean (Glycine max L. Merrill) cultivars under different planting dates in Sennar State of the Sudan Journal of Applied Biosciences (J. Appl. Biosci.)Volume 49: 3363 - 3370.

Uddin, M. K., Hasan, M. K., Alam, A.K.M.A. 2007. Effect of planting time on canopy structure and biomass production in some soybean cultivars. Journal of Agriculture and Rural-Development Gazipur. 5(1/2): 25-29.

Vishawakarma, S. K., Sharma, R.S. and Upadhyaya, V. B. 1998. Effect of source and level of sulphrur on chlorophyll, protein and oil inputs in soybean (Glycine max (L.) Merrill). J. oilseed Res. 16 (2): 343-345.

Vanangamudi, K. 1988.Storability of soybean as influenced by variety, seed size and storage container. Seed Res, 16(1):81-87.

Wells, R., Burton, J.W., Kilen, T.C. 1993. Soybean growth and light interception response to differing leaf and stem morphology. Crop Science. 33: (3), 520-524.

Whitehead, F.H. and Myers Cough, P.J. 1962. Growth analysis of plants. The ratio of mean relative growth rate to mean relative growth rate of leaf area. New physiol. 61: 314 - 321.

Yadav, R.K. 2007. Path analysis for seed yield and quality attributes in soybean (Glycine max. L. Merrill). International J. of Plant Sci. Muzaffarnagar. 2007; 2(1): 16-17.

Yadav, R.K. 2007. Path analysis for seed yield and quality attributes in soybean (Glycine max. L. Merrill). International J. of Plant Sci. Muzaffarnagar. 2007; 2(1): 16-17.

Yashima, Y., Kaihatsu, A., Nakajima, T. & Kokubun, M. (2005). Effects of source/sink ratio and cytokinin application on pod set in soybean, Plant Production Science 8: 139-144.

Yogendra Mohan and Hari Har Ham. Seed quality aspects in soybean [Glycine max (L.) Merrill] G.B. Pant University of Agriculture and Technology. Pantnagar - 263 145. India.

Zhang, G.D. 1994. New soybean varieties Heihe-8 crop genetic Resources. 4:50.

Zhao HongXiang, Xu KeZhang. Yang-GuangYu, Yang ChunMing, Bian-ShaoFeng, Lu-JingMei 2008. Changes and correlations between yield and partial physiological characters in leaves of soybean cultivars. Acta Agronomica Sinica 34(7): 1259-1265.

Zhang-Wei., Xie-FuTi., Zhang-HuiJun., Song-XianJun., Wang-HaiYing. 2007. Canopy and yield characteristics of super-high-yielding soybean cv. Liaodou No. 14. Scientia Agricultura-Sinica.40 (11): 2460-2467.

Appendix B

Table 3.1: Weekly patterns of different meteorological parameters during 2015-2016 at Labhandi, Raipur.

SMW	Date	Max. Temp. (°C)	Min.Temp. (°C)	Rain- fall (mm)	Rainy days	Relative Humidity (%)		Wind Velocity (Kmph)	Sun Shine (hours)
						I	II		
26	**Jun 25-01**	33.5	25.0	25.8	4	87	59	9.3	4.3
27	**Jul 02-08**	33.6	25.2	41.8	2	79	64	9.1	5.9
28	**09-15**	31.2	25.2	72.8	5	89	80	7.9	1.7
29	**16-22**	31.8	25.6	7.8	1	91	71	8.0	2.4
30	**23-29**	30.7	25.1	43.6	1	90	70	7.9	3.4
31	**30-05**	31.2	25.2	48.7	3	86	69	10.4	4.6
32	**Aug 06-12**	30.8	24.7	36.6	1	94	73	4.8	2.5
33	**13-19**	31.7	25.3	126.4	3	94	73	7.5	4.1
34	**20-26**	32.3	25.9	23.6	1	87	65	8.1	6.5
35	**27-02**	30.8	25.0	37.9	6	94	80	4.9	1.2
36	**Sep 03-09**	33.0	25.5	10.0	1	93	64	4.7	6.9
37	**10-16**	33.5	25.4	68.4	2	93	62	3.8	6.8
38	**17-23**	30.1	25.1	135.4	2	94	78	5.8	3.1
39	**24-30**	32.5	24.6	0.0	0	92	57	3.0	7.2
40	**Oct 01-07**	33.7	24.4	0.0	0	92	51	2.4	7.7
41	**08-14**	33.9	22.2	0.0	0	89	47	3.0	8.7
42	**15-21**	33.4	22.8	0.0	0	91	45	2.4	8.7

RESUME

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