

**PHYSIOLOGICAL ANALYSIS OF YIELDING ABILITY
IN COTTON (*Gossypium species* L.)**

BY

SAMIR SANTUKRAO KANHEKAR
B. Sc. (Agri.)

T 3489



Dissertation

*Submitted To The Marathwada Agricultural University
In Partial Fulfilment Of The Requirement
For The Degree of*

MASTER OF SCIENCE

(Agriculture)

IN

**AGRICULTURAL BOTANY
(PLANT PHYSIOLOGY)**

**DEPARTMENT OF AGRICULTURAL BOTANY
MARATHWADA AGRICULTURAL UNIVERSITY
PARBHANI 431 402 (M. S.) INDIA**

1998



*Affectionately
Dedicated
to my
beloved parents*



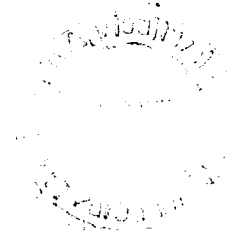
CANDIDATE'S DECLARATION

I hereby declare that the dissertation or part thereof
has not been previously submitted by me
for a degree to any other
institution or
University

PARBHANI
DATE : 13 /12/1998


(S.S. KANHEKAR)

Dr. V.S. HUDGE
M.Sc. (Agrl.), Ph.D.
Associate Professor,
Department of Plant Physiology
Marathwada Agricultural University,
Parbhani 431402. (M.S.), India.

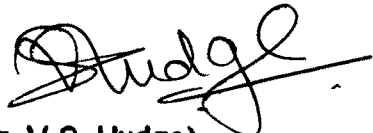


CERTIFICATE I

This is to certify that **Shri Kanhekar Samir Santukrao** has satisfactorily prosecuted his course of research for a period of not less than four semesters and that the dissertation entitled "**PHYSIOLOGICAL ANALYSIS OF YIELDING ABILITY IN COTTON (*Gossypium species* L.)**" submitted by him, is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination.


I also certify that, the dissertation or part thereof has not been previously submitted by him for the award of a degree of any university.

PARBHANI
DATE 13/12/1998

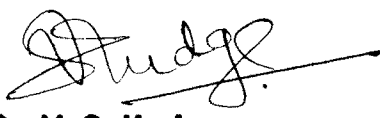

(Dr. V.S. Hudge)
Guide

CERTIFICATE II

This is to certify that the dissertation entitled "**PHYSIOLOGICAL ANALYSIS OF YIELDING ABILITY IN COTTON (*Gossypium species* L.)**" submitted by **Shri Kanhekar Samir Santukrao** to the Marathwada Agricultural University, Parbhani in partial fulfillment of the requirement for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in the subject of **AGRICULTURAL BOTANY (Plant Physiology)** has been approved by the student's advisory committee after oral examination in collaboration with the external examiner.

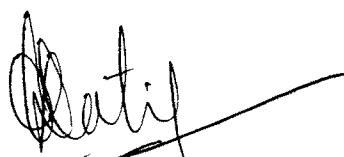


External Examiner



Dr. V. S. Hudge
Guide

Members of Advisory Committee



Associate Dean (P.G.),
College of Agriculture,
M.A.U., Parbhani.



Dr. M.B. Misal



Prof. M.R. Shobhane

ACKNOWLEDGEMENT

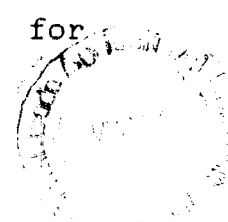
Emotions can not be adequately expressed in words because then emotions are transferred in to more formality. My acknowledgements are many times more than what I am expressing here.

First of all. I would like to express deep sense of gratitude to Hon'ble Research Guide Dr. V.S. Hudge, Associate Professor, Plant Physiology, M.A.U., Parbhani for suggesting the problem, his valuable guidance, keen interest, timely suggestions, constructive criticism and constant encouragement during the entire course of study till the finalization of dissertation.

I am gratefully acknowledged my thanks to Dr. M.R. Salunke, Professor, Plant Physiology, M.A.U., Parbhani for providing all the facilities required to conduct the present investigation and constant encouragement during the entire course of study.

I am grateful to Advisory Committee Members, Dr. M.B. Misal, and Prof. M.R. Shobhane for their timely suggestions and valuable guidance throughout the conduct of research and finalization of this dissertation.

I am grateful towards Dr. R.K. Bhalerao, Dr. Sathe, Dr. A.N. Gitte, Prof. S.S. Bhosale, Prof. B.D. Borade, Shri Dhoke, V.D. and other staff members of Plant Physiology Department for



their time to time help and encouragement in successfully completion of my post-graduation study.

I am thankful to Dr. V.D. Patil. Associate Dean (P.G.), College of Agriculture. Parbhani for providing the required facilities of post-graduate study.

Words will be inadequate to express my sense of gratitude and indebtedness towards my father Shri. Santukrao Ramrao Kanhekar and mother Sow. Suhasini Santukrao Kanhekar who have encouraged me in building my career from better to best. I am also thankful to my everloving brother Mr. Sachin Kanhekar for his help, co-operation and constant encouragement throughout my educational career.


I have no words in my mind to express my thanks to dear Dr. V.M. Bhale for his valuable guidance, useful suggestions and untiring help, co-operation and constant encouragement throughout my educational career.

I am very much thankful to my uncle Shri. S.S. Sontakke and my friend Shri. Jitendra for his neatly type setting, shaping and timely completion of computerized printing of the thesis.

Place : Parbhani

Date : /12/1998




(S.S. Kanhekar)



C O N T E N T S

Sr. No.	CHAPTER	PAGE NO.
1.	INTRODUCTION	1-4
2.	REVIEW OF LITERATURE	5-16
3.	MATERIALS AND METHODS	17-25
4.	RESULTS	26-54
5.	DISCUSSION	55-60
6.	SUMMARY AND CONCLUSION	61-64
	LITERATURE CITED	I-IX



LIST OF FIGURES

Sr. No.	TITLE	BETWEEN PAGE
1.	Plan of layout.	19-20
2.	Genotypic differences in respect of plant height of cotton.	26-27
3.	Genotypic differences in respect of number of leaves of cotton.	27-28
4.	Leaf area as expressed by genotypes of cotton.	29-30
5.	Genotypic differences in respect of number of squares of cotton.	31-32
6.	Total dry matter accumulation in various genotypes of cotton.	37-38
7.	Seed cotton yield of different genotypes of cotton.	50-51

LIST OF TABLES



Sr. No.	TITLE	PAGE NO.
1.	Weekly weather data during crop growth period.	18
2.	Mean height (cm/plant) of different hybrids and varieties of cotton.	26
3.	Mean number of functional leaves of hybrids and varieties of cotton at various growth stages.	28
4.	Mean leaf area / plant (cm ²) of different hybrids and varieties of cotton at various growth stages.	30
5.	Number of squares per plant of hybrids and varieties of cotton at various growth stages.	32
6.	Mean dry weight of leaves (g/plant) of different hybrids and varieties of cotton at various growth stages.	33
7.	Mean dry weight of stem (g/plant) of different hybrids and varieties of cotton at various growth stages.	36
8.	Total dry weight (g/plant) of different hybrids and varieties of cotton at various growth stages.	37
9.	Absolute Growth Rate (AGR) for different hybrids and varieties of cotton at various growth stages.	40



Sr. No.	TITLE	PAGE NO.
10.	Relative Growth Rate (RGR) for different hybrids and varieties of cotton at various growth stages.	41
11.	Leaf Area Index (LAI) of different hybrids and cotton at various growth stages.	43
12.	Leaf Area Ratio (LAR) of different hybrids and varieties of cotton at various growth stages.	44
13.	Specific Leaf Area (SLA) of different hybrids and varieties of cotton at various growth stages.	45
14.	Specific Leaf Weight (SLW) of different hybrids and varieties of cotton at various growth stages.	47
15.	Mean Leaf Weight Ratio of different hybrids and varieties of cotton at various growth stages.	48
16.	Net assimilation rate (NAR) of different hybrids and varieties of cotton at various growth stages.	49
17.	Mean yield (kg/ha) and post harvest studies of cotton cultivars.	51
18.	Chlorophyll, Nitrogen, Phosphorus and Potassium content of leaves in per cent at 50 per cent flowering stage of different hybrids and varieties of cotton.	53

LIST OF FIGURES



Sr. No.	TITLE	BETWEEN PAGE
1.	Plan of layout.	19-20
2.	Genotypic differences in respect of plant height of cotton	26-27
3.	Genotypic differences in respect of number of leaves of cotton.	28-29
4.	Leaf area as expressed by genotypes of cotton.	30-31
5.	Genotypic differences in respect of number of squares of cotton.	32-33
6.	Total dry matter accumulation in various genotypes of cotton.	37-38
7.	Seed cotton yield of different genotypes of cotton.	51-52

LIST OF FIGURES



Sr. No.	TITLE	BETWEEN PAGE
1.	Plan of layout.	19-20
2.	Genotypic differences in respect of plant height of cotton	26-27
3.	Genotypic differences in respect of number of leaves of cotton.	28-29
4.	Leaf area as expressed by genotypes of cotton.	30-31
5.	Genotypic differences in respect of number of squares of cotton.	32-33
6.	Total dry matter accumulation in various genotypes of cotton.	37-38
7.	Seed cotton yield of different genotypes of cotton.	51-52



Introduction

INTRODUCTION

Cotton (*Gossypium species*) is the major commercial crop of the world and particularly in India. The agricultural commodity in the world has exercised such a profound influence on men and matter as cotton has done for time immemorial. Cotton provides raw material to the textile industries which is the largest industry in India. Millions of men, women and cultivators are engaged in the textile industry. Indian cotton plays a dominating role in the international trade for its gross and quality fibres.

Origin of cotton plant and use of cotton fibre are shrouded in obscurity. The references made in the Vedas and Mant other historical literature, however indicate that the earliest civilization to spin and weave cotton was that of India and for over 3000 years. India was recognized as grade of cotton industry since time immemorial. India has been the producer of cotton and the first and most beautiful cotton fibres.

Chiefly as fibre crop, cotton is cultivated in about 60 countries of the world but ten countries viz. Russia, USA, China, India, Brazil, Pakistan, Turkey, Egypt, Mexico and Sudan accounts nearly 85 per cent of the total production.

India accounts eight million hectares area under cotton and ranking first in acreage but stands fourth in the total production, while USA stands second in area and first in production. India producing 7.8 million bales of cotton annually

weighing each of 170 kg.

In India, Maharashtra stands first in area as well as production of cotton which accounts 270 thousand hectares and 1630 thousand bales of 170 kg (Anonymous, 1997).

Even though a large area is under cultivation of this crop, the average per hectare yield of cotton in India is less. Efforts are being made for stepping up the cotton yield by adopting various breeding techniques and agronomical practices. New high yielding varieties are being evolved but a variety, however can not reach its maximum potential without the corresponding improvement in cultivation packages.

In general the indigenous or Asiatic varieties are grown almost entirely under rainfed conditions and the American varieties under irrigation. The yield potential of American cotton is higher as compared to *arboreum* cotton but it is also evident that *arboreum* can produce higher yield than other cotton species under better management.

Inamdar et al. (1925) were the first workers to carry out growth analysis of the cotton plant under Indian conditions. They compared the relative growth rate of plants grown in different periods of the year. The maximum of the case was reached sooner or later according to the duration of the vegetative period. The shorter the vegetative period, the earlier the maximum reached. The maximum increase was then a phenomenon of some physiological importance and required further elucidation.

Among the many other reasons for low yield of cotton, physiological boll shedding is recognized as an important reason. Sun (1965) reported that the development of squares in to flowers was 78.4 per cent and that of flowers in to bolls was 22.4 per cent in cotton. Abscission is one of the important causes of boll shedding in cotton. Formation of abscission zone depends upon the ratio of hormones on distal and proximal side of abscission zone. Abscission does not occurs when the endogenous auxin concentration is high at the distant side and low at the proximal side of the abscission zone. Abscission occurs when the gradient become slight or natural and is accelerated when gradient is reversed.

It is to note that treatment with growth regulators such as NAA, increased boll setting and yield of seed cotton (Bharadwa) and Similote, 1972), but effects have not been consistently obtained apparently due to operation of some unfavorable seasonal factors.

Crop yields are influenced by several factors like variety, environment and agronomical practices. Yield levels are different with the varieties under a given set of environmental conditions. The knowledge of plant physiology helps to understand the several processes responsible for growth and yield variation in a particular crop variety. It is therefore necessary to know which of the growth and yield characters are responsible for improving seed cotton yield so that their potentiality may be fully exploited to achieve higher production.

The vertical differences do exist in the crop growth and yield in any crop as a result of complementary action of many physiological growth components like leaf area, leaf area index, leaf area duration, net assimilation rate, relative growth rate and crop growth rate.

A physiological probe on the development of crop in logical sequences to elucidate and account the causes for the differences in yield through the events that had occurred earliest in the growth is the growth analysis technique (Krishnamurthy *et al.*, 1973).

Growth analysis techniques has greatly helped scientists to brake the yield barriers in cotton, wheat, barley and sugarcane. These techniques have helped in manipulating outer environment, agronomical practices and reconstitution of recognized genes in increasing yield.

In view of the above consideration, the present investigation "Physiological analysis of yielding ability in cotton (*Gossypium species* L.)" was undertaken with the following objectives.

1. To study the physiological parameters at critical stages of crop growth and
2. To study the growth and yield of *hirsutum* and *arboreum* cottons.



***Review of
Literature***



REVIEW OF LITERATURE

Cotton is a major cash crop of Maharashtra being cultivated on large areas in *kharif* season. Many genotypes are available for the cultivation from Agricultural Universities and private organization. The growth pattern of these genotypes belonging to *arboreum* and *hirsutum* species differed genetically. Growth is important parameter for efficient crop production, various factors and close relevance like photosynthesis, respiration, transpiration are prominent for healthy growth and subsequently for good production. The present investigation was conducted to study the growth pattern of various genotypes. The research work carried out by various scientists on the physiological analysis of growth, yield and yield attributing performance of different hybrids and varieties of cotton is briefly reviewed in this chapter under appropriate heads.

2.1 Growth and development

Watson (1947) suggested that since dry matter increase is due to photosynthesis and interception of light, a better measure of the 'Reproductive capital' would be leaf size, and therefore, he proposed use of LAI defined as the area of leaf material divided by the ground area occupied by plant.

Pearce *et al.* (1965), Ludwig *et al.* (1965), Ashley *et al.* (1965), Bik and Hanway (1966), Hayashi (1966), Weber *et al.* (1966) and Iwata and Okuba (1971) concluded that dry matter

production was proportional to LAI development at early stage.

Another important development is that the leaf area duration (LAD) has got more relation with dry matter and grain yield than LAI, as noted in wheat (Welbank *et al.*, 1966), Groundnut (Enyi, 1977 and Shastry *et al.*, 1979 and 1980).

Zeid (1973) recorded optimum curves of dry matter of individual leaves reaching the peak values nearly 40 days after the start of leaf growth in wheat.

Akiyama and Takeda (1975) stated that the dry matter production was regulated by the amount of leaf development and there was correlations between LAI and CGR.

Studies on growth analysis of maize hybrids by Pressenya *et al.* (1976) revealed that CGR, relative leaf growth rates were the same for both the hybrids under study (OSSK-288 and DK x L 342) up to the 14th week by which time leaf growth rate had fallen practically to zero. RGR was positively correlated to CGR for both hybrids.

John and Jones (1977) could obtain little or no success. It was assumed that the partitioning of photosynthesis in to new leaf etc. is an important concept of growth. RGR was compared to NAR. Partitioning of daily weight gain in to new leaf area and leaf weight of nine species grown in growth chamber under three temperature regimes. Day / night temperature of $21^{\circ}/10^{\circ}$, $32^{\circ}/21^{\circ}$ and $38^{\circ}/27^{\circ}\text{C}$ caused large difference in RGR. RGR was closely correlated with leaf area partitioning in seven of the nine species but were inversely correlated with leaf weight partitioning for six of the nine species. RGR was correlated with

NAR for five of the nine species. These results indicated that the growth responses due to temperature shifts was more sensitive to changes in leaf area partitioning on relative leaf area expansion rates than to NAR.

Fairey (1978) observed that stem, root leaves and husk of the primary ear were the sites for the temporary storage of dry matter during the early stage of maize grain growth. The dry matter, principally sugars, was remobilized and translocated to maturing grains during the second half of the grain filling period. Leaves supply assimilates preferentially to proximally located sinks in maize crop. Stem dry matter of maize increased during early grain growth and then declined (Fairey and Daynard, 1978). The dry matter production declined towards grain maturity.

Kalabarne and Pande (1979) reported that the differences between cultivars for RGR and NAR were not significant. The differences in CGR were noticed at 28-35, 35-52 and 42-49 days after sowing. Further it was noticed that the changes in CGR, NAR, LAR and SLW were markedly pronounced with advancement of the development stages. It was observed that there was a marked decline in NAR during the flowering and early seed setting stages of different cultivars. This was possibly due to an increase in leaf area and consequent mutual shading.

Lad (1979) reported no significant differences in functional leaves per plant at any of the stages of crop growth after studying the comparison of two *hirsutum* cotton varieties at Parbhani.

Ibrahim and Buxton (1981) reported that dry matter accumulation of okra and super okra leaves was lower than that of normal leaves. It was also noticed that dry matter partitioning into leaf area was also lower for the mutant leaf types particularly super okra types.

Bhatt and Nathan (1983) observed irrespective of the species treatments reduced significantly the height, number of bolls, boll weight and yield of seed cotton, though there were varietal differences in the number of nodes and fruiting branch. Main stem leaf appeared to influence vertical growth, fruit set and fruit growth in cotton.

In a varietal trial, Patil and Patil (1983) recorded highest leaf area and LAI in the variety 111P.

Bozhinov and Dimitrova (1984) compared growth and development of five cotton cultivars in 1976, a cold year (heat sum 3167 C) and in 1978 on normal year (heat sum 3517 C). It was noticed that the low temperature in June, July and August increased plant height, which was higher in low yielding and late maturing cultivars and under irrigated condition the stem height at which the sympodial branches appeared was directly correlated with temperature in May and June. In 1976 there was positive correlation between height of plant and number of fruiting organs formed.

At Surat, plant of G-2637 and G.Cot-10 were found significantly taller than those of Surat dwarf but almost similar with each other (Anonymous, 1984-85a). In the same studies, the former two varieties recorded almost similar number of monopodial

branches per plant but produced significantly higher number of monopodial branches per plant than Surat dwarf. Also different cotton varieties showed variation in number of sympodial branches per plant. Dry matter accumulation per plant recorded at first boll bursting was significantly higher in G.Cot-10 and G-2637 than variety Surat dwarf.

Height of plant denotes the vigour in growth. Sarkar *et al.* (1984) studied six crosses of cotton and noticed highly significant and positive correlation between height of plant, monopodial branches per plant.

In studies on indexing boll development and retention in cotton varieties for estimating yield of seed cotton, Patil (1986) noticed that the boll development index / efficiency (BDI) was significantly and negatively correlated with the mean maximum number of squares / plant. The index of boll retention (BRI) was higher than the BDI showing higher sensitivity of squares to competition between adjacent fruiting parts than the developed bolls. It was also seen that the harvest index showed weak association with most of the characters.

Kumaraperumal and Naidu (1986) studied the patterns of boll growth in linted and lintless cotton genotypes. Growth patterns of boll and its components in cotton cultivars, Suvin and MCU-5 and one lintless mutant genotype of MCU-5 were investigated. Relative growth rate of boll and its components declined with the advancement of boll age. RGR was found to be significant to entire boll, whereas among the individual component, it was significant for fibres only. Cultivars

exhibited increase in RGR of fibre during mid course of fibre development when growth rates of seeds and fibres decreased. Fibre RGR declined comparatively in MCU-5 due to early maturation of boll. Lintless mutant of MCU-5 showed significant increase in RGR's of boll, fibre and seed during active boll growth period due to compensatory increase in growth rates in the absence of fibre.

Singh (1986) studied the effect of low light intensity on growth and yield of rainfed cotton. Reduction in light intensity reduced the rate of photosynthesis as indicated by NAR and LAE (leaf area efficiency) but LAR and SLA increased. Dry matter of the genotypes increased significantly with 35 per cent reduction in light intensity. When it was further reduced to 65 per cent, the dry matter of SRT-1 and B-1007 remained unchanged and that AKH-4 was the same as under natural light but reduced significantly in C-1412. The genotypes AKH-4 and C-1412 appeared outstanding as they mentioned higher seed cotton yields and higher fruiting coefficients by apportioning more photosynthates for seed cotton production even when the light intensity was reduced to 65 per cent.

Giri (1988) reported in his studies that the variety NH-262 gave taller plants, more values of functional leaves, sympodia, leaf area, LAI, dry matter accumulation in stem, leaves than the cultivar PH-36, Purnima and variety PK-081.

Kumarao Perumal and Rao (1991) studied effect of low light during ontogeny in five cotton genotypes and observed 30 per cent reduction in normal light increased cotyledonary area.

plant height and leaf area. Low light increased stomatal resistance and chlorophyll content in leaf, leaf weight and T_r constant decreased under low light.

Wollschleger and Oosterhuis (1991) studied photosynthesis, transpiration and water use efficiency of cotton leaves and fruits. They found subtending leaves at main stem nodes of 8 and 10, achieved the maximum P_n of $0.82 \text{ mg (CO}_2\text{) m}^{-2}\text{s}^{-1}$ as compared to $0.12 \text{ mg (CO}_2\text{) m}^{-2}\text{s}^{-1}$ for the bracts. In general the rate of transpiration was $260 \text{ mg (H}_2\text{O) m}^{-2}\text{s}^{-1}$ at 10 days after anthesis. Estimate of daily fruit WUE increased from $22 \text{ g (dry mass produced) kg}^{-1} \text{ (H}_2\text{O lost)}$ at six days after anthesis to over $140 \text{ g (dry mass) kg}^{-1} \text{ (H}_2\text{O)}$ during peak dry matter accumulation.

Prado *et al.* (1992) worked on comparison of the growth and photosynthetic activity of two varieties of cotton and observed no significant differences during first six week period.

Reddy *et al.* (1992) observed cotton crop responses to a changing environment. It is suggested that cotton species or cultivars tolerant to high temperatures will be highly desirable.

Dhingra *et al.* (1993) studied the reproductive functions of cotton using six genotypes of *arboreum* and one *hirsutum* cotton. These cultivars differed in the number of flowers per plant, anthers per flower, pollens per anther, pollen germination behaviour and sensitivities to incubation temperatures and number of ovules / pistil.

Koniger and Winter (1993) studied growth and photosynthesis of *G. hirsutum* L. at high photon flux densities, effect of soil temperature and nocturnal air temperature. The total dry weight and leaf area decreased with decreasing temperatures and light use efficiency of II were not affected. The higher soil temperature increased total Dw by 28-55 per cent.

Rasulov (1993) studied the regulation of Pn CO₂ exchange in cotton leaves under progressive soil water deficiency and observed indirect effect on components determining the rate of photosynthesis / CO₂ exchange.

Bondada *et al.* (1994) studied anatomical consideration related to photosynthesis in cotton leaves, bracts and the capsule walls. Light microscopy revealed that leaf thickness was about 102 um and that had a wall defined internal organization with elongated palisade mesophyll cells and loosely packed spongy mesophyll cells.

Ronde *et al.* (1995) studied biochemical responses of six cotton cultivars to heat stress and found that the efficiency of protein synthesis is increased from control treatment (29^o) to moderate stress (40^o) and decreased during severe stress.

Sassenrath-Cole (1995) studied dependence of canopy light distribution on leaf and canopy structure for two cotton species and observed diverse growth habits at different stages. The leaves of *G. barbandense* showed more electrophile canopy as compared to other species.

Warner Donn *et al.* (1995) studied responses of carbon metabolism to night temperature in cotton. They found cotton is sensitive to low temperature during all phases of growth. Less starch accumulation occurred during the day in the cool night temperatures. Similarly, reduced shoot and root growth; increased days to first bloom, delay in boll development were noticed. It involves dampening of starch accumulation during the day and its catabolism at night. Suggesting the CHO supply is balanced to sink demand at these temperatures.

Zheng *et al.* (1996) found that the seed yield and dry matter accumulation in aerial parts of four tested upland cotton (*Gossypium hirsutum*) cultivars were higher than those of four sea island cotton (*G. barbadense*) cultivars between the square stage and boll opening stage. Most rapid dry matter accumulation in all cultivars was from initial flowering to effective flowering. The main period of dry matter accumulation in sea island cotton finished about 2 weeks earlier than in upland cotton. Patterns of dry matter distribution at different growth stages are described. Root and flower weight were higher in sea island than in upland cotton.

2.2 Yield and yield attributes

Watson (1952) noted that dry matter production increased almost linearly with increase in mean LAI over the whole range, but an assessment of the relative importance of the variation in leaf area and in NAR as determinants of dry matter yield between species must take in to account the differences in

the length of the growth period and stated that the appropriate measure for that purpose is the integral of LAI, over the growth period and it has the dimension of time and is termed as LAD.

Ashley *et al.* (1965). Bik and Honway (1966) and Hayashi (1966) reported linear relationship between yield and LAI in various crops.

Wankhede and Sadaphal (1977) noted that the yield of dwarf plant types was significantly superior to those of medium tall and tall ones.

Shaikh and Upadhyay (1981) conducted a field experiment on cotton and revealed that number of sympodial branches and picked bolls per plant had strong direct effect on yield of seed cotton per plant, plant height with yield was positive and significant but not strong. The yield of seed cotton was much influenced by number of sympodial branches, picked bolls per plant and height of the plant. Weight of boll was having negative direct effect on yield.

Devendra Singh and Bharadwaj (1983) compared nine varieties of *hirsutum* cotton and found that seed cotton yield was controlled by boll number as well as dry matter produced. Negative correlation was observed between boll number and boll weight and between dry matter and fruiting coefficient, suggested that for achieving higher seed cotton yield and optimum balance between dry matter and fruiting coefficient is necessary.

Bhatt *et al.* (1984) reported some physiological considerations for improving growth and yield of rainfed cotton. According to them higher seed cotton yields were given by early

maturing than by late maturing under rainfed conditions the early maturing varieties utilize soil moisture more efficiently.

At Surat amongst three varieties tried, G-2637 recorded significantly higher seed cotton yield (2132 kg/ha) than G.Cot-10 (1793 kg/ha) which intern differed significantly from Surat dwarf (1594 kg/ha). Earliness index of Surat dwarf was higher (0.81) than that of G.Cot-10 (0.60) and G-2637 (0.56). This indicates that Surat dwarf is earlier in maturity than G.Cot-10 and G-2637 (Anonymous, 1984-85a)

At Rahuri, the highest seed cotton yield of 2803 kg/ha was produced by PDN-86, followed by Kop-498 (2730 kg/ha), LRA-5166 (2667 kg/ha) and Laxmi (2225 kg/ha) all the varieties being at par with each other (Anonymous, 1984-85c).

In an experiment on promising strains, conducted at Cotton Research Station, Nanded, no significant differences were reported amongst NH-262, PH-36 and Purnima (Anonymous, 1985-86).

At Nanded, significant increase in the yield of seed cotton was obtained by the varieties 081, NH-262 and Surat dwarf over Purnima (Anonymous, 1986-87).

At Marathwada Agricultural University, Parbhani, NH-210 cotton variety had recorded the highest seed index (9.93) over other varieties. The second highest seed index was recorded in NH-352 (9.0) (Anonymous, 1986-87),

PH-36 recorded the highest seed cotton yield of 1154 kg/ha and 1836 kg/ha at Parbhani and Nanded, respectively and it was significantly superior over NH-262 and Purnima. However, it was at par with 081 (Anonymous, 1986-87).

Dhopte *et al.* (1988) studied influence of leaf morphology in ten cotton cultivars of *G. hirsutum*. They observed Tr was reduced in all leaf traits. Red pigmentation increased boll number by a minimum of 12.2 per cent irrespective of CV tested. Path analysis indicated direct effect of Tr and SC more prominent on seed cotton yield.

Dhopte *et al.* (1991) observed in cotton that genotypes differed in respect of various growth and yield attributes. H₄ had broad lobed and glabrous leaf, while AHH-468 had broad lobed with dense hairs (pilose) and higher canopy radiation reflection. 9

Masur (1991) studied the comparison of net photosynthesis rate, stomatal resistance and yield of two cotton cultivars under water stress and observed that differences in stomatal resistance was greater and photosynthesis rate lower, leaf water potential was grater. Fibre length decreased with water stress. Number of bolls per plant was affected but boll weight was not affected.

Bondada *et al.* (1996) studied canopy photosynthesis, growth, yield and boll N¹⁵ accumulation under N stress in cotton. They found that leaf number, leaf area, boll number and dry weights of leaf and boll were higher in the middle of the canopy than in the top or bottom portions.



Materials and Methods

MATERIALS AND METHODS

The investigation reported herein was carried out in the field during the *kharif* season of 1997-98. The details of the material used and methods applied during the course of investigation are described in this chapter.

3.1 Experimental site and soil

The field experiment was laid out in plot number 5 of the Department of Plant Physiology, College of Agriculture, Parbhani. The topography of the plot was fairly leveled. The soil was medium black with high water retention capacity.

3.2 Climate and weather conditions

Geographically Parbhani is situated at 19° 16' North latitude and 76° 47' East longitude and at 409 m altitude above mean sea level and has subtropical climate. The average annual precipitation is 920 mm in 70 rainy days which is received mostly during June to September. The precipitation is assured for *kharif* crop only. The daily mean maximum temperature varies from 27.8 to 31.6°C in winter to 38.3 to 42.6°C in summer, whereas the mean minimum temperature varies from 9.2 to 16.7°C in winter and from 23.8 to 26.9°C in summer. The weather data recorded at the Meteorological laboratory, Marathwada Agricultural University, Parbhani during the period of experimentation is given in Table 1.

Table 1 : Weekly weather data during crop growth period (1997).

Met. Week No.	Date	Rainfall (mm)	Temperature ($^{\circ}$ C)		Humidity	
			Max.	Min.	A.M.	P.M.
22	28-5 to 3-6	2.00	39.8	24.3	44	21
23	4-6 to 10-6	0.00	38.7	25.3	43	24
24	11-6 to 17-6	11.8	36.2	24.5	63	33
25	18-6 to 24-6	57.6	33.6	23.3	75	43
26	25-6 to 1-7	14.2	35.1	23.9	74	39
27	2-7 to 8-7	68.9	31.4	22.5	88	58
28	9-7 to 15-7	14.6	33.2	23.7	73	46
29	16-7 to 22-7	2.6	33.7	23.2	71	44
30	23-7 to 29-7	19.5	32.6	23.8	79	51
31	30-7 to 5-8	24.4	31.6	23.7	79	54
32	6-8 to 12-8	2.4	33.4	22.5	74	42
33	13-8 to 19-8	23.5	33.5	23.1	74	44
34	20-8 to 26-8	78.0	29.7	22.6	82	65
35	27-8 to 2-9	3.5	30.5	22.6	80	57
36	3-9 to 9-9	114.3	31.7	22.5	86	56
37	10-9 to 16-9	0.8	31.9	22.8	79	52
38	17-9 to 23-9	72.7	30.0	22.0	87	67
39	24-9 to 30-9	16.4	31.5	22.0	81	55
40	1-10 to 7-10	2.4	52.2	19.1	83	46
41	8-10 to 14-10	0.0	33.0	18.8	71	43
42	15-10 to 21-10	47.4	32.6	18.6	74	45
43	22-10 to 28-10	102.8	29.3	18.7	91	59
44	29-10 to 4-11	10.4	29.5	18.4	84	56
45	5-11 to 11-11	6.6	30.6	16.9	83	46
46	12-11 to 18-11	13.4	29.2	19.3	90	54
47	19-11 to 25-11	30.4	29.7	18.1	90	57
48	26-11 to 2-12	101.0	28.5	19.6	90	66
49	3-12 to 9-12	38.0	27.6	17.0	90	59
50	10-12 to 16-12	3.6	26.5	13.2	84	45
51	17-12 to 23-12	24.0	27.7	17.9	94	60
52	24-12 to 31-12	0.0	29.6	16.0	87	49

3.3 Material for investigation

Fourteen cotton genotypes which includes three high yielding *hirsutum* hybrids viz. NHH-44, PHH-316, PKV^{Hy}73 and their parents viz. BN-1 (M), AC-738 (F), PH-93 (F), PH-325 (M), AK-32 (F) and DHY-286^{Hy}(M), respectively. One straight American variety (LRA-5166), two *arboreum* varieties (PA-141 and PA-183) and one *arboreum* hybrid (Pha-46) used during investigation. Certified seeds of these genotypes were obtained from the Assistant Cotton Specialist, Cotton Research Station, Marathwada Agricultural University, Parbhani.

3.4 Layout design

The experiment was laidout in simple randomized block design with two replications. The 14 genotypes were randomly distributed in two blocks in each replication. The plan of layout adopted is given in Fig. 1.

3.5 Seeds and sowing

Sowing of the different genotypes was done on June 23, 1997 by hand dibbling. The spacing adopted was 60 x 60 cm for American hybrids and 60 x 30 cm for American straight varieties and *arboreum* varieties. The gross plot size, was 1.8 m x 2.4 m and the net plot size was 0.60 m x 1.8 m, 0.60 m x 1.20 m for American straight and American hybrids, respectively. The gap filling was done on tenth day of sowing. The thinning was done on fifteenth day of sowing followed by second week later, keeping one healthy and vigorous plant per hill.

PA-183
PHH-316
PKV-HY-3
PHA-46
NHH-44
DHY-286-IR
NH-452

PA-141
BN-1
PH-93
AC-738
LRA-5166
AK-32
PH-325

PH-93
AK-32
BN-1
PH-325
LRA-5166
AC-738
NHH-44

PKV-HY-3
PA-183
PA-141
PHH-316
PHA-46
NH-452
DHY-286-IR

Spacing (cm)

American hybrid

: 60 x 60 cm

American straight and arborium varieties

: 60 x 30 cm

Gross plot size

: 1.8 m x 2.4 m

Net plot size (American straight)

: 0.60 m x 1.2 m

Net plot size (American hybrids)

: 0.60 m x 1.8 m

FIG. 1 : PLAN OF LAYOUT.

3.6 Fertilizer application

Fertilizer application was done @ 100 kg N, 50 kg P_2O_5 and 50 kg K_2O per hectare in the form of urea, single superphosphate and muriate of potash to the American hybrids and its parents. However, fertilizers that is 50:25:25 NPK kg/ha were applied to *arboresum* genotypes. The 50 per cent of N was given as a basal dose and remaining 50 per cent was applied one month after sowing the crop.

3.7 Cultural operations

The operation of land preparation, fertilizer application, weeding and after care and harvesting was carried out as per the package of practices recommended by the Marathwada Agricultural University, Parbhani.

3.8 Biometric observations

Five plants were selected at random in each net plot for recording the morphological observations viz. plant height, number of monopodial and sympodial branches per plant, number of leaves, number of squares, number of bolls per plant and other characters.

3.9 Sampling techniques

One plant from each net plot was selected randomly for recording leaf area and dry matter studies. These plants were uprooted at each growth stages carefully without injury to the root system. The leaf area was recorded by Punch method. Plants

were then separated in to various component parts for dry matter determination. Dry weight was determined by separated each plant part and dried in hot air oven at 50°C till constant weight was obtained.

3.10 Growth analysis

The data recorded on growth characters viz. leaf area (LA) and dry matter (DM) per plant were further analyzed to find out absolute growth rate (AGR), relative growth rate (RGR), net assimilation rate (NAR), leaf area index (LAI), leaf weight ratio (LWR), specific leaf weight (SLW), specific leaf area (SLA) and leaf area ratio (LAR).

3.10.1 Absolute growth rate (AGR) (g/day/plant)

The absolute growth rate (AGR) is the total gain in weight (g) or height (cm) by a plant within a specific time interval. It is generally expressed as g/day or week/plant and was worked out by using the formula given by Richards (1969).

$$\text{AGR} = \frac{W_2 - W_1}{t_2 - t_1}$$

Where,

W_1 and W_2 are total dry weight at time t_1 and t_2 , respectively.

3.10.2 Relative growth rate (RGR) (g/g/day)

Relative growth rate at which plant incorporate new material in to its substances and is measured by relative growth rate of dry matter accumulation. It is calculated by using the formula given by Fisher (1921).

$$\text{RGR} = \frac{\text{Log}_e W_2 - \text{Log}_e W_1}{t_2 - t_1}$$

Where,

W_1 and W_2 are total dry weight at time t_1 and t_2 , respectively.

3.10.3 Net assimilation rate (NAR) (g/dm²/day)

Analysis of dry matter accumulation based on differentiation between assimilating leaves and rest of the plant is more important. The concept of Net assimilation rate (NAR) on area basis was introduced and used by Gregory (1917) to obtain from the simple growth measurement on estimate of the assimilatory efficiency of leaves. NAR is expressed as g/dm²/week.

$$\text{NAR} = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{\text{Log}_e A_2 - \text{Log}_e A_1}{A_2 - A_1}$$

Where,

A_1 and A_2 are the leaf areas at time t_1 and t_2 , respectively and W_1 and W_2 are the total dry weight of plant in gram at time t_1 and t_2 , respectively

3.10.4 Leaf area index (LAI)

Leaf area index (LAI) was calculated by using formula given by Watson (1952).

$$\text{LAI} = \frac{\text{Leaf area per plant (cm}^2\text{)}}{\text{Area covered by plant (cm}^2\text{)}}$$

3.10.5 Leaf area ratio (LAR)

Mean leaf area ratio is the extent of assimilatory surface supplying the unit by weight of the plant (White Head and Myerscough, 1962).

$$\text{LAR} = \frac{\text{Leaf area (cm}^2\text{/plant)}}{\text{Dry weight (g/plant)}}$$

3.10.6 Specific leaf weight (SLW)

Mean specific leaf weight was calculated according to Evans (1972) in mg/cm².

$$\text{SLW} = \frac{\text{Leaf dry weight (g)}}{\text{Leaf area (cm}^2\text{)}}$$

3.10.7 Specific leaf area (SLA)

Mean SLA is the measure of thickness of leaf and it was calculated according to Evans (1972) and expressed in dm²/g of dry leaf weight.

$$\text{SLA} = \frac{\text{Leaf area (dm}^2\text{)}}{\text{Dry leaf weight (g)}}$$

3.11 Post harvest studies

Three plants from each net plot were selected for post harvest studies. Post harvest studies on different yield attributing characters such as weight of seed cotton per plant, 1000 seed weight, halo length, ginning percentage and harvest index were recorded. The yield of seed cotton per plot was recorded and expressed in q/ha.

3.11.1 Ginning percentage

The ginning percentage of cotton samples was calculated in duplicate by hand ginning. The weighted quantity of seed cotton was ginned and the results were expressed in percentage.

3.11.2 Halo length (mm)

This was determined by taking five cotton seeds randomly with the help of halo disc and it is expressed in mm.

3.12 Chemical estimations

The leaves of different cotton genotypes under study were dried and finally powdered. This fine leaf powder was used for estimation of nitrogen, phosphorus and potassium contents of cotton leaves.

3.12.1 Nitrogen

Nitrogen was estimated on oven dry basis using Micro Kjeldahl's method as reported in A.O.A.C. (1963).

3.12.2 Phosphorus

Phosphorus was determined by Vandomolybdate's method (Johnson, 1962). The readings were recorded on spectronic 20 at 470 nm and standard curve was worked out by using KH_2PO_4 solutions of known concentrations.

3.12.3 Potassium

Potassium content was determined with the help of 'Flame Photometer'.

3.12.4 Chlorophyll content

The total chlorophyll content in the leaves was estimated by colorimetric method (Snell and Snell, 1954) at 50 per cent flowering stage. One gram fresh leaf sample was weighted accurately and chlorophyll was extracted in 80 per cent acetone. Volume of the extract after filtration was made to 100 ml. The readings were recorded on spectronic 20 using red filter at 550 nm. The readings were directly tabulated as optical density.

3.13 Statistical analysis

The data were statistically analyzed by the method of analysis of variance (Panse and Sukhatme, 1967).



Results



IV RESULTS

The data collected during the present investigation are reported here in this chapter.

4.1 Biometric observations

4.1.1 Height of plant

The data collected on mean height of plant are given in

Table 2.

Table 2 : Mean height (cm/plant) of different hybrids and varieties of cotton.

Varieties	Days after sowing				
	67	91	103	115	127
NHH-44	36.5	49.5	61.5	68.5	70.0
AC-738	24.3	53.6	62.0	71.5	78.5
LRA-5166	25.1	37.0	63.0	71.0	73.5
PH-325	45.1	61.6	67.5	78.0	81.9
BN-1	32.3	60.3	66.0	70.0	78.0
AK-32	42.0	51.4	57.5	69.0	73.0
PH-93	40.2	59.0	64.0	75.3	77.5
DHY-286-1A	42.3	56.3	58.5	71.4	76.5
NH-452	31.5	40.2	50.0	63.5	68.0
PHA-46	57.6	61.7	68.5	71.9	74.9
PHH-316	40.5	44.9	48.3	65.0	71.6
PA-141	35.7	54.5	68.0	85.0	90.0
PA-183	52.0	62.1	73.5	79.5	86.1
PKV-3	48.0	57.0	60.5	76.0	79.5
S.E. +	3.05	5.0	3.9	4.6	4.0
C.D. (p=0.05)	9.41	15.6	13.0	13.6	12.5

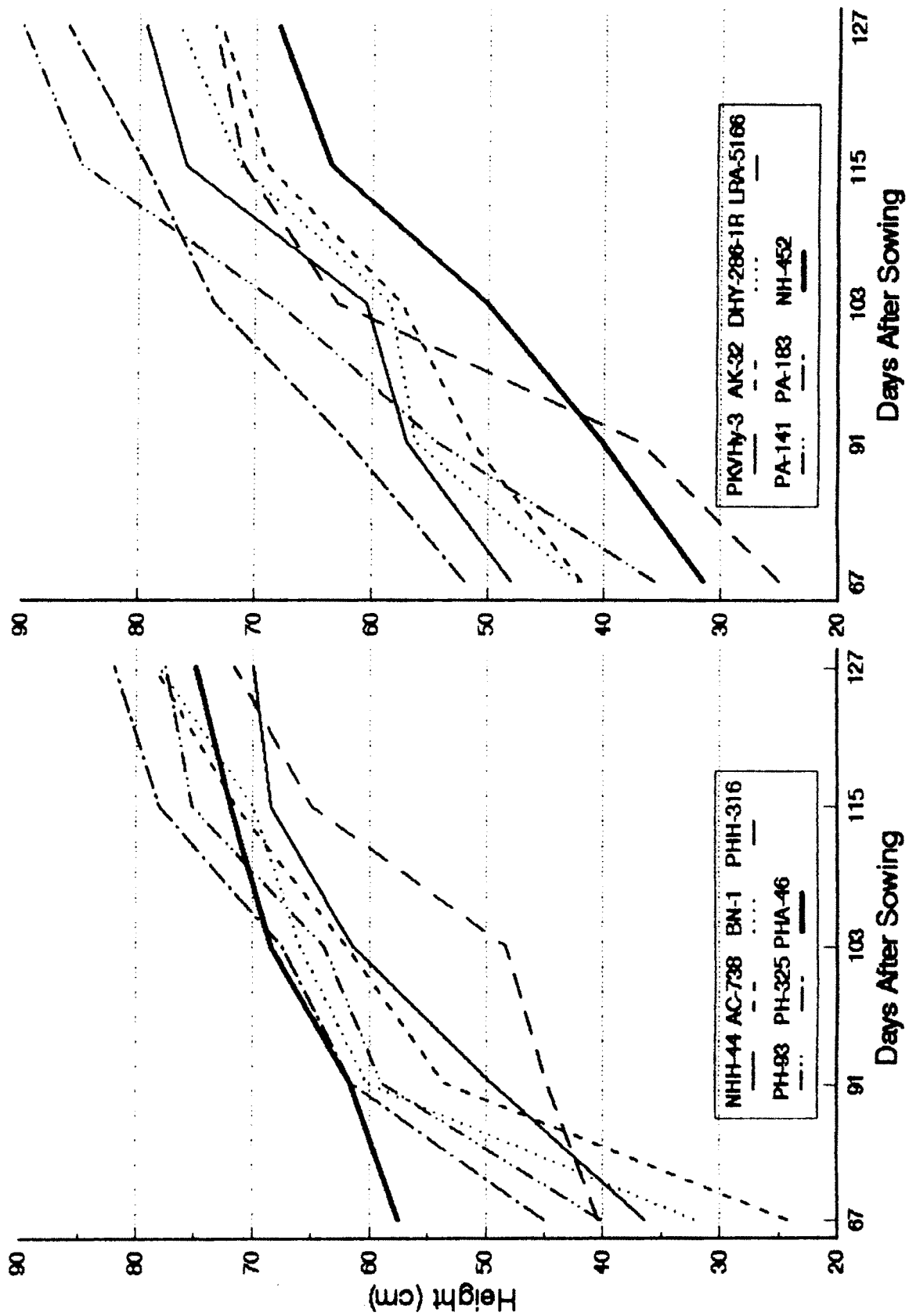


Fig. 2 : Genotypic differences in respect of plant height of cotton.

Cotton genotypes both hybrids and varieties showed increasing trend in the height of the plant. The height of all genotypes increased till the 127 days after sowing but the rate of increase was rapid between 67 to 91 days in most of the genotypes (Fig. 2).

Cotton genotypes showed significant variations in the height of the plant at all the stages of crop growth. At initial stage (67 DAS) the maximum height was noticed in PHA-46 which was significantly more than rest of the cultivars except PHH-316, PA-183 and PKV-3 genotypes.

At 91 and 103 DAS, maximum height was noticed in the genotypes PA-141 and PA-183. The *arboreum* genotypes recorded maximum height as compared to rest of *hirsutum* hybrids and *hirsutum* genotypes. At 127 DAS, the maximum height was recorded by PA-141 which was significantly superior to rest of the cultivars except PA-183, PKV-3, PH-325 and AC-738.

4.1.2 Mean number of leaves per plant

The data on mean number of functional leaves of hybrids and varieties of cotton at various growth stages are given in Table 3 and depicted in Fig. 3.

Table 3 : Mean number of functional leaves of hybrids and varieties of cotton at various growth stages.

Treatments	Days after sowing					
	55	67	91	103	115	127
NHH-44	19.5	35.5	47.5	63.0	56.5	29.0
AC-738	14.5	21.0	25.0	39.0	31.5	16.0
LRA-5166	17.0	22.0	28.0	44.0	36.5	19.0
PH-325	24.0	33.5 ✓	47.0 ✓	56.0	47.0	27.3
BN-1	23.0	30.0	42.5	58.5	43.5	27.5
AK-32	23.5	36.0 ✓	42.0 ✓	51.5	59.5	18.5
PH-93	14.9	20.5	22.1	36.0	34.0	12.0
DHY-286-1R	10.0	17.5	28.0	41.5	36.0	21.0
NH-452	9.0	11.0	33.5	38.5	28.5	32.5
PHA-46	19.0	35.0 ✓	39.0 ✓	56.0	46.0	24.5
PHH-316	27.6	32.0 ✓	34.0 ✓	53.5	43.5	27.0
PA-141	16.0	28.0	34.5	61.5	52.5	21.0
PA-183	14.0	22.5	36.0	45.0	35.0	13.5
PKV-3	20.0	37.0	47.5	65.0	54.5	34.5
S.E. +	3.47	2.23	2.32	4.48	4.56	3.58
C.D. (at 5%)	10.60	6.80	7.16	13.67	13.90	10.69

The functional leaves per plant were increased up to 103 DAS with subsequent decline during 115 and 127 DAS.

The differences among the genotypes for the production of functional leaves were statistically significant at all the crop growth stages (Table 3).

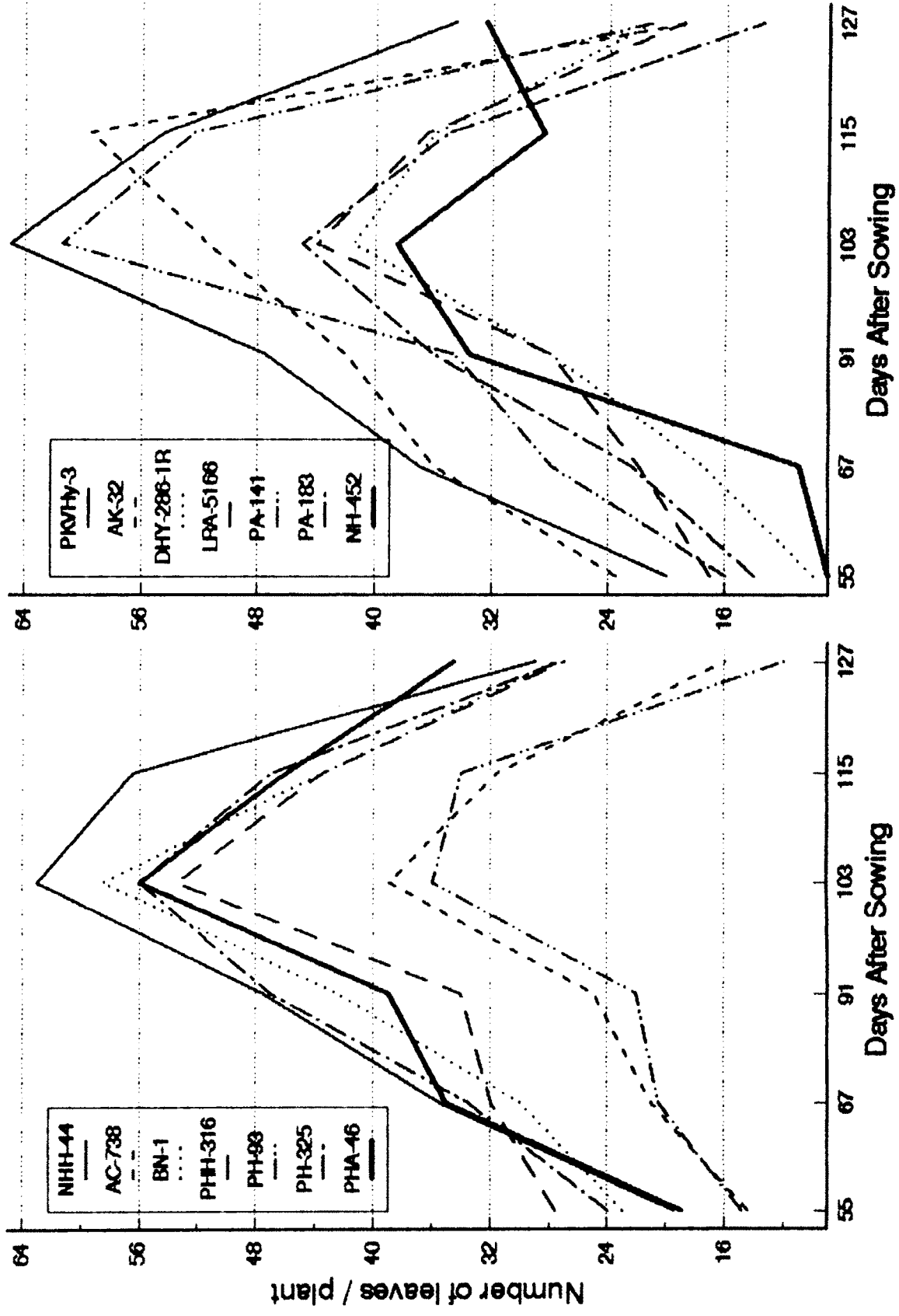


Fig. 3 : Genotypic differences in respect number of leaves of cotton.

The maximum functional leaves at early growth stage (55 DAS) were recorded in genotype PHH-316 which was statistically significant over the genotypes NH-452, DHY-286 and on par with rest of cultivars. ✓

At 67 days of growth stage, the maximum functional leaves were observed in the genotype PKV-3 which was on par with NHH-44, ✓ PH-325, AC-32, ~~PHA-46~~^M, PHH-316, PH-93 and significantly superior over rest of the cultivars at 91 days. The maximum number of functional leaves were consistently more in the cultivar NHH-44 at all the growth stages. ✓

At 103 DAS, the maximum functional leaves were observed in the hybrid NHH-44, followed by PKV-3 which was on par with PH-325, AK-32, PHA-46, PHH-316, PA-141 and significantly superior to rest of the genotypes. ✓

At 127 days of crop growth stage, NHH-44 recorded the maximum number of functional leaves which were significantly higher than rest of the genotypes except NH-452 with which it was at par. The lowest number of functional leaves were recorded in PH-93.

4.1.3 Mean leaf area per plant

The data recorded on leaf area per plant of different hybrids and varieties of cotton at various growth stages are given in Table 4 and depicted in Fig. 4.

Table 4 : Mean leaf area / plant (cm²) of different hybrids and varieties of cotton at various growth stages.

Treatments	Days after sowing						
	55	67	79	91	103	115	127
NHH-44	1044	1606	2707	4108	5834	5514	3645
AC-738	774	1075	1309	1621	3477	3895	2160
LRA-5166	907	1127	1405	1749	3923	4514	2250
PH-325	1281	1716	2409	3053	4993	5112	3713
BN-1	1231	1537	2112	2756	5223	5379	2362
AK-32	1254	1844	2502	3369	5051	5140	3147
PH-93	1281	1562	2119	2724	3923	4205	2620
DHY-286-RL	533	890	1379	1815	3670	4619	2835
NH-452	481	1079	1652	2173	3385	3525	4056
PHA-46	1014	1804	2109	2529	4993	5689	2437
PHH-316	1341	1406	1692	2205	2270	5304	945
PA-141	854	1434	1903	2238	5573	6497	2838
PA-183	747	1152	1743	2335	5012	4328	472
PKV-3	1067	1895	2488	3081	5750	6183	1957
S.E. +	186	114	152	433	714	575	510
C.D.(at 5%)	566	350	465	1289	2178	1756	1556

It was seen that the cotton genotypes exhibited increasing trend in the leaf area per plant and the peak value reached at 115 DAS and declined there after till 127 days of sowing (Table 4).

At 55 DAS, the genotypes PHH-316 recorded the maximum leaf area which was significantly higher than AC-738, DHY-286, NH-452 and PA-183 and on par with rest of the genotypes. At 67 DAS, the hybrid PKV-3 produced the maximum leaf area which

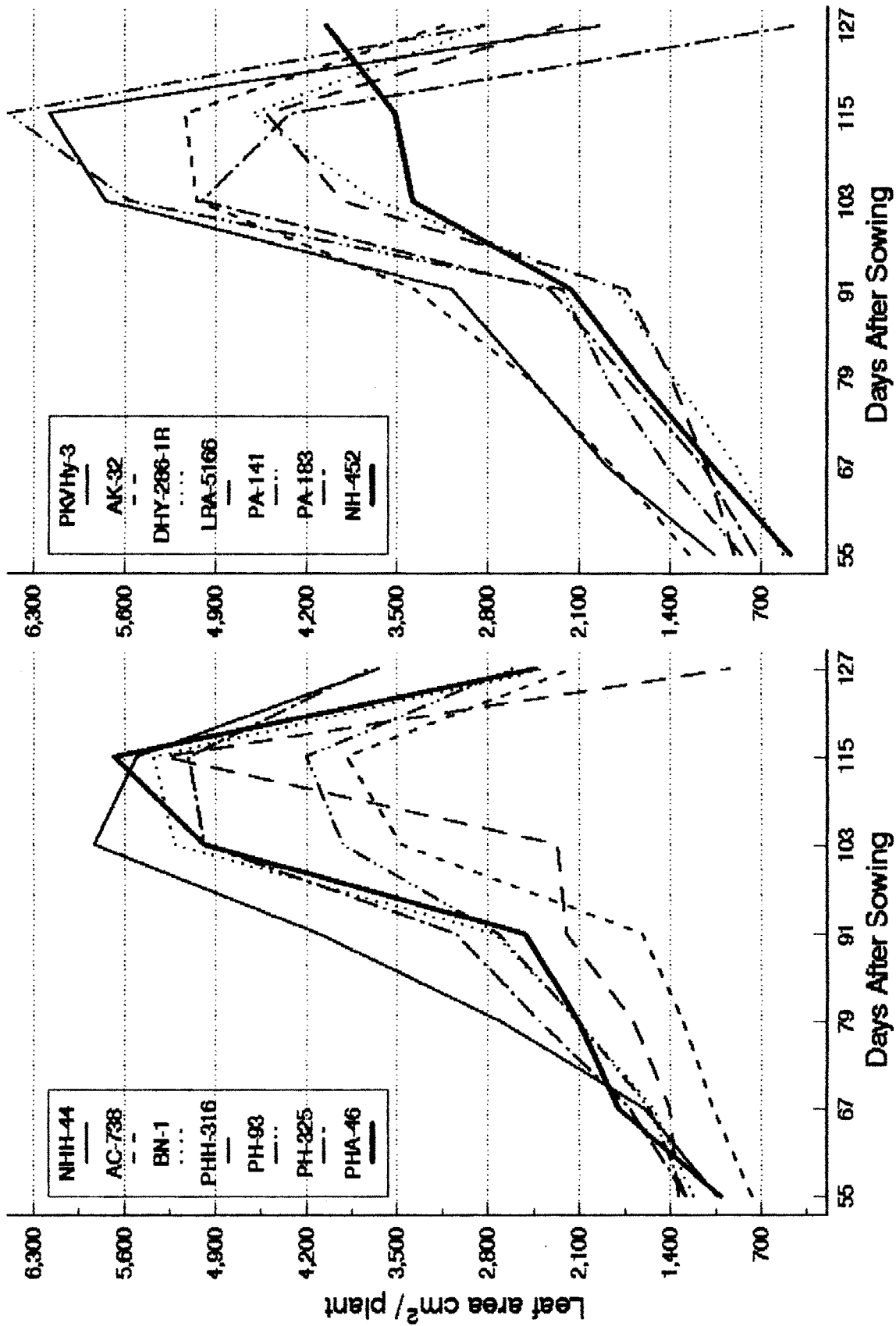


Fig. 4 : Leaf area as expressed by genotypes of cotton.



Fig. 4. Leaf area as expressed by genotypes of cotton.

was on par with genotypes NHH-44, AK-32, PH-325, PH-93, PHH-46 and significantly superior to rest of the genotypes.

At 79 and 91 days of sowing, the hybrid NHH-44 produced more leaf area which was on par with PH-325, AK-32 and PKV-3 and significantly more than rest of the genotypes.

At 115 days of crop growth stage, the maximum leaf area was observed in the genotypes AK-32, PA-141 followed by PKV-3, NHH-44. However, the lowest leaf area was noticed in the genotypes PHH-316.

At 127 days of crop growth stage, the genotype NH-452 recorded the maximum leaf area which was significantly higher than rest of the hybrids and varieties.

4.1.4 Number of squares per plant

The data on mean number of squares per plant of hybrids and varieties of cotton at various growth stages are mentioned in Table 5 and depicted in Fig. 5.

The data presented in Table 5 indicated that the number of squares per plant were increased up to 103 days of crop growth stage and declined there after in most of the varieties.

At 55 DAS, variety NHH-44 recorded maximum number of squares which were significantly higher than varieties AC-738, PH-325, DHY-286, PH-316 and PA-183 and on par with rest of varieties. At 67 DAS, variety PA-141 recorded significantly higher number of squares than rest of all genotypes.

T 3489



Table 5 : Number of squares per plant of hybrids and varieties of cotton at various growth stages.

Treatments	Days after sowing					
	55	67	91	103	115	127
NHH-44	5.20	9.5	15.5	30.0	40.5	47.0
AC-738	2.10	8.5	12.0	19.0	17.0	11.0
LRA-5166	3.50	13.0	24.5	34.0	18.0	9.0
PH-325	2.00	8.5	16.0	45.0	35.5	27.5
BN-1	3.10	11.5	13.2	44.5	29.5	17.5
AK-32	3.20	13.5	20.0	29.0	24.0	8.5
PH-93	3.40	11.5	16.5	26.0	14.5	12.0
DHY-286 4R	2.51	11.6	22.5	33.0	28.0	21.0
NH-452	3.10	10.5	16.0	39.0	27.5	32.5
PHA-46	4.12	15.1	22.0	35.5	22.0	14.5
PHH-316	2.50	9.0	20.0	24.0	17.0	7.0
PA-141	5.00	20.5	31.5	35.2	26.0	18.0
PA-183	2.00	9.0	12.5	20.5	9.5	8.5
PKV-3	3.50	17.5	28.0	27.0	20.5	14.5
S.E. ±	0.91	1.20	2.90	4.4	4.0	5.60
C.D. (at 5%)	2.80	3.71	8.85	12.9	11.3	17.16

Variety PHA-46 also recorded significantly more squares than rest of the genotypes. The lowest squares were noticed in the genotypes AC-738. At 103 days of crop growth, the genotypes PH-325 and BN-1 recorded the highest squares which were on par with NH-452, LRA-5166, NH-452, PHA-46, PA-141, DHY-286⁸ and found significantly superior to rest of the genotypes.

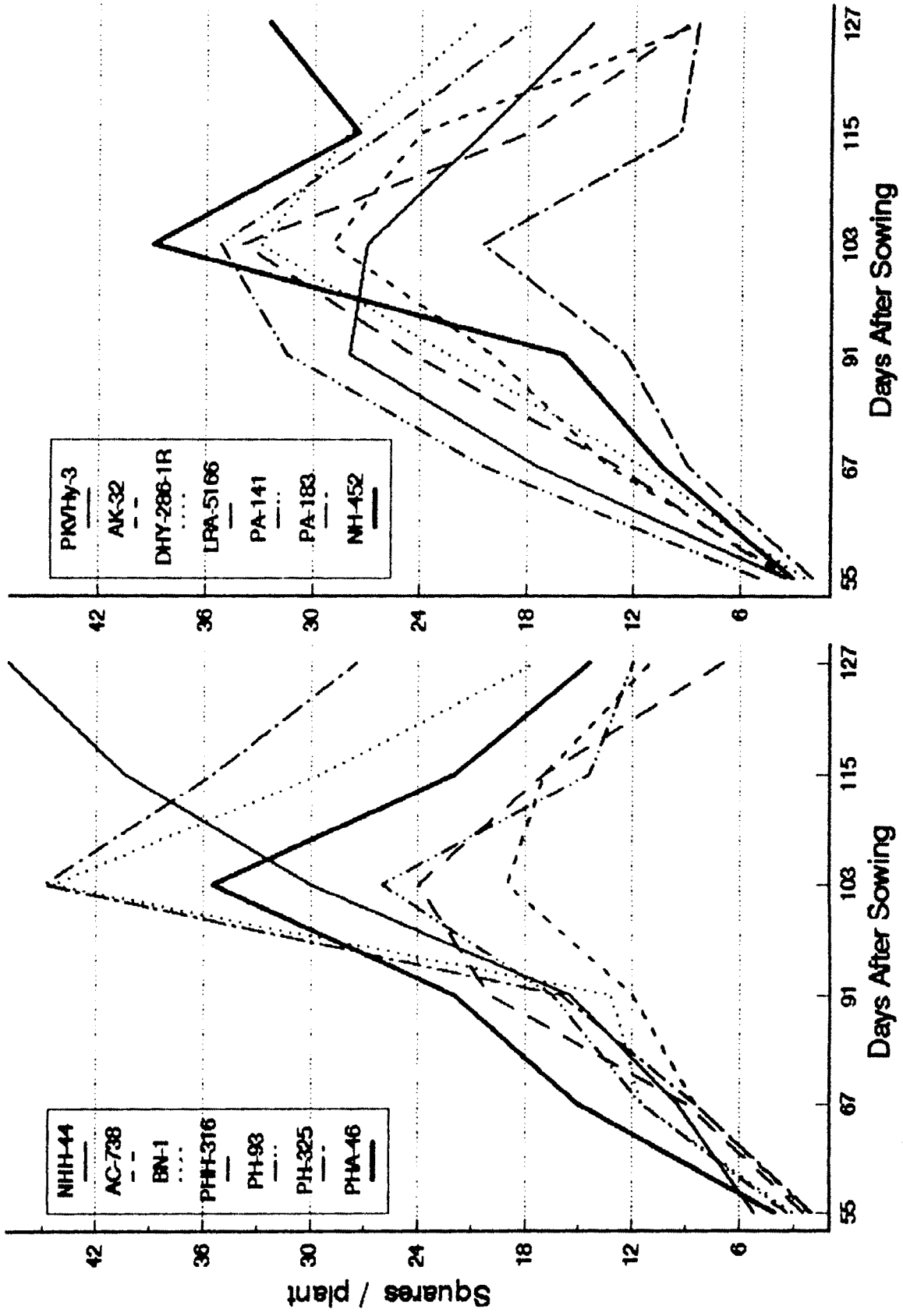


Fig. 5 : Genotypic differences in respect of number of squares of cotton.

At 115 and 127 days after sowing, the hybrid NHH-44 recorded the highest number of squares which were significantly more than rest of the cultivars except BN-1 and NH-452 at 115 and 127 DAS, respectively.

4.1.5 Dry weight of leaves per plant

The data on dry weight of leaves per plant of hybrids and varieties of cotton at various growth stages are mentioned in Table 6.

Table 6 : Mean dry weight of leaves (g/plant) of different hybrids and varieties of cotton at various growth stages.

Treatments	Days after sowing						
	55	67	79	91	103	115	127
NHH-44	4.45	6.37	10.6	15.66	19.85	17.28	9.14
AC-738	4.78	6.36	9.7	12.12	22.56	11.46	5.42
LRA-5166	5.61	6.41	8.4	13.49	19.80	13.15	3.04
PH-325	2.97	4.93	11.3	13.65	15.20	16.10	9.32
BN-1	2.34	3.37	10.3	10.00	26.32	15.83	5.93
AK-32	2.75	6.05	11.5	15.06	21.02	19.83	2.89
PH-93	2.92	3.60	14.1	10.24	19.80	12.37	4.06
DHY-286-1R	3.45	7.80	10.9	13.49	18.67	13.10	7.07
NH-452	2.99	6.59	9.2	16.14	17.32	10.37	11.01
PHA-46	6.27	10.59	12.3	18.79	25.20	16.74	4.91
PHH-316	6.91	9.81	11.5	16.35	24.07	15.83	2.37
PA-141	5.28	12.48	14.2	16.62	23.97	19.10	7.11
PA-183	4.62	10.00	12.5	17.35	20.25	12.74	5.60
PKV-3	5.10	6.50	11.5	14.20	22.00	18.19	4.91
S.E. +	1.12	1.00	1.30	1.12	2.27	1.65	1.62
C.D. (at 5%)	3.42	3.06	3.80	3.42	6.93	5.06	4.94

The data presented in Table 6 indicated significant variation in dry matter content of leaves per plant.

The cotton genotypes exhibited gradual increase in leaf dry matter content per plant at 79 days and there after a sudden increase was noticed relating peak values at 91 days. After reaching peak dry matter content in leaves, a decline was noticed after 115 days till harvest.

The differences in dry matter of leaves was significant at all the stages of observations during the crop growth period. The cotton genotypes under study didn't show consistently either in decrease or increase in dry matter content of leaves per plant at various growth stages of observations.

At the initial stage of observation (55 days) genotype PH-316 recorded more leaves dry matter which was significantly superior to BN-1 but found on par with rest of the genotypes.

At 67 DAS, cotton variety PA-141 recorded the highest leaves dry matter which was significantly superior over rest of the genotypes except PHA-46, PA-183 and PHA-316.

At 79 days of crop growth stage, the genotype PA-141 produced higher dry matter which was significantly more than NH-452, AC-738, LRA-5166 and on par with rest of the genotypes.

At 91 DAS, the variety PH-93 produced more dry matter which was significantly higher than all genotypes except PA-183, PHA-46 and BN-1.

At 103 days of crop growth, higher dry matter of leaves was noticed in genotype BN-1 which was significantly

superior to PH-325, NH-452 and DHY-286¹⁸ but on par with rest of the genotypes.

At 115 DAS, the genotype AK-32 recorded the highest dry matter of leaves followed by PA-141. At 127 days of crop growth, the genotype PH-325 recorded the maximum dry matter of leaves which was significantly higher than LRA-5166, AK-32, PH-93, PH-316 and on par with rest of the genotypes. The consistent increase or decrease in the leaves dry matter was not observed in most of the genotypes.

4.1.6 Dry weight of stem per plant

The data on dry weight of stem per plant of hybrids and varieties of cotton at various growth stages are mentioned in Table 7.

The data in Table 7 indicated that the dry matter of stem per plant was significantly differed among the genotypes at all the crop growth stages. The dry matter of stem was increased till 115 days of crop growth and decreased there after except the genotypes LRA-5166 and NH-452.

The stem dry matter produced by genotype PH-325 was significantly superior than all other genotypes. At 67 and 79 days of crop growth stage, the genotype PA-183 recorded significantly higher dry matter than rest of the genotypes.

At 91 DAS, the genotype PA-183 registered the highest dry matter which was significantly superior than AC-738, NH-452, DHY-286¹⁸ and PHA-46.

286¹⁸

Table 7 : Mean dry weight of stem (g/plant) of different hybrids and varieties of cotton at various growth stages.

Treatments	Days after sowing						
	55	67	79	91	103	115	127
NHH-44	2.55	2.13	9.0	34.00	44.12	41.20	29.20
AC-738	2.22	2.64	10.7	20.00	27.20	29.30	27.00
LRA-5166	2.39	2.69	11.2	33.00	39.25	40.20	41.00
PH-325	5.78	2.27	11.0	13.00	23.57	25.29	20.39
BN-1	1.16	3.13	9.0	33.35	37.67	38.00	35.32
AK-32	1.95	2.00	4.3	22.75	32.80	31.00	29.09
PH-93	4.15	5.60	9.5	21.20	31.83	36.32	34.30
DHY-286-1R ^R	4.05	1.20	9.5	20.50	34.83	36.23	32.46
NH-452	4.21	1.70	14.5	18.90	34.68	34.70	36.60
PHA-46	2.83	3.93	14.0	18.00	22.18	24.23	20.60
PHH-316	2.59	4.39	11.0	27.65	32.00	33.00	34.90
PA-141	3.42	11.02	21.5	30.88	35.00	34.00	32.20
PA-183	1.88	12.10	20.0	42.05	44.00	46.00	41.34
PKV-3	2.11	4.00	14.3	38.11	39.23	35.23	28.39
S.E. +	0.19	0.22	1.32	4.2	5.1	4.1	5.2
C.D. (at 5%)	0.56	0.64	3.94	12.4	14.9	12.6	16.3

At 103 DAS, the genotypes NHH-44, LRA-5166, BN-1, NH-452, PHH-316, PA-141, DHY-286-1R and PKV-3 recorded on par stem dry matter. The lowest dry matter was noticed in PHA-46 genotype.

At 115 days of crop growth stage, PA-183, NHH-44 and LRA-5166 recorded more than 90 g dry matter of stem.

At 127 DAS, the variety PA-183 recorded significantly higher dry matter of stem than the genotypes PH-325 and PA-46 and found on par with rest of the genotypes. The

different genotypes didn't show consisting either in decrease or increase in trend in dry matter of stem per plant during entire growth of crop plant.

4.1.7 Total dry weight of plants

The data on total dry weight of plant of hybrids and varieties of cotton at various growth stages are mentioned in Table 8 and depicted in Fig 6.

Table 8 : Total dry weight (g/plant) of different hybrids and varieties of cotton at various growth stages.

Treatments	Days after sowing						
	55	67	79	91	103	115	127
NHH-44	7.0	7.57	10.6	15.66	19.85	17.28	9.14
AC-738	4.7	6.36	9.7	12.12	22.56	11.46	5.42
LRA-5166	5.6	6.41	8.4	13.49	19.80	13.15	3.04
PH-325	2.9	4.93	11.3	13.65	15.20	16.10	9.32
BN-1	2.3	3.37	10.3	10.00	26.32	15.83	5.93
AK-32	2.7	6.05	11.5	15.06	21.02	19.83	2.89
PH-93	2.9	3.60	14.1	10.24	19.80	12.37	4.06
DHY-2864R ^R	3.4	7.80	10.9	13.49	18.67	13.10	7.07
NH-452	2.9	6.59	9.2	16.14	17.32	10.37	11.01
PHA-46	6.2	10.59	12.3	18.79	25.20	16.74	4.91
PHH-316	6.9	9.81	11.5	16.35	24.07	15.83	2.37
PA-141	5.2	12.48	14.2	16.62	23.97	19.10	7.11
PA-183	4.6	10.00	12.5	17.35	20.25	12.74	5.60
PKV-3	5.1	6.50	11.5	14.20	22.00	18.19	4.91
S.E. +	1.12	1.00	1.30	1.12	2.27	1.65	1.62
C.D. (at 5%)	3.42	3.06	3.80	3.42	6.93	5.06	4.94

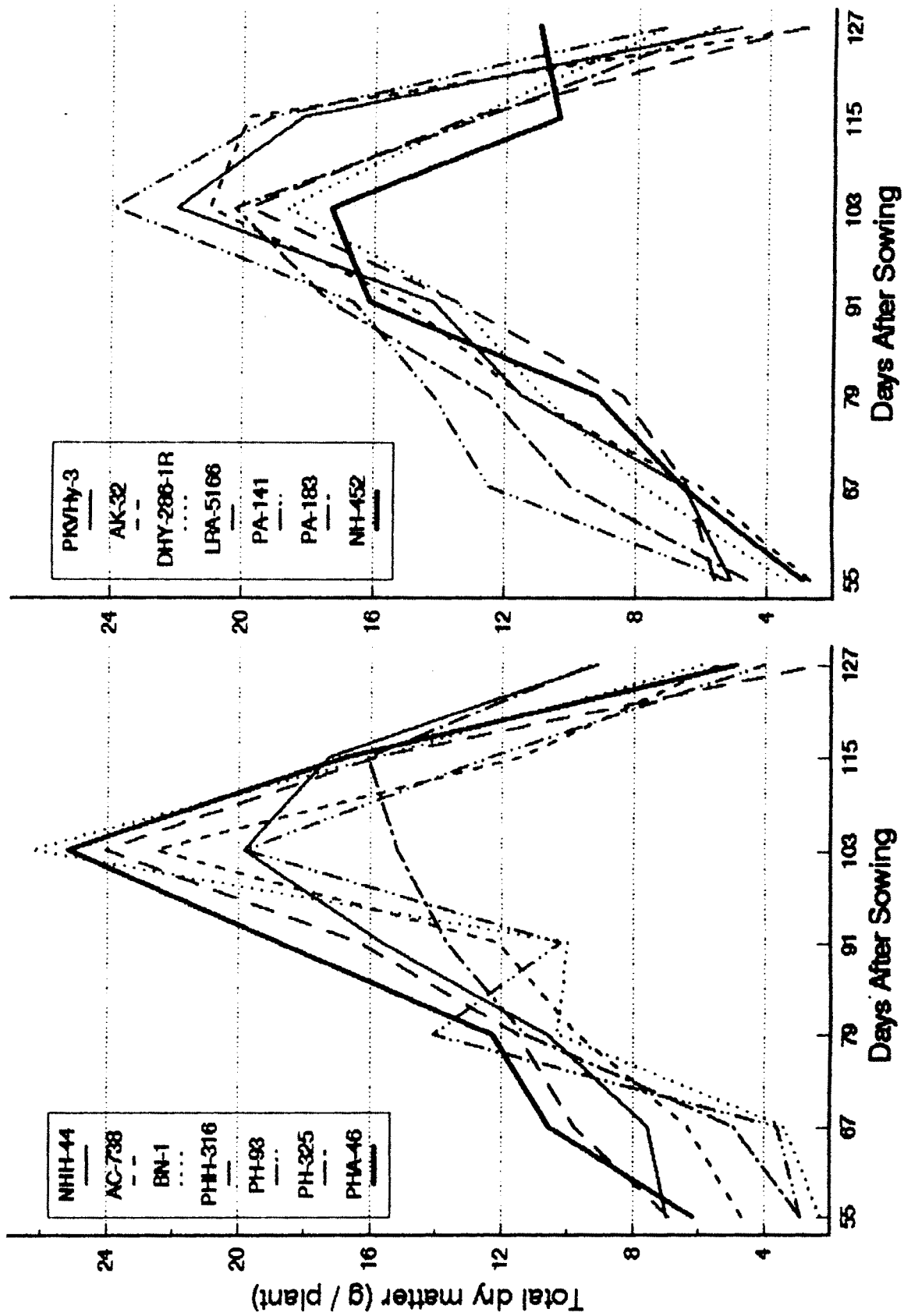


Fig. 6 : Total dry matter accumulation in various genotypes of cotton.

The data presented in Table 8 indicated that the dry weight of plants was increased till 103 days after sowing and there after it was reduced due to senescence of leaves and the boll bursting. The difference among the genotypes for dry matter production was statistically significant at all the crop growth stages.

At 55 DAS, the maximum dry matter was recorded in PHH-316 which was on par with LRA-5166, NH-452, PHA-316, PA-141, PA-183 and PKV-3 and found statistically significant over rest of the genotypes. The lowest total dry matter per plant was noticed in BN-1. At 67 DAS, the maximum dry matter was observed in PA-141 genotype which was statistically significant over rest of the genotypes.

At 79 days of crop growth, variety PA-183 recorded significantly higher total dry matter which was significantly more than rest of genotypes followed by PA-141 and PHH-316.

At 91 days of crop growth, the maximum total dry matter was observed in PA-183 which was on par with PA-141, AK-32, PHH-316, BN-1 and LRA-5166 and significantly superior to rest of the genotypes.

At 103 DAS, the maximum dry weight was observed in the genotype NHH-44 followed by PKV-3 and found significantly superior to AC-738, PH-325, PHA-46 and on par with rest of the genotypes.

At 115 days, NH-452 recorded significantly more dry matter which was on par with PA-141, PA-183 and significantly superior to rest of the genotypes.

At 127 DAS, NHH-44 and PKV-3 recorded higher dry matter and found significantly superior to AC-738 and PHA-46. None of the variety showed consistence trend regarding production of dry matter throughout the crop growth period.

4.2 Growth factors

The data obtained on various growth factors such as AGR, RGR, NAR, LAI, SLA, SLW and LWR are not subjected to statistical analysis. Hence, the results on these factors are presented on the basis of mean values.

4.2.1 Absolute Growth Rate (AGR)

The data on absolute growth rate recorded at various stages of crop growth in different hybrids and varieties of cotton are presented in Table 9.

The data presented in Table 9 indicated considerable genotypic differences in AGR per plant. However, either cotton hybrids or varieties failed to show clear cut differences either in increase or decrease in AGR per plant during the period of crop growth.

The AGR values were lower during early stages 55-67 days. It was increased till 80-91 days period and decreased there after.

Table 9 : Absolute Growth Rate (AGR) for different hybrids and varieties of cotton at various growth stages.

Treatments	Days after sowing					
	55-67	68-79	80-91	92-103	104-115	116-127
NHH-44	0.125	0.950	2.50	0.375	-1.66	-0.120
AC-738	0.166	0.930	1.91	0.520	-1.58	-0.330
LRA-5166	0.175	0.830	2.83	-0.116	-1.29	-0.330
PH-325	0.500	1.116	1.41	0.166	-1.04	-0.083
BN-1	0.250	1.410	2.00	0.330	-0.66	-0.830
AK-32	0.416	0.512	2.07	-0.110	-1.12	-0.910
PH-93	0.341	0.990	2.94	-0.410	-0.99	-0.110
DHY-286-RR	0.375	1.250	2.66	0.042	-1.25	-1.330
NH-452	0.192	0.750	2.92	-0.580	-0.40	-0.420
PHA-46	0.450	1.410	1.83	1.116	-0.83	-0.410
PHH-316	0.470	0.660	1.91	0.166	-1.65	-0.720
PA-141	0.970	2.100	2.16	-0.550	-0.25	-1.370
PA-183	0.23	1.125	1.58	0.250	-1.29	-0.830
PKV-3	0.190	1.210	2.41	0.220	-1.25	-0.166

At 55-67 days of crop growth the maximum value of AGR was noticed in the genotype PA-141 followed by PH-325 and the lowest by the hybrid NHH-44. At 68-79 days period, the variety PA-183 recorded the highest AGR followed by BN-1 and PHA-316 genotypes. At 80-91 days period, the highest AGR value was in PH-93 followed by NH-452. At 92-103 days, the genotypes LRA-5166, BN-1, AK-32, PH-93, PHA-46 and PA-141 recorded negative values of AGR. However, the highest value was noticed in the genotype AC-738 followed by NHH-44.

At 104-115 days period of crop growth, all the genotypes recorded negative values of AGR and the lowest value was noticed in the genotype PA-141. Similar trend of negative values was observed during 116-127 days period of crop growth.

4.2.2 Relative Growth Rate (RGR)

The data on relative growth rate (RGR) computed at various growth stages of the crop on dry weight basis is given in Table 10.

Table 10 : Relative Growth Rate (RGR) for different hybrids and varieties of cotton at various growth stages.

Treatments	Days after sowing					
	55-67	68-79	80-91	92-103	104-115	116-127
NHH-44	0.0969	0.4036	0.4110	0.0380	-0.2033	-0.02670
AC-738	0.1249	0.3069	0.3380	0.0570	-0.2200	-0.06440
LRA-5166	0.1139	0.3240	0.4450	0.0049	-0.1519	-0.04310
PH-325	0.2340	0.4640	0.5030	0.0219	-0.1681	-0.01000
BN-1	0.2088	0.5780	0.3100	-0.0336	-0.0944	-0.13750
AK-32	0.3612	0.4190	0.5150	-0.0018	-0.1508	-0.18960
PH-93	0.3010	0.3471	0.4320	-0.0378	-0.1178	-0.13060
DHY-286-IR	0.1203	0.3679	0.4060	-0.3010	0.1178	-0.16200
NH-452	0.1200	0.3114	0.3853	-0.5850	-0.1223	-0.18250
PHA-46	0.2020	0.2900	0.3133	-0.1470	-0.0420	-0.06810
PHH-316	0.2220	0.3390	0.2450	-0.1562	-0.1816	-0.11930
PA-141	0.1315	0.1230	0.2655	0.0520	-0.1933	-0.15800
PA-183	0.1450	0.2190	0.3260	-0.0215	-0.0248	-0.12662
PKV-3	0.1370	0.3227	0.3030	0.0129	-0.1378	-0.02617

The different cotton genotypes exhibited different trend of RGR values. In all the varieties the RGR values were increased till 80-91 days of crop growth. The genotype AK-32 recorded the highest RGR values (0.3612) followed by genotypes PH-93 during 68-79 days period. The variety BN-1 recorded the highest RGR values followed by PH-325. The maximum RGR value 0.563 was recorded between 80-91 days period by the variety PH-325 followed by AK-32.

The RGR values were drastically reduced between 92-103 days. The genotypes BN-1, AK-32, PH-93, DHY-286, NH-452, PHA-46 and PA-183 recorded negative values of RGR. At 104-115 days period, the hybrid DHY-286^{16R} only recorded positive values. However, rest of the genotypes recorded negative values.

At last stage of observation 116-127 days period, all the genotypes recorded negative values of RGR and the maximum negative value was noticed in the genotype AK-32.

4.2.3 Leaf Area Index (LAI)

The data on leaf area index of different hybrids and varieties of cotton recorded at various growth stages are presented in Table 11.

The data on LAI per plant presented in Table 11 indicated that the cotton genotypes under study valued differently. In general cotton varieties had higher values of LAI than hybrids and their parental genotypes.

Table 11 : Leaf Area Index (LAI) of different hybrids and varieties of cotton at various growth stages.

Treatments	Days after sowing						
	55	67	79	91	103	115	127
NHH-44	0.5800	0.3627	0.4740	0.5850	1.0650	1.253	1.0120
AC-738	0.4300	0.5972	0.7272	0.9005	1.9316	2.163	1.2000
LRA-5166	0.5038	0.6261	0.7805	0.9716	2.1790	2.507	0.6944
PH-325	0.7111	0.9533	1.3880	1.6960	2.7730	3.288	2.0620
BN-1	0.6838	0.8538	1.1730	1.5311	2.9072	2.988	1.3120
AK-32	0.7112	1.0240	1.3900	1.8716	3.1980	3.744	0.6374
PH-93	0.1280	0.4340	0.5886	0.7566	1.0890	1.168	0.4500
DHY-286-10 R	0.2070	0.4944	0.7661	1.0080	2.0380	2.566	1.5750
NH-452	0.7855	1.0120	1.2050	1.4050	2.7750	3.166	1.3540
PHA-46	0.4012	0.5011	0.6080	0.7025	1.3870	1.580	0.6769
PHH-316	0.3244	0.7960	1.2500	1.2250	1.2601	3.160	1.3450
PA-141	0.4754	0.6140	0.9400	1.2400	3.0960	3.606	1.5760
PA-183	0.4150	0.6400	0.9680	1.2683	2.7970	2.404	0.2620
PKV-3	0.2963	0.5263	0.6911	0.8558	1.4860	1.718	0.5436

The LAI per plant in all the genotypes showed increasing trend till 115 days of crop growth and declined there after towards the maturity of crop.

At 55, 67 and 79 days of crop growth, the varieties PH-93 and PHA-46 recorded more values of LAI compared to hybrids and other genotypes. At later stages of crop growth, variety AK-32 produced the highest LAI at 91, 103 and 115 days of crop growth. However, at 127 days after sowing the highest LAI was noticed in the genotypes PHA-325 followed by PA-141. The lowest value at this stage is recorded in the genotype PA-183.

4.2.4 Leaf Area Ratio (LAR)

The data on leaf area ratio of different hybrids and varieties of cotton recorded at various growth stages are presented in Table 12.

Table 12 : Leaf Area Ratio (LAR) of different hybrids and varieties of cotton at various growth stages.

Treatments	Days after sowing						
	55	67	79	91	103	115	127
NHH-44	174.00	174.13	89.84	43.02	71.66	134.74	115.72
AC-738	129.00	134.37	67.12	38.14	71.69	134.27	86.40
LRA-5166	129.57	123.85	73.17	32.93	74.72	122.00	37.31
PH-325	305.00	238.33	114.72	79.29	123.28	211.34	140.11
BN-1	351.71	236.46	91.82	59.65	120.00	153.68	92.63
AK-32	338.99	283.69	177.44	72.92	125.15	207.38	54.62
PH-93	251.18	169.78	103.36	49.45	77.68	109.22	56.84
DHY-286-1R _R	118.44	98.88	65.61	33.92	68.69	69.25	108.21
NH-452	66.80	113.57	67.49	48.69	57.08	74.68	195.45
PHA-46	111.42	124.41	94.30	109.95	149.04	183.52	91.90
PHH-316	169.52	77.88	54.58	40.45	42.03	146.52	34.36
PA-141	98.16	61.02	54.23	38.35	44.58	98.22	25.20
PA-183	118.57	103.78	42.52	83.53	98.45	104.28	15.23
PKV-3	172.09	222.94	110.57	60.41	108.10	179.21	60.58

Cotton genotypes differed considerably in LAR per plant at various stages of observations in cotton genotypes during crop growth (Table 12).

In general cotton genotypes exhibited decreasing trend in LAR per plant and reached the minimum values at 91 days after sowing. After receiving minimum values at 91 days, there was an increase in LAR which continued at the time termination of observation that is 127 days after sowing.

4.2.5 Specific Leaf Area (SLA)

The data on specific leaf area of different hybrids and varieties of cotton recorded at various growth stages are presented in Table 13.

Table 13 : Specific Leaf Area (SLA) of different hybrids and varieties of cotton at various growth stages.

Treatments	Days after sowing						
	55	67	79	91	103	115	127
NHH-44	234.60	243.20	265.72	139.71	198.13	339.90	398.79
AC-738	161.92	169.02	194.94	133.74	154.12	339.87	398.52
LRA-5166	161.67	175.81	167.26	129.65	198.13	343.26	476.97
PH-325	441.72	114.93	213.18	203.66	198.13	339.88	398.39
BN-1	526.06	456.08	205.04	269.14	198.44	339.79	398.31
AK-32	456.00	304.79	217.56	134.43	198.17	339.93	396.88
PH-93	438.69	433.88	150.28	137.57	198.13	339.93	402.98
DHY-286- W	154.49	114.10	106.89	266.01	196.57	352.59	429.13
NH-452	160.86	163.73	179.56	154.54	195.43	339.92	357.99
PHA-46	161.72	170.34	176.34	134.65	198.05	339.04	550.04
PHH-316	208.58	112.74	147.13	134.59	194.37	351.06	496.33
PA-141	161.74	114.90	134.01	134.86	232.99	339.89	398.73
PA-183	161.68	115.20	109.44	104.81	247.50	339.71	399.15
PKV-3	209.21	291.53	299.75	239.02	198.14	339.91	391.25

The data on SLA per plant presented in Table 13 would indicate that the cotton genotypes differed considerably.

The cotton hybrids NHH-44, PKV-3, NH-452 recorded increasing trend in SLA per plant till 79 days except BN-1 and DHY-286. After first decline in SLA at 91 days it again increased at 103 days and reached second peak at 127 days. However, in contrast to the other genotypes of cotton like BN-1, PH-325, AK-32, PH-93 and PHA-316 where in SLA value was maximum at 55 days, which was declined at 91 days of sowing. It started increasing from 103 days and reached maximum SLA value at 127 days of crop growth. The maximum SLA value was observed (525) in the genotype BN-1 at 55 days of crop growth stage. At 127 days of crop growth, the maximum SLA value was registered in PHA-316 and the lowest in the genotype PKV-3.

4.2.6 Specific Leaf Weight (SLW)

The data on specific leaf weight of different hybrids and varieties of cotton recorded at various growth stages are presented in Table 14.

The data presented in Table 14 indicated existence of considerable variations in SLW per plant of cotton genotypes under study. SLW per plant of cotton genotypes showed increasing trend from 55 to 91 days and it was decreased there after with the advancement of crop growth. The lowest values of SLW was recorded at 127 DAS in all the genotypes.

At 94 days of crop growth, the maximum value of SLW was observed in the genotype AC-738. LRA-5166 followed by BN-1, PA-141, while the lower values recorded in genotype PH-93 and PKV-3.

Table 14 : Specific Leaf Weight (SLW) of different hybrids and varieties of cotton at various growth stages.

Treatments	Days after sowing						
	55	67	79	91	103	115	127
NHH-44	0.00426	0.00514	0.07900	0.00792	0.00504	0.00294	0.00251
AC-738	0.00822	0.00902	0.00925	0.00139	0.00640	0.00294	0.00250
LRA-5166	0.00518	0.00568	0.00597	0.00960	0.00505	0.00292	0.00243
PH-325	0.00231	0.00287	0.00409	0.00566	0.00504	0.00294	0.00251
BN-1	0.00190	0.00219	0.00487	0.00958	0.00504	0.00294	0.00251
AK-32	0.00219	0.00328	0.00459	0.00744	0.00505	0.00294	0.00252
PH-93	0.00227	0.00230	0.00665	0.00683	0.00726	0.00505	0.00294
DHY-286-1R	0.00647	0.00876	0.00935	0.00943	0.00472	0.00224	0.00188
NH-452	0.00621	0.00611	0.00556	0.00743	0.00512	0.00294	0.00182
PHA-46	0.00518	0.00584	0.00669	0.00743	0.00504	0.00294	0.00201
PHH-316	0.00479	0.00684	0.00694	0.00730	0.00432	0.00244	0.00135
PA-141	0.00707	0.00108	0.00814	0.00912	0.01030	0.00451	0.00151
PA-183	0.00618	0.00861	0.00717	0.00743	0.00404	0.00294	0.01190
PKV-3	0.00478	0.00343	0.00336	0.00418	0.00505	0.00505	0.00251

4.2.7 Leaf Weight Ratio (LWR)

The data on leaf weight ratio of different hybrids and varieties of cotton recorded at various growth stages are presented in Table 15.

The cotton genotypes varied considerably in LWR per plant at various stages of observations (Table 15).

Table 15 : Mean Leaf Weight Ratio of different hybrids and varieties of cotton at various growth stages.

Treatments	Days after sowing						
	55	67	79	91	103	115	127
NHH-44	0.84	0.71	0.54	0.32	0.57	0.39	0.29
AC-738	0.79	0.70	0.49	0.28	0.77	0.39	0.21
LRA-5166	0.80	0.70	0.45	0.25	0.53	0.35	0.09
PH-325	0.70	0.68	0.53	0.35	0.62	0.62	0.35
BN-1	0.66	0.51	0.62	0.21	0.60	0.45	0.23
AK-32	0.74	0.63	0.81	0.54	0.63	0.60	0.13
PH-93	0.57	0.39	0.68	0.18	0.38	0.32	0.14
DHY-286-IR	0.76	0.66	0.61	0.25	0.35	0.34	0.26
NH-452	0.41	0.67	0.50	0.32	0.33	0.21	0.35
PHA-46	0.68	0.67	0.46	0.45	0.53	0.63	0.18
PHH-316	0.81	0.69	0.37	0.30	0.44	0.43	0.08
PA-141	0.60	0.53	0.45	0.29	0.47	0.35	0.18
PA-183	0.77	0.86	0.30	0.30	0.35	0.30	0.18
PKV-3	0.82	0.76	0.36	0.25	0.54	0.53	0.15

All the cotton genotypes expressed decreasing trend in LWR per plant during earlier stages of observations with sudden and considerable increase at 103 days after sowing which was considerably higher than that recorded at the 91 days of crop duration. There was no consistence performance of any particular genotype over a particular period of crop growth stage. However, the maximum value of LWR was noticed at initial stage (55 days). The genotypes NHH-44, PKV-3, LRA-5166 and PA-141 recorded more

values compared to other genotypes. At the later stage (127 days), PHA-46, PH-325 and NHH-44 produced more values of LWR compared to rest of the genotypes.

4.2.8 Net assimilation rate (NAR)

The data on net assimilation rate of different hybrids and varieties of cotton at various growth stages are presented in Table 16.

Table 16 : Net assimilation rate (NAR) of different hybrids and varieties of cotton at various growth stages.

Treatments	Days after sowing					
	55-67	68-79	80-91	92-103	104-115	116-127
NHH-44	0.0000158	0.0000520	0.0000539	0.0000482	0.0000164	0.0000652
AC-738	0.0000295	0.0000420	0.0000600	0.0009240	-0.0001090	0.0001240
LRA-5166	0.0000199	0.0000572	0.0001172	0.0000848	-0.0000571	0.0001124
PH-325	0.0000493	0.0001126	0.0000313	0.0000142	0.0000065	0.0000565
BN-1	0.0000868	0.0001386	0.0000448	0.0001530	-0.0000716	-0.0000987
AK-32	0.0000792	0.0000918	0.0006440	0.0000839	-0.0000048	-0.0001075
PH-93	0.0000179	0.0002081	0.0000579	0.0000574	-0.0000671	-0.0000891
DHY-286-1R	0.0002286	0.0001004	0.0000591	0.0000162	-0.0000488	-0.0000597
NH-452	0.0001804	0.0002570	0.0001932	0.0000484	-0.0000733	-0.0000612
PHA-46	0.0001158	0.0000322	0.0001015	0.0000771	-0.0000574	-0.0001100
FHH-316	0.0000767	0.0000396	0.0000906	0.0001248	-0.0000834	-0.0001927
FA-141	0.0002354	0.0000375	0.0000423	0.0000730	-0.0000290	-0.0000980
FA-183	0.0002090	0.0000634	0.0000867	0.0000299	-0.0000555	-0.0001480
PKV-3	0.0000251	0.0000831	0.0000353	0.0000559	-0.0000231	-0.0001300

It is clearly indicated from the Table 16 that cotton genotypes behaved differently with regard to NAR per plant at various stages of observations. The cotton arborium variety PA-141 and PA-183 produced maximum NAR values at earlier stages. The cotton hybrids NHH-44 and PKV-3 produced NAR values maximum between 80-91 days period. The genotypes NH-452, PH-93, BN-1 and PKV-HY-3 showed increasing trend of NAR values till 68-79 days period. However, the genotype AC-738 and PKV-3 showed increasing NAR values till 92-103 days period. The negative values were recorded in most of genotypes during 104-115 days period and thereafter. The cotton hybrids and varieties did not show any particular trend in NAR per plant during the entire period of crop growth.

4.3 Post harvest studies and yield of cotton genotypes

The number of days required for first date of flowering, 50 per cent of boll opening, 1000 seed weight, halo length, ginning percentage and seed cotton yield of various genotypes are presented in Table 17 and the seed cotton yield is depicted in Fig. 7.

Table 17 : Mean yield (kg/ha) and post harvest studies of cotton cultivars.

Treatments	Days to			1000 seed wt. (g)	Har- vest index (%)	Halo len- gth (mm)	Gin- ning (%)	Seed cotton yield (kg/ha)
	Matu- rity	First flower	50 % boll ope- ning					
NHH-44	162	50	91	45	15.0	25.0	36.5	2029
AC-738	160	52	110	46	14.0	26.5	36.3	1694
LRA-5166	151	48	105	40	13.0	26.5	34.0	505
PH-325	150	49	115	42	13.6	24.0	34.5	470
BN-1	170	54	95	51	16.0	28.0	37.5	1398
AK-32	172	52	115	50	16.4	24.5	37.0	232
PH-93	170	52	105	50	17.4	28.5	40.5	963
DHY-286-1R	168	56	110	49	15.0	27.2	40.8	1319
NH-452	168	52	95	45	14.6	25.0	41.5	865
PHA-46	165	50	105	45	17.0	24.5	40.5	917
PHH-316	160	58	104	43	16.2	24.0	36.5	1785
PA-141	158	60	110	42	18.0	23.8	36.0	632
PA-183	170	58	107	45	18.4	23.5	36.0	460
PKV-3	172	58	110	46	20.0	23.8	36.0	1819
S.E. +	--	1.10	1.05	0.90	1.81	2.01	0.69	128.5
C.D. (at 5%)	--	3.29	3.24	2.68	5.04	N.S.	2.08	385.0

The cotton genotypes under study differed significantly in yield and other quality parameters including days required for flowering and 50 per cent boll opening (Table 17).

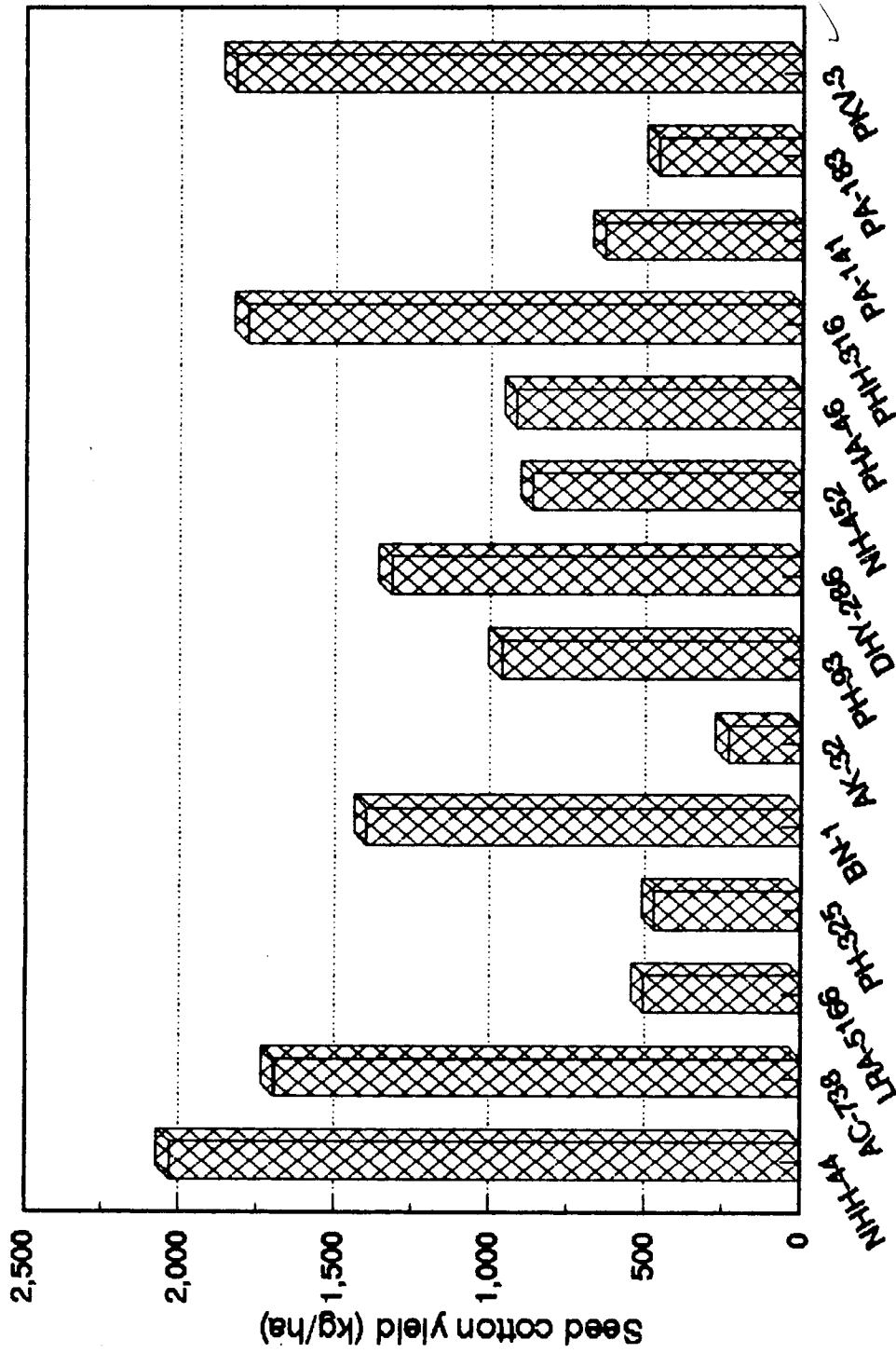


Fig. 7. Seed cotton yield of different genotypes of cotton.

The maturity of various cotton genotypes ranged between 150-172 days. The first flower was opened in the cultivar LRA-5166 which was significantly earlier than rest of the genotypes except NHH-44, PHA-46 and PH-325. The variety PA-141 took maximum days to first flower to open.

The hybrid NHH-44 produced 50 per cent boll opening at 91 DAS which was significantly earlier than rest of the genotypes.

The maximum 1000 seed weight was noticed in the genotypes BN-1 which was at par with AK-32, PH-93, PHY-286 and significantly more than rest of the genotypes. The lowest 1000 seed weight was recorded in the genotype LRA-5166.

The harvest index was significantly differed among the genotypes. The maximum harvest index was recorded in PKV-3 which was significantly higher than AC-738, LRA-5166, PH-325 and NH-452. However, it was at par with rest of the genotypes.

The maximum halo length was noticed in the genotype PKV-3, BN-1 and PH-93. However, the lower values was noticed in PHH-316, PA-141 and PA-183.

The maximum ginning percentage was observed in NH-452 which was on par with PH-93, DHY-286^{VR}, PHA-316 and significantly superior to rest of the genotypes. The lowest ginning percentage was recorded in LRA-5166.

The cotton yield was significantly differed among the genotypes (Fig. 7). It varied from 231 to 2029 kg/ha. The maximum cotton yield was recorded by NHH-44 and it was at par with PKV-3, PHH-316 and AC-738 and found significantly more than rest of the genotypes. The genotype PKV-3, AC-738 and PHH-316 also recorded significantly more seed yield than rest of the genotypes. The lowest seed cotton yield was noticed in AC-32.

4.4 Chemical composition of leaves

The data on chlorophyll, nitrogen, phosphorus and potassium content of leaf in per cent are presented in Table 18.

Table 18 : Chlorophyll, Nitrogen, Phosphorus and Potassium content of leaves in per cent at 50 per cent flowering stage of different hybrids and varieties of cotton.

Treatments	Chlorophyll	Nitrogen	Phosphorus	Potassium
NHH-44	3.55	1.240	0.235	1.31
AC-738	2.11	1.085	0.270	1.43
LRA-5166	3.11	1.225	0.305	1.51
PH-325	3.65	1.170	0.200	1.28
BN-1	3.00	1.150	0.600	1.23
AK-32	3.15	1.080	0.185	1.19
PH-93	3.25	1.210	0.285	1.21
DHY-2861R	2.80	1.110	0.255	1.12
NH-452	2.61	1.100	0.288	1.45
PHA-46	3.06	1.160	0.300	1.41
PHH-316	3.22	1.105	0.165	1.38
PA-141	3.11	1.190	0.225	1.39
PA-183	3.21	1.090	0.311	1.22
PKV-3	3.97	1.140	0.275	1.41
S.E. +	0.045	0.0087	0.0124	0.014
C.D. (at 5%)	0.139	0.0265	0.0342	0.043

The data presented in Table 18 indicated significant genotypic differences in chlorophyll, total nitrogen, phosphorus and potassium content of leaves. The cotton genotype PKV-3 produced the highest chlorophyll content in leaves at 50 per cent flowering stage and was significantly superior over rest of the genotypes. The genotypes NHH-44 and PH-325 recorded on par chlorophyll content but produced significantly higher than rest of the genotypes.

Nitrogen content also exhibited significant genotypic variation. Cotton genotype NHH-44 recorded the highest N content in leaves, which was significantly more than rest of the genotypes except LRA-5166.

Phosphorus content in leaves of various genotypes varied significantly among the genotypes. Maximum P content was observed in PA-183 which was on par with LRA-5166, PH-93, NH-452, PHA-46, PKV-3 and significantly superior to remaining genotypes.

The maximum potassium content (Table 18) was recorded in the genotype LRA-5166, which was significantly more than rest of the genotypes. Next to this genotypes AC-738 also recorded significantly more K content in leaves than rest of the genotypes.



Discussion



DISCUSSION

The findings of the present investigation entitled "Physiological analysis of yielding ability" in cotton (*Gossypium hirsutum* L.)" are discussed in the subsequent papers of this chapter.

In general, the season was not favourable for cotton cultivation as the crop faced drought condition for quite a larger time and inadequate rains received during the critical period of crop growth, which affect the normal growth of crop and the genotypes fails to exhibit their developmental characters. The *arboreum* genotypes performed better during stress as compared to *hirsutum* genotype for same period.

It is evident from the data on height that significant genotypic differences existed at all the stages of observations during the entire period of crop growth. The cotton genotypes exhibited increasing trend in height of plant throughout the period of crop growth. The rate of increase in height of plant was faster at earlier stages, however it decreased at later stages as the cotton crop advanced towards maturity. In general the *arboreum* genotypes recorded maximum height as compared to rest of *hirsutum* hybrids and *hirsutum* genotypes. The cultivars PA-141 recorded more height at later stages of crop growth. However, genotypes PHA-46 and PA-183 were faster in growth producing more height at early stages of crop growth.

The data (Table 3) indicated significant genotypic differences in respect of functional leaves per plant during entire period of crop growth. At early stage (55 days) PHH-316 recorded more functional leaves. However, in the later stages at 109 days the hybrids NHH-44 and NH-452 recorded in general maximum functional leaves as compared to *arboreum* genotypes. Earlier studies reported maximum functional leaves in H-4 and NHH-44 hybrids as compared to other varieties.

The significant differences in respect of leaf area per plant existed at all the stages of crop growth. There was no consistent trend in leaf area of a particular genotypes during the entire crop growth period. However, the hybrid exhibited little consistence in producing higher leaf area at grand growth phase of crop. The hybrids NHH-44, PKV-2 and variety NH-452 recorded higher leaf area as compared to *arboreum* genotypes. In early stage, PHH-316 recorded more leaf area, may be due to its early establishment of seedlings. Giri (1988) reported more leaf area in cotton hybrids as compared to varieties at Parbhani.

It was interesting to note the significant differences in number of squares per plant during entire period of crop growth in cotton genotypes. At early growth stage hybrid NHH-44 produced maximum squares which was higher than its parents and other genotypes. At later stages, the hybrid NHH-44 recorded highest number of squares compared to rest of the genotypes. Similar findings were reported by earlier workers

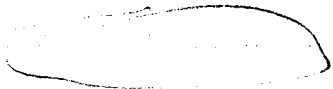
(Giri, 1988). The total dry matter content per plant as well as stem, leaf dry weight of cotton genotypes differed

significantly at all the stages of observations. The total dry matter was increased till 103 days after sowing and there after it was reduced due to senescence of leaves and the boll bursting. The genotype PH-183 produced maximum total dry matter at earlier stages compared to other genotypes. However, at later stages of crop growth the total dry matter was more in NHH-44, PKV-Hy-3 and NH-452 as compared other genotypes. Zheng *et al.* (1996) reported higher dry matter between square stage to boll opening stage in cotton.

In general the faster rate of increase in the height of plant, number of leaves (green), leaf area, and dry matter content of plant and its components may be due to the maximum growth occurred during the grand growth period of the cotton genotype. The decline in respect of the above parameters may be due to translocation of photosynthates towards the reproductive organs at the later stage of growth.

The inconsistency in the observations recorded in cotton genotypes in respect of plant height, number of leaves, leaf area and dry matter accumulation of plants and its different components during various period of crop growth may be due to the heterogeneous cotton genotypes.

The genotypic differences recorded in respect of plant height, number of functional leaves, leaf area and dry matter accumulation in plant and its various components (leaves, stem) in the present investigation are in conformity with the earlier work done on cotton (Ibrahim and Burten, 1981).

Sunflower,  : Salem *et al.*, 1978 and Hur, 1978) and soybean (Jonstan and Pandelton, 1968). The reduced dry matter content in leaves and stems of various cotton genotypes at later stages of crop growth indicated that the dry matter produced by leaves was translocated to the fruiting bodies, and the excess was accumulated in stem. Fairey (1978) reported that stem, root, leaves were the sites for the temporary stage of dry matter in maize during early stages of growth. The dry matter contents, principally the sugars were remobilized and translocated to the maturing grains during 2nd half of grain filling period and levels supplied assimilates preferentially to proximally located sink in maize crop.

many in
ital

Various growth factors such as AGR, RGR, NAR, LAI, LAR, SLA, SLW and LWR indicated considerably genotypic differences at various stages of observation during the period of crop growth. However, consistency in trend was not noticed in entire growth period of cotton crop. The different cotton genotypes varied differently at various stages of observations. A genotype showing increase either of the growth factors at one stage failed to show the same at other stages. Hence a definite conclusion could not be drawn in respect of the various growth factors studied during the course of the present investigation. Difference in cotton genotypes in respect of various growth factors noticed are evident by the several workers on cotton (Akiyama and Tekade, 1975; Patil and Patil, 1983 and Sgusa *et al.*, 1984) maize (Pressenya *et al.*, 1976 and Kalubarhme and Pande, 1979) and rice (Lian, 1975 and Yoshida and Perco, 1976).

The cotton genotypes expressed significant differences in 1st and 50 per cent boll opening, 1000 seed weight, HI, halo length, ginning percentage and seed cotton yield (Table 16).

In general cotton varieties proved to be earlier in 1st flower and 50 per cent boll opening. Further it was noticed that PA-141 was considerably late in first flower and PH-325 for 50 per cent boll opening. The hybrid NHH-44 was considerably earlier in maturity as compared to other *hirsutum* hybrids. The 1000 seed weight was maximum in BN-1, AK-32 and PH-93. The maximum harvest index (HI) was recorded in PKV-3 followed by PA-141 and PA-183. In respect of halo length, BN-1 and PH-93 registered more halo length. However, in NHH-44 and PVK-3 it was 25.0 mm and 23.0 mm, respectively. The halo length in *arboreum* genotypes was comparatively less. Maximum ginning percentage was recorded in NH-452, followed by PH-93 and BN-1. The lowest ginning percentage was observed in LRA-5166.

In the present study, the genotypic differences observed in respect of the characters like earliness and 1000 seed weight. The similar observations were also noticed in cotton by Ishenko, 1980; Bhatt et al., 1984; Guo, 1985 and Duhoon and Lather, 1986.

The maximum cotton yield was (2029 kg/ha) recorded in the hybrid NHH-44 followed by hybrid PKV-3, which was contributed mainly because of higher bolls, total dry matter, HI and number of squares per plant. The lower yield was recorded in the genotypes AK-32 and PH-325. Leaves are the sites of

assimilation and leaf area in the case of NHH-44 and PKV-3 at maturity is considerably better considering its plant types as compared other cotton hybrids and varieties and this might have reflected to produce maximum yield as compared to other genotypes.

The cotton genotypes behaved differently in respect of chlorophyll, nitrogen, phosphorus and potassium content of leaves at 50 per cent flowering stage. The differences were statistically significant. The hybrid NHH-44 and PKV-3 recorded maximum chlorophyll content which may contribute for more synthesis of photosynthates and reflecting finally in more cotton yield. The N content at 50 per cent flowering in NHH-44 was maximum which also might have contributed towards cotton yield. The maximum phosphorus and potassium contents were noticed in the genotypes in BN-1 and LRA 5166, respectively as compared to other genotypes.

The genotypic variation in respect of chlorophyll nitrogen, phosphorus and potassium contents of leaves were noticed in the present studies. These findings are supported by Rao (1973), Squasa *et al.* (1984) in cotton. Zeid (1973) and Johali *et al.* (1977) in sorghum and Chgo *et al.* (1980) in rice.



Summary and Conclusion



SUMMARY

The present investigation entitled, "Physiological analysis of yielding ability in cotton" was carried out during the *kharif* season of 1997-98 to analyze the physiological basis for yield differences in cotton (*Gossypium species* L.). Fourteen genotypes which included *hirsutum* hybrids (NHH-44), PKV-3, PHH-310 and their parents, the *arboreum* genotypes (PA-141, PA-183, AK-32) other genotypes LRA 5166, DHY-286, NH-452, PH-325, BN-1, AC-738, PHH-316, PH-93 were replicated twice in the randomized block design.

The season was not favourable for the cultivation of cotton crop. The soil moisture was the limiting factor due to low and erratic distribution of rainfall during the period of crop growth. The cotton varieties performed better at early growth stage but in the later stage hybrids improved their performance.

The differences in the height of plant of various cotton genotypes were significant at all the stages of observations. The *arboreum* genotypes (PH-141 and PHA-46) recorded more plant for height as compared to *hirsutum* hybrids.

The average number of functional leaves and leaf area per plant was significantly different among the genotypes at all the growth stages. The functional leaves and its area was increased till 103 days and decline thereafter till 127 days of crop growth. The hybrid PKV-3 and NHH-44 produced significantly more values as compared to other genotypes during the most of the growth stages.

The dry matter of leaves, stem and the mean number of squares was 2.8 at early stages and increased to 17.16 at final growth stages. The maximum squares was noticed in the NHH-44 at later stages of crop growth. However, at early stages *arboreum* recorded more number of squares per plant.

The total dry matter of plants was statistically significant among the various genotypes at all the growth stages of crop. The maximum dry matter was noticed in the *arboreum* genotypes viz. PA-183, till 91 days of crop growth. However, the *hirsutum* genotypes produced more total dry matter at later growth stages. The genotypes NHH-44, LRA 5166 recorded more stem dry matter at 103 and 115 days of crop growth. The variety PA 141 produced more leaf dry matter as compared to hybrids and *hirsutum* genotypes at various crop growth stages.

In general growth factors such as RGR, AGR, LAI, SLA, SLW and LWR per plant recorded significant differences during the entire period of crop growth. However, the cotton hybrids as well as varieties failed to maintain consistency in those

aspects. The maximum AGR values was recorded in PA-141 genotype for the period of 55-67 and 68-79 days. However, PH-93 recorded more AGR values between 80-91 days. The RGR values in all the genotypes was increased till 80-90 days of crop growth. The genotype AK-32 recorded highest RGR values during early growth period. The LAI was increased in all the genotypes till 115 days and declined thereafter towards the maturity of crops.

Cotton genotypes exhibited decreasing trend in LAR and reached the minimum at 91 days after sowing. There was no consistent trend for SLA, SLW and LWR. The cotton hybrid NHH-44 PKV-3 and NH-452, in general, recorded higher values of those parameters.

The cotton genotypes LRA-5166 and PH-335 proved to be earlier and the 50 per cent boll opening was observed earliest in the hybrid NHH-44. The maximum 1000 seed weight was recorded by AK-92 and PH-93. The hybrid PKV-WY-3 gave highest harvest index. The variety DHY-286^{IR} produced maximum hallow length. However, maximum ginning out turn was noticed in NH-452, PH-93 and DHY-286^{IR} genotypes. The NHH-44 and PKV-WY-3 gave 36 per cent ginning out turn.

The hybrid NHH-44 and PKV-3 recorded highest cotton yield which was significantly more than other genotypes. The seed cotton yield was ranged between 232 to 2029 kg/ha. The variety AK-32 recorded the lowest and (highest seed cotton yield was noticed in NHH-44 hybrid.

The cotton genotypes under study showed genotypic differences in respect of chlorophyll, N, P and K contents of leaves at 50 per cent flowering. The cotton hybrid PKV-3 recorded maximum chlorophyll content (3.97 mg/g) followed by NHH-44 (3.55 mg/g). The maximum N content was noticed in NHH-44 (1.240 %). The maximum phosphorus content (0.6100 %) was observed in BN-1 genotypes. The potassium content was maximum (1.51 %) in the *hirsutum* genotype LRA-5166. These studies indicated that under unfavourable condition, cotton hybrid performed better than genotypes during the peak crop growth period. It was also seen that the cotton genotypes with earliness in flowering, higher number squares per plant increased 1000 seed weight, more HI, leaf area and LAI showed better performance with regard to seed cotton yield.

However, further studies, in this regards and with special reference to physiological aspects of growth and yield of cotton, may help in the improvement of cotton productivity.



Literature Cited



LITERATURE CITED

- Akiyama, R. and Takeda, T. 1975. Studies on dry matter production in corm plant. Changes and interaction of plant factors constituting canopy photosynthesis according with the development of growth stages. Proceeding of Crop Sci. Soc. of Japan, 44(1):7-13.
- Anonymous 1977. Package of practices for high yield. University of Agricultural Sciences and Department of Agriculture in Karnataka, Bengalore : 12-21.
- Anonymous 1984-85a. Annual Report of Agronomy, Research Work on Cotton. Submitted to the Panel Meeting, All Indian Co-ordinated Cotton Improvement Project, Nagpur, 9-10 May, 1978 : 39-42.
- Anonymous 1984-85c. Annual Report of the Work Done on the Agronomical Research Under All Indian Co-ordinated Cotton Improvement Project, M.P.K.V., Rahuri : 6.
- Anonymous 1985-86. Annual Report of the Work Done on cotton, M.A.U., Parbhani. Submitted to the Crop Sci. (cash crop), Sub-committee of AGRESCO, April, 1986 : 6-42.
- Anonymous 1986-87. Annual Report of the Research Work Done on cotton, M.A.U., Parbhani, Submitted to the Crop Sci. (cash crop), Sub-committee of AGRESCO. April, 1987 : 8-51.
- Anonymous 1997. Agricultural Situation in India.

- A.O.A.C. 1963. Official and tentative method of analysis. Association of Official Agricultural Chemists (A.O.A.C.). Washington, '4' D.C.
- Bharadwaj, R.P. and Simlote, K.M. 1972. Correlation studies in American cotton. *Indian Agriculturist*, 12 : 51-53.
- Bhatt, J.G. and Nathan, R.S. 1983. Effect of excision of main stem leaves in cotton. *Indian J. Plant Physiol.*, 34(3):228-290.
- Bhatt J.G., Raman, C.V. and Indira Kutty, K.N. 1984. The effect of removing bracts on boll growth, oil and protein content of seeds and fibre characters of lint in cotton. *Indian J. Pl. Physiol.*, XXVII(1): 8-14.
- Bondada, B.R.; Oosthemis, D.M.; Wullschileger, S.; D. Kim, K.S. and Harris, W.M. 1994. Anatomical considerations related to photosynthesis in cotton leaves, bracts and the capsule wall. *J. Expt. Bot.*, 45(270):111-118.
- Bozhinov, M. and Dimitrova, L. 1984. Effect of low temperature on growth, development and yield of cotton. *Rasteniev dul Nauki*, 21(7):52-64.
- Devendra Singh and Bharadwaj, M.D. 1983. Physiological analysis and yielding ability in *hirsutum* cotton. *Indian J. Plant Physiol.*, 26(3):264-275.
- Dhingra, H.R.; Goswami, C.L. and Singh, D.P. 1993. Studies on the reproductive functions of cotton. *Indian J. Plant Physiol.*, 36(2):118-120.

- Dhopte. A.M.; Mohad, V.K.; Potkile, N.N. and Wankhede, S.T. 1988. Influence of leaf morphology on stomatal conductance, transpiration, leaf temperature in isolines of ten cotton cultivars under optimum soil moisture and their association with productivity. *Ann. Pl. Physiol.*, 2(2):140-148.
- Dhopte. A.M.; Jamdar, S.L.; Rahangdale, S.L. and Potkile, N.N. 1991. Influence of light intensity during pre-flowering on leaf physiology and anatomy in cotton genotypes. *Ann. Pl. Physiol.*, 5(1):10-17.
- Enyi, B.A.C. 1977. Physiology of grain yield in groundnut. *Expt. Agric.*, 13 : 101-110.
- Evans, G. Clifford 1972. The quantitative analysis of plant growth. Blackwell Scientific Publications. Oxford, London, Edinburgh Melbourne.
- Fairey, N.A. 1978. Assimilate distribution and utilisation in maize. *Dissertation Abstract. Int.*, 38(7):29-81.
- Feirey, N.A. and Daynard, T.B. 1978. Quantitative distribution of assimilates in component organs of maize during reproductive growth. *Canadian J. Plant Sci.*, 58(3):709-717.
- Fisher. R.A. 1921. Some remarks on methods formulated in recent articles on qualitative analysis of plant growth. *Ann. Appl. Biol.*, 5 : 367-372.

- Giri, D.G. (1988). Production agronomy of short statured cottons (*Gossypium hirsutum* L.). Ph.D. thesis. M.A.U., Parbhani.
- Gregory, F.G. 1917. Physiological conditions in cucumber house. Expt. Res. Sta. Turners Hill Chestnut, Hert. Ann. Rept., 3:19-29 (1977).
- Hayashi, K. 1966. Efficiency of solar energy conversion of rice varieties as affected by planting density. Proc. Crop Sci. Soc. Japan, 35 : 205-211.
- Ibrahim, M.E. and Buxton, D.R. 1981. Early vegetative growth of cotton as influenced by leaf type. Crop Sci., 21(5):639-643.
- Iwata, F. and Okubo 1971. Physiological and ecological studies on corn growth and yield. Proc. Crop Sci. Soc. Japan, 40:462-467.
- Johnston, T. and Pendelton, J.W. 1968. Contribution of leaves at different canopy levels to seed production of upright and lodged soybeans. Crop Sci., 8:291-292.
- John, R.; Potter, James and Jones, W. 1977. Leaf area partitioning as an important factor in growth. Plant Physiol., 59(1):10-14.
- Kalubarne, M.H. and Pandey, R.K. 1979. Note on growth analysis of green gram genotypes. Indian J. Agric. Sci., 49(12):975-977.

- * Koniger, M. and Winter, K. 1993. Growth and photosynthesis of *Gossypium hirsutum* L. at high photon flux densities. Effect of soil temperature and nocturnal air temperature. *Agronomy*, 13:423-431.
- Krishnamurthy, K.; Bomme Gowda, A.; Raghunath, G.; Rajashekhar, B.G.; Venugopal, N.; Jagannath M.K.; Jayaram, G. and Ramchandra, T.V. 1973b. Structure of grain yield in sorghum genotypes under comparable leaf area index at flowering. In investigations on the structure of yield in cereals (maize and sorghum). Technology Report (PL-480). Deptt. Agron. UAS, Bangalore, 1973, pp: 155-161.
- Kumara, P. and Rao, P.K. 1991. Effect of light during ontogeny. *Indian J. Plant Physiol.*, 34(3):288-290.
- Kumarapermal, N. and Mohan Naidu, K. 1986. Patterns of boll growth in linted and lintless cotton genotypes. *Indian J. Pl. Phy.*, XXIX(3):225-229.
- Lad, N.G. 1979. Studies on some agronomic requirements of promising varieties "SH-175 and H-655-C" of cotton under irrigated conditions. M.Sc. (Agri.), thesis submitted to M.A.U., Parbhani.
- Ludwig, L.J.; Saeki, T. and Evans, L.T. 1965. Photosynthesis in artificial committees with progressive defoliation of mature plant. *Aust. J. Biol. Sci.*, 18:1103-1118.

- * Masur. C.J. 1991. Comparison of net photosynthetic rate, stomatal resistance and yield of two cotton cultivars under water stress. *Persiquisa Agro Peunaria Brazilia*, 26(2):153-161.
- Panase. V.G. and Sukhatme. P.V. 1967. *Statistical Methods for Agricultural Workers*. ICAR, New Delhi, Publ., II Eds.
- Patil. B.P. and Patil. S.S.D. 1983. Variation in the leaf area of the cotton varieties. *J. Maharashtra Agric. Univ.*, 8(2):176-177.
- Patil. B.P. 1986. Indexing boll development and retention in cotton varieties for estimating yield of seed cotton. *Int. J. Tropical Agric.*, 4(1):77-84.
- Pearce, R.B.; Brown. R.H. and Blaser, R.E. 1965. Relationship between leaf area index, light interception and net photosynthetic rate in orchard grass. *Crop Sci.*, 5 : 553-556.
- * Prado. R.; Romera and Dominaguez Calerrio, E. 1992. Comparison of the growth and photosynthetic activity of two varieties of cotton Coker 310 and Crema. *Spanish Weed Sci. Soc.*, 311-314.
- Pressenya. I.G.; Czimber. G.; Csabe, G. and Szocs, Z. 1976. Studies on the growth analysis of maize hybrids. *Acta. Botanica Academiae Scientiarum Hungaricae*, 22(4):185-207.

- Rasulov. B.K.H. 1993. Regulation of photosynthetic CO₂ exchange in cotton leaves under progressive soil water deficiency. Russian J. Plant Physiol. 40(4):578-580.
- Reddy. K.R.; Hodges, H.F. and Mackinont, M. 1995. Cotton crop response to changing environment. ASA Special Publ., 59(3):30.
- Richards. F.J. 1969. The quantitative analysis of growth in plant physiology. 5A(ad) F.C. Steward, 1969, Academic Press, New York.
- Ronde. J.A.; Mescht, A. Wander and Cress, W.A. 1995. The biochemical response of six cotton cultivars to heat stress. South African J. Sci., 91(7):363-366.
- Sa Ssenrath and Cole, G.F. 1995. Dependence of canopy light distribution on leaf canopy structure for two cotton species. Agril. and Forest Meteorology, 77(1/2):55-92.
- Sastry. K.S.K.; Sashidhav, V.R.; Mehkri, A.A. and Parameshwara, G. 1979. Paper presented at Symposium on Water Availability and Plant Response at the Water Technology Centre. Indian Institute of Agril. Res., New Delhi.
- Sastry. K.S.K.; Dayakumar, M.V. and Vishwanath, H.R. 1980. Desirable plant characteristics in genotypes of finger millet (*Eleusine coracana*), for rainfed conditions. Trop. Agric., (In Press).

- Shaikh. A.R. and Upadhyav. U.C. 1981. Correlation and path coefficient analysis in rainfed cotton (*G. hirsutum* L.). Cotton Dev., 12(3&4):17-18.
- Sun, I.M. 1965. Shedding rate of upland cotton in Tainas J. Agric. Asso., China, 50:47-51.
- Wankhede, N.P. and Sadaphal, M.N. 1977. Response of the germplasm of upland cotton to population pressures and fertility levels and their reaction to bollworm damage. Indian J. Agric. Sci., 47 : 8-14.
- Warner, D.A.; Scott Holaday, A. and John, J. Burke 1995. Response of cotton to night temperature. Agron. J., 87:1193-1197.
- Watson. D.J. 1947. Comparative physiological studies on the growth of field crops. I. Variation in net assimilation rate and leaf area between species and varieties within and between years. Ann. Bot., 11:41-76.
- Watson. D.J. 1952. The physiological basis of variation in yield. Adv. Agron., 4 : 101-145.
- Weber. C.R.; Shibles, R.M. and Byth, B.E. 1966. Effects of plant population and row spacing in soybean development production. Agron. J., 58 :99-102.
- Welbank, P.J.; French, S.A.W. and Witts, K.G. 1966. Dependence of yield variations on their leaf area duration. Ann. Bot., 30 : 291-300.

- Whithead. F.H. and Myerscough. P.J. 1962. Growth analysis of plant. The ratio of mean relative rate to mean relative rate of leaf area. *New Phytol.*, 61 : 314-321.
- Wullschlegel. S.D. and Dosterhurs. D.M. 1991. Photosynthesis, transpiration and water use efficiency of cotton leaves and fruits. *Photosynthetica*, 25(4):505-515.
- Zeid, F.A. 1973. Protein in the individual organs of spring wheat plants during growth. *Zeitschrift fur Pflanzenernahrung und Bodenkunde*, 135(3):208-214.
- Zheng Dething, Jains YiJaians 1996. The accumulation and distribution of dry matter characteristics of upland and sea island cottons. *Chino Cottons*, 23(4):8-9.

* Original not seen.