YSIOLOGICAL STUDIES OF HETEROSIS IN OTTON HYBRID-4 (Gossypium hirsutum L.)

A

THESIS

SUBMITTED TO THE FACULTY OF AGRICULTURE

GUJARAT AGRICULTURAL UNIVERSITY

IN PARTIAL FULFILMENT OF THE REQUIREMENTS

FOR THE AWARD OF THE DEGREE OF

MASTER OF SCIENCE

(AGRICULTURE)

IN

PLANT PHYSIOLOGY

BY

MAHENDRASINH DALPATSINH GOHIL

DEPARTMENT OF BOTANY

N. M. COLLEGE OF AGRICULTURE,

GUJARAT AGRICULTURAL UNIVERSITY,

NAVSARI CAMPUS, NAVSARI.

(GUJARAT STATE)

MAY, 1985

PHYSIOLOGICAL STUDIES OF HETEROSIS IN COTTON HYBRID 4 (*Gossypium hirsutum* L.)

Student : M. D. Gohil

Major Advisor : Dr. K. G. Mehta
Research Scientist and Head,
Gujarat Agricultural University,
Arnej (Bhal.).

ABSTRACT

The present investigation on physiological studies of heterosis in cotton Hybrid 4 (*G. hirsutum* L.) in relation to its parents (viz. Gujarat 67 and American Nectariless) was carriedout on the field of Main Cotton Research Station, Gujarat Agricultural University, Surat during the year 1980-81.

Based on these findings, it is suggested that more emphasis should be given to the pattern of translocation of photosynthates and nutrients. The data on accumulation of dry matter and its partitioning into different plant parts indicated that the female parent produced more dry matter during its lifespan eventhough it proved to be a poor yielder, because of its lower translocation ability. The probable reason could be the poor mobilization of photosynthates and major nutrients as indicated from partitioning and nutrient uptake studies. On the contrary, the male parent American Nectariless produced least dry matter but utilized it most efficiently as evident from partitioning pattern and harvest index. The hybrid, showed a good combination of the two

characters of the parents i.e. it not only produced higher amount of dry matter like the mother parent but also showed better efficiency to mobilize it like the male parent. Data of growth and developmental traits also depicted that the hybrid adjusted its growth and formed an efficient skeleton. This was evident from the intermediate values of plant height, number of monopodials and sympodials, leaf number and area, leaf area duration, leaf area ratio, relative growth rates and net assimilation rates. The positive or negative values of relative heterosis for these characters indicated that the hybrid utilized its vigour to increase the yield potentiality, which was proved by significantly higher harvest index. Similarly, hybrid also established earliness by attaining significant higher Bartlett 's index than its female parent.

All the yield contributing characters viz. number of bolls, seeds per boll and boll weight also contributed significantly to build up higher yield of the hybrid. Similar effects were also observed for economic characters. The results of fibre properties did not show any significant heterotic effect but hybrid had longer fibres and better span length. Its fibres were uniform and matured but coarser with average strength.

The results of nutrient uptake studies indicated that hybrid uptook maximum amount of nitrogen and phosphorus. Particularly the seeds of hybrid contained higher percentage of nitrogen and proved its better mobilization efficiency than its parents. However, the leaves of both the parents contained higher percentage of nitrogen but appeared to have been locked up there only. Almost similar pattern of translocation of phosphorus and potash was also observed.

Dr. K. G. Mehta
Research Scientist and Head,
Gujarat Agricultural University
Arnej (Bhal).

CERTIFICATE

This is to certify that the thesis entitled " PHYSIOLOGICAL STUDIES OF HETEROSIS IN COTTON HYBRID 4 (*Gossypium hirsutum* L.) " submitted by Shri M. D. Gohil in partial fulfilment of the requirements for the degree of Master of Science (Agriculture) in the subject of Plant Physiology to the Gujarat Agricultural University, Sardar Krishinagar, Dantiwada (District Banaskantha) is a record of bonafide research work carried out by him under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma or other similar title.

The assistance and help received during the course of the investigation and source of literature have been duly acknowledged.

Arnej.

Dt. 22.5.1985

(K. G. Mehta)
Major Advisor.

ACKNOWLEDGEMENT

It gives me immense pleasure and joy in expressing my profound sense of gratitude and heartfelt thanks to my learned guide, Dr. K. G. Mehta, Research Scientist and Head, Gujarat Agricultural University, Arnej for suggesting the problem and constant encouragement throughout the course of this investigation. His keen interest and constructive criticisms have been a source of inspiration and helped me to bring out this project in the present form.

I also take this opportunity to express my profound sense of gratitude and heartfelt thanks to Dr. J. G. Bhatt, Physiologist, C.I.C.R., Coimbatore who also took keen and constant interest in this work.

My sincere thanks are also due to the Director of Research and Dean, Post Graduate Studies, Gujarat Agricultural University, Ahmedabad, Director of Campus, Gujarat Agricultural University, Navsari and the Principal, N.M. College of Agriculture, Navsari for providing necessary facilities for carrying out my studies to a successful conclusion.

I also wish to put on record my special appreciation to Dr. N.P. Mehta, Research Scientist (Cotton), Main Cotton Research Station, Gujarat Agricultural University, Surat for his ever readiness to provide all facilities so as to make me completely at home.

I feel gratified in acknowledging the valuable guidance accorded by Dr. K. B. Desai, Research Scientist (Sorghum), Gujarat Agricultural University, Surat and Dr. K.R.V. Raja, Assoc. Research Scientist (Statistics), Gujarat Agricultural University, Surat. I also gratefully acknowledge the help rendered by Shri L. R. Jambunathan, Quality Evaluation Officer (Retd.), C.T.R.L. Unit, Surat and his associates during the course of these studies.

Dr. V. Kumar, Assoc. Research Scientist (Plant Physiology), Surat deserves a great deal of my respect and devotion for his keen interest, valuable suggestions, timely encouragement throughout the course of my studies. I also acknowledge the help rendered by Dr. D. P. Singh, Assoc. Professor (NARP), Navsari and Dr. R.K. Sharma, Assoc. Research Scientist (Plant Physiology), Arnej for their sincere help.

I am very much indebted to my dear friends Rajnikant G. Vashi in the chemical analyses of the samples and Narendra Modi without whose cooperation and sincere help this work would have remained incomplete.

While reviewing the help and support received during my research work I cannot overlook the help rendered by my dear colleagues in the Plant Physiology Division, Surat.

In the final analysis it is the everlasting love and affection of my father Dalpatsinhji and the late mother Nayanaben, that encouraged me during this investigation. My uncle and aunt did also help me to make me to feel at ease. My wife Daksha and kids Hetal and Viral also gladly sacrificed all their happiness and personal inconveniences so as to fully utilize my entire time for this work. I also express my gratitude to my well wishers Shri Bhikhubhai and Mr. Ramanbhai.

M. Gohil

(M. D. Gohil)

Navsari.

Date : 23rd May, 1985.

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I - INTRODUCTION

Cotton is among the earliest of the wild plants to be domesticated. It holds a very important position among Indian fibre crops and as a cash crop, it plays a vital role in the economy of Indian farmers. It provides means of livelihood to millions of people. Since cotton forms the backbone of our gigantic textile industry, it is considered as a white gold and also a king of the textile fibres in the world.

India is perhaps the only country where all the four cultivated species of cotton are grown commercially. The credit for introduction of superior varieties of American (upland) cotton (G. hirsutum L) rests with the British East India Company. It was introduced for the first time and subsequently more exotic varieties were introduced in the nineteenth century.

The country's production of cotton per unit area is very low (156 kg/ha) as compared to other countries (1129 kg/ha in North America and 1051 kg/ha in Israel). Gujarat ranks second in area covering about 19 to 20 percent of the total area at country level, with regard to production the state stands first with an average production of 18 lakh bales which is 25 to 26 percent of the total production. Therefore strategies need to be developed for understanding and removing the constraints, which hamper the high yield

of seed cotton. Some of the problems related to low yield of cotton are poor seed germination, long flowering and maturation periods, bud and boll shedding, poor boll setting, indeterminate growth etc. which are related to the physiology of cotton plant. If these barriers are removed then there are chances for improving the seed cotton yield. During recent years a number of investigations have been conducted to determine the extent of hybrid vigour manifested in cotton (G. hirsutum L) hybrids.

The problem of producing hybrid seed in cotton on commercial scale was considered to be prohibitive but a simple technique for crossing described by Patel (1955) made it possible to produce hybrid seeds on a large scale for commercial cultivation.

Utilizing this situation, two high yielding hybrids viz., Hybrid 4 in Gujarat and Varalaxmi in Karnataka were released for large scale commercial cultivation in 1971-72. A few more cotton hybrids have been released since then. India can be proud of, being the first country in the world to make commercial success of hybrid vigour in cotton.

Hybrid 4 is intraspecies hybrid between two hirsutum viz. Gujarat 67, an elite variety of Gujarat and Nectariless, an exotic cultivar from the U.S.A. It made its debut on farmer's fields in 1967-68 and was an instant success due to its prolific bearing habit and other desirable characters. Indeed, it was the harbinger of hybrid cotton era in India and perhaps in the world.

Inspite of numerous genetical explanations of expression of hybrid vigour, knowledge about its physiological basis still remaines unveiled. The ultimate capacity of a plant community to produce dry matter depends on the degree of exploitation of solar radiation which is related to vegetative growth of plant. A chain of physiological reactions finally build up the ultimate total harvestable products in crop plants. It is often reviewed that the genes provide only the basic blueprints and determine the operative frame work for the vital plant processes and systematically govern the physiological reactions. Heterotic hybrids usually seem to have better initial embryo weight, seedling vigour and greater capacity to synthesize growth promoting substances, utilize and assimilate more nutrients. The earlier studies of hybrid vigour in certain crops (Ashby, 1930, 1932) attributed the greater size of hybrid than that of the parents. Austin (1963) found that the hybrid plants were photo-synthetically more efficient than the inbreds. Such physiological mechanisms need a detail studies for getting information on such aspects which may provide clues for better selection and introducing superior hybrids in future.

Heterotic hybrids are known to produce more dry matter and to give higher yield in comparison to their inbred parents in the same environment. Moreover the heterotic hybrids represent a good combination of complimentary and

multiplicative physiological and bio-chemical characters which appear to be controlled by simple genetic factors. In cotton, limited studies covering only few individual aspects of physiological basis of heterosis have been reported and therefore an effort has been made here to get a convincing clue to understand the mechanism of manifestation of heterosis in cotton with the help of some important physiological parameters.

In the present investigation the cotton variety Hybrid 4 and its parents viz. Gujarat 67 (female) and American Nectariless (male) were employed to study the following aspects.

(1) To know the pattern of dry matter accumulation in different plant parts and their association with seed cotton yield.

(2) To know the relationship of canopy development and relative growth rates of hybrid and its parents.

(3) To know the relative degree of heterosis at different stages of plant growth and development.

(4) To know the degree of heterosis in the economically important plant products.

(5) To assess the degree of heterosis in Hybrid 4 towards grow and yield, production of biomass.

(6) To determine the content and uptake of major nutrients in different parts of cotton Hybrid 4 and its parents at maturity.

II - REVIEW OF LITERATURE

Investigations of heterosis in cotton have been concerned primarily with attaining maximum increase in yield and other economic characters at the first generation level. Significant increases at this level have been reported by several investigators (Kime and Tilley, 1947; Jones and Loden, 1951; Loden and Richmond, 1951 and Turner, 1953). Loden and Richmond (1951) in a comprehensive review stated that "evidences of significant increases in most plant characters and yield resulting from heterosis have been reported in interspecific intervarietal and intravarietal crosses".

After the unprocedental success of F_1 hybrids with maize, several attempts were made to apply the same principle to other crops as well.

Hybrid vigour effects with cotton are most pronounced in interspecific crosses and advantages proved to be such that the production of F_1 hybrids on a commercial scale has often been advocated (Balls, 1908; Cook, 1909; Ayyer, 1936; Patel and Patel, 1952). Singh *et al.* (1964) found that hybridization in intraspecific crosses was more pronounced in the characters contributing towards yield, while in interspecific crosses it was obvious in vegetative characters. As a result of further efforts made in this direction, Patel (1971) evolved a new hybrid in cotton *G. hirsutum* L. viz. Hybrid 4 which has opened a new line of intrest among the cotton growers because it has a very high productive

potential together with good quality. Therefore, it was thought proper to study the physiological basis of heterotic effect in different characters viz. growth and development, yield and yield contributing characters, economic aspects, fibre properties, and bio-chemical parameters of hybrid as well as it's parents.

While reviewing the literature it is found that very few studies have been undertaken pertaining to the heterotic effect in some physiological parameters either on average basis or at different critical stages of life cycle of cotton. However efforts have been made to trace out all the literature that is available for each character.

2.1 GROWTH AND DEVELOPMENT

I. Plant height :

Bolls (1908) and Ware (1930) noticed low value of heterosis in interspecific crosses of American cotton. Several other workers reported heterosis for plant height. Ali and Lewis (1962) reported 121 per cent heterosis over mid parent. Young and Murray (1966) noticed hybrid vigour in upland cotton ranging from 0.14 to 10.32 per cent over mid parent. Akthar et al. (1973) observed greatest heterotic values for plant height among characters studied in G. hirsutum L. cotton. Khan and Ali (1980) also reported heterosis for plant height in G. hirsutum L. cotton

II. Monopodials on main stem :

Abo, El and Metwaly (1979) reported heterosis for this character in G. barbadense L. cotton. Khan and Ali (1980) observed negative heterosis for this character in G. hirsutum L. cotton. Barkat Ali et al. (1982) reported heterosis for this character in G. hirsutum L. cotton.

III. Number of sympodials on main stem :

Khan and Ali (1980) reported positive heterosis for this character in G. hirsutum L. cotton. Singh and Tyagi (1981) reported positive and significant correlation between sympodial number and yield. Barkat Ali et al. (1982) reported that out of six hybrids, two exhibited heterosis for this character in G. hirsutum L. cotton.

IV. Number of leaves per plant :

Fernando (1958) and Army and Gree (1967) reported that shaded lower leaves might be parasitic using more carbohydrate for respiration than they produce by photosynthesis. Bhatt (1970) during the course of studies of yielding capacity of cotton plant in relation to dry matter production suggested that the leaves and the branches through their lateral bushy growth contribute largely towards the production of excessive dry matter in these types and thus considerably lower the fruiting co-efficient. Marani and Avieli (1973) observed that the interspecific crosses of cotton showed significant heterosis for leaf number.

V. Leaf area index (LAI) :

Harris and Loden (1954) reported no hybrid vigour in leaf blade area in hybrid of G. hirsutum L. Bhatt (1974) reported that unshaded leaf area is more effective than a greater area madeup partly of shaded leaves in intercepting sunlight and may result in the greater efficiency of plant with low LAI.

VI. Leaf area duration (LAD) :

Maksin and Lilyana (1973) observed that the early maturing cultivars are characterized by a shorter period of growth.

VII. Dry weight per plant (g) :

Harris and Loden (1954) reported expression of hybrid vigour was evident in dry weight of stems, leaves, fruiting parts and also in total dry weight of above ground plant. Dastur (1960) suggested accumulation of dry matter as a yield determining parameter. Brown (1966) reported that the vegetative vigour of UKA 67/17/86 was the result of a more rapid accumulation of dry matter especially during the period between 50 and 70 days after sowing. Most of the increased dry matter was incorporated in to stem material and produced taller plants. Gupta et al. (1980) observed during the course of study of growth parameters of parents and hybrid, that heterosis for dry matter trait was exhibited by cotton hybrid "Jai x PS 10" and "PS 73 x Coker" during early stages of plant growth.

VIII. Partitioning of photosynthates :

Armstrong and Albert (1931) studied the variations in the distribution of dry weight in various parts of the cotton plant at different stages of growth. They found that the dry weight of leaves steadily decreased, the dry weight of the stems remained fairly constant while that of fruiting parts steadily increased. Donald (1962) and Wallance and Munger (1966) reported that genetic improvement in economic yield of several crops derives in part from higher percentages of biological yield being partitioned to the plant organs constituting economic yield. Bassett et al. (1970) reported that in mature cotton plant (G. hirsutum L.) the average distribution of dry matter was in stem 23.1 per cent, leaves 17.4 per cent, burs 16.3 per cent, seed 25.3 per cent and lint 17.9 per cent.

IX. Relative growth rate :
and
Net assimilation rate :

Ullal and Narasimhachar (1963) observed higher RGR during the vegetative phase at Dharwar then there was steep fall, reaching minimum at the commencement of the reproductive phase. Gupta et al. (1980) investigated the growth pattern of hybrids and their parents for seven developmental traits at various stages of plant growth in upland cotton. They observed that the RGR and NAR for parents and hybrids did not fall into any set pattern.

Patil and Patil (1982) observed that RGR of dry matter was highest at 40 days after sowing thereafter, it decreased gradually upto 100 days after sowing and sharply upto 130 days. The NAR was highest during 40-70 days after sowing.

(XI. Days to 50 per cent squaring,

XX Days to 50 per cent flowering
and
Days to 1st boll bursting :

Katarki et al. (1970) observed low and negative heterotic values for 50 per cent flowering in hybrids developed from hirsutum x barbadense varieties. He also reported similar effect for boll bursting in G. hirsutum L. cottons. Joshi (1976) also observed negative heterotic effects in Hybrid 4 to the extent of 28.4 per cent over better parent. Vallejo et al. (1976) reported singificant negative heterosis for days to first flowering in crosses of upland cotton. Krishnaswami and Kothandaraman (1977) observed significant and negative heterosis for days to 50 per cent squaring, flowering and for first boll bursting in interspecific crosses of G. hirsutum L. and G. barbadense L. Sharma (1979) also observed similar effect for days to 50 per cent flowering and boll bursting in the crosses of G. hirsutum L. x G. barbadense L.

2.2 YIELD AND YIELD CONTRIBUTING CHARACTERS

I. Number of bolls per plant :

Turner (1953) observed significantly more number of bolls in hybrid and high degree of relative heterosis for boll production in upland cotton. Pandya and Patel (1959) showed that the hybrid Co2 x S.I. produced as many as 400 bolls per plant and also produced higher yield. Vysokji (1961) reported that a cross of Upland x Egyptian cotton developed more fruits per plant than either parents. Dorairaj (1968) reported heterosis for number of bolls in intraspecific crosses. Bhatole (1971) recorded 90.2 per cent heterosis over mid parent for number of bolls per plant in F_1 of Gujarat 67 and American Nectariless.

Govil and Singh (1979) also reported that out of fourteen hybrids twelve showed the positive heterotic effect ranging from 7.87 to 219.69 per cent for this trait.

II. Number of seeds per boll :

Marani (1967) obtained much more pronounced effect of heterosis in number of seeds per boll during the experiment on seven G. hirsutum L. and eight G. barbadense L. varieties and their possible crosses. Bhalala (1976) also reported heterosis in seeds per boll ranging from 0.5 to 31.36 per cent over mid parental values in the intervarietal crosses of Upland cotton. Joshi (1976) observed high positive heterotic effect in G. hirsutum L. crosses for this trait.

III. Boll weight (g) :

Dastur (1949) observed higher boll weight in hybrid than in pure barbadense type. Miller and Marani (1963) observed heterosis in intraspecific crosses of G. hirsutum L. Katarki et al. (1970) reported significant heterotic effect for boll weight in interspecific hybrid DCH 1 and DCH 3 over superior parent. Bhatole (1971) observed 4.5 per cent heterosis over mid parent in F_1 of Gujarat 67 and American Nectariless. Khan and Ali (1980) reported heterosis over the mid parent value ranging from -38.88 to 19.23 per cent for this character in G. hirsutum cotton.

IV. Seed cotton yield per plant (g) :

The heterosis for seed cotton yield is now an established fact. Several workers observed heterosis for this character in intraspecific crosses. Jones and Loden (1951) reported heterosis of 34.6 per cent for mid parent. Turner (1953) studied heterosis in 21 intrahirsutum crosses of seven selected inbred lines with two tester upland cotton variety and found that some of the hybrids showing vigour in yield of seed cotton. Dorairaj (1968) found significant heterosis in intrahirsutum crosses. Marani (1968a) found heterosis in intraspecific crosses. Bhatole (1971) in his thesis reported 70.6 per cent heterosis over mid parent in F_1 of Gujarat 67 x American Nectariless. High heterosis in intraspecific crosses of G. hirsutum L. was reported by Patel (1974). He observed 148 to 184 per cent heterosis over better parent for seed cotton yield in first commercially successful Hybrid 4.

V. Harvest index :

Crowther (1944) expressed the view that the efficiency of a cotton plant in the production of seed cotton may be judged by its fruiting efficiency. Bhatt (1970) suggested that the importance of the fruiting co-efficient can be viewed from the fact that some varieties of cotton giving similar yield of seed cotton, differed widely in the production of dry matter because of their differing fruiting co-efficient. Singh and Bhardwaj (1983) reported that the association between dry matter production and harvest index tended to be negative. The variety with higher dry matter accumulation rate gave low value for harvest index. On the other hand the variety had low dry matter accumulation rate but higher harvest index.

2.3 ECONOMIC CHARACTER

I. Ginning outturn :

Pandya and Patel (1959) observed moderate heterosis for ginning outturn in interspecific crosses. Miller and Marani (1963) reported relatively small heterotic effect for this character in G. hirsutum L. cotton. Katarki et al. (1970) also reported very low i.e. 0.7 per cent heterotic value for this trait in interspecific crosses. Bhatole (1971) observed 0.06 per cent heterosis over mid parent in F_1 of Gujarat 67 x American Nectariless. Sundaram et al. (1972) also reported 36 and 34 ginning percentage value for Hybrid 4 and Gujarat 67 respectively. Chinnadurai (1973) claimed heterosis of -0.3 to 7.5 per cent over mid parent in Upland cot

II. Seed index :

Akthar et al. (1973) reported 5 per cent heterosis over mid parent in the crosses of G. hirsutum cotton. Bhalala (1976) observed significant and positive heterosis for this character in nine out of twenty-eight crosses. Joshi (1976) also observed high heterotic effect for the trait in crosses of upland cotton.

III. Lint index :

Akthar et al. (1973) observed 11.75 per cent heterosis for lint index in G. hirsutum L. cotton. Govil and Singh (1979) reported nine of the fourteen hybrids showed positive heterosis for this character, the value of which ranged in between 2.34 and 18.27 per cent.

2.4 FIBRE CHARACTERS

I. Mean fibre length (mm) :

Sundaram et al. (1972) reported that Hybrid 4 had significantly lower mean fibre length than Gujarat 67. Srinivasan and Gururajan (1973) reported heterosis of 0.8 per cent over mid parent in intrahirsutum crosses.

II. 2.5 per cent span length (mm) :

Marani (1968b) observed only small heterotic effects for upper half mean length in G. hirsutum L.

III. Fibre uniformity ratio :

Marani (1968b) reported that F_1 had lower uniformity than mid parent. Katarki et al. (1970) observed a moderate but positive heterosis for this character in interspecific crosses of G. hirsutum L. and G. barbadense L. Patel (1980) recorded heterotic values ranging from 0.47 % to 2.46 per cent over mid parent in intervarietal crosses of G. barbadense L. cotton.

IV. Fibre fineness :

Al-Rawi and Kohel (1969) using intraspecific hybrids, found that the fineness for the F_1 was within the range of the parent. Patel (1974) observed heterosis for fibre fineness in Hybrid 4 as compared to its female parent Gujarat 67. Patel (1980) reported 0.24 to 18.88 per cent heterotic values in inter varietal crosses of G. barbadense L. cotton.

V. Fibre maturity co-efficient :

Katarki et al. (1970) recorded 0.37 per cent heterotic values for this trait in interspecific crosses. Patel (1974) reported that F_1 of Gujarat 67 x American Nectariless was superior for this trait.

VI. Fibre bundle strength :

Kime and Tilley (1947) and Stroman (1961) obtained weaker F_1 hybrids in interspecific crosses. Barnes and Stalen (1961) and Marani (1968a) have found no heterosis for fibre strength in intraspecific crosses.

2.5 BIO-CHEMICAL STUDIES

Dastur and Ahad (1945) during their studies on bad opening of cotton bolls found that the cotton crop removed large quantities of major nutrients on a unit area basis. Bassett et al. (1970) reported that nitrogen accumulated mainly in the seed as the plant neared maturity. Concentration of nitrogen in the leaves dropped from above 4 per cent in the early season to slightly less than 3 per cent as the season progressed. Similar decreases occured in the burs and stems. Nitrogen averaged 3.7 per cent in the mature seed. They noted that the removal of nitrogen from the field at harvest was 63 to 83 kg per hectare and that of phosphorus and potassium was 9 to 12 and 16 to 24 kg per hectare, respectively. They also observed that most of the phosphorus taken up by the plant was in the seeds which contained 0.56 to 0.61 per cent of phosphorus. Khare et al. (1970) observed the highest concentration of nitrogen in the fruiting parts and it was followed by leaves and stem with lowest figure in roots. Bhatt and Appukuttan (1971) found that the cotton varieties giving same yield but with contrasting morphological forms differ significantly in their nutrient uptake. Halevy (1976) observed higher percentage of potash in all plant parts in Acala 4-42 than in Acala 1517-6. The concentration of nitrogen in the leaves was 2.5 per cent, in stem 1.0 to 1.5 per cent and in root 0.5 to 0.9 per cent at maturit At harvesting lint and the seed contained 0.2 and 3.8 per cent of nitrogen respectively. The leaves contained 0.3 to 0.5 per cent of phosphorus while the seed contained 0.7 per cent. The uptake of phosphorus by seeds was 19 to 21 kg per hectare. At harvestin the cotton plant contained about 1 per cent of potash. In burs it was 2.1 to 3.0 per cent and in lint 0.5 per cent.

Leffler and Tubertini (1976) reported the major mineral accumulated by the seeds was nitrogen and at maturity it was maximum in the seeds, while the most abundant mineral in the fibre was potash. Wanjura and Sundaraman (1976) reported that stem, leaves, petioles, squares and burs fractions decreased in nitrogen concentration from first squaring to maturity while the seed's nitrogen concentration increased between near bloom and maturity. The concentration of nitrogen was in between 3.76 to 4.18 per cent. Giri and Upadhyay (1980) reported 2.31 to 3.36 per cent and 1.737(g) to 3.586 (g) content and uptake respectively of nitrogen in cotton Hybrid 4 at boll bursting. Maylswamy and Iruthayaraj (1980) also observed 12.2 to 74.3, 2.6 to 13.9 and 13.0 to 74.4 kgs uptake per hectare of nitrogen, phosphorus and potash respectively.

III - MATERIALS AND METHODS

LOCATION OF EXPERIMENT

The present investigation was carried out to study some physiological aspects, influencing the exploitation of vigour in cotton Hybrid 4 (*Gossypium hirsutum* L.). Field experiment was conducted during Kharif season of year 1980-81 at Main Cotton Research Station, Gujarat Agricultural University, Athwa Farm, Surat. The soil of the experimental plot was deep black (cotton soil) with 7.9 pH. Geographically, Surat is situated at 20^{0} - 12^{0} N latitude, 72-52' E longitude and at altitude of 11.34 meters above mean sea level. The average annual precipitation of the last ten years is 1211.5 mm. During the year 1980-81 the total rainfall recorded was 983.3 mm. The details of rainfall, temperature and relative humidity data of this station for the period under study are presented in Figure-I.

3.1 EXPERIMENTAL MATERIALS

The experimental materials comprised of cotton Hybrid 4 (an interhirsutum hybrid) and its parents, namely, Gujarat 67 (an elite variety of Gujarat) and American Nectariless (an exotic cultivar from U.S.A.). The identification characters of these cultivars are presented in Table-I.

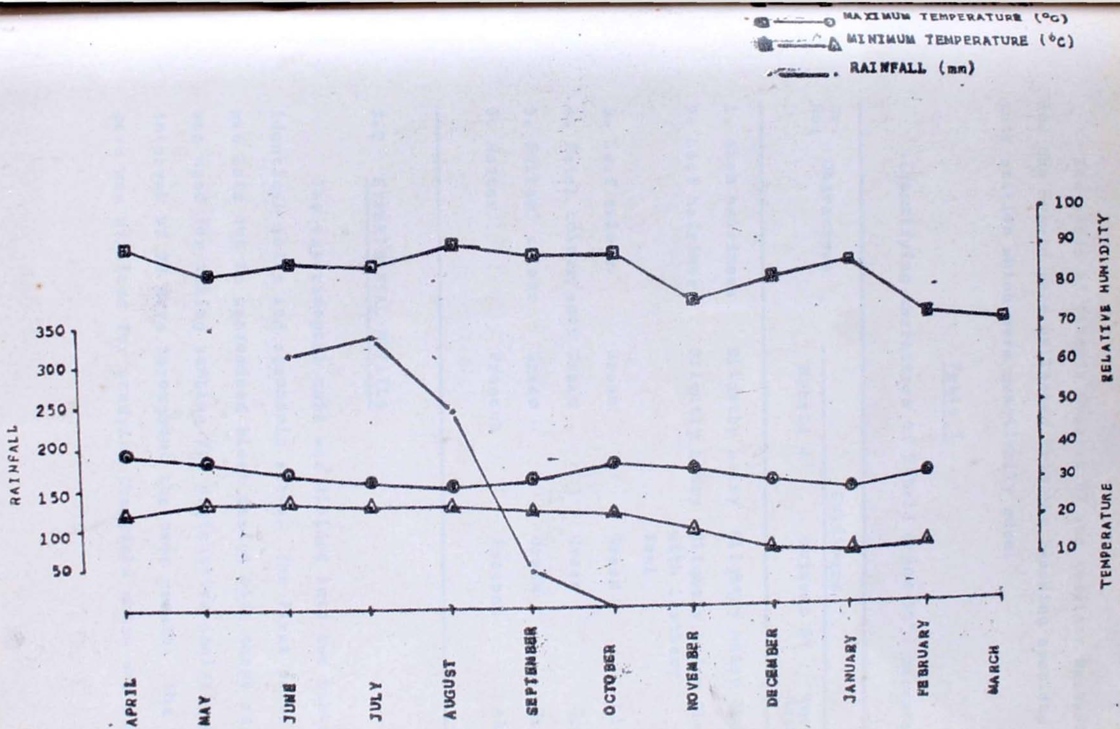

Fig. I: METEROLOGICAL DATA FOR THE EXPERIMENTAL YEAR (980-81)

The seeds of parents Gujarat 67 and American Nectariless and the hybrid were collected from the breeding sections of this station which were genetically pure.

Table I

Identifying characters of Hybrid 4 and it's parents

Sr. No.	Characters	Cultivars		
		Hybrid 4	Gujarat 67	American Nectariless
1.	Stem hairiness	Slightly hairy	Slightly hairy	Glabrous
2.	Leaf hairiness	Slightly hairy	Slightly hairy with leathery feel	Glabrous
3.	Leaf colour	Green	Green	Light green
4.	Petal colour/spot	Cream	Cream	Cream
5.	Pollen colour	Cream	Cream	Cream
6.	Nectar[illegible]	Present	Present	Absent

3.2 EXPERIMENTAL DETAILS

The experimental unit was divided into two parts having identical soils and agronomic sites. The first part, which was laid out in randomized block design with three replications, was used for taking samples for distructive analysis at an interval of 20 days throughout the crop growth. The second part was utilized for studying the yield which was also

laid out in a R.B.D. with seven replications. The three cotton cultivars were sown in both the experimental parts. In the experimental area meant for the yield study, the gross plot area consisted of 9.0 x 4.8 meters and the net plot area was of 7.8 x 2.4 meters. There were 4 rows in each of the plots. In the experimental area for sampling, the gross plot area was of 9.0 x 10.8 meters which accomodated 9 rows and the net area was of 7.8 x 8.4 meters. Recommended spacing of 120 x 60 cm was followed for all the cultivars in both the experimental parts. The parents and their hybrid were sown on 24th June 1980 when there was sufficient moisture due to the monsoon showers. The seedlings were thinned and gaps were filled up in order to keep adequate plant stand.

All the recommended agronomic practices alongwith necessary plant protection measures were adopted. The fertilizers applied were N - 200 kg, P_2O_5 - 100 kg and K_2O - 100 kg per hectare. The crop was irrigated as and when required. All the operations were done evenly in both the parts of the experiment.

3.3 METHOD OF PLANT SAMPLING

For sampling purpose full plant stand was maintained. The plants uprooted for sampling were selected in such a manner that they represented plants under normal growth conditions. Before uprooting the plant, it was assured that it is fully encompassed by 4 plants on all the four sides. At every sampling period one plant was uprooted from each plot of each

cultivar under each replication measuring a total of three plants (replication) of each cultivar. The first sample was drawn on 31st July, 1980, i.e. one month after germination. Thereafter the remaining samples were taken regularly at an interval of every 20 days, till maturity. Thus in all, there were 13 samplings during the whole life cycle of the crop.

3.4 DISSECTION OF THE PLANTS

The randomly selected plants were carefully uprooted and then these plants were immediately brought to the laboratory. First, the roots were cut-off from a specific demarcation which was found on the stem separating the underground and top portion of the plant. The root was utilized for the estimation of N, P and K content. The shoot was further dissected into different components viz. leaves, stem (Main+Branches), reproductive organs (squares, buds, flowers and bolls) for measuring the dry matter of each part separately. The leaves (without petioles) were used for studying leaf area also.

3.5 PLANT GROWTH AND DEVELOPMENT

Observations on following plant growth and developmental characters were recorded from sampling block.

I Plant height (cm) of main stem :

The plant height was recorded in centimeters from the zero node (where cotyledonary node appears) to the terminal growing point on the main stem at each sampling date.

II. Number of monopodials on main stem :

The number of monopodials was counted on each sampling date on the main stem of the plant and was recorded.

III. Number of sympodial on main stem :

The number of sympodials on the main stem of the plant at each sampling date was counted and recorded.

IV. Number of leaves on the plant :

The number of leaves appeared on the plant was counted and recorded at each sampling date.

V. Leaf area index (LAI) :

This was calculated by using the formula -

$$LAI = \frac{\text{Leaf area}}{\text{Land area}}$$

For determining leaf area, planimeter was used in the first sample as the number and area of leaves was small. In the subsequent samplings, leaf area of only a part of the leaf samples were measured by planimeter and their dry weight determined. For the remaining part of leaf sample, their dry weight was determined and the area was calculated by proportion. Thus, the total leaf area of the plant was calculated in square centimeters. The data were then converted into square meters per plant to calculate NAR.

VI. Leaf area duration (LAD) :

This was calculated by using the following formula -

$$LAD = \frac{(LaI_1 + LaI_2)}{2} (t_2 - t_1)$$

Where,

LaI_1 = Leaf area indices at 1st sampling

LaI_2 = Leaf area indices at 2nd sampling

t_1 = Time in terms of days at 1st sampling

t_2 = Time in terms of days at 2nd sampling

VII. Dry weight per plant (g) :

The uprooted plants from each sampling were separated into leaves, stem and reproductive organs, if any, after recording the earlier stated 1st to 3rd observations and thereafter these parts were chopped into small pieces and dried in the forced air oven at 70° C until constant weight was recorded. They were then ground for chemical analysis.

VIII. Partitioning of photosynthates :

For partitioning of photosynthate into the major plant components viz. stem, leaves and fruiting parts the percent of dry matter in each of these plant component was calculated for hybrid as well as parents at each of the selected plant growth stages.

IX. Leaf area ratio (LAR) :

It is a measure of the amount of "growth producing material" per unit dry weight and is expressed as the rate of change of leaf area with respect to dry weight. This was also calculated by using the following formula, and

expressed in Cm^2/g

$$LAR = \frac{(La_2 - La_1)(Log^e W_2 - Log^e W_1)}{(Log^e La_2 - Log^e La_1)(W_2 - W_1)}$$

Where,

La_1 = Leaf area at 1st sampling

La_2 = Leaf area at 2nd sampling

$Log^{"e"} La_1$ = $Log^{"e"}$ of Leaf area at 1st sampling

$Log^{"e"} La_2$ = $Log^{"e"}$ of Leaf area at 2nd sampling

W_1 = Dry weight of plant at 1st sampling

W_2 = Dry weight of plant at 2nd sampling

$Log^{"e"} W_1$ = $Log^{"e"}$ of Dry weight of plant at 1st sampling

$Log^{"e"} W_2$ = $Log^{"e"}$ of Dry weight of plant at 2nd sampling

X. Relative growth rate(RGR) :

The relative growth rate is an index of the growing material per unit dry weight of plant per unit time. The development of this concept and its uses were thoroughly reviewed by Watson (1952). The RGR was calculated by the following formula.

$$RGR = \frac{Log^e W_2 - Log^e W_1}{t_2 - t_1}$$

This was expressed in g.g./day.

XI. Net assimilation rate (NAR) :

This is the net increase in dry matter (photosynthesis minus respiration) per unit time per unit area. This was calculated as

$$NAR = \frac{(W_2 - W_1)\ (\text{Log}^e\ La_2 - \text{Log}^e La_1)}{(La_2 - La_1)\ (t_2 - t_1)}$$

This was expressed in $g/M^2/day$.

For recording following growth and developmental characters five plants were randomly selected from the net plot of the yield block. Those plants were then utilized for studying yield and yield contributing characters and other economic as well as fibre characters also.

XII. Days to 50 % squaring :

The days were counted from the date of sowing to the date of 50 % squaring on a plot-to-plot basis.

XIII. Days to 50 % flowering :

The number of days taken from sowing date to 50 % flowering was recorded for each plot.

XIV. Days to first boll bursting :

Similarly the number of days taken from sowing to first boll bursting was recorded for each plot.

XV. Bartlett's index :

For the observations of this trait, weekly pickings of seed cotton from selected plants were done from 1st January to

12th April, 1981 and the number of bolls per plant per picking was noted. Bartlett's index was calculated by the formula worked out by Bartlett (1937).

$$B.I. = \frac{P_1 + (P_1 + P_2) + \cdots (P_1 + P_2 + \cdots Pn)}{n (P_1 + P_2 + \cdots P_n)}$$

Where,

B.I. = Bartlett's index

$P_1 P_2 \cdots P_n$ are the number of bolls harvested in 1st 2nd...n^{th} pickings and n is the number of pickings done.

3.6 YIELD AND YIELD CONTRIBUTING CHARACTERS

I. Number of bolls per plant :

The total number of matured bolls on each of the selected five plants from the yield block were counted at each picking and were summed, averaged and recorded as the number of bolls per plant.

II. Number of seeds per boll :

Five bolls were randomly picked up from each selected plant in each plot and the seeds in each bolls were counted, averaged-out and recorded.

III. Boll weight (g) :

Hundred well opened bolls were randomly picked up from each plot and averaged to get the average weight of boll.

IV. Seed cotton yield per plant (g) :

The seed cotton yield per plant was recorded in grams separately from each of the randomly selected five plants in each plot and averaged.

V. Harvest index (H.I) :

It is the ratio of yield of seed cotton and biological yield of the plant on a dry weight basis, expressed as percentage. This was worked out from each randomly selected five plants of each plot at the time of harvest and their averaged was recorded.

$$H.I. = \frac{\text{Yield of seed cotton/plant}}{\text{Biological yield/plant}} \times 100$$

3.7 ECONOMIC CHARACTERS

I. Ginning outturn :

Ginning outturn or ginning percentage is the ratio of weight of lint to that of seed cotton expressed as percentage. It was calculated by the following formula -

$$G.P. = \frac{\text{Weight of lint}}{\text{Weight of seed cotton}} \times 100$$

II. Seed index (S.I.) :

Seed index was worked out by weighing 100 seeds obtained from each of the individual randomly selected plant averaged, and expressed in grams.

III. Lint index (L.I.) :

Lint index represents the absolute weight of lint produced per seed. This was computed by the following formula

$$L.I.= \frac{\text{Weight of 100 seeds x Ginning percentage}}{100 - \text{Ginning percentage}}$$

3.8 FIBRE CHARACTERS

All these characters were studied by CTRL unit, Surat attached to the research station.

I. Mean fibre length (mm) :

It indicates the arithmetic mean length of a tuft of fibres and it is derived from the value of 2.5 per cent span length determined on Digital Fibrograph by applying the conversion equation recommended by CTRL; Bombay. This was also worked out from individual selected plant of each plot.

II. 2.5 per cent span length (mm) :

It was measured by Digital Fibrograph. For measurement, fibre beards are prepared on special combs and the tuft was placed in the path of a narrow beam of a light. The light intensity transmitted through the fibre beard is fed to a computer circuit and a span length value is directly indicated by the instrument on counters. This character corresponds well with American Closser's Staple length which is expressed in mm.

This was also worked out on individual plant selection basis of each plot per replication and was recorded.

III. Fibre uniformity ratio :

This was measured on the Digital Fibrograph. The uniformity ratio is the ratio of 50 per cent span length expressed as a percentage of the 2.5 per cent span lengths given by the Digital Fibrograph.

IV. Fibre fineness :

The fibre fineness was measured by the "Micronaire" (by air flow method). It measures the fibre weight per unit length directly. In otherwords, it indicates the extent of resistance to air flow offered by fibre plug of known weight of fibre packed in standard dimensions of one inch in the length and one inch in diameter. It is calibrated in micrograms per inch (i.e. 10^{-6} gm/inch).

V. Fibre maturity co-efficient (%) :

Fibre maturity co-efficient is an index of the extent of development of the secondary cell wall of fibre and unitary expression to indicate the relative maturity of fibres.

The maturity was measured in this investigation by micronaire instrument with 3/8 inch spaces and without spaces. The difference between these two values is an indication of the maturity. The maturity co-efficient was calculated as per the following formula -

$$Mc = 0.1579\ B + 0.4670$$

Where,

Mc = Maturity co-efficient

B = Difference between reading with and without spaces

It is expressed in percentage.

VI. Bundle strength (at zero gauge length) :

It has been determined on a stelometer and expressed in units of g/tex. A small ribbon of about 200 fibres is broken on the stelometer after mounting the fibres on a pair of Pressley clamps and clipping off the extra length of fibres protruding on either side of the clamps. Subsequently the broken fibres are carefully collected and weighed on a precision torsion balance to give the weight of bundle in milligrams. The breaking load in kilogram divided by the bundle weight in mg and multiplied by a factor 11.81 gives the tenacity value in g/tex.

The fibre bundle strength was calculated by the following formula -

$$\text{Tenacity(g/tex)} = \frac{\text{Breaking load of bundle in kg} \times 11.81}{\text{Weight of bundle in mg}}$$

3.9 BIO-CHEMICAL ANALYSIS

Bio-chemical estimation, viz, N, P and K were worked out from all the plant parts like roots, stems, leaves and reproductive organs at the period of maturity. . In this analysis, content and uptake of major nutrients, like Nitrogen, Phosphorus and Potash were studied. Roots were taken to determine only the content. The following methods were adopted to determine N, P and K content.

Nitrogen (N)

Nitrogen was estimated by micro-kjeldahl method (Snell and Snell, 1955). A suitable quantity of the material was digested with H_2SO_4. The digested material was neutrilized by 10 % sodium potassium tartrate and the colour was developed by Nessler's reagent. The percentage transmission was read at 410 nm on Bausch and Lomb (Model sp. -20) colorimeter. Its content was expressed in percentage (N) and uptake in g/plant.

Phosphorous (P_2O_5)

A suitable quantity of dry material was taken and acid extract was prepared by wet digestion method using triacid mixture (Ratio of 10 : 1 : 4 of nitric acid, sulphuric acid and percloric acid respectively). Again suitable aliquot was taken. The colour was developed by Vanadomolybodate yellow colour method in nitric acid system (Method-V-Jackson, 1958), and the colour was read at 400 nm. Its content (P_2O_5) was expressed in percentage and uptake in g/plant

Potassium (K_2O)

A suitable aliquot of digested material, obtained after wet digestion for P, was used for K_2O estimation. The readings were recorded on a EEL flame photometer (Jackson-1958) and referred to a standard curve and the content was expressed as percentage and uptake as g/plant.

3.10 STATISTICAL ANALYSIS

A Analysis of variance :

The replicationwise mean values were subjected to statistical analysis. The analysis of variance was carried out by the method outlined by Panse and Sukhatme (1969).

I. For yield, yield contributing and economical characters

Source of variance	d.f.	M.S.
Replication	r-1	Mr
Treatments	t-1	Mt
Error	(r-1)(t-1)	Me
Total	(rt-1)	-

II. For growth, development and bio-chemical characters

Source of variance	d.f.	M.S.
Replication	r-1	Mr
Treatment	t-1	Mt
Stage	S-1	Ms
Variety	V-1	Mv
Stage x variety	(S-1)(V-1)	Msv
Error	(r-1)(t-1)	Me
Total	(rt-1)	-

Where,

r = number of replications

t = number of treatments

S = number of stages

V = number of varieties

S x V = interaction of stage and variety

The error variance Me was used as the error component in the further analysis.

In the analysis of variance the data of some of the characters were found to be not normal and hence they were analysed after the square root transformation. The data of the characters which were subjected to this transformation were

1) number of monopodials on the main stem

2) number of sympodials on the main stem

B Heterosis :

Heterosis expressed as percentage increase or decrease in the mean value of the F_1 hybrid over mid-parental value (Relative heterosis) and it was calculated as follows -

$$\text{Relative heterosis } \% = \frac{F_1 - \overline{M.P.}}{\overline{M.P.}} \times 100$$

Where,

M.P. = mid-parental value or mean of the parental value

Test of significante of heterosis and 't' test (Mani, 1972).

Heterosis over mid-parent :

$$\text{C.D. for variety} = \left(\frac{3Me}{2rs}\right)^{\frac{1}{2}} \times \text{"t" value}$$

$$\text{C.D. for stage} = \left(\frac{3Me}{2rv}\right)^{\frac{1}{2}} \times \text{"t" value}$$

IV - EXPERIMENTAL RESULTS

The results obtained in the present investigation are described below :

4.1 PLANT GROWTH AND DEVELOPMENT

I. Plant height (cm) of main stem :

The data on plant height are presented in Figure II and Table II. The data revealed that the differences due to stages and interaction were significant.

The hybrid was taller (85.7 cm) than its male parent (84.7 cm) but was shorter than its female parent (88.2 cm).

Initially, the average plant height increased significantly with each sampling upto 150 days. Thereafter, the increase in plant height was slow and not significant. After 230 days it is more or less stabilized at a level of about 125 cm.

No significant differences were observed in plant height among the varieties upto 50 days after germination. During the period of sampling between 50 and 110 days, the elongation of main stem in hybrid was greater and significant. In case of the female, a sudden spurt in the elongation of the main stem was observed during the period between 50 and 150 days when the height jumped from 12.53 cm to 116.33 cm. At

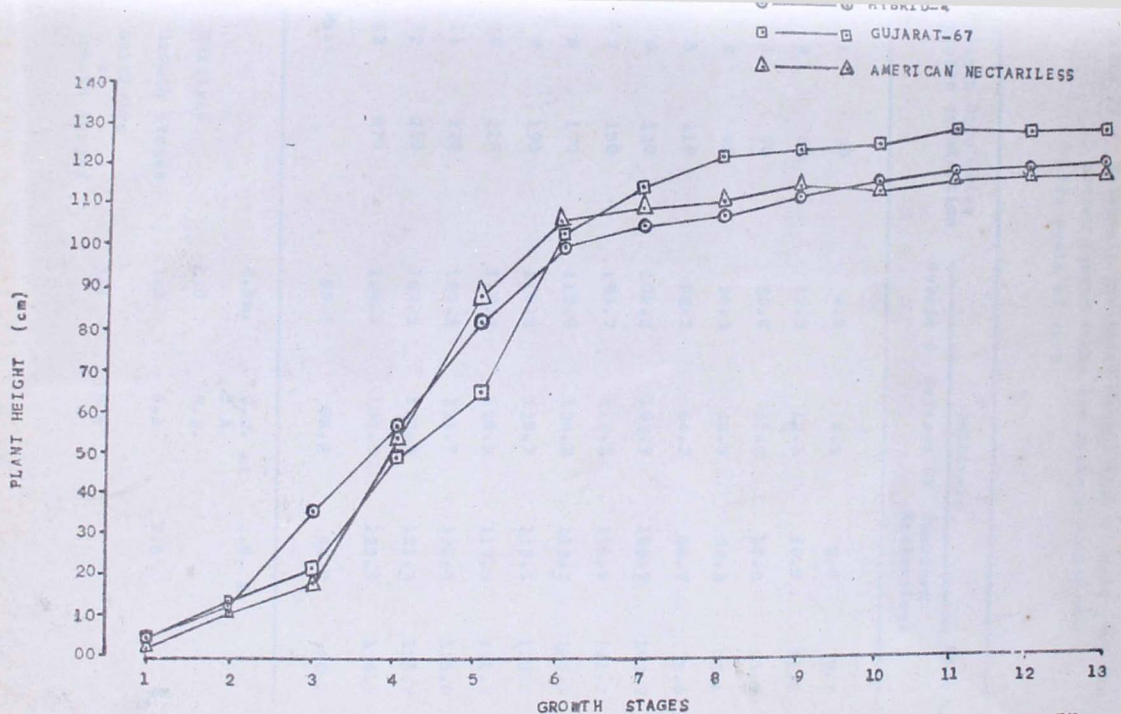

Fig.11: PLANT HEIGHT (cm) OF COTTON HYBRID-4 AND IT'S PARENTS AT SELECTED PLANT GROWTH STAGES DURING THEIR LIFECYCLE.

Table II : Heterosis for plant height (cm) of main stem in cotton Hybrid 4 and its parents during the life cycle of crop

Growth stages	Days after germination	Cultivars			Mean	% Heterosis
		Hybrid 4	Gujarat 67	American Nectariless		
1	30	4.2	4.2	2.8	3.7	20.00
2	50	12.2	12.5	10.8	11.8	4.72
3	70	36.0	21.3	18.2	25.2	82.30*
4	90	56.3	48.5	54.3	53.1	9.50
5	110	82.3	64.7	88.7	78.6	7.30*
6	130	101.3	103.7	106.7	103.9	- 3.70
7	150	106.7	116.3	111.0	111.3	- 6.10*
8	170	110.0	124.3	113.3	116.0	- 7.40*
9	190	115.3	125.7	116.0	119.0	- 4.60*
10	210	119.3	128.3	117.3	121.7	- 2.60
11	230	122.3	131.7	121.0	125.0	- 3.20
12	250	123.3	132.3	121.3	125.7	- 2.80
13	270	124.7	132.7	122.3	126.6	- 2.20
Mean		85.7	88.2	84.9	86.2	- 0.98

	S.Em.	C.D. at 5 %	C.V. %
Cultivar	1.0	N.S.	
Growth stages	2.2	6.1	7.5
Cultivars x Growth staged	3.8	10.6	

maturity the height of this cultivar was maximum as compared to the other two. Almost similar trend was observed in American Nectariless i.e. the significant was observed from 70 days to 130 days.

However, on an average the hybrid displayed a negative heterotic effect (-0.98 %) which was not significant. Positive and significant relative heterosis was observed during 70 and 110 days, whereas significantly negative heterosis was observed during 150 to 190 days.

II. Number of monopodials on main stem :

The data presented in Figure III-A and Table III suggested that the differences due to cultivars and stages were significant whereas, their interaction was not significant with respect to number of monopodial branches on the main stem.

The female parent produced significantly highest average number of monopodials (3.66) on main stem and was followed by hybrid (2.60) and the male parent (2.05).

The data on the average number of monopodial branches at different stages indicated that with the advancement in growth the number of monopodials per plant also increased. However, the increase at each stage was not significant except at 90 days.

The average relative heterosis (-8.93 %) was observed to be negative and significant. The hybrid showed significantl negative heterosis throughout its growth and development,

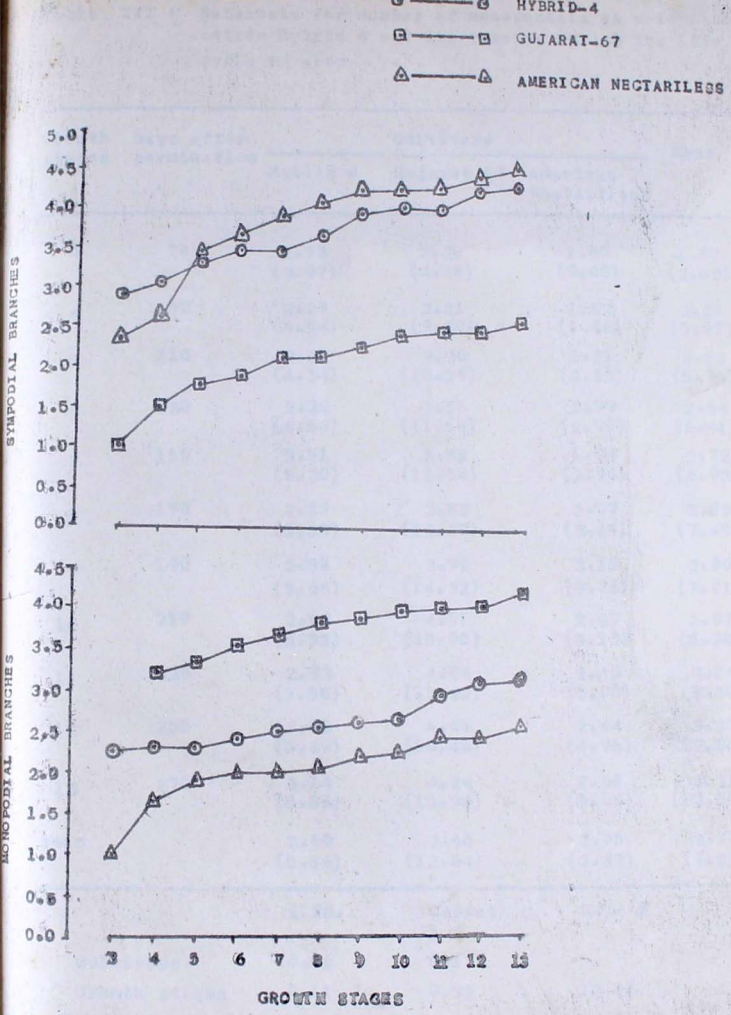

Fig.11b MONOPODIAL AND SYMPODIAL BRANCHES OF COTTON HYBRID-4 AND IT'S PARENTS AT SELECTED PLANT GROWTH STAGES DURING THEIR LIFECYCLE.

Table III : Heterosis for number of monopodials on main stem in cotton Hybrid 4 and its parents during the life cycle of crop

Growth stages	Days after germination	Cultivars			Mean	% Heterosis
		Hybrid 4	Gujarat 67	American Nectariless		
3	70	2.23 (3.97)	2.38 (4.48)	1.00 (0.00)	1.87 (2.82)	31.91*
4	90	2.29 (4.24)	3.21 (9.30)	1.63 (1.66)	2.38 (5.07)	- 5.11
5	110	2.31 (4.34)	3.36 (10.29)	1.91 (2.65)	2.53 (5.76)	-12.50*
6	130	2.38 (4.66)	3.55 (11.60)	1.99 (2.96)	2.64 (6.41)	-14.09*
7	150	2.51 (5.30)	3.68 (12.54)	1.99 (2.96)	2.73 (6.93)	-11.45*
8	170	2.55 (5.50)	3.83 (13.67)	2.07 (3.28)	2.82 (7.48)	-13.54*
9	190	2.58 (5.66)	3.92 (14.32)	2.18 (3.75)	2.90 (7.91)	-15.56*
10	210	2.63 (5.92)	4.01 (15.08)	2.27 (4.15)	2.97 (8.38)	-16.11*
11	230	2.93 (7.58)	4.04 (15.32)	2.45 (5.00)	3.14 (9.30)	- 9.68*
12	250	3.08 (8.49)	4.06 (15.48)	2.44 (4.95)	3.20 (9.64)	- 5.12
13	270	3.14 (8.86)	4.24 (16.98)	2.58 (5.66)	3.31 (10.50)	- 7.99*
Mean		2.60 (5.86)	3.66 (12.64)	2.05 (3.37)	2.77 (7.29)	- 8.93*

	S.Em.	C.D.at 5 %	C.V. %
Cultivars	0.06	0.17	
Growth stages	0.11	0.32	12.24
Cultivars x Growth stages	0.20	N.S.	

The figure in parenthesis indicates the retransformed value and the mean is the average of three cultivars.

except at 70 days.

III. Number of sympodials on main stem :

The data on the average number of sympodials per plant are presented in Figure III-B and Table IV.

The data presented in table revealed that in case of both the cultivars and stages, the differences were significant, however, their interaction was not.

The hybrid produced significantly more number of sympodials (3.72) than the female parent (2.09) but was at par with its male parent (3.85).

The increase in the number of sympodials was found to a significant extent at 70 and 110 days after germination, though it continued till maturity.

On an average positive significant heterosis was exhibited by hybrid to an extent of 25 per cent. The percentage heterosis was positive and significant throughout the growth period of the crop.

IV. Number of leaves per plant :

It can be seen from the data presented in Figure IV and Table IV , that the differences due to cultivars, stages and their interaction were significant.

Both the female and the hybrid produced significantly more number of leaves than the male parent, however, the female produced significantly higher number among all the cultivars.

Table IV : Heterosis for number of sympodials on main stem in cotton Hybrid 4 and its parents during the life cycle of crop

Growth stages	Days after germination	Cultivars			Mean	% Heterosis
		Hybrid 4	Gujarat 67	American Nectariless		
3	70	2.89 (7.35)	1.00 (0.00)	2.37 (4.62)	2.09 (3.99)	71.06*
4	90	3.04 (8.24)	1.52 (1.31)	2.64 (5.97)	2.40 (5.17)	46.22*
5	110	3.36 (10.29)	1.82 (2.31)	3.46 (10.97)	2.88 (7.86)	27.42*
6	130	3.51 (11.32)	1.91 (2.65)	3.68 (12.54)	3.04 (8.84)	25.51*
7	150	3.51 (11.32)	2.15 (3.62)	3.95 (14.60)	3.20 (9.85)	15.03*
8	170	3.70 (12.69)	2.15 (3.62)	4.16 (16.31)	3.34 (10.87)	17.14*
9	190	4.02 (15.16)	2.29 (4.24)	4.32 (17.66)	3.54 (12.35)	21.69*
10	210	4.08 (15.65)	2.44 (4.95)	4.32 (17.66)	3.61 (12.75)	20.52*
11	230	4.06 (15.48)	2.52 (5.35)	4.35 (17.92)	3.64 (12.92)	18.28*
12	250	4.35 (18.92)	2.51 (5.30)	4.50 (19.25)	3.78 (14.49)	24.10*
13	270	4.39 (18.22)	2.64 (5.97)	4.64 (20.53)	3.89 (14.91)	20.51*
Mean		3.72 (13.15)	2.09 (3.57)	3.85 (14.37)	3.22 (10.36)	25.16*

	S.Em.	C.D.at 5 %	C.V.%
Cultivars	0.05	0.14	
Growth stages	0.09	0.27	8.78
Cultivars x Growth stages	0.16	N.S.	

The figure in parenthesis indicates the retransformed value and the mean is the average of three cultivars.

No definite pattern was observed in case of the average number of leaves at different stages. In general, the number of leaves significantly increased during 90 to 150 days. After 150 days the number of leaves decreased gradually and significantly except at 210 days.

Hybrid produced significantly more number of leaves during 70 to 150 days. Thereafter, the number of leaves declined with two successive samples. However, due to fresh growth, the number of leaves started increasing at 210 days and reached at a significant level at 230 days and again declined.

The number of leaves constantly increased upto 210 days in female and then declined gradually. In case of male also, the number of leaves constantly increased upto 150 days, but then gradually decreased.

The number of leaves was highest in hybrid and its male parent at 150 days (600 and 555 leaves respectively) whereas in the female it reached to a maximum level at 210 days (872 leaves).

Negative average heterosis of 7.04 per cent was observed for this character. Heterosis was also found to be significant from 70 days till maturity. However, positive heterosis was evident during 70, 110 to 130 days and again during 230 to 270 days.

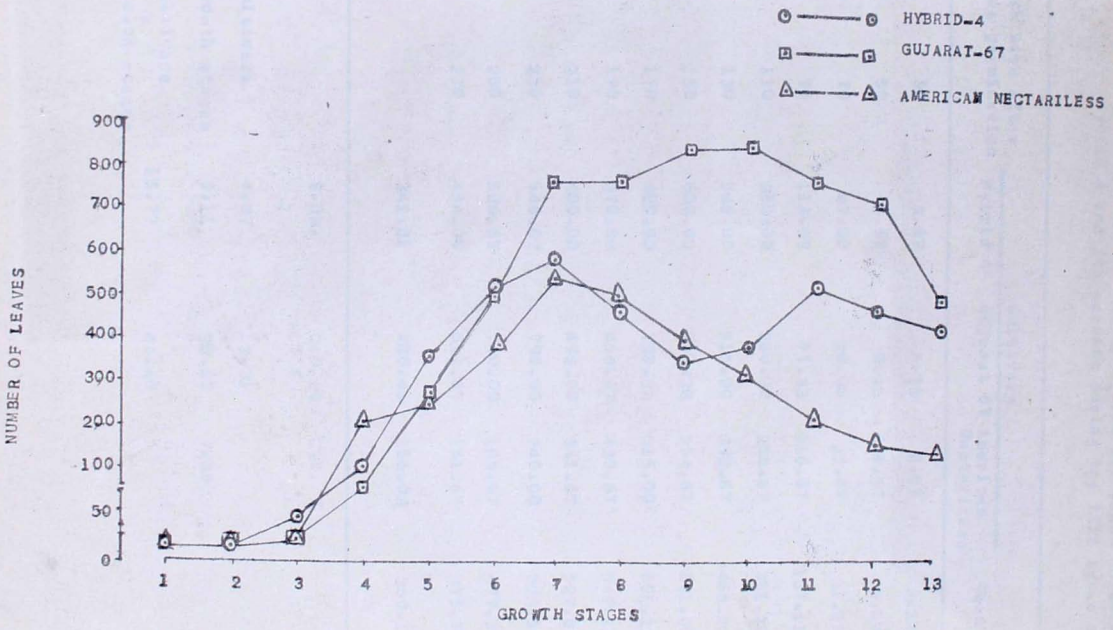

Fig.IV: NUMBER OF LEAVES PER PLANT OF COTTON HYBRID-4 AND IT'S PARENTS AT SELECTED PLANT GRWOTH STAGES DURING THEIR LIFECYCLE.

Table V : Heterosis for number of leaves per plant in cotton Hybrid 4 and its parents during the life cycle of crop

Growth stages	Days after germination	Cultivars			Mean	% Heterosis
		Hybrid 4	Gujarat 67	American Nectariless		
1	30	3.67	3.33	2.67	3.22	22.23
2	50	8.67	9.33	8.67	8.89	- 3.70
3	70	47.00	20.00	22.67	21.89	120.31*
4	90	113.33	81.33	216.67	137.11	- 23.94*
5	110	365.00	280.00	258.67	301.22	35.52*
6	130	545.00	515.00	398.67	486.22	19.30*
7	150	600.00	768.33	554.67	641.00	- 9.30*
8	170	490.00	798.33	515.00	601.11	-25.38*
9	190	370.00	856.67	420.67	549.11	-42.07*
10	210	400.00	872.00	341.67	537.89	-34.08*
11	230	546.67	790.00	240.00	525.56	6.15*
12	250	506.67	740.00	186.67	477.78	9.35*
13	270	454.00	511.67	161.67	375.78	34.85*
Mean		342.31	480.46	256.03	360.11	- 7.04*

	S.Em.	C.D.at 5 %	C.V. %
Cultivars	4.37	12.31	
Growth stages	9.11	25.63	7.59
Cultivars x Growth stages	15.77	44.40	

V. Leaf area index (LAI) :

The data of leaf area index presented in Figure V and Table VI showed that the differences due to cultivars, stages and their interaction were highly significant.

The hybrid had significantly greater leaf area index (1.462) than its male parent (0.964) but significantly lower than its female parent (2.571).

Leaf area index increased significantly upto 150 days and then significantly declined till maturity except at 190 days.

Leaf area index of hybrid showed almost similar trend as that of parents, except at 230 days, where leaf area index suddenly increased, as evident by the number of leaves per plant (Table V). Female also increased its leaf area index significantly during 70 to 190 days and then declined till maturity; while male showed significant increase in leaf area index during 70 to 150 days and then declined till maturity.

The average maximum leaf area index for hybrid was 3.426 as compared to 5.240 and 2.550 of female and male parent respectively.

On an average negative and significant heterosis of 17.28 per cent was displayed by the hybrid. It also exploited positive heterosis during the growth period of 70th, 130 to 150 and 230 days after germination.

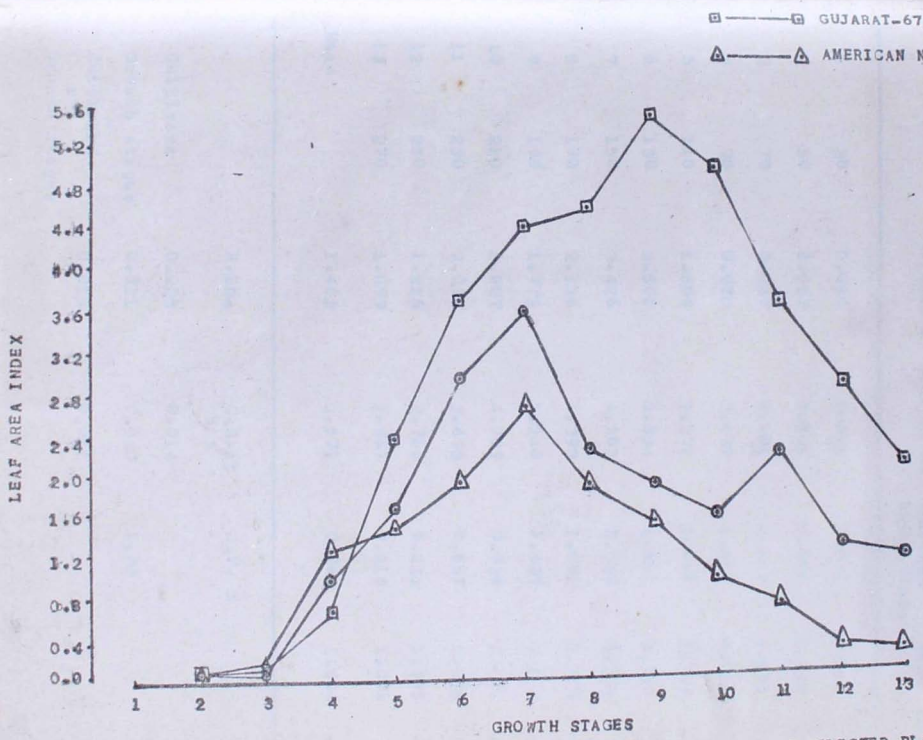

Fig.V: LEAF AREA INDEX OF COTTON HYBRID-4 AND IT'S PARENTS AT SELECTED PLANT GROWTH STAGES DURING THEIR LIFECYCLE.

Table VI : Heterosis for leaf area index in cotton Hybrid 4 and its parents during the life cycle of crop

Growth stages	Days after germination	Cultivars			Mean	% Heterosis
		Hybrid 4	Gujarat 67	American Nectariless		
1	30	0.004	0.005	0.004	0.004	- 11.11
2	50	0.037	0.046	0.034	0.039	- 7.50
3	70	0.347	0.102	0.149	0.199	176.49*
4	90	0.970	0.697	1.219	0.962	1.25
5	110	1.609	2.271	1.428	1.769	- 13.00*
6	130	2.801	3.524	1.861	2.729	4.03*
7	150	3.426	4.205	2.550	3.394	1.44*
8	170	2.126	4.393	1.801	2.773	- 31.35*
9	190	1.772	5.240	1.439	2.817	- 46.94*
10	210	1.507	4.769	0.936	2.404	- 47.17*
11	230	2.097	3.493	0.667	2.086	0.82*
12	250	1.216	2.716	0.223	1.385	- 17.25*
13	270	1.099	1.967	0.216	1.094	0.69
Mean		1.462	2.571	0.964	1.666	- 17.28*

	S.Em.	C.D.at 5 %	C.V. %
Cultivars	0.005	0.014	
Growth stages	0.011	0.030	1.90
Cultivars x Growth stages	0.018	0.051	

VI. Leaf area duration (LAD) :

The data presented in Figure VI and Table VII revealed that the differences due to cultivars stages and their interaction were observed to be highly significant so far as the leaf area duration is concerned.

The hybrid had significantly greater average leaf area duration (27.82), than its male parent (21.29) but at the same time, it produced significantly lower leaf area duration than the female parent (54.08). This trend was similar to that of leaf area index.

The average leaf area duration significantly increased during the period of 2nd to 6th stages after germination and then gradually declined. Up to 3rd stage the cultivars did not show any significant differences. Thereafter, the hybrid remained statistically at par with the male parent till 9th stage except at 6th stage but from 10th stage it was significantly higher than the later one. Female exhibited a far superior leaf area duration than the other two cultivars.

Gradual increase in leaf area duration of hybrid was observed in the early growth stages upto 6th stage (130 to 150 days). Thereafter there was a decline and again it increased at 10th growth stage (210-230 days). Female parent showed more or less continuous increase upto 9th stage (190 to 210 days) and than there was a slight reduction. Male parent showed similar tendancy in the begining

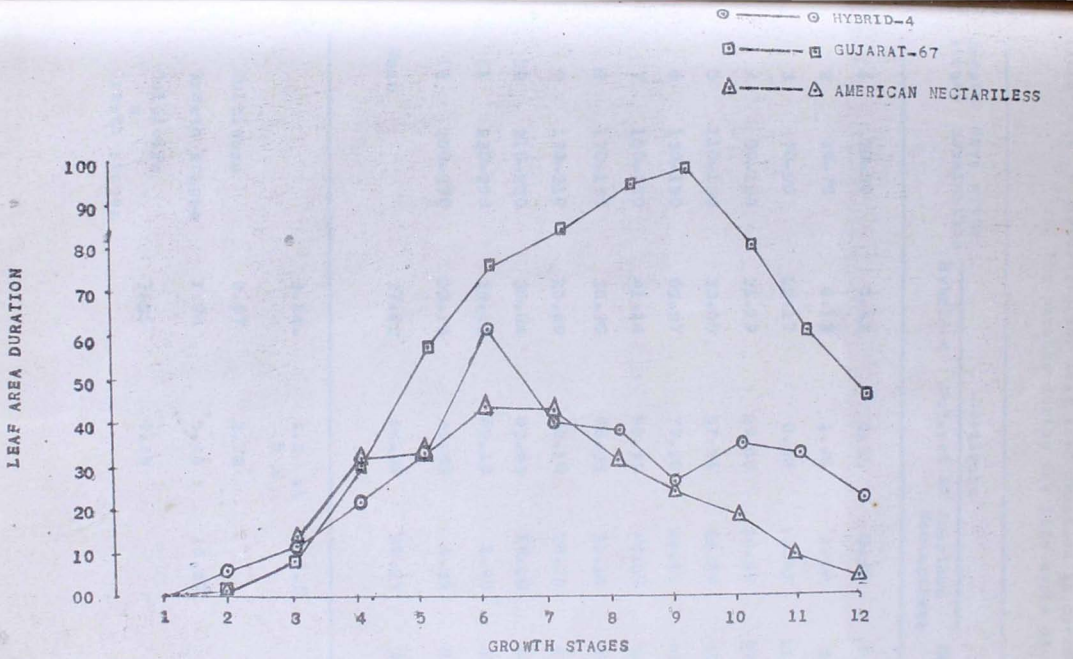

Fig.VI: LEAF AREA DURATION OF COTTON HYBRID-4 AND IT'S PARENTS AT SELECTED PLANT GROWTH STAGES DURING THEIR LIFECYCLE

Table VII : Heterosis for leaf area duration in cotton Hybrid 4 and its parents during the life cycle of crop

Growth stages	Days after germination	Cultivars			Mean	% Heterosis
		Hybrid 4	Gujarat 67	American Nectariless		
1	30-50	0.42	0.51	0.38	0.44	- 5.62
2	50-70	6.13	1.48	1.84	3.15	269.39
3	70-90	12.17	8.00	13.67	11.28	12.35
4	90-110	21.19	29.69	30.59	27.15	- 29.70*
5	110-130	33.55	57.96	32.89	41.46	- 26.15*
6	130-150	62.27	77.30	44.11	61.22	2.58
7	150-170	41.14	85.99	43.50	56.88	- 36.46*
8	170-190	38.98	96.33	32.40	55.90	- 39.43*
9	190-210	25.69	100.10	23.75	49.85	- 58.52*
10	210-230	36.04	82.63	19.10	45.92	- 29.15*
11	230-250	33.13	62.10	8.90	34.71	- 6.68
12	250-270	23.15	46.83	4.39	24.79	- 9.61
Mean		27.82	54.08	21.29	34.40	- 26.18*

	S.Em.	C.D. at 5 %	C.V.%
Cultivars	0.97	2.73	
Growth stages	1.94	5.45	16.87
Cultivars x Growth stages	3.35	9.45	

(upto 130-150 days) but latter on there was a gradual reduction till maturity.

The hybrid showed significant but negative heterosis for this character, (-26.18 %). It also displayed similar heterosis during 4th to 10th stages except at 6th stage during crop growth.

VII. Dry weight per plant (g) :

The data of dry weight per plant presented in Figure VII Table VIII revealed that the differences were highly significant so far as the cultivars, stages and their interaction are concerned.

Significantly highest average dry weight (416.40 g) was observed in Gujarat 67 followed by that of Hybrid 4 (324.40 g) and American Nectariless (215.70 g).

A continuous increase in the dry weight at different growth stages was a unique phenomenon. Increase in dry weight during 70 to 150 days was found to be higher.

All the cultivars were statistically at par in their dry weight upto 70 days after germination. Thereafter the trend remained fluctuating, but after 130 days female accumulated significantly higher dry weight than the hybrid and the male parent.

The dry weight of hybrid increased with each sampling from 70 to 150 days and then from 210-230 days and again at 270 days, whereas in female the dry weight successively

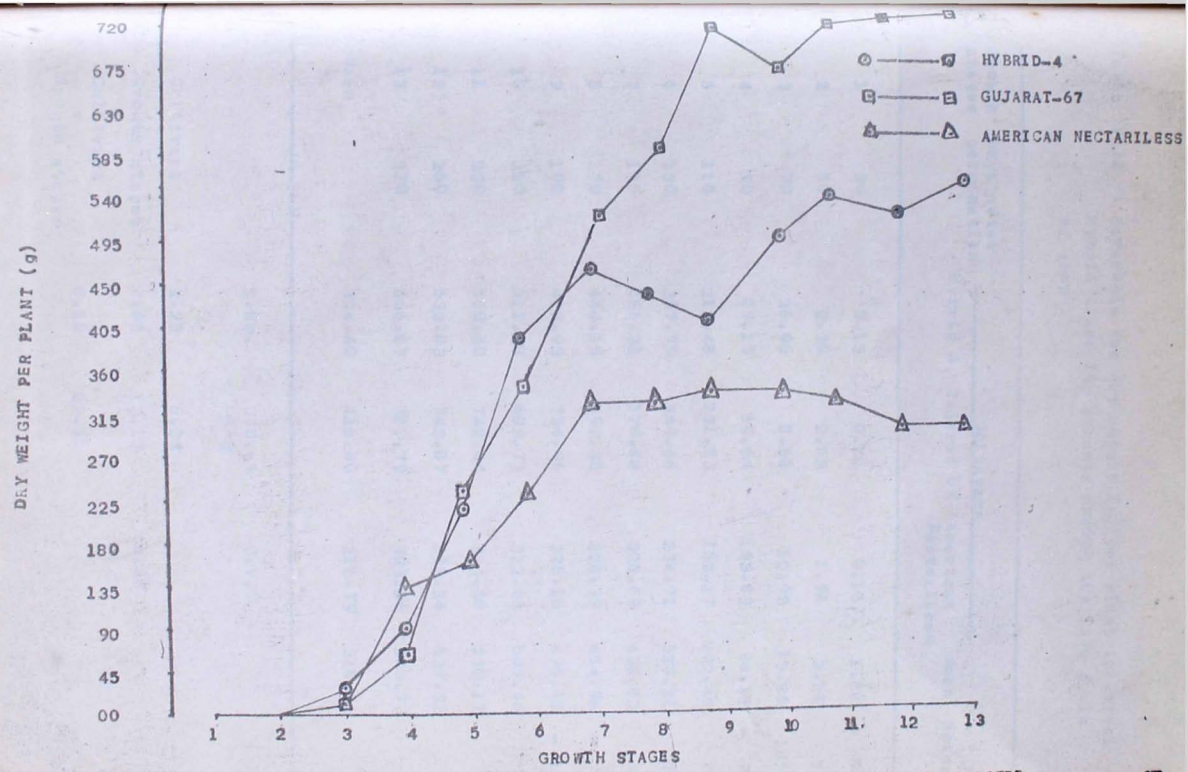

Fig.VII: DRY WEIGHT PER PLANT (g) OF COTTON HYBRID-4 AND IT'S PARENTS AT SELECTED PLANT GROWTH STAGES DURING THEIR LIFECYCLE.

Table VIII : Heterosis for dry weight (g) per plant in cotton Hybrid 4 and its parents during the life cycle of crop

Growth stages	Days after germination	Cultivars			Mean	% Heterosis
		Hybrid 4	Gujarat 67	American Nectariless		
1	30	0.15	0.18	0.15	1.58	- 9.09
2	50	2.36	2.53	1.96	2.28	5.12
3	70	26.06	8.58	12.93	15.86	142.36*
4	90	89.10	59.64	133.63	94.12	- 7.79
5	110	213.48	231.83	162.17	202.49	8.37*
6	130	397.75	340.46	234.71	324.31	38.31*
7	150	466.31	520.88	328.69	438.62	9.78*
8	170	444.15	592.35	328.39	454.96	- 3.52*
9	190	415.93	734.96	336.15	495.68	- 22.35*
10	210	511.98	683.73	332.66	509.46	0.74
11	230	550.40	742.44	324.68	539.17	3.16*
12	250	532.83	743.87	305.24	527.31	1.58
13	270	566.67	751.79	303.86	540.77	7.36*
Mean		324.40	416.40	215.79	318.41	2.63*

	S.Em.	C.D.at 5 %	C.V.%
Cultivars	2.25	6.33	
Growth stages	4.68	13.17	4.40
Cultivars x Growth stages	8.10	22.81	

increased from 90 days till 190 days and again at 230 days. In male the increase was from 90 to 150 days only.

The hybrid showed significant and positive average heterosis of 2.63 per cent. It exhibited positive heterosis during 70th, 110 to 150; and on 230th and 270th days of crop growth.

VIII Partitioning of photosynthates :

The dry matter accumulated in different parts of the plant and percentage distribution their is reported in Figure VIII-a to f and Table IX a,b and c.

It would appear from the data that in the hybrid, more photosynthates remained confirmed in the leaves, the prime seat of photosynthesis, upto 110 days leading to the better development of the plant as compared to both of its parents. Therefore, the partitioning to the leaves was more than the other two cultivars. However, major part of the dry matter produced by the leaves in case of both the parents, was translocated to the stem as compared to fruiting parts, whereas in the hybrid reverse was the case and thereby the fruiting parts could get a large share of dry matter produced in the plant. This is evidenced from harvest index also.

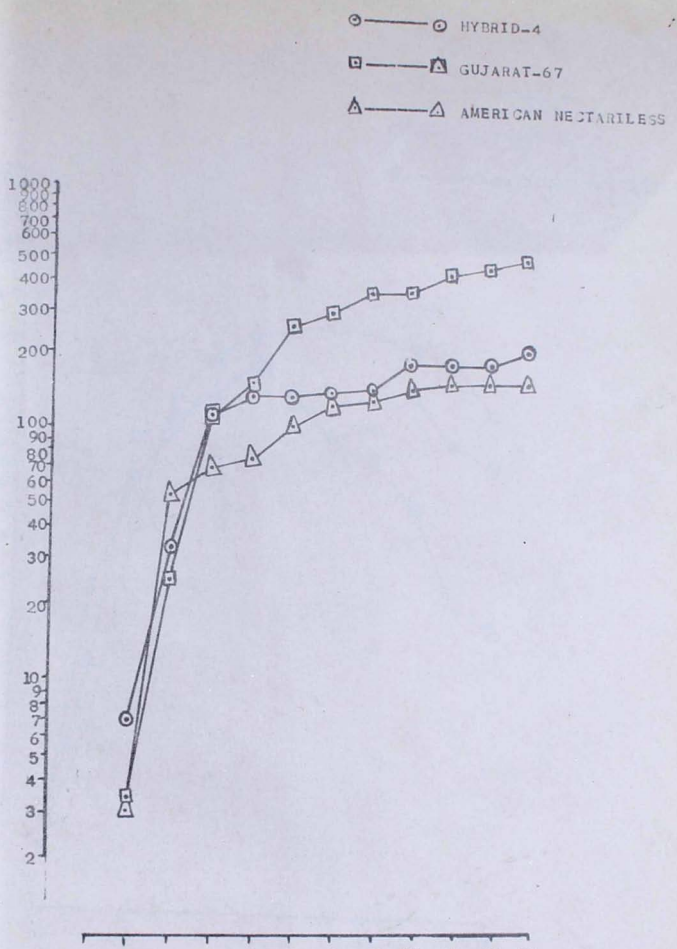

Fig. VIIa DRY WEIGHT OF STEM (g) OF COTTON HYBRID-4 AND IT'S PARENTS AT SELECTED PLANT GROWTH STAGES DURING THEIR LIFECYCLE.

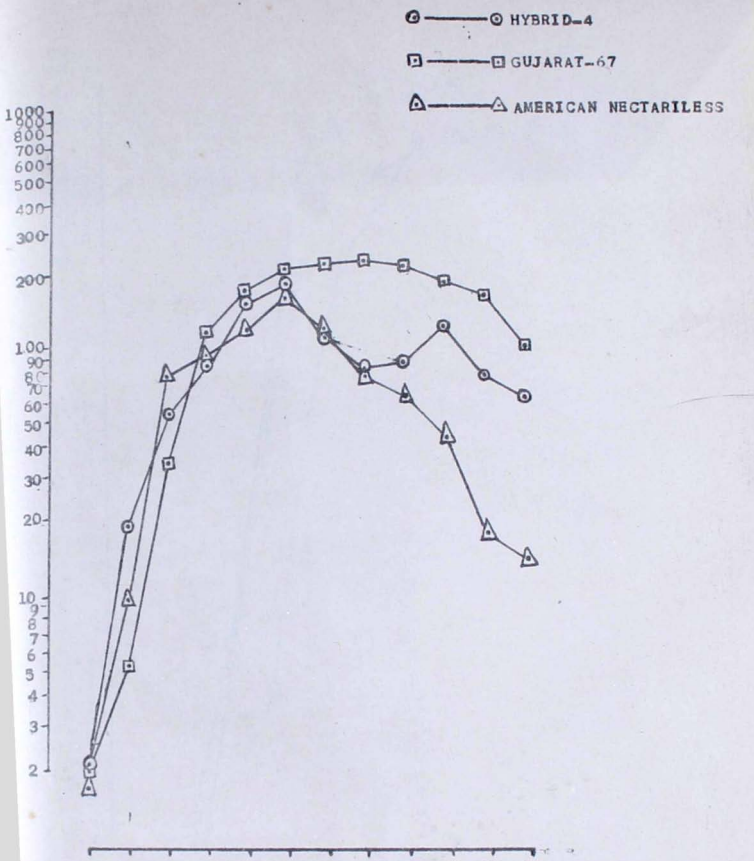

Fig. VII, b: DRY WEIGHT OF LEAVES (g) OF COTTON HYBRID-4 AND IT'S PARENTS AT SELECTED PLANT GROWTH STAGES DURING THEIR LIFECYCLE.

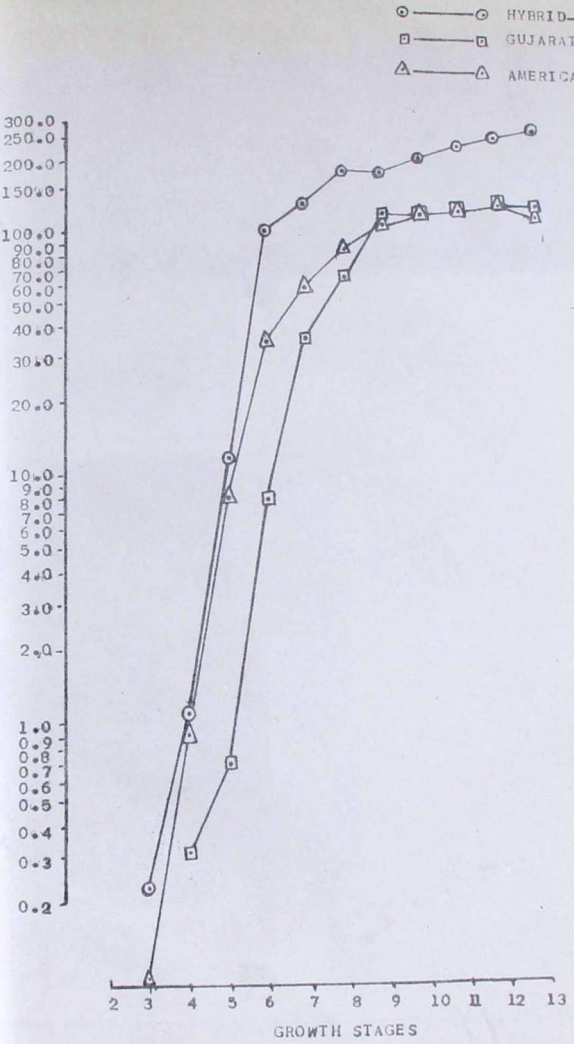

Fig. VIII, c: DRY WEIGHT (g) OF FRUITING PARTS OF COTTON HYBRID-4 AND IT'S PARENTS AT SELECTED PLANT GROWTH STAGES DURING THEIR LIFECYCLE

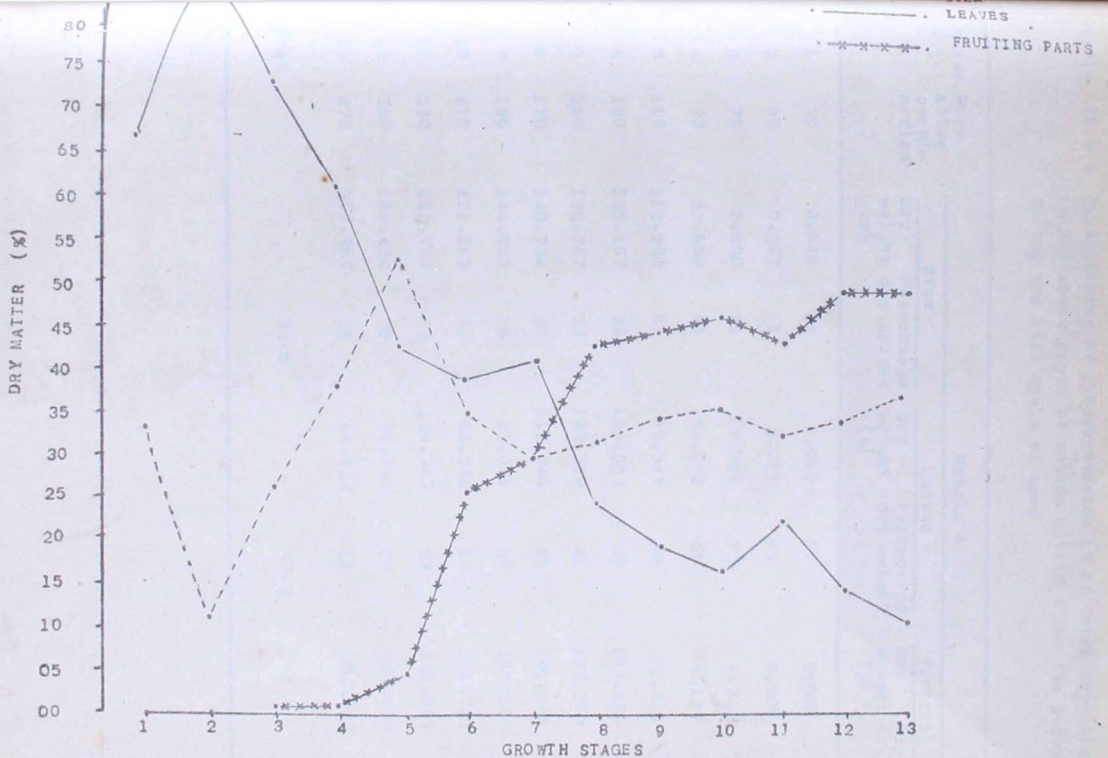

Fig. VIII,d: PARTITIONING OF DRY MATTER (%) IN DIFFERENT PLANT PARTS OF COTTON HYBRID-4 DURING IT'S LIFECYCLE.

Table IX a : Partitioning of photosynthates (% of total dry weight) in different parts of cotton Hybrid 4 and its parents during the life cycle of crop

Stage No.	Days after germination	Hybrid 4					
		Stem		Leaves		Fruiting parts	
		Dry weight (g)	Percentage dry weight	Dry weight (g)	Percentage dry weight	Dry weight (g)	Percentage dry weight
1	30	0.049	33	0.099	67	0.000	00
2	50	0.267	11	2.088	89	0.000	00
3	70	6.800	26	19.028	73	0.233	01
4	90	33.800	38	54.170	61	1.129	01
5	110	112.200	53	89.347	42	11.933	06
6	130	138.167	35	156.383	39	103.200	26
7	150	138.767	30	189.760	41	137.800	30
8	170	140.734	32	111.946	25	191.466	43
9	190	144.867	35	83.558	20	187.500	45
10	210	181.867	36	88.376	17	241.733	47
11	230	183.767	33	124.767	23	241.867	44
12	250	186.434	35	78.996	15	267.400	50
13	270	217.967	38	64.034	11	284.667	50
Mean			33.5		40.2		26.3

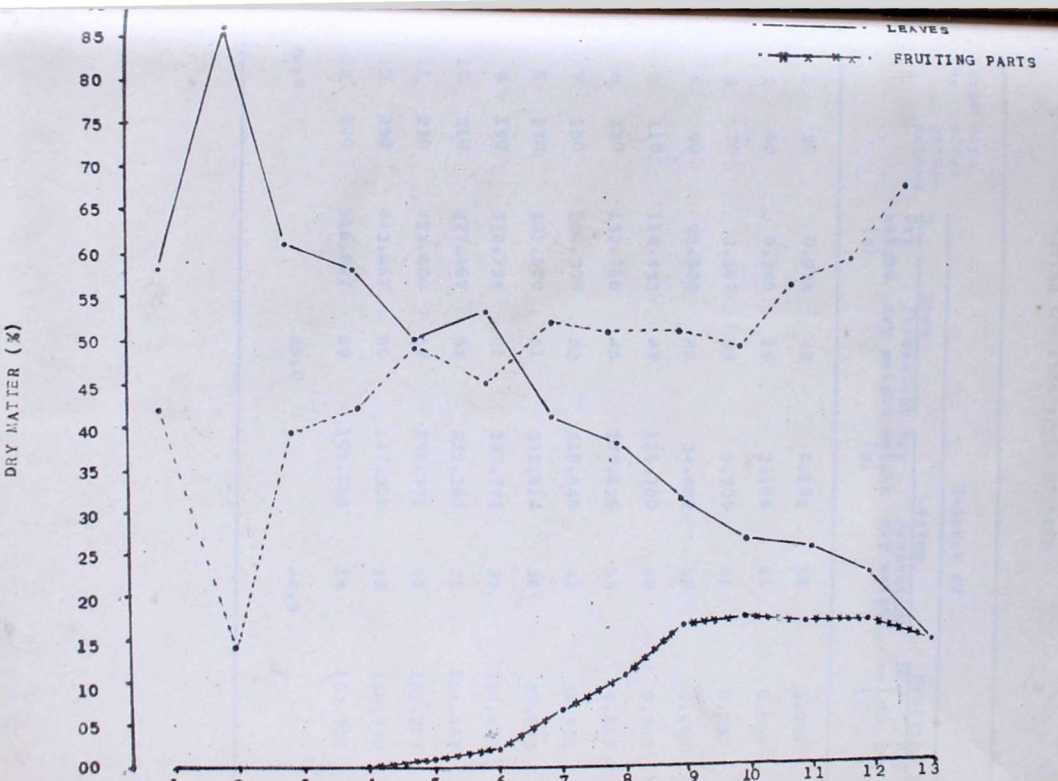

Fig. VIII.e: PARTITIONING OF DRY MATTER (%) IN DIFFERENT PLANT PARTS OF COTTON GUJARAT-67 DURING IT'S LIFECYCLE.

Table IX b : Partitioning of photosynthate (% of total dry weight) in different parts of cotton Hybrid 4 and its parents during the life cycle of crop

Stage No.	Days after germination	Gujarat 67					
		D Stem		Leaves		Fruiting parts	
		Dry weight (g)	Percentage dry weight	Dry weight (g)	Percentage dry weight	Dry weight (g)	Percentage dry weight
1	30	0.074	42	0.102	58	0.000	00
2	50	0.345	14	2.186	86	0.000	00
3	70	3.367	39	5.209	61	0.000	00
4	90	25.000	42	34.482	58	0.158	00
5	110	114.433	49	116.700	50	0.700	01
6	130	152.766	45	179.625	53	8.067	02
7	150	268.300	52	215.645	41	36.933	07
8	170	301.500	51	223.814	38	67.033	11
9	190	372.734	51	237.793	32	124.433	17
10	210	377.467	52	222.267	31	121.667	17
11	230	423.400	57	191.771	26	127.267	17
12	250	443.467	60	167.505	23	132.900	17
13	270	516.867	69	102.018	14	132.900	17
Mean			48.0		44.0		8.0

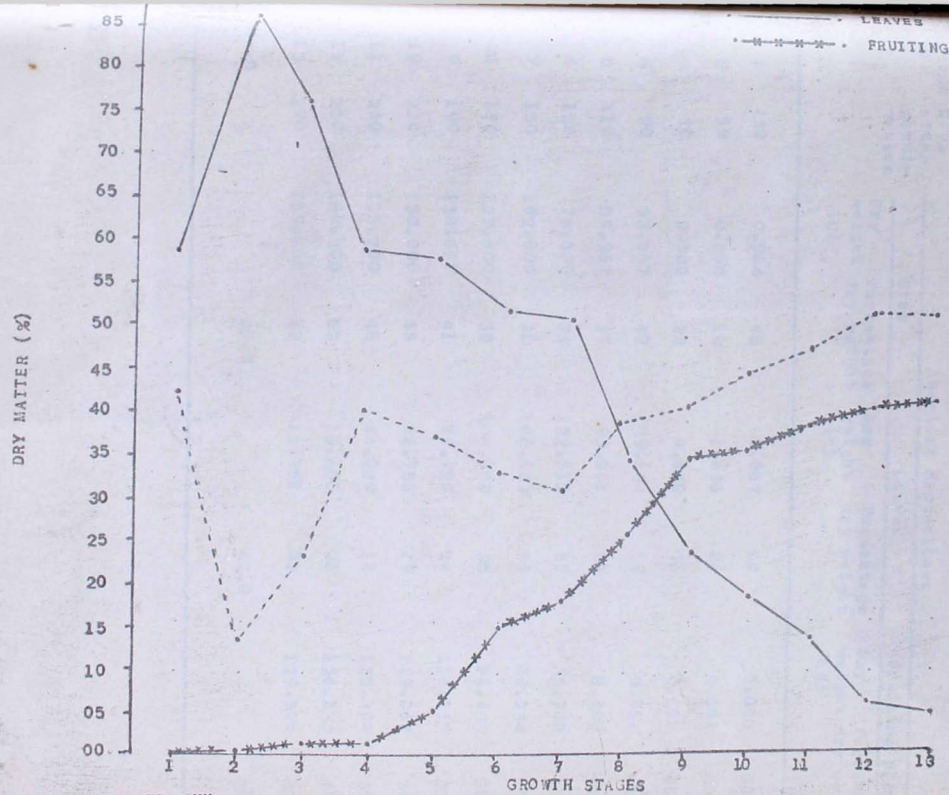

Fig. VIII PARTITIONING OF DRY MATTER (%) IN DIFFERENT PLANT PARTS OF COTTON AMERICAN NECTARILESS DURING IT'S LIFECYCLE.

Table IX c : Partitioning of photosynthates (% of total dry weight) in different parts of cotton Hybrid 4 and its parents during the life cycle of crop

Stage No.	Days after germination	American Nectariless					
		Stem		Leaves		Fruiting parts	
		Dry weight (g)	Percentage dry weight	Dry weight (g)	Percentage dry weight	Dry weight (g)	Percentage dry weight
1	30	0.064	42	0.087	58	0.000	00
2	50	0.264	13	1.696	86	0.004	00
3	70	3.000	23	9.830	76	0.100	01
4	90	53.567	40	79.134	59	0.924	01
5	110	59.967	37	93.801	58	8.400	05
6	130	76.500	33	122.512	52	35.700	15
7	150	102.000	31	166.453	51	60.234	18
8	170	127.400	39	144.559	35	86.433	26
9	190	138.867	41	80.720	24	116.567	35
10	210	150.000	45	62.788	19	119.867	36
11	230	155.200	48	44.080	14	125.400	39
12	250	160.300	53	18.406	06	126.533	41
13	270	159.800	53	14.758	05	129.300	42
Mean			38.3		42.0		20.0

IX. Leaf area ratio (LAR Cm^2/g) :

The data from the Figure IX and Table X revealed that the differences due to the cultivars, stages and their interactions were found to be highly significant.

The hybrid on an average showed significantly lower (55.055 Cm^2/g) leaf area ratio over its female parent (66.678 Cm^2/g) but higher than its male parent (52.125Cm^2/g).

The averages of cultivars indicated that the leaf area ratio declined successively and significantly right from 30 days after germination to 270 days. However, the magnitude of reduction was less in each successive sampling.

The differences within the cultivars were not significant upto 2nd stage (50 to 70 days), but during 3rd stage (70 to 90 days) the hybrid and its female parent registered higher leaf area ratio than the male parent. Afterwards, the hybrid and its male parent ran almost parallel upto 10th stage (210 to 230 days) and thereafter the hybrid again showed significantly higher leaf area ratio. After 3rd growth stage (70 to 90 days), the female parent surpassed the other two cultivars and maintained highest leaf area ratio till maturity.

The hybrid indicated significant average heterosis in negative direction (7.32 %). Further it was noticed that the hybrid exhibited significant heterotic effect from 3rd to 10th growth stages. However, it was only positive on 3rd stage (i.e. 70 to 90 days).

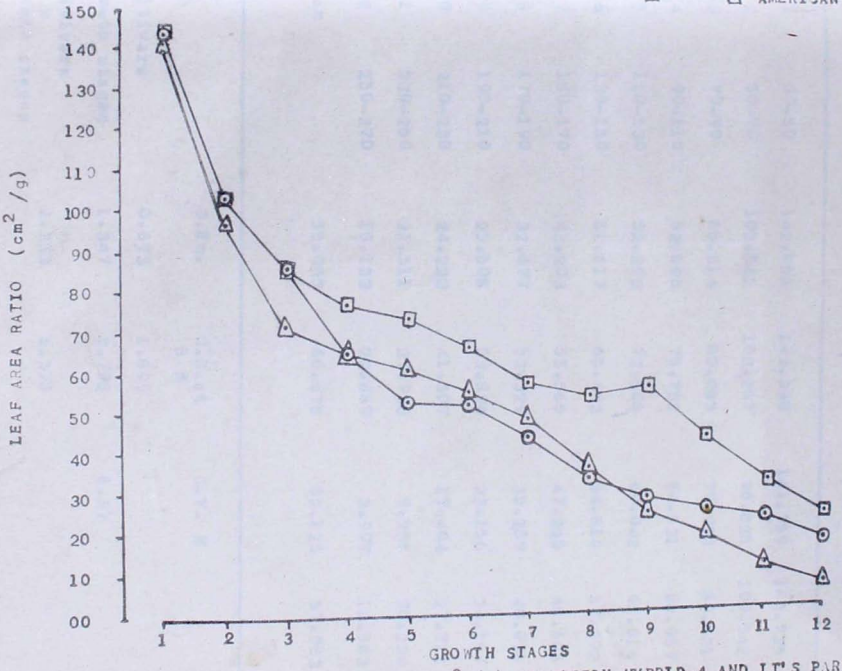

Fig-IX: LEAF AREA RATIO (cm^2 /g) OF COTTON HYBRID-4 AND IT'S PARENTS AT SELECTED PLANT GROWTH STAGES DURING THEIR LIFECYCLE.

Table X : Heterosis for leaf area ratio (Cm^2/g) in cotton Hybrid 4 and its parents during the life cycle of crop

Growth stage	Days after germination	Cultivars			Mean	% Heterosis
		Hybrid 4	Gujarat 67	American Nectariless		
1	30-50	142.856	143.390	141.959	142.735	0.001
2	50-70	102.542	102.257	96.828	100.542	3.01
3	70-90	85.214	85.085	70.993	80.431	9.19*
4	90-110	63.895	75.752	64.531	68.059	- 8.91*
5	110-130	52.293	72.508	60.042	61.614	-21.10*
6	130-150	51.617	65.442	54.816	57.292	-14.16*
7	150-170	43.203	55.565	47.226	48.665	-16.01*
8	170-190	32.677	52.329	35.289	40.098	-25.41*
9	190-210	25.508	53.896	23.156	34.187	-33.79*
10	210-230	24.223	41.507	17.404	27.711	-17.76*
11	230-250	21.511	29.933	9.258	20.234	9.78
12	250-270	15.123	22.469	3.997	13.863	14.28
Mean		55.055	66.678	52.125	57.953	- 7.32*

	S.Em.	C.D.at 5 %	C.V. %
Cultivars	0.673	1.899	
Growth stages	1.347	3.798	6.97
Cultivars x Growth stages	2.333	6.578	

X. Relative growth rate (RGR, g.g./day)

The data presented in Figure X and Table XI revealed that the differences in relative growth rate of the cultivars were non-significant, however, due to the stages as well as their interactions with the cultivars were highly significant.

The relative growth rate in general, declined upto 7th stage and thereafter it increased during 8th stage and again it declined gradually.

The cultivars, in general did not show any significant variation in the relative growth rate. However, when interacted with the stages, the cultivars behaved differently. The hybrid showed systematic decrease in the relative growth rate upto 8th growth stage and then there was a slight increase. Such trend was not observed in case of the parents.

The overall heterosis (4.5 %) was found to be positive but not significant. Whereas heterosis during crop growth stages was significant throughout the crop growth period excepting during 10th and 11th growth stages. It was negative during 3rd and from 6th to 9th stages but was positive during rest of the stages.

XI. Net assimilation rate (NAR g/M^2/day) :

The data presented in Figure XI and Table XII revealed that the differences due to the cultivars, stages and their interaction were highly significant.

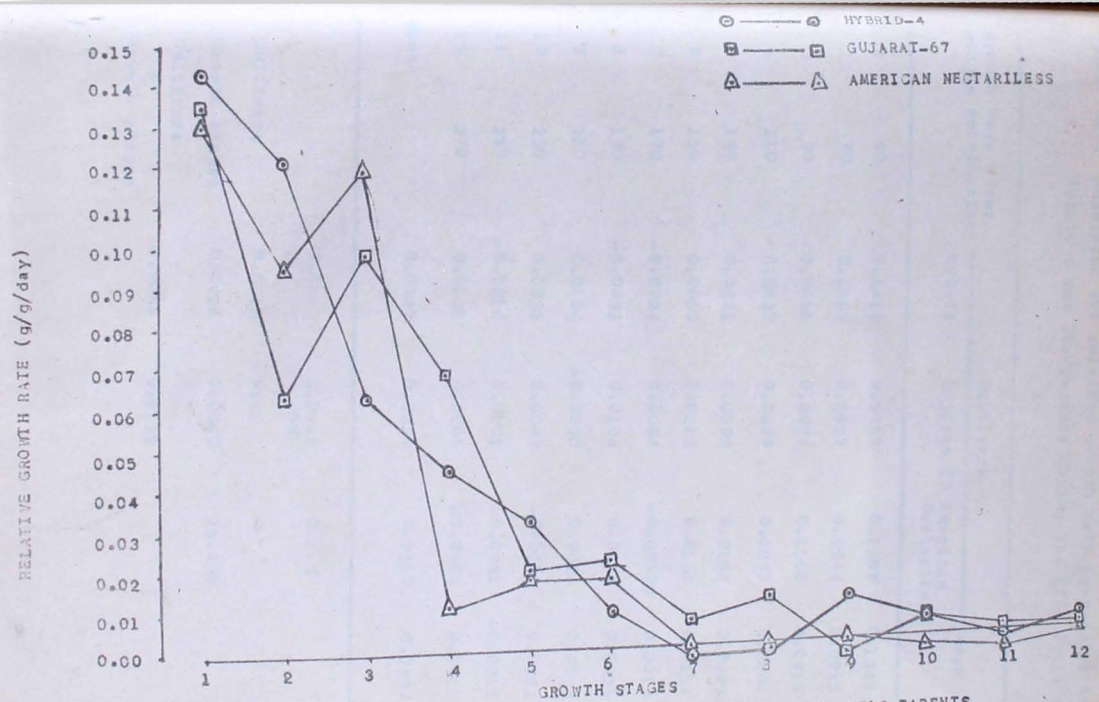

Fig. X: RELATIVE GROWTH RATE (g/g/day) OF COTTON HYBRID-4 AND IT'S PARENTS AT SELECTED PLANT GROWTH STAGES DURING THEIR LIFECYCLE.

Table XI : Heterosis for relative growth rate (g.g./day) in cotton Hybrid 4 and its parents during the life cycle of crop

Growth stages	Days after germination	Cultivars			Mean	% Heterosis
		Hybrid 4	Gujarat 67	American Nectariless		
1	50	0.1419	0.1337	0.1287	0.1348	8.16*
2	70	0.1203	0.0627	0.0944	0.0923	53.74*
3	90	0.0616	0.0974	0.1168	0.0919	- 42.48*
4	110	0.0437	0.0679	0.0097	0.0404	12.63*
5	130	0.0311	0.0192	0.0184	0.0229	65.43*
6	150	0.0080	0.0213	0.0168	0.0154	- 58.01*
7	170	-0.0024	0.0064	-0.00003	0.0013	-175.35*
8	190	-0.0033	0.0108	0.0003	0.0026	-159.46*
9	210	0.0104	-0.0038	0.0004	0.0023	-711.76*
10	230	0.0036	0.0043	-0.0012	0.0022	132.26
11	250	-0.0016	0.0001	-0.0031	-0.0015	6.67
12	270	0.0031	0.0005	-0.0002	0.0011	-1966.67*
Mean		0.0347	0.0350	0.0317	0.0339	4.05

	S.Em.	C.D.at 5%	C.V.%
Cultivars	0.0013	N.S.	
Growth stages	0.0026	0.0047	23.430
Cultivars x Growth stages	0.0046	0.0129	

The hybrid showed significantly higher average net assimilation rate 4.043 g/M^2/day over the male parent 3.208 g/M^2/day but it was at par with female parent (3.801 g/M^2/day).

The average net assimilation rate significantly increased at 3rd stage (70 to 90 days) of sampling after germination and thereafter it significantly decreased during subsequent sampling till 7th stage (150 to 170 days). It again increased during 9th (190-210 days) and 11th stage (230 to 250 days).

NAR shows different pattern in hybrid and parents. The hybrid showed two peaks during 50 to 70 days (11.755 g/M^2/day) and 190 to 210 days (4.078 g/M^2/day) whereas the female parent showed four peaks i.e. 70 to 90 days (11.508 g/M^2/day); 130-150 days (3.250 g/M^2/day); 170 to 190 days (2.052 g/M^2/day) and 210 to 230 days (0.989 g/M^2/day). The male parent also showed two peaks, between 70 to 90 days (16.454 g/M^2/day) and 110 to 130 days (3.078 g/M^2/day).

An average relative heterosis (15 %) was significant and this trend was continued throughout the crop growth period. However, it was found to be positive during 1st (30 to 50 days), 2nd (50 to 70 days), 4th (90 to 110 days), 5th (110 to 130 days) and 10th (210 to 230 days).

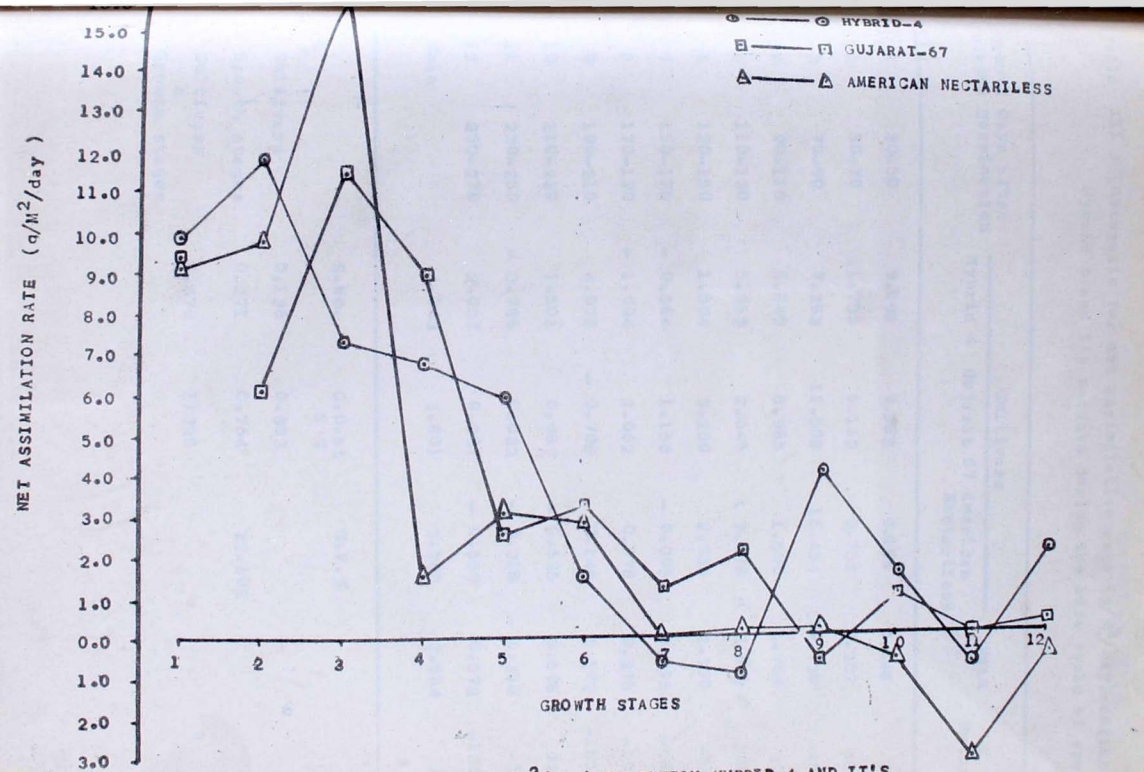

Fig.XI NET ASSIMILATION RATE (g/M²/day) OF COTTON HYBRID-4 AND IT'S PARENTS AT SELECTED PLANT GROWTH STAGES DURING THEIR LIFECYCLE.

Table XII : Heterosis for net assimilation rate ($g/M^2/day$) in cotton Hybrid 4 and its parents during the life cycle of crop

Growth stages	Days after germination	Cultivars			Mean	% Heterosis
		Hybrid 4	Gujarat 67	American Nectariless		
1	30-50	9.898	9.363	9.084	9.448	7.31*
2	50-70	11.755	6.112	9.755	9.207	48.17*
3	70-90	7.253	11.508	16.454	11.738	-48.12*
4	90-110	6.840	8.965	1.500	5.768	30.72*
5	110-130	5.953	2.645	3.078	3.892	108.04*
6	130-150	1.534	3.250	2.985	2.590	-50.79*
7	150-170	- 0.564	1.156	- 0.008	0.195	-198.26*
8	170-190	- 1.004	2.062	0.076	0.378	-193.92*
9	190-210	4.078	- 0.708	0.146	1.172	-1551.25*
10	210-230	1.501	0.989	- 0.695	0.598	921.09*
11	230-250	- 0.765	0.032	- 3.318	- 1.350	-53.44*
12	250-270	2.037	0.237	- 0.559	0.572	-1365.25*
Mean		4.043	3.801	3.208	3.684	15.37*

	S.Em.	C.D.at 5 %	C.V.%
Cultivars	0.136	0.383	
Growth stages	0.271	0.764	22.102
Cultivars x Growth stages	0.470	1.325	

XII. Days to 50 per cent squaring :

The data are presented in Table XIII. Significant differences were observed amongst the cultivars. The male parent found to be significantly earliest (63.7 days) and was followed by hybrid (71.4 days) and the female parent (99.4). The hybrid showed significant and negative heterosis (-12.45 %).

XIII. Days to 50 per cent flowering :

The data presented in Table XIV revealed that the hybrid was significantly earlier (99.00 days) than its female parent (139.43), however it was more or less similar to its male parent so far as earliness is concerned. Hybrid exhibited significant and negative relative heterosis to an extent of -13.65 per cent.

XIV. Days to 1st boll bursting :

The data presented in Table XV showed that the female parent was significantly late in maturity, than hybrid and male parent. However, the male parent was significantly early than the remaining cultivars. Hybrid exhibited significant and negative heterosis (-13.81 %).

XV. Bartlett's index (B.I.) :

The average of Bartlett's index are presented in Table XVI.

Table XIII : Heterosis for days to 50 per cent squaring in cotton Hybrid 4 and it's parents

Sr. No.	Cultivars	Mean of days to 50 per cent squaring	Percentage Heterosis
1	Hybrid 4	71.40	-12.45*
2	Gujarat 67	99.40	-
3	American Nectariless	63.70	-
4	S.Em. ±	01.11	
	C.D.at 5 %	03.43	
	C.V. %	03.76	

Table XIV : Heterosis for days to 50 per cent flowering in cotton Hybrid 4 and its parents

Sr. No.	Cultivars	Mean of days to 50 per cent flowering	Percentage Heterosis
1	Hybrid 4	99.00	-13.65*
2	Gujarat 67	139.43	-
3	American Nectariless	89.86	-
	S.Em. ±	00.60	
	C.D. at 5 %	01.86	
	C.V. %	01.46	

Table XV : Heterosis for days to 1st boll bursting in cotton Hybrid 4 and its parents

Sr. No.	Cultivars	Mean days to 1st boll bursting	Percentage Heterosis
1	Hybrid 4	151.57	-13.81*
2	Gujarat 67	211.29	-
3	American Nectariless	140.43	-
	S.Em ±	000.68	
	C.D. at 5%	02.08	
	C.V. %	01.07	

The data revealed that the trait was highly significant. Both hybrid (0.84) and male parent (0.88) gave almost one and half time greater index than the female parent (0.57). The relative heterosis was found to be significant (15.86 %).

4.2 YIELD AND YIELD CONTRIBUTING CHARACTERS

I. Number of bolls per plant :

The data are presented in Table XVII. It revealed that the differences in number of bolls per plant was significant. Hybrid and its male parent produced significantly more number of bolls than the female parent.

The relative heterosis was also found to be significant (36.09 %).

II. Number of seeds per boll :

The average data are presented in Table XVIII.

Hybrid and its male parent produced significantly higher number of seeds than its parent. The average number of seeds per boll in case of hybrid, male and female parents were 29.6, 27.7 and 25.1 respectively.

Relative heterosis (12.12 %) was also found to be significant.

III. Boll weight (g) :

The averages presented in Table XIX revealed that the hybrid produced significantly higher boll weight than both the parents.

Table XVI : Heterosis for Bartlette's index in cotton Hybrid 4 and its parents

Sr. No.	Cultivars	Mean days to Bartlette's Index	Percentage Heterosis
1	Hybrid 4	0.84	15.87*
2	Gujarat 67	0.57	
3	American Nectariless	0.88	
	S.Em. ±	0.02	
	C.D. at 5 %	0.06	
	C.V. %	6.96	

Table XVII : Heterosis for number of bolls per plant in cotton Hybrid 4 and its parents

Sr. No.	Cultivars	Mean number of bolls per plant	Percentage Heterosis
1	Hybrid 4	37.90	36.09*
2	Gujarat 67	21.60	
3	American Nectariless	34.10	
	S.Em. ±	01.50	
	C.D. at 5 %	04.62	
	C.V. %	12.91	

Table XVIII : Heterosis for number of seeds per boll in cotton Hybrid 4 and its parents

Sr. No.	Cultivars	Mean number of seeds per boll	Percentage Heterosis
1	Hybrid 4	29.60	12.12*
2	Gujarat 67	25.10	
3	American Nectariless	27.70	
	S.Em. ±	00.76	
	C.D. at 5 %	02.34	
	C.V. %	07.31	

The hybrid exhibited heterotic effect to an extent of 16.51 per cent which was significant.

IV. Seed cotton yield per plant (g) :

The data presented in Table XX showed that the differences in yield per plant were significant. Hybrid produced significantly higher seed cotton per plant (189.07 gram) than its female (101.06 gram) and male (127.45 gram) parents respectively. However, the male parent was significantly superior over the female parent so far as yield level is concerned.

The heterotic effect (65.48 %) exhibited by hybrid in yield was also found to be significant.

V. Harvest index (H.I.) :

The mean values are reported in Table XXI. The data showed that the hybrid and its male parent were found to have significantly higher harvest index than its female parent (26.38 %, 24.61 % and 13.55 % respectively).

The data further revealed that the fruiting efficiency of hybrid and its male parent is significantly higher than its female parent.

The mid parental value of heterosis (38.26 %) is also significant.

Table XIX : Heterosis for boll weight (g) in cotton Hybrid 4 and its parents

Sr. No.	Cultivars	Mean boll weight (g)	Percentage Heterosis
1	Hybrid 4	5.08	16.51*
2	Gujarat 67	4.71	
3	American Nectariless	4.01	
	S.Em. ±	0.09	
	C.D. at 5 %	0.26	
	C.V. %	5.28	

Table XX : Heterosis for seed cotton yield per plant (g) in cotton Hybrid 4 and its parents

Sr. No.	Cultivars	Mean yield of seed cotton per plant (g)	Percentage Heterosis
1	Hybrid 4	189.07	65.48*
2	Gujarat 67	101.06	
3	American Nectariless	127.45	
	S.Em. ±	07.25	
	C.D.at 5 %	22.35	
	C.V. %	13.79	

Table XXI : Heterosis for harvest index in cotton Hybrid 4 and its parents

Sr. No.	Cultivars	Mean harvest index	Percentage Heterosis
1	Hybrid 4	26.38	38.26*
2	Gujarat 67	13.55	
3	American Nectariless	24.61	
	S.Em. ±	0.93	
	C.D. at 5 %	2.86	
	C.V. %	4.64	

4.3 ECONOMIC CHARACTERS

I. Ginning outturn :

The data presented in Table XXII revealed that the differences in ginning outturn was significantly higher in male (39.81 %) and hybrid (37.52 %) as compared to female parent (34.59 %). However, no significant heterosis was observed for this trait.

II. Seed index (S.I.) :

The data reported in Table XXIII showed that the hybrid produced significantly heavier (11.92 gram) seeds than its male parent (9.91 gram). However its female parent had higher seed index (13.02 gram).

The heterotic value of hybrid was significant (3.97 gram).

III. Lint index (L.I.) :

The data presented in Table XXIV showed that the differences in lint index were significant. Hybrid had significantly greater lint index (8.16) than both the parents.

Hybrid exhibited significant heterosis (23.82 %) for this character.

Table XXII : Heterosis for ginning outturn of cotton Hybrid 4 and its parents

Sr. No.	Cultivars	Mean ginning outturn	Percentage Heterosis
1	Hybrid 4	37.52	0.86
2	Gujarat 67	34.59	
3	American Nectariless	39.81	
	S.Em. ±	00.56	
	C.D. at 5 %	01.73	
	C.V. %	04.00	

Table XXIII : Heterosis for seed index of cotton Hybrid 4 and its parents

Sr. No.	Cultivars	Mean seed index	Percentage Heterosis
1.	Hybrid 4	11.92	3.97*
2	Gujarat 67	13.02	
3	American Nectariless	09.91	
	S.Em. ±	00.14	
	C.D. at 5 %	00.45	
	C.V. %	03.37	

Table XXIV : Heterosis for lint index of cotton Hybrid 4 and its parents

Sr. No.	Cultivars	Mean lint index	Percentage Heterosis
1	Hybrid 4	08.16	23.82*
2	Gujarat 67	06.61	
3	American Nectariless	06.57	
	S.Em. ±	00.11	
	C.D. at 5 %	00.34	
	C.V. %	04.26	

4.4 FIBRE CHARACTERS

I. Mean fibre length (mm) :

The data are presented in Table XXV . Significant differences were observed amongst hybrid and its parents. The hybrid (26.95 mm) was found to have a significantly longer fibres than its male parent (23.95 mm). However, female parent had longer fibre length (30.15 mm).

Hybrid did not exhibit any significant effect on heterosis (-0.37 %).

According to gradation the above values of hybrid, male and female may be classified as supperlong, superior medium and extra long staple respectively.

II. 2.5 per cent span length (mm) :

The data reported in Table XXVI showed that the hybrid is significantly superior (29.90 mm) over its male (25.50 mm) parent but it could not reach the span value of 33.80 mm recorded by its female parent.

No significant effect of heterosis was observed so far as this character is concerned.

III. Fibre uniformity ratio :

The data are presented in Table XXVII. Neither the significant difference nor the heterotic effect was observed for this character. However, the cultivars viz. Hybrid 4, Gujarat 67 and American Nectariless can be placed in the group of good, average and good respectively.

Table XXV : Heterosis for mean fibre length (mm) of Hybrid 4 and its parents

Sr. No.	Cultivars	Mean fibre length (mm)	Percentage Heterosis
1	Hybrid 4	26.95	-0.37
2	Gujarat 67	30.15	
3	American Nectariless	23.95	
	S.Em. ±	00.34	
	C.D. at 5 %	01.06	
	C.V. %	03.36	

Table XXVI : Heterosis for 2.5 per cent span length (mm) of Hybrid 4 and its parents

Sr. No.	Cultivars	Mean of 2.5 per cent span length (mm)	Percentage Heterosis
1	Hybrid 4	29.90	00.84
2	Gujarat 67	33.80	
3	American Nectariless	25.50	
	S.Em. ±	00.27	
	C.D. at 5 %	00.84	
	C.V. %	02.43	

Table XXVII : Heterosis for fibre uniformity ratio of Hybrid 4 and its parents

Sr. No.	Cultivars	Mean of fibre uniformity ratio	Percentage Heterosis
1	Hybrid 4	46.60	01.08
2	Gujarat 67	44.70	
3	American Nectariless	47.50	
	S.Em. ±	00.81	
	C.D. at 5 %	N.S.	
	C.V. %	04.60	

IV. Fibre fineness :

The data reported in Table XXVIII revealed that the female parent had better fineness (3.8) than both the hybrid and its male parent. However, hybrid was found to be finer (4.1) than the male parent (4.3). Hybrid could not exhibit heterotic effect to a significant level for this trait.

V. Fibre maturity co-efficient (%) :

The data are presented in Table XXIX.

There was no significant difference amongst the averages of cultivars. The heterotic effect for this character in case of hybrid was also non-significant.

VI. Bundle strength (at zero gauge length)

The data are presented in Table XXX.

The data did not show any significant difference amongst the averages of cultivars. The value of relative heterosis was also below the level of significance.

4.5 BIO-CHEMICAL STUDIES

Concentration and uptake of nitrogen, phosphorus and potash in hybrid and its parents at maturity.

The data are presented in Table XXXI.

It is infered from the data that the uptake of nitrogen and phosphorus was more in case of hybrid as compared to parents, while that of potash was more in female parent.

Table XXVIII : Heterosis for fibre fineness of Hybrid 4 and its parents

Sr. No.	Cultivars	Mean of fibre fineness	Percentage Heterosis
1	Hybrid 4	04.10	01.23
2	Gujarat 67	03.80	
3	American Nectariless	04.30	
	S.Em. ±	00.06	
	C.D. at 5 %	00.19	
	C.V. %	04.01	

Table XXIX : Heterosis for fibre maturity co-efficient of Hybrid 4 and its parents

Sr. No.	Cultivars	Mean of fibre maturity co-efficient	Percentage Heterosis
1	Hybrid 4	0.82	0.61
2	Gujarat 67	0.80	
3	American Nectariless	0.83	
	S.Em. ±	0.01	
	C.D. at 5 %	N.S.	
	C.V. %	1.72	

Table XXX : Heterosis for bundle strength of Hybrid 4 and its parents

Sr. No.	Cultivars	Mean bundle strength	Percentage Heterosis
1	Hybrid 4	42.80	02.76
2	Gujarat 67	42.90	
3	American Nectariless	40.40	
	S.Em. ±	01.03	
	C.D. at 5 %	N.S.	
	C.V. %	06.50	

So far as the content of nitrogen in different plant parts of hybrid and parents was concerned, seeds contained maximum percentage nitrogen and it was highest in seeds of hybrid, followed by that of stem. Further the roots of female, leaves of both the parents (identical) and the carpels and lint of male parent contained more nitrogen.

With regard to uptake in different plant parts, the seeds absorbed maximum nitrogen. The seeds, carpels and lint of hybrid and stem and leaves of female parent removed maximum amount of nitrogen from soil.

The content of P_2O_5 in different parts of American Nectariless excepting the carpel was more than their counter parts of hybrid and the female parent. However, it was similar in the lint of hybrid and parents.

Among different parts, seeds have removed maximum amount of phosphorus. The carpels, seeds and lint of hybrid, and stem and leaves of female parent removed maximum amount of phosphorus from soil.

All the plant parts of male parent were rich in the content of K_2O, except the lint where the female parent was found to have more content of K_2O, however, it was similar in both the parents.

As compared to different plant parts, the stem removed maximum amount of K_2O from the soil. However, the stem and leaves of female parent and carpel, seeds and lint of hybrid removed more amount of K_2O from soil.

Table XXXI : Concentration (%) and uptake (g/plant) of N, P_2O_5 and K_2O in Hybrid 4 and its parents at maturity

Plant parts	Hybrid 4			Gujarat 67			American Nectariless		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
	CONCENTRATION (%)								
1 Root	0.40	0.13	0.98	0.44	0.14	0.82	0.40	0.15	1.11
2 Stem	0.48	0.07	0.95	0.43	0.08	0.96	0.39	0.11	1.28
3 Leaves	1.80	0.23	1.55	1.85	0.24	1.49	1.85	0.25	1.73
4 Carpels	0.55	0.24	0.55	0.64	0.22	0.64	0.83	0.21	0.83
5 Seeds	3.75	0.53	1.52	3.22	0.39	1.61	3.41	0.56	1.61
6 Lint	0.20	0.03	0.71	0.21	0.03	0.88	0.26	0.03	0.66
	UPTAKE PER PLANT (g)								
1 Stem	1.046	0.153	2.071	2.223	0.413	4.962	0.623	0.176	2.045
2 Leaves	1.153	0.147	0.992	1.887	0.245	1.520	0.341	0.037	0.255
3 Carpels	0.607	0.265	0.607	0.312	0.107	0.312	0.463	0.061	0.463
4 Seeds	4.071	0.579	1.659	1.405	0.170	0.702	1.136	0.187	0.537
5 Lint	0.131	0.020	0.465	0.048	0.007	0.203	0.057	0.007	0.145
Total	7.608	1.164	5.794	5.875	0.942	6.997	2.620	0.468	3.445

V - DISCUSSION

The data reported in this investigation suggest that the heterosis manifested by the hybrid is the result of optimum growth and development, which lead to higher productivity. The structure of the plant is most important as it is directly or indirectly related to the yielding ability. The phenomenon is more true for Hybrid 4 as it has more number of sympodial branches together with greater number of leaves, desired leaf area index, leaf area duration, dry weight, leaf area ratio, relative growth rate and net assimilation rate during the initial stages of life cycle as compared to its parents. Similar results were reported by Gupta *et al.* (1980); Brown (1966); and Patil and Patil (1982).

The high rate of growth and development as indicated in Hybrid 4 during early stages is most desirable because such characters have compound effect and thereby lead to greater photosynthetic size as the growth advances resulting into the production of more photosynthate, which ultimately leads to better productivity. This is more so particularly when maximum portion of photosynthate is partitioned into fruiting bodies as it is seen in case of Hybrid 4. On an average the hybrid exhibited negative heterotic effect for plant height. It was not significant and very low. Similar effect was noticed by Balls (1908) and Ware (1930) in interspecific crosses of American cotton.

Some workers observed positive heterosis for plant height with some other hybrids of cotton(Ali and Lewis, 1962, Young and Murray, 1966, Akthar et al., 1973 and Khan and Ali, 1980).

Generally more number of monopodial branches provide more vegetative and luxurious structure to the plant. Similar effect was observed in the present study. The data revealed that the female produced significantly higher number of monopodials on the main stem than hybrid and male parent. Plants with greater number of leaves are considered to have low leaf efficiency due to shade on lower leaves which consume more carbohydrates for respiration than what they produce (Fernando, 1958 and Army and Gree, 1967). However, the case with the female Gujarat 67 appears little different as this variety not only had higher number of leaves and area but also produced highest dry matter, thereby indicating its better photosynthatic efficiency as depicted by RGR and NAR values during most of the stages. However, Bhatt (1970) has also reported excess vegetative growth (higher LAI, having long leaf area duration) adversely affacting the fruiting co-efficient. So was in this variety resulting in the low harvest index and poorer productivity. On the other hand, Hybrid 4 which has high number of sympodial branches provide more fruiting points. Singh and Tyagi (1981) reported positive and significant correlation between sympodial number and yield. Thus the higher proportion of sympodial branches in case of hybrid

indicated its better efficiency of utilizing its vigour in the development of economic parts of plant. It is interesting to note that average monopodial number in case of hybrid exhibited significant and negative heterosis during the crop growth period and during different stages of growth.

The results are in agreement with those of Khan and Ali (1980) who also report negative heterosis for monopodial number in G. hirsutum L. cotton. However, Abo El and Metwaly (1979) and Barkat Ali et al. (1982) did observe a positive effect of heterosis for this character. Their observations with regard to sympodial numbers were in agreement with the present investigation.

The data indicated that both hybrid and its female parent significantly produced higher number of leaves than the male parent. However, the hybrid remained intermediate and showed significant but negative heterotic effect. This suggests that probably the hybrid remained nearer to the optimum number of leaves and utilized the surplus photosynthates in the formation of reproductive organs. This hypothesis is supported by the fact that the hybrid has significantly higher harvest index value. The results are in agreement with those of Marani and Avieli (1973).

The hybrid attained significantly greater leaf area index than its male parent but not over its female parent. This may be due to the fact that the hybrid followed its female parent so far as the number and size of the leaves are

concerned. On an average, the hybrid showed significant and negative heterotic effect. Specifically, during initial as well as some of the later stages of life cycle, the heterotic effect was significantly negative. However, LAI during the peak differentiation period (70 to 130 days after sowing) was found to be significantly positive, except on 110th day. The results are in partial agreement with Harris and Loden (1954) who reported no hybrid vigour or differences among cultivars and hybrid for leaf area development. A comparison of LAI in case of hybrid with that of parents very clearly indicated that it neither surpassed the female parent nor remained below the male parent but maintained more or less in intermediate position, making it more efficient for higher production. These findings supports the earlier report of Bhatt (1974).

The timespan of active photosynthesis by leaves, represented by the leaf area duration, appears to be obvious factor governing of biological yield. The findings in this regard indicated that the female parent significantly maintained highest leaf area duration followed by hybrid and male parent. On an average the hybrid exhibited significantly negative heterosis and also showed similar effects during most of the growth stages. The data also indicated that the hybrid showed two peaks of higher leaf area duration during the life cycle. The trend thus remained more or less similar to that of number of leaves and leaf area index. Further, it was noticed that the female attained higher leaf area duration

and was also late in maturity. The trend was viceversa in case of hybrid and male parent. The results indicated that the earliness of Hybrid 4 as compared to its female parent is characterized by it's shorter period of vegetative growth. Similar results were reported by Maksin and Lilyana (1973).

The rate of accumulation of dry matter has been considered as one of the yield determining parameters (Dastur, 1960). In this investigation it was found that the female parent accumulated significantly highest amount of dry matter followed by that of hybrid and its male parent. The number and size of the leaves seem to be the major factors for accumulating significantly higher amount of dry matter. The male parent produced highest dry matter on 7th growth stage (i.e. on 150 days), thereafter, it did not show any appreciable changes till harvest. So, the photosynthates produced after 150 days, were just sufficient to compensate the respiratory and metabolic losses. The female continued to accumulate the dry matter linearly till maturity because of its profuse vegetative growth evident from the significantly more number of monopodial branches, leaves, leaf area index and prolonged leaf area duration. The hybrid exhibited positive heterosis during the 3rd (70 days), 5th to 7th (110-150 days), 11th (230 days) and 13th (270 days) growth stages. But the effect was significantly negative on 8th and 9th (170-190 days) growth stages but on an average, the effect was significantly positive. The results are in agreement with the report of Harris and Loden (1954). They reported that in cotton (G. hirsutum L.)

hybrid, expression of hybrid vigour was evident in dry weight of upper plant parts and total dry weight. Similarly, Gupta et al. (1980) also reported heterosis for total dry matter in two hybrids and the heterosis was exhibited at all the stages with respect to all the dry matter traits except dry matter in leaves in one cross.

The pattern of partitioning of photosynthates in hybrid as well as its parents showed wide variation. In case of hybrid the leaves continued to have increasing proportion of photosynthates upto 50 days. Thereafter the accumulation of photosynthates in the leaves started declining with the exception on the 150th and 230th days, when the number of leaves were more. This might be due to the fact that the major part of photosynthate was mainly partitioned into the stem portion during this period. The reproductive organs showed a linear increase from 90 to 170 days and thereafter, the increase remainined to be of low order till harvest. The mobilization of photosynthates into the stem remained higher upto 110 days but thereafter the partitioning by and large remained in favour of reproductive organs.

In case of female parent, leaves showed increased photosynthates partitioning upto 50 days accompanied with less partitioning into the stem. From 50 days to 110 days the gain in partitioning remained more in favour of stem. The reproductive organs became apparent at this stage and partitioning of photosynthates continued into them upto

190 days. Broadly, from 150 to 190 days, leaves mainly acted as contributing source for the translocation of photosynthates to reproductive organs. After 190 days this pattern seems to have been changed, wherein the leaves contributed major part of the photosynthates to the stem. This indicated that the female parent diverts more of its photosynthates towards vegetative growth.

In case of male parent, the leaves showed increasing trend of partitioning of photosynthates till 50 days. During this period the percentage contribution to the stem decreased. But during 50 to 90 days much of the photosynthates were partitioned into the stem. After 90 days reproductive organs started showing an increasing trend for dry matter. The linear increase observed between 90 and 190 days in case of reproductive organs is mainly due to significant diversion of photosynthates from the leaves to the reproductive organs and the smaller rise after 190 days might be the result of partitioning of photosynthates from the leaves equally to the stem as well as reproductive organs. These findings suggest that the mobilization of photosynthates from the leaves to the reproductive organ is much more during 90 to 190 days but later on the stem becomes a competitive part as a good proportion of dry matter migrates to the stem disallowing it to reach to reproductive organs. Thus the translocation of photosynthates from the stem to reproductive organs was inefficient during later stages of plant growth.

These findings very clearly show that the production of dry matter matter alone is not sufficient for better yield but its efficient and timely partitioning into the economic parts is more important. This is more so in case of cotton where there is a simultaneous growth of vegetative and reproductive parts after reproductive differantiation. These findings confirm the earlier view of Armstrong and Albert (1931), Donald (1962), Ullal and Narasimhachar (1963), Wallance and Munger (1966) and Bassette et al. (1970) who also reported more or less similar distribution pattern of photosynthates in different plant parts in cotton.

Leaf area ratio (LAR) in case of hybrid was found to be near the mid parent value and significant, while, in case of the female, the LAR was found to be the highest. The data also indicate that the rise of leaf area ratio in case of female may be due to its long and continuous vegetative habit. The heterotic effect, both on an average as well as during different growth stages is found to be negative with the exception of 3rd growth stage where it was significantly positive. It is a good indication that the hybrid is able to provide better photosynthatic size in the begining, leading to better cumulative effect on the production of photosynthate at the later stages.

The data on relative growth rate indicated that no significant difference was observed among the cultivars. However, female attained higher value of relative growth rate and was followed by hybrid and the male parent.

In the hybrid, more relative growth rate was observed during the initial stages but later on there was a continuous decline till maturity. In both the parents also the RGR declined with advancement of growth. However a rise during the later stages was evident in the hybrid and female parent. The female parent showed much higher RGR values than hybrid during the 3rd, 4th, 6th, 7th and 10th stages as well as on an average. This indicated that higher relative growth rate imparts high dry matter productivity in the female parent over the hybrid and the male parent. The result of net assimilation rate indicated that the hybrid and it's female parent were significantly superior than the male parent. This indicates that the leaves of hybrid and the female parent have better photosynthatic efficiency. This was further supported with the result obtained in case of heterotic effect, because the hybrid was found to be at par with female but was superior than the male parent. The significant heterotic effect was also evident throughout the life period of crop. However, it was found positive during some growth stages. Similar results were reported by Ullal and Narsimhachar (1963), and Gupta et al. (1980).

The data of 50 per cent squaring, flowering and 1st boll bursting and Bartlett's index suggested that the male parent was earliest and hybrid closely corraborated with it. However, the female parent was significantly late. The hybrid displayed significant and positive heterosis only for Bartlett's index but it showed negative effect for the rest suggesting its earliness. The results are in the

confirmation with the findings of Katarki et al. (1970), Joshi (1976), Vallejo et al. (1976), Krishnaswami and Kothandaraman (1977) and Shrama (1979).

The results of yield contributing characters indicated that the hybrid produced significantly higher number of bolls per plant, seeds per boll and boll weight, lint index, seed index and ginning outturn. Moreover, the hybrid showed significant heterosis for all these yield contributing characters which further confirms its high yielding capacity together with good quality of lint. These characters ultimately contributed towards high seed cotton yield to a significant level.

Moreover, high yielding ability is reflected in the hybrid through its higher translocation efficiency of photosynthates as revealed from the high level of partitioning of photosynthate to reproductive organs. The results are in agreement with the reports of Dastur (1949), Jones and Loden (1951), Turner (1953), Pandya and Patel (1959), Vysockji (1961), Miller and Marani (1963), Singh et al. (1964), Marani (1967), Marani (1968a), Dorairaj (1968), Katarki et al. (1970), Bhatole (1971), Patel (1971), Akthar et al. (1973), Chinnadurai (1973), Patel (1974), Bhalala (1976), Joshi (1976) and Govil and Singh (1979).

The relationship between economic and biological yields form the harvest index, which is considered to be a useful measure for judging the yielding efficiency of plant (Crowther, 1944) and Bhatt, 1970).

The results indicate that eventhough the female parent accumulated maximum dry weight, it attained significantly lower harvest index than hybrid and male parent. Similar result was obtained by Singh and Bhardwaj (1983). The hybrid further established its higher efficiency for yield by exhibiting significant heterotic effect for harvest index, thus indicating higher capacity of the sink.

The results indicated that the hybrid produced significantly longer fibres over its male parent. For fibre uniformity, fineness, maturity and bundle strength, the cultivar did not show any significant effects. Moreover, it has good uniformity, good maturity but coarser and average fibres strength. The heterotic effect varied with the characters, viz. it was negative for mean fibre length, low for 2.5 per cent span length, fibre uniformity ratio, fibre fineness and for fibre maturity co-efficient. However, in case of fibre bundle strength, the heterotic effects could not reach a significant level. Similar results were reported by Kime and Tilley (1947), Barnes and Stalen (1961), Stroman (1961), Marani (1968a), (1968b), Al-Rawi and Kohel (1970), Katarki et al. (1970), Sundaram et al. (1972), Srinivasan and Gururajan (1973), Patel (1974) and Patel (1980).

The production of high yield is much dependent on adequate nutrient uptake and its efficient translocation towards the economic parts of the plant. The uptake of nitrogen and phosphorus was maximum in case of hybrid whereas

that of potash was maximum in female parent. The range of uptake and content of major nutrients in hybrid and in other cultivars are more or less similar to the values reported by Giri and Upadhyay (1980), and Mayilswamy and Iruthayaraj(1980). Dastur and Ahad (1945) also reported that the cotton plant removes large quantities of major nutrients per unit area basis.

The variation in content and uptake by different plant parts of hybrid and its parents may be due to their distinct morpho-physiological characteristics. Bhatt and Appukuttan (1971) suggested that the contrasting morphological forms differ significantly in their nutrient uptake.

The translocation efficiency of hybrid may be attributed, partially, to the fact that the hybrid absorbs higher amount of major nutrients particularly nitrogen and phosphorus than the parents, from the soil and utilize them to build up the dry matter in seed cotton as evident from higher harvest index.

In case of female and male parent the leaves contained higher percentage of nitrogen as compared to hybrid at the time of harvest. It suggests that nitrogen of leaves has more or less remained unutilized and untranslocated, whereas in case of hybrid, the higher percentage of nitrogen is accumulated in seeds than its parents. The nitrogen uptake by the seeds of hybrid is of a very high order than the parents. This shows that the mobilization of nitrogen to the seeds is more efficient. Similarly, in carpels and lint

also high uptake of N was observed in hybrid. Less content of P_2O_5 in stem and leaves and more in reproductive organs indicates that the mobilization of this nutrient from leaves and stem to reproductive parts is more efficient. Similarly, the transportation of K_2O to reproductive parts is much high in case of hybrid as compared to parents. The stem is found to have better efficiency in this regard. Thus the hybrid is more efficient in translocating the nutrients (N, P_2O_5 and K_2O) to the reproductive organs.

Similar trend of content and uptake of N, P_2O_5 and K_2O either separately or combined have been reported by some research workers (Khare et al. 1970, Bassatt et al. 1970, Halevy 1976, Leffler and Tubertini 1976 and Wanjura and Sundaram 1976).

VI - SUMMARY

The present findings have shown that the higher yield potential in case of Hybrid 4 may be attributed to the desired level of plant growth and development resulting from the optimum and composite effect of some important physiological parameters like LAI, LAR, LAD, RGR and NAR.

The better potentiality of Hybrid 4 was accounted and evident from the heterotic effects, exhibited for different characters. On an average negative heterotic effect was observed for plant height, monopodial branches, number of leaves, leaf area index and leaf area duration. The average values of these characters indicated that the hybrid avoided a luxurious vegetative growth and diverted the vigour for more reproductive turn over. However, for production of sympodial branches and for accumulation of dry matter, on an average basis, the relative heterosis was positive which indicated that hybrid also facilitated to build up a productive skeleton. This was evident from significantly higher yield of seed cotton attained by hybrid than its parents. This was also supported by positive heterotic effects exhibited for yield attributing characters viz. number of bolls per plant, number of seeds per boll, average boll weight etc.

The study also showed that for the growth and development the hybrid remained more close to the female parent but that for earliness it was nearer to the male parent as evident from the average value of 50 per cent squaring, flowering and

1st boll bursting and negative heterotic effect exhibited for these characters. This was also supported by significant and positive heterotic effect of Bartlett's index.

The efficiency of hybrid was very well established from the percentage partitioning of photosynthates in different plant parts. Eventhough, the value of accumulation of dry matter by hybrid at maturity was observed near to mid parental value, it out-yielded both the parents, since it efficiently translocated about 50 per cent of the photosynthates towards economic site (growing bolls) as compared to female and male parent with 17 and 42 per cent respectively at maturity. The data also indicate that least percentage of photosynthates in the stem was present in the hybrid at maturity, while the least percentage of photosynthates in the leaves was in the male parent, thus indicating that there was further scope for increasing translocation efficiency of the hybrid.

The value of economic characters, viz, ginning outturn, seed index and lint index indicated that the G.P., S.I. and L.I. were significantly higher in hybrid and the significant heterotic effect also was observed for seed index and lint index.

The values of fibre properties showed that hybrid and female parent were significantly better for fibre length and 2.5 per cent span length, however, for fibre fineness hybrid and male parent were significantly superior. No significant effect was observed for fibre uniformity ratio, maturity co-efficient and for bundle strength. None of the fibre character showed heterotic effect.

The data of bio-chemical study showed that the hybrid absorbed maximum amount of nitrogen and phosphorus and little less of potash than both the parents. The hybrid also efficiently transported them towards fruiting organs that made hybrid more productive.

In general, the hybrid was found to be more efficient as it diverted not only the photosynthates but the major nutrients also towards the economic sites which in turn resulted in higher harvest index.

The present study has brought out that the indeterminate plant habit with three or more flushes of growth gives low yield of seed cotton although it produces higher amount of dry matter. On the other hand a determinate plant type with adequate dry matter production but having efficient mobilization of its photosynthates from leaves and stem to reproductive organs, could out yield the indeterminate plant type.

It is, therefore, necessary to restrict the production of dry matter of the cotton plant for its efficient utilization for the development of fruiting parts and create a balance between vegetative and reproductive parts leading to higher harvest index.

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