EFFECT OF AGROCHEMICALS ON PHYSIOLOGICAL TRAITS, YIELD AND FIBRE QUALITY ON COMPACT COTTON

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INTRODUCTION

Cotton (*Gossypium hirsutum* L.), a crop of prosperity, is an industrial commodity of worldwide importance. It is one of the most ancient and important commercial crops next only to food grains. Cotton crop is grown for its lint, a major textile raw material and the seed yields oil and protein. Due to its importance in agriculture as well as in industrial economy, it is also known as "white gold" is the most important cash crop of India. It is the backbone of our sprawling textile industry contributing 7.0 per cent to our GDP, fetching an export earning besides providing employment in the production, promotion, processing and trade of cotton. Cotton accounts for 45 per cent of the world fibre and supplies 10 per cent world edible oil (Rathore, 2005).

India has a pride place in the global cotton scenario due to several distinct features such as largest cotton growing area, cultivation of all four cultivated species, large area under tetraploid cotton, one of the largest producer of long and extra-long staple cotton, possibly the only country to grow hybrid cotton, native home of old cultivated cotton and wide diversity in agro climatic conditions under which cotton is grown.

India is the largest cotton growing country with an area of 12.178 million hectares and production of 35.30 million bales of cotton lint with an average productivity of 491 kg per ha (Anon., 2012). Karnataka produces around 1.20 million bales of cotton lint from an area of 0.55 million hectares with a productivity of 368 kg per ha (Anon., 2012). The reasons for high yield and increased productivity are mainly because of cultivation of Bt cottons, favorable seasons and good agronomic practices.

India accounts for 33 per cent (10.7 mha) of world cotton area and 22 per cent (5.4 mt) of world cotton production. In India, about 70 per cent area is covered by hybrids, 20 per cent by upland varieties and 10 per cent by diploid cultivars (Anon., 2012). The Egyptian cotton is cultivated in a very little area (2%) in few pockets of Tamil Nadu and Andhra Pradesh. The *G. herbaceum* is confined to two states, Gujarat and Karnataka. Two species *viz. G. hirsutum* and *G. arboreum* are cultivated in all the nine cotton growing states in India.

The physiological efficiency of a plant can be improved by prolonging photosynthesis, reducing photorespiration, better partitioning of photo assimilates, improving mineral ions uptake and stimulating nitrogen metabolism. All these processes are inter-linked through several interactions and influence growth and productivity. Plant growth regulators have been found to influence these processes in one way or the other.

The most commonly used growth regulator in cotton is mepiquat chloride, which is an inhibitor of gibberlic acid. This curtails excessive vegetative growth and increases the yield. Plant growth regulators are shown to change leaf resistance by altering stomatal aperture, the rate of photosynthesis could be manipulated through this technology. In several species, the application of growth retardants is shown to stimulate photosynthesis by increasing LAI, delaying leaf senescence, increasing the functional duration of the leaf or delaying degradation of chlorophyll which has improved source-sink relationship.

The plant type plays an important role in achieving the yield in cotton. In spite of much effort on the classification of different plant types in many crops, more success appears only in cotton crop. The different plant types such as tall compact, medium compact and dwarf compact giant bushy, normal bushy, characteristics and their productivity features have been classified. It is well known that micro climate in a plant canopy affects yields. But, little research has been conducted to study differences in plant architecture and their effect on yield levels. Attempts are made to assess the potentiality of compact cotton genotype at different plant population densities. In such studies it was inferred that a spacing 30 x 20 cm (0.06 m^2) is suitable for giving highest yield up to 19 q/ha. Several types of plant architecture confer resistance to insect and have contributed to improve yield and quality of product

The earlier varieties were late maturing, tall growing and spreading types leading to bushy appearance. The upland cotton varieties cultivated are often beset with high vegetative growth leading to the lower yields. They also require the wide spacing resulting in the production of netted canopy there by posing problems in taking up plant protection measures, machine picking, inefficient in trapping of solar energy, physiological efficiency and harvest index. Further, these varieties require more number of pickings, thus the tall plant types having a large number of monopodial and sympodial branches are not efficient.

The compacts have the advantage or shorter sympodial branches with reduced inter nodal length giving morphological features of compressed habit and clustered boll habit on account of low vertical and horizontal growth it occupies minimum space. They offer great scope for reducing not only row width but also spacing between the plants in a row. The reduced plant height makes the plant protection operations easier and effective also to improve input use efficiency and sustainability is more. These compacts also provide the scope for increasing plant population per unit area by virtue of their shorter stature and are as productive as or even more productive than robust. Intermediate plant types combining the desirable features of both robust and compacts are the ideal plant types (Kanavi, 2003). These compact types have the added advantage of requiring few pickings only. It provides scope for double cropping and also mechanical harvesting. Application of defoliants is necessary because as the indeterminate nature of the cotton (*Gossypium* sp.) plant crops are often still actively growing late in the growing season .As a result many cotton growers have experienced difficulty in satisfactory defoliating the crop in preparing for harvest. Ideally growers would like to accomplish a complete and satisfactory defoliation with single application defoliation. These are chemicals that either impact plant hormonal activity related to leaf loss or cause direct injury to leaves, both at a level that promotes leaf drop (abscission) and are often represents the final step in the production of a cotton crop. With the emphasis on premium quality associated with cotton production, efficient defoliation is a matter of supreme concern in late season crop management (Silvertooth, 2001). Defoliants are therefore necessary to increase harvest efficiency, reduce lodging, reduce trash and lint staining, reduce cotton seed moisture and decrease insect populations and also to remove vegetative material to facilitate mechanical harvesting and to synchronize the opening of the bolls. There are a range of defoliants available in the market, but comparison of their speed of action its physiological impact in relation to yield and crop value (quality) is too little. Hence, the present study on effect of defoliant and plant growth regulators on physiological traits, yield and quality in cotton is under taken with the following objectives.

1. To know the productivity of compact cotton at different plant population levels and plant growth regulators.
2. To know the physiological changes in compact cotton at different plant population and plant growth regulators and
3. To study the interaction effect of plant population and plant growth regulators on yield, yield components and quality parameters in compact cotton.

REVIEW OF LITERATURE

The growth of a plant is the net result of interplay of diverse metabolic activities taking place in different parts of the plant during its growth and development in accordance with supply of growth factors *viz.*, water, light and nutrients from the environment. The indeterminate growth habit of cotton results in coincide ting *viz.*, vegetative and reproductive growth often beset with high vegetative growth, require the wide spacing leading to the lower yields. The cotton varieties with late maturing, tall growing and spreading types leading to netted canopy there by posing problems in machine picking and these require more number of pickings.

The role of agrochemicals on various physiological and bio-chemical processes of plants is well known, which enables rapid changes in the phenotype of the plant within a season to achieve desirable results. Cotton often produces more vegetative growth than is needed for maximum boll production and yield especially when climatic conditions favor vegetative growth, thereby directing the photo-assimilates towards the vegetative growth rather than reproductive growth. However, in the recent past, different workers have emphasized the use of various growth regulating chemicals for the control of vegetative growth in cotton. Mepiquat chloride a growth retardant when applied decreases the cell elongation by interfering in the biosynthetic path way of gibberellins thereby reduces the vegetative growth and application of ethylene promotes senescence and abscission by promoting the synthesis of cell wall degrading enzymes like cellulose and dehydrogenase enzymes resulting in defoliation of leaves. So in this chapter, the review work on influence of agrochemicals and different plant spacing on morphological, physiological, bio-chemical parameters and yield attributes in cotton are emphasized.

2.1 Morphological characters

2.1.1 Plant height (cm)

Plant height plays an important role in determining the morphological frame work relating to plant type and canopy development in cotton. It is one of the important characters of growth and yield of cotton and is influenced by both genetic and environmental factors. Chokhey Singh *et al.* (1970) indicated an increase in plant height by increase in sympodial branches and number of bolls per plant. Plant height had strong correlation with number of branches and days to first flower. Kim *et al* (1987) observed that plant height is positively correlated with the number of fruiting branches, yield, boll weight and lint percentage. Singh and Narayanan (1993) suggested ideal plant type of upland cotton (*G. hirsutum*) for rainfed condition. The main features of proposed ideotype including earliness (150-160days), fewer, small and thick leaves, compact and short stature, indeterminate growth habit, sparse hairness, medium to big boll size, synchronous bolling, high response to nutrients and resistance to insect and disease.

Nagabhushana (1984) reported from the canopy modification studies under rianfed cotton (*G. hirsutum*) that the genotypes with short stature, compact with few number of monopodial branches, less height to first fruiting branch out yielded than the other genotypes when compared with tall lankey with more number of monopodial branches and less number of fruiting branches and fruiting points. Xu (1984) studied the technique for improvement of fibre quality and increasing seed cotton yield through desired plant type which was cylindrical with a plant height 110-120 cm. Basu and Bhat (1987) observed that the plant height and number of monopodial branches have no influence on harvest index unlike number of sympodial branches and seed cotton yield.

Gao and Jein (1989) reported that changes in leaf production is associated with changes in plant height. Chen *et al* (1991) reported that plant height and sympodial branches per plant were significantly correlated with each other and negatively correlated with first pick in cotton harvest. Arshad *et al* (1993) reported that plant height; number of bolls per plant and sympodial branches were positively correlated with seed cotton yield per plant. The number of bolls per plant were also positively correlated with plant height. Mosande *et al* (1981) reported that the yield of seed cotton was positively and significantly correlated with plant height and they also indicated that the yield of cotton could be increased by improving the characters such as plant height, leaf area per plant, total dry matter per plant, number of bolls per plant and boll size. Ansari *et al.* (1989) reported that yield per plant correlated with plant height and boll number, but not with number of monopodial branches.

Mulder *et al.* (1981) reported that spraying of mepiquat chloride at an early reproductive stage in cotton reduced the plant height. James (1991) reported that pix reduced plant size and enhanced earliness. Pix partially inhibits one of the enzymes that is involved in GA biosynthesis, produce fewer fruiting branches, shorter plant, shorter internodes and higher per cent of fruit set by the application of pix (453.6 g ha^{-1}) at early blooming stage (Charles Stichler, 1991). Boquet and Coco (1993) opined that MC can be used to manage the vegetative development of cotton plants to offset the effect of excessive irrigation or N2 application by decreasing both overall plant height and length of lateral branches. Wallace *et al.* (1993) reported that plant height, number of main stem nodes and length of internodes were reduced by the application of mepiquat chloride.

Patel (1993) concluded that the application of NAA @ 10 and 20 ppm at different growth stages increased the plant height in cotton. Application of MC @ 83.5 and 167.0 ml ha-1 during early bloom stage reduced plant height significantly and increased the first harvest by 2.6 to 5.5% (Boman and Westerman, 1994). Oosterhuis *et al.* (1995) observed that plant height was significantly reduced by plant growth retardants pix (567 g ha-1) and cycocel (6.25 g ha-1), to 95 cm and 116 cm respectively compared to 133 cm in the untreated control. Reddy *et al.* (1996) reported that MC decreased plant height, number of main stem nodes and internodal length, which could be attributed to the pix reduced gibberlic acid which is responsible for cell elongation. Derrick *et al.* (2000) suggested that mepiquat chloride application to cotton reduces plant height, vegetative growth by shortening internodal length. Ram Prakash and Mangal Prasad (2000) noticed that foliar spray of chloromequat chloride @ 50 and 100 ppm reduced the plant height significantly over the control. Edmisten (2000) had demonstrated that mepiquat pentaborate treatment could hasten maturity, reduce plant height, facilitate insect management, decrease boll rot and increase yield.

2.1.2 Number of leaves per plant

Reddy *et al.* (1993b) reported that biomass accumulation and growth rates were temperature sensitive and closely related to leaf growth. Zhang *et al.* (1992) reported that binomial curves represented that relationship between the numbers of expanded leaves and was higher with early sowing on 25th May than with late sowing on 8th April. The rate of leaf emergence in cotton was found to be correlated with temperature and development stages. Li and Fang, (1993) and, Wullschleger and Oosterhuis (1991) observed that the photosynthetic carbon contribution of leaf to vegetative and reproductive process was important in determining the productivity. Smith and Longstretch (1994) indicated that at the higher photosynthetic photon flux density (PPFD), leaf and mesophyll surface areas increased more rapidly during the expansion and net rate of CO^2 up take per unit leaf area was greater than at the lower PPFD. While, Shao *et al* (1994) suggested that leaf number could be used as an indicator of growth stage for applying management practice.

Silvertooth and Norton (1999) reported that defoliant Ginstar was effective in defoliation, re-growth / top-growth control and was similar to Dropp + Def combination treatment. But the combination of Prep with Ginster did not improve defoliation or top-growth control. Further, they observed that under warm weather the rate of defoliant application required is low compared to cool weather. Silvertooth (2001) reported that the combination of two or more defoliants viz., DROPP with DEF or FOLEX is much more effective than application of any one of these defoliant individually. Under warm condition the treatment combinations of low to medium rates are more effective and consistent than single defoliant application at higher rates.

2.1.3 Leaf area

In spite of plant genetic makeup, the physiological processes set a limit on yield. Crop growth analysis techniques help in quantitative estimation of morpho-physiolgoical changes that take place during plant growth caused either by genetic or environmental factors. Leaf number and size are found to have profound effect on the production of crop canopy. Reddy *et al.* (1996) observed reduced leaf size and leaf area in pix treated cotton due to smaller cells overall. They further reported that leaf expansion was less responsive to MC than stem elongation.

York (1983) noticed the reduction in canopy height, width and leaf area with the application of Mapiquat Chloride.

2.1.4 Number of monopodial and sympodial branches per plant

Selvaraj *et al.* (1978) observed that the number of monopodia were beyond three per plant and the number of sympodia exceeds 10 to 11 per plant, however the number of bolls will not commensurate with an increase in the number of sympodia and seed cotton yield will be adversely affected. Bharadwaj *et al.* (1975 b) reported that short duration, compact genotypes with determinate habit to be responsive for plant population and consequently higher yield. Giri and Upadhyay (1980) showed that sympodial branches and the picked bolls per plant are important yield components.

Barketali *et al*. (1982) noticed high positive correlation between number of sympodial branches and seed cotton yield. Mosonde *et al*. (1981) reported a positive but non-significant correlation between yield of seed cotton and number of monopodial branches per plant. Ware (1996) observed that plants which produce several strong monopodial side branches tended to be late in maturity than those which produce only few monopodia. Channaveeraiah (1983) reported that the medium sized three to four monopodial branches were considered as one of the important selection criteria among other monopodial characters for high yielding cotton genotypes.

Ansari *et al.* (1989) concluded that number of monopodia per plant was not significantly correlated with number of bolls and yield per plant. Basu and Bhat (1987) reported a high positive correlation between number of sympodial branches and harvest index in upland cotton. Khorgade and Ekbote (1980) indicated that number of sympodia per plant is an important factor determining direct influence on yield and suggested that selection based on the number of sympodia, boll number and boll weight may be helpful in evolving high yielding varieties of upland cotton.

2.1.5 Number of nodes per plant

Rana and Singh (1974) reported that seed cotton yield was associated with number of nodes. Node number was also one of the components of earliness in cotton (Kadapa, 1975). Bourland *et al*. (1994) reported that crop development and maturation can be followed by monitoring main stem nodal development through out the season. Ware (1996) reported that plants which produce several strong monopodial side branches, tended to be late in maturity than those which produce only few monopodia.

Edmisten (2000) reported that the application of mepiquat chloride reduces vegetative growth, internodes and also reduces length and number of fruiting branches. This is due to energy is directed towards boll produced and away from vegetative growth. Bourland *et al.* (1994) found that main stem nodes were related to other measurement of crop yield. The number of main stem nodes was found to be positively related to canopy photosynthesis. The total number of monopodial branches produced per plant is often considered as a factor affecting growth and yield of cotton (Sikka and Joshi, 1960). Chen and Zhao (1991) found significant difference between the cultivars in the number of fruiting branches on the main stem.

2.2 Phenological characters

Developmental pattern in cotton is an important aspect as the phenological characters are varied and distinct. Seed cotton yield is dependent on many factors, of which, the rate of flowering, length of flowering period, the percentage of setting and the size of the bolls are important. This was known to be influenced by environmental conditions such as growing season, PGR's, fertilizer application, irrigation, etc. Earliness of crop maturity in cotton may be defined as the extent to which square initiation, flower occurrence, complete boll opening and maturity occur in relation to the time of planting

2.2.1 Days to 50 per cent squaring

Villareal (1991) reported that in earliness traits, early genotype might be described as short with few nodes to first sympodial branch, early squaring, flowering and boll opening. The earliness attributes were, however associated with reduced levels of lint recovery, fibre length and fibre strength. Reddy *et al.* (1993) reported that two cotton species *G. hirsutum* and *G. barbadense* developed squares faster than cultivars of other species grown in similar temperature. Sharma and Govila (1981) observed higher yield in early maturing varieties as they are less damaged by boll worm. Further, they found that seed cotton yield was negatively correlated with number of days to square formation, number of days to flower formation, indicating the importance of earliness yielding stability of a genotype. Redulovich (1985) concluded that water stress in early season reduced the vegetative growth and had more reproductive parts than irrigated plants.

2.2.2 Days to 50 per cent flowering

Das (1982) showed a significant negative association between days to flower and yield in *G.hirsutum*. The path analysis also indicated negative effect of days to flower with seed cotton yield. Negative correlation between days to first flowering and boll number, boll weight, yield and halo length was observed (Jagtap and kolhe, 1986; Kumar and Choudhary, 1986). Jambunathan (1968) stated that maturity was not significantly affected by flowering date, the early formed flowers matured into bolls in a lesser number of days than the later ones as these were prone to shedding. Shaha and

Dasgupta (1974) stated that seed cotton yield can be predicted from the date of the number of freshly opened flowers per day during first few days after the start of flowering.

2.2.3 Days to 50 per cent boll opening

Trent *et al.* (1993) indicated that the cotton plants treated with PIX (mepiquat chloride) took slightly more time for boll opening and this difference between treated and untreated plants was statistically significant at lower temperatures. Palomo and Godoy (1994) reported that in a comparison of two cultivars Laguna 89 and Deltapine 80, the boll set of Laguna 89 was a week earlier than in Deltapine 80. It had a 181-day crop cycle, a week longer than that of Laguna 89 and Laguna 89 takes same number of days for boll opening but the boll opening rate is higher than Deltapine 80.

2.2.4 Number of days to maturity

Patil (1973) suggested that days to 50 per cent flowering and boll opening were the reliable method of finding out earliness in cotton, while time of appearance of fruiting node on first sympodial branch and mean date of maturity were the next best method in its reliability. Vijendradas (1982) reported significant negative association of day to flowering and yield in *G. barbadense* which reflects on maturity phases and had adverse effect on seed cotton yield. Palomo and Godoy (1994) in comparison trials of two cultivars boll set of Laguna was one earlier than in Deltapine 80 boll maturation period was also 3-5 days shorter

2.3 Growth parameters

2.3.1 Total dry matter production and distribution

Meredith and Wells (1989) opined that increased seed cotton yield in cotton (*G. hirsutum.* L.) genotypes can be achieved through enhanced partitioning of dry matter from vegetative to reproductive structures. Analysis of morpho-physiological parameters for biomass production in cotton (*G. hirsutum L.*) genotypes revealed that the foliage area, its duration and assimilatory rate were the parameters of biomass production (Anon., 1991). Janagoudar *et al*. (1987) reported that high yielding cotton cultivars partitioned a greater proportion of the assimilates in reproductive parts during the boll development stage and at harvest. Mosande *et al*. (1981) revealed that the seed cotton yield was positively correlated with total dry matter per plant. Singh and Bhardwaj (1983a) opined that improvement in seed cotton yield could be achieved with varieties having high total dry matter, low shedding of squares and bolls and early setting of bolls at lower node positions.

Halevy (1976) reported that the dry matter distribution was slow till flowering and first boll opening. Constable and Gleeson (1977) recorded maximum dry matter accumulation at LAI of about 3.0 and showed that early and highest boll growth rate was some times associated with the lowest LAI. Muramoto *et al.* (1965) found that difference in rate of leaf area development were associated with differences in rates of dry matter production among American cultivated cottons (*G. hirsutum* L.) and other species. Ibrahim and Buxton (1981) reported that dry matter accumulation was less in Okra and super Okra leaf cotton (*G. hirsutum L.*) Cv. Stoneville than that of normal leaves. Dry matter partitioning into leaves was also less in mutant particularly super okra.

2.3.2 Leaf area index (LAI)

Fernandez *et al.* (1992) reported that Mapiquat Chloride inhibits leaf expansion; while, Dhillon *et al.* (1992) indicated that treatment with PGR-IV increased the LAI. Tom an Oosterhius (1993) reported that pix treated plants showed an increase in leaf thickness but reduction in leaf area. Ram Prakash and Mangal Prasad (2000) found that the application of chloromequat chloride @ 50 and 100 ppm reduced the LAI over control. Joel *et al.* (2005) reported that with the application of mepiquat chloride, LAI can be decreased by 5 to 10 per cent compared to non-treated crop. Landiver *et al.* (1983) reported that the cotton genotypes with higher SLW were efficient in CER and also kept the leaves photosynthetically active for a period of up to 70 days. This resulted in higher LAI, more solar radiation interception and produced higher lint yield Kudachikar and Janagoudar (1999) reported that the higher productivity of high yielding genotypes was largely controlled by low leaf area index (LAI), low leaf area duration (LAD), higher boll number and increased boll weight.

2.3.3. Absolute growth rate (AGR)

The average daily increment of plant stand biomass called absolute growth rate is an Important characteristic (Watson, 1952). It is widely used to assess the production efficiency of plant stand and helps in comparing different plant types. In intra-hirsutum hybrids, absolute growth rate

(AGR) increased with up to 75-90 DAS, when leaf cover is optimum and more solar energy is harvested. AGR was low at initial stages because of incomplete leaf coverage and also at maturity due to cessation of vegetative growth and less number of leaves. Similar results were obtained by Patil (1989). Vaibhav Lohot (2000) reported that significantly more AGR was noticed with cytozyme (1000 ppm) followed by miraculan (500 ppm) as compared to control. Significantly higher AGR was observed with NAA (20 ppm) spray at 90 DAS followed by chamatkar (500 ppm) spray at 45 DAS and chamatkar (750 ppm) sprayed at 45 DAS compared to control (Kiran Kumar, 2001).

2.3.3.1 Crop growth rate (CGR)

Channaveeraiah (1983) observed that high yielding cotton cv. Sharada possessed moderate dry matter production (114.3 g/plant) and moderate values of CGR (4.6 $g/m^2/day$). Further, CGR was positively correlated with LA and specific leaf area (SLA), but negatively associated with leaf weight ratio and boll number (Anon, 1991).Vaibhav Lohot (2000) observed significantly higher CGR with miraculan (250 ppm) as compared to control. Significantly higher CGR was recorded in NAA (20 ppm) sprayed at 90 DAS followed by chamatkar (500 ppm) sprayed at 45 DAS and chamatkar (750 ppm) sprayed at 45 DAS as compared to control (Kiran Kumar, 2001).

2.3.3.2 Relative growth rate (RGR)

Channaveeraiah (1983) found that high yielding cotton cv. Sharada had moderate values of RGR (0.71 g/g/day) under rainfed conditions. RGR in most crop varieties has positive correlation with leaf area and inverse correlation with leaf dry weight. Similarly, RGR showed positive correlation with SLA (Anon., 1991). Vaibhav Lohot (2000) reported that significantly higher RGR was found with Rimon (200 ppm) as compared to control. Significantly higher RGR was recorded in chamatkar (500 ppm) sprayed at 45 DAS followed by NAA (20 ppm) sprayed at 90 DAS (Kiran Kumar, 2001).

2.3.3.3 Net assimilation rate (NAR)

Channaveeraiah (1983) reported that high yielding cv. Sharada had moderate values of NAR (0.32 g/m2/day). Cotton genotypes with high NAR and LAI resulted in higher dry matter per plant, low HI and low seed cotton (Patil and Patil 1983). (Wells and Meredith, 1986). Vaibhav Lohot (2000) reported that significantly higher NAR was found in Rimon (200 ppm) as compared to control. Whereas, NAA (20 ppm) recorded the lowest NAR. Significantly higher NAR was found in NAA (20 ppm) sprayed at 90 DAS followed by chamatkar (1000 ppm) sprayed at 45 DAS as compared to control (Kiran Kumar, 2001).

2.4 Bio-physical parameters

The photosynthetic rates of cotton leaves under a given environmental condition is a function of the various bio-physical and bio-chemical process involved during the diffusion of CO2 from atmosphere to chloroplast and the subsequent enzymatic reactions. A brief review of the important parameters associated with biophysical process of carbon exchange rates in cotton is presented here.

2.4.1 Rate of photosynthesis

Peng and Krieg (1991) reported that single leaf photosynthesis rate decreased (23.28%) with an increase in the plant age (from 70 to 115 DAS) in cotton (*G. hirsutum* L.) cv. Pay master 792 having normal or Okra leaf type. Whereas, Cornish *et al*. (1991) reported that in the gas exchange properties compared among the cultivated types, genetic advances were closely associated with increasing single leaf photosynthetic rate (A) and stomatal conductance (gs) especially in the morning. The A and gs of the primitive non-cultivated lines approached those of the cultivated types early in the morning, but were much lower for the rest of the day.

Zhao and Oosterhuis (1995) reported that by reducing the light intensity to 37 percent of full sun light during flowering and fruiting, the photosynthetic rate decreased by 47-55 percent, resulting in a significant increase in boll shedding, with a concomitant decrease in lint yield of 18-52% and this reduction in lint yield increased at later growth stages due to shedding. Jing and Ma (1990) observed that stomatal resistance increased with an increase in the water stress and leaf water potential reached a certain threshold value for the initial stomatal closure and decrease of net photosynthetic rate was lower than that of transpiration rate. Fernandez *et al*. (1993) reported that the inhibition of leaf area production was primary effect of the limited N supply

Channaveeraiah (1983) observed that high yielding medium duration genotypes under rainfed conditions had moderate LAI and LAD (80-85 days) with few monopodial and sympodial branches.

High yielding rainfed cotton cv. Sharada was associated with lower LAI and LAD but higher SLW. He further reported that the lower values of LAI and LAD might have been compensated by higher photosynthetic rate during the active period of yield formation (Nagabhusana, 1984).

2.4.2 Stomatal conductance

Bowman (1989) studied the relationship between leaf water status, gas exchange and spectral reflectance in cotton leaves and found that photosynthetic rate and stomatal conductance decreased curvilinearly as leaf water potential decreased and approached zero at 1.2 MPa. However, Puech-swanzes *et al.* (1989) found no significant differences among cultivars of cotton (*G. hirsutum L.*), in net leaf photosynthesis per unit area, leaf conductance and photosynthetic photon flux density under water stress conditions. Percy *et al*. (1996) found that stomatal conductance in improved Pima cotton cultivars (*G. barbadence*) was positively associated with leaf resistance and yield potential. The mode of inheritance of stomatal conductance was determined in crosses of six *G. barbadence* parents varying in origin of agronomic development and stomatal conductance.

2.4.3 Rate of Transpiration

Jing and Ma (1990) observed that stomatal resistance increased with an increase in water stress and water potential reached a certain threshold value for the initial stomatal closure and the decrease of net photosynthetic rate was lower than that of transpiration rate. Singh and Sahay (1991) reported a significant reduction in relative water content (RWC), biomass, leaf area, transpiration rate and seed cotton yield at lower water potential of 1-3 MPa. Wullshleger and Oosterhais (1991) reported that transpiration rate (E) of leaves was 260 mg H2O $m^{-2}S^{-1}$ at 10 days after anthesis, followed by that of the bracts and the capsule wall where E averaged 25 and 11 percent of leaves, respectively. Lopez *et al*. (1993) reported that higher transpiration and photosynthetic rates in some cultivars were probably due to greater water uptake in those cultivars.

2.4.4 Light transmission rate

Heitholt *et al*. (1992) reported that narrow rows increased the efficiency of photosynthetic photon flux density (PPFD) interception. The lint yield of okra-leaf cotton but not the normal leaf, was greater when grown in narrow (0.5 m) rather than wide rows. The use of narrow spacing for the okra leaf type provided an opportunity for overcoming its low leaf area, increasing the light interception and increasing its lint yield. Staggenborg *et a*l. (1992) also reported that reduced row spacing resulted in increased light interception, growth rate, total biomass production and water use efficiency. At narrow row spacing, more light was intercepted at equivalent LAI than at the traditional spacing, but the amount of biomass produced per unit light intercepted was not improved.

Reddy *et al*. (1996) reported that leaves varied greatly in mature leaf size, depending on leaf position, rates of expansion also leaf growth rates were higher at 25- 65 days after emergence than in earlier growth period, apparently reflecting greater light interception during that period. Gausman *et al.* (1979) found that pix significantly decreased leaf CO^2 uptake. Pando and Srivastav (1985) reported that the application of growth retardants enhanced the photosynthetic carbon dioxide fixation rates, RuBP carboxylase activity and translocation of photosynthates towards capitulum, thereby increasing the yield in sunflower. Fernandez *et al.* (1992) reported that Mapiquat Chloride decreases leaf diffusive resistance and plant photosynthetic rate. Reddy *et al.* (1996) noticed that net photosynthetic rate was 25 per cent less in pix treated leaves.

2.5 Bio-chemical parameters

2.5.1 Chlorophyll content

Chlorophyll is a green pigment present in chloroplasts of all green plant cells and tissues. These are essentially photosynthetic pigments capable of absorbing light energy for the synthesis of corbohydrates. Chlorophyll content of the plant tissue represents the photosynthetic capacity of the plant. Reddy *et al.* (1996) reported that pix treated leaves had more chlorophyll content. Bharadwaj and Singh (1988) found that cotton genotypes with higher SLW had higher leaf chlorophyll, boll number and high leaf conductance. Krasichkova *et al.* (1989) reported that higher yielding cotton genotypes had higher levels of chlorophyll content and photosynthetic activity as compared to low yielding cotton genotypes. Ahmed *et al*. (1989) observed the same results. Singh and Arora (1997) found that chlorophyll 'b' content was more in cotton genotypes thus lowering chlorophyll a:b ratio. It may be attributed that chlorophyll 'b' has an affinity to the weather conditions during the growing period (Singh *et al.* 1988).

Jayakumar and Thangaraj (1998) reported that mepiquat chloride (120 ppm) increased total chlorophyll activity in groundnut. Shivakumar *et al.* (2002) concluded that the chlorophyll content and soluble proteins increased with the application of PGR's. Ayala *et al.* (2004) studied the effect of growth regulators on flax and observed an increase in fine fibre yield, chlorophyll content and stem diameter, but decreased fibre strength and fineness over untreated controls.

2.4.15 Water potential

Tolerant genotypes were able to maintain photosynthesis, stomatal conductance and relative water content in most plants, leaf water potential is reduced under drought conditions, but cotton has the ability to osmotically adjust and maintain a higher leaf turgor potential. The bound water in living tissue is more likely to play a major role in tolerance to abiotic stresses in cotton by maintaining the structural integrity and/or cell wall extensibility of the leaves whilst an increased amount of free water might be able to enhance soluteac acumulation, leading to better osmotic adjustment and tolerance to water stress and maintenance of the volumes of sub-cellular compartments for expansive leaf growth (Singh *et al*., 2006).

Ackerson (1980) reported that adopted plants exhibited lower daily minimum leaf water potential and maintained turgor at lower leaf water potential than non-adopted cotton plants. Because of this turgor maintenance photosynthesis continued in adopted plants at lower leaf water potential. Quisenberry *et al.* (1985) used the leaf turgidity as an index to select for cotton drought tolerance. Under drought conditions, T-15 had higher leaf water potential than did T-169. At 70-80 days after planting, T-15 had higher leaf conductance, photosynthetic rates and higher seed cotton yield than did T-169. Gorham *et al.* (1998) reported that leaf chlorophyll contents increased under water deficit. Stomatal conductance was reduced by water deficit with consequent reductions in gas exchange parameters (net photosynthesis, transpiration and water use efficiency and an increase in leaf temperature of cotton.

Nepomuceno *et al.* (1998) reported that in response to water deficits, Siokra L-23 (drought tolerant) and T-152 (moderately drought tolerant) cotton varieties showed 25 and 20 per cent reduction in leaf as respectively compared with un-stressed controls. At the same time of these two genotypes did not differ significantly. Conversely, the decrease in the size of CS-50 (moderately susceptible) and stoneville 506 (susceptible) was not significant while their size decreased significantly. By maintaining a higher size during stress, the water content near to un-stressed control levels. Somashekhargouda Patil,(2011) studied the effect of water stress on performance of the cotton genotypes, the study revealed that, water stress reduced water potential, water use efficiency, rate of photosynthesis in all the genotypes under water stressed condition compared to well watered control.

2.6 Yield and yield components

Crop productivity in general, depends on potentiality of the genotypes and environmental interactions. Its associated character decided genotypic ability. A precise understanding of the crop yield build up is necessary for improvement of yielding ability of crop and its genotypes.

2.6.1 Number of bolls per plant

The total number of bolls that a cotton plant bears at maturity is an important yield component having the greatest effect on it. The character is greatly influenced by physiological and environmental factors. Faqir *et al*. (1984) showed that 69.72 percent of variability in cotton yield was due to variability in boll number per plant, which has the greatest positive correlation with yield (r=0.835). Kumar and Choudhary (1986) revealed from correlation studies that seed cotton yield per hectare plant was strongly correlated with boll number and boll weight. Similar results were also observed by Jagtap and Kolhe (1986). Bharadwaj (1988) noticed that, boll number depends on biomass produced which in turn was related to leaf area index. Ansari *et al*. (1989) reported that seed cotton yield was positively correlated with boll number per plant and plant height but not with number of monopodial branches. Chen and Zhao (1991) reported that seed cotton yield was correlated with some characters and the characteristics that played as important role in the correlation were boll number per plant, boll weight and plant height.

2.6.2 Boll weight

Singh and singh (1984) suggested that high coupled with high boll weight, high ginning percentage and high mean halo – length in superior germplasm of *G. hirsutum L*. were the new accessions useful for cotton improvement programmes in India. Boll weight and boll number were negatively associated with days to first flowering in cotton (*G. hirsutum L.*) (Jagtap and Kolhe, 1986). Bharadwaj and Kalindi (1986) suggested that higher boll weight could result from higher rate of CO^2 fixation by the bracts and transfer of assimilates to the seeds in the developing bolls. Boll weight had highly significant positive association with lint weight per boll, seed weight per boll, seeds per locule and burr weight (Singh, 1988). Mahla and Singh (1988) reported that boll weight is positively correlated with the number of seeds per boll (r=0.64) and ginning out turn (r=0.49).

2.6.3 Yield

Since yield is dependent on many component characters, such as boll weight, number of bolls per plant and harvest index and hence the study of interrelationship of these characters and their relationship with yield is essential.

Gadakh *et al.* (1988) reported significantly higher yield with pix (100 ppm) than its lower concentration (50 ppm). But the yield due to pix was superior over cycocel (25 and 50 ppm). Shaw *et al.* (1990) reported that the pix application increased the yield due to early boll set. Gadakh *et al.* (1992) reported that application of 100 ppm pix or 50 ppm cycocel increased seed yield by 60 and 47%, respectively. Koraddi *et al.* (1993) observed that the application of cycocel (60 ml/ha) increased yield. While, Dippenaar *et al.* (1994) found that neither earliness nor seed cotton yield was affected by the application of MC compared to untreated control.

Donald *et al.* (2001) reported that the application of plant growth regulators led to a significant increase in lint and fibre yield in cotton. While, Owen and Craig (2003) studied the effect of mepiquat chloride which significantly hastened the progress of flowering, increased fruit harvest percentage relative to untreated cotton. Joel (2005) found that mepiquat chloride shortened internodal length and further increased the lint fibre. Mujeera and Arunachalam (2006) studied the effect of PGR's in malvaceae and observed an increase in fibre quality and yield. Similarly, Russel *et al.* (2006) observed linear increase in yield with the application of MC, further lint and fiber yield were also improved. Edmisten (1994) observed that the application of pix (192 ml ha^{-1}) at squaring at an interval of 10-14 days increased the yield compared to control.

Zakaria *et al.* (2006) reported the effect of mepiquate chloride at 70 and 95 days after planting and observed increased number of opened bolls per plant, boll weight, seed index, lint yield per plant and lint yield per hectare. Joseph and Johnson (2006) studied the effect of mepiquat chloride on reduction in height to node ratio and nodes above white flower which further contributed to increase in yield.

William *et al.* (2002) observed that defoliation at 750, 850, 950, or 1050, HU's after physiological cutout had no significant effect on yield or crop value with application of defoliants like Dropp + Deft + Etheplus followed by Etephon + Deft . Further, they recorded defoliation prior to 850 HUs resulted in low yield and poor quality. Derrick *et al.* (2008) observed an increased membrane leakage in Adios on 4 days compared to Dropp and was significant on day 8 and after one day of treatment imposition there was a significant decrease in quantum yield by Adios compared to the untreated control and Dropp further they noticed that the Adios had greater detrimental effect on photosynthesis than Dropp.

Osman copur *et al.* (2010) reported that, application of Dropp ultra (DU) defoliant at 60 days after flowering reduced seed cotton yield, number of bolls, boll weight, and lint index. While these increased with delayed defoliation and there was no significant difference between the treatments in terms of ginning outturn, fiber length, fiber strength, and fiber fitness. Further, they observed that the application of 2000cc/ha thidiazuron + diuron + Roundup (RU) was not enough as a dose to affect leaf defoliation and it should be used in combination with other defoliants and the defoliation of 75 and 90 days after flowering was better in terms of no of boll on the plant and seed cotton yield compared to 60 days after flowering. Kosmidou *et al.* (1998) reported that PGR's useful for enhancing yield and controlling plant growth in cotton, yield increases resulting from these PGR's (cytoplex, cytokin, PHCA and atonic) were associated with fruiting pattern, alteration such as total bolls, number of sympodia and bolls retention. Kosmidou *et al.* (1998) evaluated PGRIV on field grown cotton (*G. hirsutum*) at eight locations for three years (1995-97) in Greece and found increase in seed yield up to 20 per cent in most of the locations, compared to control.

2.7 Fiber quality

Shaw *et al.* (1990) reported that pix application increased yield due to early boll set and fiber maturation and produced stronger, longer, less uniform and lower micronair fiber. Patel (1992) reported that fiber length, fineness, maturity co-efficient and ginning per cent were increased by growth regulator treatments. Oneal *et al.* (1998) reported that significantly higher lint yield and no difference in height by the application of mepiquat chloride (4.2%) at pin head square stage.

MATERIAL AND METHODS

Field experiments were conducted during 2012-13 to study the effect of plant growth regulators under different plant population on morphological, physiological, biochemical, yield and yield components in compact cotton (DSC-8). The details of materials used and techniques adopted during the course of investigation are described in this chapter.

3.1 Experimental site and soil properties

A field experiment was laid out at Agricultural Research Station, Dharwad Farm on medium black soil.

3.2 Climate

The Agricultural Research Station, Dharwad Farm is situated in the transitional belt of Karnataka at 15^0 17'N latitude, 76^0 46' E longitude with an altitude of 678 m above mean sea level. The annual average rainfall is 762 mm and is fairly well distributed from June to October.

The meteorological data for the year 2012 and the mean of previous 25 years is presented in Table 2 and Fig. 1. During the crop growth period the total rainfall received was 420.4 mm and the maximum of 103.8 mm received during October 2012. And the average monthly maximum and minimum temperature recorded were 30.3 ^{0}C and 18.2 ^{0}C, respectively.

3.3 Experimental details

3.3.1 Experimental material

The seeds of compact cotton genotype (DSC- 8) were obtained from Principal Scientist (Cotton), Agricultural Research Station, Dharwad. Two plant growth regulators viz., Mepiquat chloride 100 ppm and Ethrel 2000 ppm at 90 and 140 DAS respectively were used in the present study.

3.3.2 Design and plan of layout

The experiment consisted of five main treatments (plant population / spacing) and four sub treatments (foliar spray of agrochemicals) laid out in a split plot design with three replications in a plot size of 23.1 x 18.6 m. The details of the treatments are as follows,

Treatments

Main treatments: (Plant population/ spacing)

P1-83,333 plants/ha (60 x 20 cm)

P2- 1, 11,111 plants/ha (60 x 15 cm)

P3-1, 66,666 plants/ha (60 x 10 cm)

P4 -1, 48, 148 plants /ha (45x15 cm)

P5-2, 22,222 plants /ha (45x10 cm)

Sub treatments: (Agrochemicals)

S1-Control

S2- Mepiquat chloride 100 ppm (90DAS)

S3- Mepiquat chloride 100 ppm (90DAS) + Ethrel 2000 ppm (140 DAS)

S4- Ethrel 2000 ppm (140 DAS)

The detailed plan of layout of the experiment is given in Fig. 1.

3.3.3 Cultural practices

After the harvest of the previous crop, the land was brought to a fine tilth. The fertilizer @ of 40:40:40 kg N, P2O5 and K2O, respectively were applied at the time of sowing. Cotton seeds were sown by hand dibbling with a spacing of 60 x 20 cm, 60 cm x 15 cm, 60 x 10 and 45 x 15, 45 x 10 cm. A top dressing of 40 kg N was given at 30 DAS. The plots were inter cultured twice after sowing and maintained weed free by hand weeding. Plant protection measures were taken throughout the crop growth period as per the recommended schedule.

Table 1: Physical and chemical properties of the soil from experimental field

Particulars	Value obtained	Procedure employed
Physical properties		
I Particle size distribution		
a. Coarse sand (%)	8.1	International pepette method (Piper, 1966)
b. Fine sand (%)	9.9	-do
c.Silt (%)	18.2	-do
d.Clay (%)	63.5	-do
II Field capacity (%)	36.0	Field method
III Wilting point (%)	15.3	Sunflower method
IV Bulk density (%)	1.34	Core sampler method
CHEMICAL PROPERTIES		
i. Total nitrogen (%)	0.064	Modified micro kjeldhal method(Jackson, 1967)
ii. Available phosphorus (%)	0.0014	Olsen's method (Muhr *et al.,* 1965)
iii. Available potassium (%)	0.0133	Flame photometer method (Muhr*et al.,* 1965)
iv. Organic carbon (%)	0.45	Walkey and Black's wet oxidation Method
v. Soil Ph	8.0	PH meter (2.5:1) (Piper, 1966)
vi. E.C. (dS/m)	0.33	E.C. bridge

Table 2: Rainfall and temperature data at Agricultural Research Station, Dharwad Farm, Dharwad Karnataka during 2012

Months	Normal Rainfall (mm)	2012 rainfall (mm)	Temperature	
			Max.	Min.
January	2.18	0.0	29.2	12.6
February	2.42	0.0	30.8	14.0
March	7.44	0.0	35.2	18.6
April	45.63	70.6	34.9	20.6
May	68.82	29.2	34.7	21.3
June	126.3	28.8	27.5	21.3
July	133.55	90.2	26.9	20.6
August	103.79	72.4	26.7	20.7
September	115.93	88.8	28.1	19.9
October	119.05	103.8	29.9	19.5
November	33.95	60.8	29.8	15.8
December	-	4.4	29.5	13.7
Total	**759.06**	**549.00**	**30.3**	**18.2**

LEGEND

Main treatments: (Plant population/ spacing)

P_1-83,333 plants/ha (60 x 20 cm)

P_2- 1, 11,111 plants/ha (60 x 15 cm)

P_3-1, 66,666 plants/ha (60 x 10 cm)

P_4 -1, 48, 148 plants /ha (45x15 cm)

P_5-2, 22,222 plants /ha (45x10 cm)

Sub treatments: (Agrochemicals)

S_1-Control

S_2- Mapiquot chloride 100 ppm (90DAS)

S_3- Mapiquot chloride 100 ppm (90DAS) + Ethrel 2000 ppm (140 DAS)

S_4- Ethrel 2000 ppm (140 DAS)

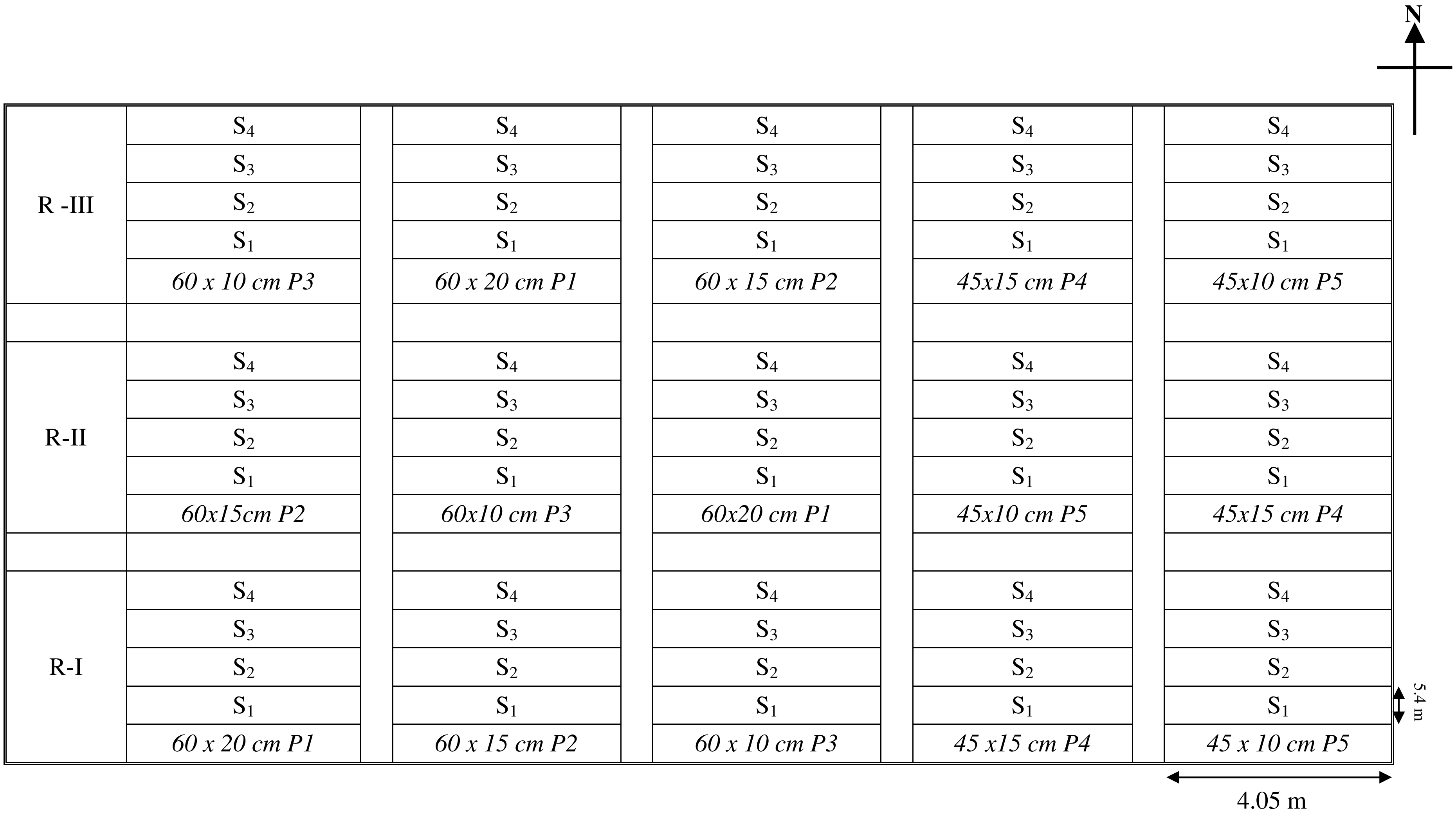

Fig. 1: Plan of layout of the experiment

Plate 1. General view of experimental plot

3.4 Observations

Five plants from each treatment were selected randomly and tagged for recording various observations on morphological, growth and physiological parameters and yield and yield components.

3.4.1 Morphological Parameters

3.4.1.1 Plant height (cm)

The average plant height of five tagged plants was recorded from the ground level to the growing tip at all the growth stages from 75 days after sowing till harvest and expressed in centimeters.

3.4.1.2 Number of leaves per plant

The number of leaves was recorded by counting the leaves from top to bottom of the plant and the mean value of the five tagged plants selected at random in each treatment was expressed as number per plant.

Leaf area per plant (LA)

Five randomly selected plants were uprooted and their leaves were separated. The area of leaves was measured by using leaf area meter (LI-COR Inc, Lincon, NE, USA, Model LI- 3000) and expressed in dm^2 leaf area per plant.

3.4.1.3 Number of monopodial branches per plant

Monopodial branches were counted separately in five tagged plants and the average value was recorded.

3.4.1.5 Number of sympodial branches per plant

Fruiting branches arising from the main stem were counted separately in five tagged plants and the average value was recorded.

3.4.1.6 Number of nodes per plant

The number of nodes present on the main stem of the tagged plants was counted and the mean value of the five plants selected at random in each treatment was expressed.

3.4.2 Phenological characters

3.4.2.1 Days to 50 per cent squaring

Total number of days from the date of sowing to the date on which 50 per cent of the plants initiated squaring in a plot was recorded.

3.4.2.2 Days to 50 per cent flowering

Total number of days from the date of sowing to the date on which 50 per cent plants initiated flowering in a plot was recorded.

3.4.2.3 Days to 50 per cent boll opening

Total number of days from the date of sowing to the date on which 50 per cent bolls were opened was recorded.

3.4.3 Growth Parameters

3.4.3.1 Dry matter production and its distribution

From each plot, two plants were selected randomly, cut at the base and partitioned into different parts *viz.*, stem, leaf and reproductive parts at different growth stages. The samples were dried to 80 ^{0}C till a constant weight was achieved and expressed as g Plant ^{1}. From this observation, the total dry matter production per plant and its distribution in stem, leaf and reproductive parts was worked out, which was used further for computing other growth parameters.

3.4.3.2 Leaf area index (LAI)

The leaf area index was determined at different growth stages by using plant canopy analyzer (LI-COR Inc, Lincon, NE, USA model LI-2000) and is defined as the assimilatory surface area per unit land area.

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

3.4.3.4 Specific leaf weight (SLW)

The specific leaf weight or the leaf thickness was determined by the following formula and expressed as mg dm^2.

$$SLW\ (mg/dm^2) = \frac{\text{Leaf dry weight (mg)}}{\text{Leaf area } (dm^2)}$$

3.4.3.5 Leaf area duration (LAD)

Leaf area duration or the persistence of the assimilatory surface was determined by the following formula and expressed as days.

$$LAD\ (days) = \frac{(L_1 + L_2)}{2} \times (t_2 - t_1)$$

Where,

L_1 and L_2 are leaf area indices at time t_1 and t_2, respectively.

3.4.3.7 Absolute growth rate (AGR)

The absolute growth rate was calculated by using the formula given by Radford (1967) and expressed in g plant/day.

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

Where,

W_1 = Dry weight of Plant in g at time t_1

W_2 = Dry weight of plant in g at time t_2

3.4.3.8 Crop growth rate (CGR)

Crop growth rate is defined as the rate of dry matter accumulation per unit ground area (Watson, 192) and expressed as grams per square meter per day. It was calculated by using the following formula.

$$CGR = \frac{w_2 - w_1}{t_2 - t_1} \times \frac{1}{P}$$

Where,

w_1 and w_2= the dry weight per m^2 at time t1 and t2 respectively

P= ground area covered by each plant (m^2)

3.4.3.9 Relative growth rate (RGR)

Relative growth rate is the increase in dry weight per unit dry weight per unit time and is expressed as g/ g/day and calculated by the formula of Blackman (1919) as follows,

$$RGR = \frac{\log_e W_2 - \log_e W_1}{(t_2 - t_1)}$$

Where,

W_1 and W_2 = Total dry weight per plant (g) at time t_1 and t_2 respectively.

3.4.3.10 Net assimilation rate (NAR)

Net assimilation rate is the rate of increase in dry weight per unit leaf area per unit time (Watson, 1952) and is expressed as g dm^{-2} day^{-1}. It was calculated by the formula of Radford (1967) as follows,

$$NAR = \frac{(W_2 - W_1)(\log e\, L_2 - \log e\, L_1)}{(t_2 - t_1)(L_2 - L_1)}$$

Where,

L_1 and W_1 = Leaf area (dm^2) and dry weight (g) of the plant, respectively at time t_1

L_2 and W_2 = Leaf area and dry weight of the plant respectively, at time t_2.

3.4.4 Biophysical Parameters

Measurement of rate of photosynthesis, stomatal conductance and rate of transpiration were made on the top fully expanded leaf at different growth stages by using portable photosynthesis system (LI-6400 LICOR, Nebraska, Lincoln USA,). These measurements were made between 10.00 am to 12.00 noon on all the sampling dates.

The units for different parameters were as follows,

Rate of photosynthesis: (μ mole CO^2 /m^2/s)

Rate of Stomatal conductance :(μ mole/m^2/s)

Rate of transpiration: (mmole of $H2_O$ /m^2/s)

Leaf temperature : (C^o)

3.4.5 Light transmission rate (%)

The measurement of light interception was made by using quantum radiometer (canopy transmission meter EMS-7 of PP systems U.K.). The PAR incident at the top of the canopy was measured by a reference sensor which is fixed on tripod stand 2 feet above the canopy in the middle of the field. Simultaneously, with the help of sample sensor, PAR at top, middle and bottom of the canopy was measured and the values were stored in a data logger. The ratio between the sample sensor and reference sensor is the light interception and is expressed in percentage.

3.4.6 Biochemical parameters

3.4.6.1 SPAD chlorophyll meter reading (SCMR)

Leaf nitrogen status is normally manifested with the leaf chlorophyll content. A device developed by, Minolta corp., Ramsey, NJ measures the light attenuation at 430 nm (the peak wavelength for chlorophyll a and b absorption) and that at 750 nm (near-infrared) with no transmittance. The unit less value measured by the chlorophyll meter (SPAD-502) is termed as SCMR (SPAD Chlorophyll Meter Reading) and is a good estimate of chlorophyll content and hence N content. The SPAD meter (Soil Plant Analysis Development) is a simple hand held equipment, which operates with DC power (Volts) and is portable.

SCMR values were recorded in cotton genotype in all three replications, in ARS, Dharwad farm. The third fully expanded third leaf from the apex was used for the SCMR determination. Several measurements were made on each leaf and averaged to make an approximate estimate of the whole leaf N status. The observations were recorded at different growth stages viz., at 75DAS, 100DAS, 125DAS and 150 DAS.

3.4.6.2 Water potential (-bars)

The measurement of water potential was made by pressure chamber (Scholander *et al.*, 1965). A leafy shoot or single leaf is sealed in a pressure chamber with the cut surface protruding. Pressure is applied to the shoot from a tank of compressed gas unit, xylem sap appears at the cut surface. The amount of pressure that must be applied to force water out of the leaf cell into the xylem unit it is refilled is equal to the tension originally existing in the xylem sap i.e. pure water will be exuded by osmosis. Thus the applied pressure is equal to water potential of the cells.

3.4.7 Yield and Yield Components

3.4.7.1 Number of bolls per plant

Total number of bolls picked from the five-tagged plants was counted and the average was worked out.

3.4.7.2 Boll weight (g)

Seed cotton obtained from 20 bolls selected randomly from the net plot covering top to bottom was weighed and the mean boll weight was worked out.

3.4.7.3 Seed cotton yield (kg/ ha)

The seed yield obtained from all the pickings of respective plots was recorded and expressed as kg per hectare.

3.4.7.4 Harvest index (HI)

Harvest index was calculated by using the formula of Donald (1962) and expressed as per cent.

$$HI = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

3.4.8 Fiber quality parameters

3.4.8.1 Fiber length (mm)

Fiber length of each plant was measured by using spin lab HVI-900. This instrument provides a comprehensive profile of raw fiber and measures the most important fiber characteristics according to international trading standards.

3.4.8.2 Fiber strength (tppsi)

Fiber strength of each plant was measured by using spin lab HVI-900. This instrument provides a comprehensive profile of raw fiber and measures the most important fiber characteristics according to international trading standards.

3.4.8.3 Micronair

Cotton fiber micronair was measured by using spin lab HVI-900.This instrument provides a comprehensive profile of raw fiber and measures the most important fiber characteristics according to international trading standards.

3.5 Statistical analysis

Fisher's method of analysis of variance was applied for the analysis of the data and interpretation of the results as suggested by Panse and Sukhatme (1967). The level of significance used in 'F' and't' tests was P=0.05. Critical differences (CD) values were calculated at 5 per cent probability level, whenever 'F' test was significant. Correlation analysis was carried out to study the nature and degree of relationship between morphological, physiological, growth parameters as well as biochemical, biophysical parameters, yield and yield components following the method of Panse and Sukhatme (1967).

EXPERIMENTAL RESULTS

Optimum plant populations with normal inter and intra row spacing not only utilizes light, moisture and nutrients more efficiently but also avoids excessive competition among the plants. While in lesser plant population with broader inter and intra row spacing though the yield per plant is more the ultimate yield per unit area will be reduced. Hence, either higher or lower plant populations are undesirable. The cotton varieties with late maturing, tall growing and spreading types leading to netted canopy there by posing problems in machine picking and these require more number of pickings. Hence, a field experiment was conducted during *kharif* 2012-13 to study the effect of agrochemicals (*viz*., Mepiquat chloride 100 ppm sprayed at 90 DAS and Ethrel 2000 ppm sprayed at 140 DAS) under different plant geometry with 60 x 20 cm, 60 x 15 cm, 60 x 10cm, 45 x 15 cm and 45 x 10 cm spacing on various morpho-physiological traits, yield, yield components and fiber properties of compact cotton (DSC-8) at Agricultural Research Station, Dharwad (Karnataka). The results of the experiment are presented in this chapter.

4.1 Morphological parameters

4.1.1 Plant height (cm)

The data on plant height recorded at different growth stages as influenced by foliar spray of agrochemicals under different plant spacing is presented in Table 3. In general, plant height increased with the age of the crop till harvest. Plant height differed significantly for different plant spacing in all growth stages (ie., at 75, 100 ,125 and 150 DAS) except at 75 DAS in foliar spray of agrochemicals (as the treatments were not imposed at this stage). However, the interaction effects of agrochemicals foliar spray and different plant spacing was not significant.

At 75 DAS, plant height was significantly higher (50.1 cm) in 45 x 10 cm spacing as compared to 60 x 20 cm and 60 x 15 cm spacing (41.4 and 43.6 cm respectively). Among the foliar spray of agrochemicals, higher (46.2 cm) and lower (45.2 cm) plant height was recorded in Mepiquat chloride 100 ppm sprayed at 90 DAS and in control with no spray respectively.

At 100 DAS, significantly higher plant height of 75.8cm was recorded under 45 x 10 cm spacing followed by 73.2 cm and 70.5 cm in 45 x 15 cm and 60 x 10 cm spacing respectively as compared to 63.6 cm in 60 x 20 cm spacing. Among the foliar spray of agrochemicals, control with no spray (71.0 cm) recorded significantly higher plant height as compared to Mepiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS (68.4cm). The interaction effects between foliar spray of agrochemicals with different plant spacing was not significant.

At 125 and 150 DAS, same trend was followed as in 100 DAS with significantly higher plant height of 96.4 cm and 101.3 cm was recorded in 45 x 10 cm spacing as compared to 81.1 cm and 87.9 cm at 125 and 150 DAS respectively under 60X 20 cm spacing. Among the foliar spray of agrochemicals, significantly higher plant height of 91.0 cm and 97.6 cm as compared to 86.1 cm and 92.4 cm at 125 and 150 DAS was recorded in control with no spray and Mepiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS respectively. However, no significant difference was observed for interaction of agrochemicals foliar spray with different plant spacing.

4.1.2 Number of leaves per plant

The data on the number of leaves per plant recorded in different growth stages as influenced by foliar spray of agrochemicals under different plant spacing is presented in Table 4. At 75 DAS, no significant difference was observed for spacing, agrochemicals and also for their interaction.

At 100 DAS, the difference for number of leaves under different plant spacing was not significant. Among the agrochemicals, control with no spray (64.2) recorded significantly more number of leaves as compared to (56.3) Mapiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS. The interaction effect for number of leaves was non significant.

At 125 DAS, number of leaves was significantly higher in 60 x 20 cm spacing (80.8) followed by 60 x 15 cm spacing (80.0) as compared to 45 x 15 cm (74.9) and 45 x 10 cm spacing (71.2). Among the foliar spray of agrochemicals control with no spray recorded significantly more number of leaves (82.0) as compared to (70.9) Mapiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS and (75.5) Mapiquat chloride 100 ppm sprayed at 90 DAS. The interaction effect for number of leaves was non significant.

Table 3: Influence of plant population and agrochemicals on plant height (cm) at different stages in compact cotton

Treatments	Days after sowing							
	75		100		125		150	
Main treatment (P = Plant population)								
P1-83,333 (60 x 20)	41.4		63.6		81.1		87.9	
P2- 1,11,111 (60 x 15)	43.6		66.6		84.6		90.5	
P3-1,66,666 (60 x 10)	45.8		70.5		88.5		96.3	
P4-1,48,148 (45 x 15)	46.9		73.2		93.1		100.0	
P5-2,22,222 (45 x 10)	50.1		75.8		96.4		101.3	
Sub treatment (S = Agrochemicals)								
S1-Control	45.2		71.0		91.0		97.6	
S2- MC 100 ppm (90 DAS)	46.2		69.9		88.2		94.3	
S3- MC 100 ppm (90DAS) + Ethrel 2000 ppm (140 DAS)	45.3		68.4		86.1		92.4	
S4- Ethrel 2000 ppm (140 DAS)	45.5		70.5		89.5		96.5	
Interaction (P x S)								
P1S1	41.5		64.8		83.0		90.1	
P1S2	41.8		62.7		80.0		86.5	
P1S3	40.9		61.3		78.2		84.9	
P1S4	41.4		65.7		83.2		90.3	
P2S1	43.2		67.5		86.4		92.2	
P2S2	44.3		66.3		83.7		89.6	
P2S3	43.3		64.5		81.9		87.7	
P2S4	43.6		68.0		86.3		92.4	
P3S1	45.1		71.4		91.1		99.4	
P3S2	46.6		71.0		88.0		95.4	
P3S3	45.6		69.4		86.1		93.4	
P3S4	45.8		70.3		88.7		97.0	
P4S1	49.6		77.3		99.2		104.3	
P4S2	51.0		75.6		96.3		100.2	
P4S3	49.8		74.0		93.5		98.3	
P4S4	50.0		76.2		96.5		102.5	
P5S1	46.7		73.9		95.5		102.2	
P5S2	47.6		74.1		93.0		99.8	
P5S3	46.5		72.6		91.0		97.6	
P5S4	46.8		72.3		93.0		100.3	
Grand mean	**45.6**		**69.9**		**88.7**		**95.2**	
For comparing means of	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**
Plant population (P)	1.50	4.89	2.30	7.50	2.92	9.53	2.97	9.68
Agrochemicals (S)	0.43	NS	0.66	1.90	0.83	2.40	0.70	2.01
P x S at same S	0.96	NS	1.47	NS	1.86	NS	1.56	NS
P x S at same or different S	1.71	NS	2.63	NS	3.34	NS	3.26	NS

60 X 20 Cm

60 X 15 Cm

60 X 10 Cm

Plate 2. Field view of compact genotype (DSC-8) at different spacings

45 X 15 cm

45 X 10 cm

Plate 2. Contd….

Table 4: Influence of plant population and agrochemicals on number of leaves per plant at different stages in compact cotton

Treatments	Days after sowing											
	75		100		125		140		145		150	
Main treatment (P = Plant population)												
P1-83,333 (60 x 20)	41.9		63.5		80.8		71.9		42.6		23.8	
P2- 1,11,111 (60 x 15)	41.2		62.3		80.0		71.1		41.9		23.2	
P3-1,66,666 (60 x 10)	40.2		60.9		77.1		69.0		39.7		21.5	
P4-1,48,148 (45 x 15)	38.9		59.0		74.9		67.0		36.5		20.6	
P5-2,22,222 (45 x 10)	37.4		56.6		71.2		64.1		33.8		18.2	
Sub treatment (S = Agrochemicals)												
S1-Control	42.4		64.2		82.0		72.9		43.5		40.1	
S2- MC 100 ppm (90 DAS)	39.3		59.4		75.5		67.6		40.7		38.4	
S3- MC 100 ppm (90DAS) + Ethrel 2000 ppm (140 DAS)	37.2		56.3		70.9		63.7		33.7		3.9	
S4- Ethrel 2000 ppm (140 DAS)	40.8		61.8		78.8		70.2		37.9		3.5	
Interaction (P x S)												
P1S1	44.1		66.8		85.6		75.9		47.1		43.8	
P1S2	40.7		61.7		78.4		70.2		46.1		42.6	
P1S3	39.6		60.0		75.1		67.2		36.3		4.4	
P1S4	43.1		65.3		83.9		74.4		41.0		4.3	
P2S1	43.5		65.9		85.3		75.2		46.6		43.0	
P2S2	41.4		62.7		80.7		71.9		44.4		41.3	
P2S3	37.5		56.8		72.0		64.6		34.2		4.4	
P2S4	42.3		64.0		82.0		72.8		42.2		4.2	
P3S1	42.2		63.9		81.5		72.6		44.3		40.3	
P3S2	40.5		61.3		78.0		69.8		41.7		38.4	
P3S3	36.8		55.8		69.5		62.6		32.6		4.1	
P3S4	41.2		62.4		79.6		71.0		40.5		3.3	
P4S1	42.2		63.9		81.3		72.3		42.5		38.6	
P4S2	37.8		57.3		72.4		64.9		36.0		37.1	
P4S3	37.0		56.0		71.3		64.1		33.4		3.4	
P4S4	38.8		58.8		74.6		66.6		34.4		3.3	
P5S1	40.1		60.7		76.5		68.6		37.0		34.9	
P5S2	35.8		54.2		67.9		61.4		35.1		32.4	
P5S3	35.0		53.0		66.4		60.2		31.9		3.2	
P5S4	38.5		58.3		74.0		66.3		31.3		2.5	
Grand mean	**39.9**		**60.4**		**76.8**		**68.6**		**38.9**		**21.5**	
For comparing means of	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**
Plant population (P)	1.3	NS	1.2	NS	1.5	5.0	1.4	4.5	0.8	2.6	1.1	3.5
Agrochemicals (S)	1.4	NS	1.2	3.6	1.6	4.6	1.4	4.1	0.8	2.4	0.5	1.5
P x S at same S	3.0	NS	2.8	NS	3.6	NS	3.2	NS	1.8	NS	1.2	3.4
P x S at same or different S	2.9	NS	2.7	NS	3.5	NS	3.1	NS	1.8	NS	1.5	4.3

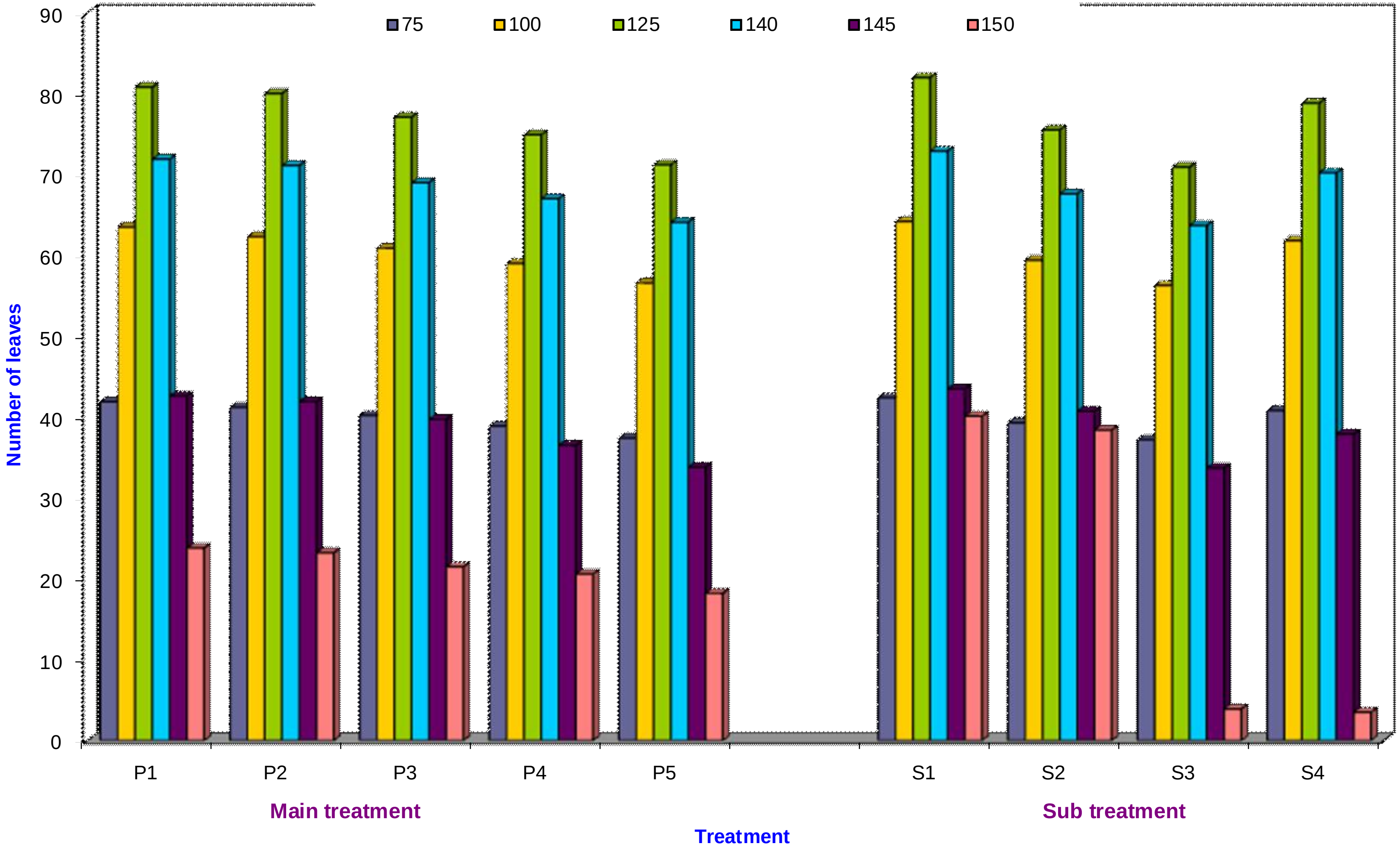

Fig. 2: Influence of plant population and agrochemicals on number of leaves per plant at different stages in compact cotton

Plate 3. Defoliation of leaves after spray of ethrel

Ethrel sprayed Control

Plate 4. Field view of experimental site after spray of ethrel

At 140 and 145 DAS, 60 x 20 cm spacing(71.9 and 42.6) followed by 60 x 15 cm spacing(71.1 and 41.9) recorded significantly more number of leaves as compared to 45 x 10 cm spacing (64.1 and 33.8). Among the agrochemicals, Mapiquat chloride 100 ppm sprayed at 90 DAS(67.6 and 40.7) either alone or Mapiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS(63.7 and 33.7) significantly reduced the number of leaves as compared to control with no spray. The interaction between plant spacing and foliar spray of agrochemicals was found non significant for number of leaves per plant.

At 150 DAS, significantly more number of leaves (23.8) was observed in 60 x 20 cm spacing followed by 60 x 15 cm spacing (23.2) as compared to 45 x 10cm spacing (18.2). Among the foliar spray of agrochemicals control with no spray (40.1) followed by (38.4) Mepiquat chloride 100 ppm sprayed at 90 DAS recorded significantly more number of leaves as compared to (3.9) Mepiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS and (3.50) Ethrel 2000 ppm alone sprayed at 140 DAS. The interaction of plant spacing with agrochemicals spray was found significant. Wherein, Ethrel 2000 ppm sprayed at 140 DAS either alone or Mapiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS significantly reduced the number of leaves in all the treatment combination with plant spacing.

4.1.3 Leaf area (cm^2/plant)

The data on leaf area per plant recorded at different stages of plant growth as influenced by agrochemicals foliar spray under different spacing is presented in Table 5. At 75 DAS, significantly higher leaf area was recorded in 60 x 20 cm spacing (1376.6) followed by 60 x 15 cm spacing (1340.9) as compared to 45 x 15cm spacing(1187.0) and 45 x 10 cm spacing(1083.1). Foliar spray of agrochemical and their interaction effect on leaf area was non significant.

At 100 and 125 DAS, 60 x 20 cm spacing (1905.9 and 2047.8) recorded significantly higher leaf area than 60 x 10 cm (1747.5 and 1869.9), 45 x 15 cm (1643.4 and 1761.5) and 45 x 10 cm spacing (1499.5 and 1593.5). While 60 x 15 cm spacing (1856.4 and 2010.3) was on par with 60 x 20 cm. Among the agrochemicals control with no spray recorded significantly higher leaf area (1957.6 and 2110.6) as compared toMapiquat chloride 100 ppm sprayed at 90 DAS (1670.8 and 1791.0) and Mapiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS (1483.1 and 1575.4). The interaction effect for leaf area was non significant.

At 150 DAS, leaf area was higher in 60 x 20 cm spacing (532.4) followed by 60 x 15 cm spacing (513.1) which were significantly higher compare to 45 x 15 cm (437.6) and 45 x 10 cm spacing (376.3). Among the agrochemicals, Ethrel 2000 ppm sprayed at 140 DAS (67.5) and Mepiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS (76.2) significantly reduce the leaf area as compare to Mapiquat chloride 100 ppm sprayed at 90 DAS (828.9) and control with no spray (884.0). No significant difference was recorded for interaction. However, all the treatment combination of different plant spacing with the foliar spray of Ethrel 2000 ppm sprayed at 140 DAS either alone or Mepiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS recorded lower leaf area than others treatments .

4.1.4 Number of Monopodia, Sympodia and Nodes per plant

The observations recorded on number of monopodia, sympodia and nodes per plant at harvest as influenced by foliar spray of agrochemicals under different plant spacing are presented in Table 6. The data on these parameters recorded no significant difference except sympodia for foliar spray of agrochemicals. Higher number of monopodia (1.7), sympodia (14.5) and nodes (15.8) per plant was observed in 60 x 20 cm spacing and 60 x 15 cm spacing. Among the foliar spray of agrochemicals more number of monopodia (1.7) was observed in Mapiquat chloride 100 ppm sprayed at 90 DAS and Mapiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS. Significantly higher number of sympodia(14.7) was recorded in Mepiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS followed by(14.4) Mepiquat chloride 100 ppm sprayed at 90 DAS as compared to(13.7) control with no spray. The interaction effect for all these parameters i.e. number of monopodia, sympodia and nodes per plant was non significant.

4.2 Phenological characters

The number of days required for 50 per cent squaring, 50 percent flowering, 50 per cent boll opening and maturity is presented in Table 7. Plant spacing, foliar spray of agrochemicals and the interaction effect had no significant effect on 50 per cent squaring and 50 per cent flowering.

Table 6: Influence of plant population and agrochemicals on number of monpodia, sympodia and nodes per plant at harvest in compact cotton

Treatments	Monopodia /plant		Sympodia /plant		Nodes/plant	
Main treatment (P = Plant population)						
P1-83,333 (60 x 20)	1.7		14.5		15.8	
P2- 1,11,111 (60 x 15)	1.7		14.5		15.8	
P3-1,66,666 (60 x 10)	1.6		14.2		15.5	
P4-1,48,148 (45 x 15)	1.6		14.0		15.3	
P5-2,22,222 (45 x 10)	1.5		13.7		15.0	
Sub treatment (S = Agrochemicals)						
S1-Control	1.5		13.7		15.0	
S2- MC 100 ppm (90 DAS)	1.7		14.4		15.7	
S3- MC 100 ppm (90DAS) + Ethrel 2000 ppm (140 DAS)	1.7		14.7		16.0	
S4- Ethrel 2000 ppm (140 DAS)	1.6		14.1		15.4	
Interaction (P x S)						
P1S1	1.6		14.1		15.4	
P1S2	1.8		14.8		16.1	
P1S3	1.8		14.9		16.2	
P1S4	1.6		14.3		15.6	
P2S1	1.5		13.7		15.0	
P2S2	1.7		14.8		16.1	
P2S3	1.8		14.9		16.2	
P2S4	1.7		14.5		15.8	
P3S1	1.5		13.6		14.9	
P3S2	1.7		14.4		15.7	
P3S3	1.7		14.7		16.0	
P3S4	1.6		14.3		15.6	
P4S1	1.5		13.7		15.0	
P4S2	1.6		14.0		15.3	
P4S3	1.7		14.6		15.9	
P4S4	1.5		13.8		15.1	
P5S1	1.4		13.4		14.7	
P5S2	1.5		13.9		15.2	
P5S3	1.6		14.2		15.5	
P5S4	1.4		13.5		14.8	
Grand mean	**1.6**		**14.2**		**15.5**	
For comparing means of	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**
Plant population (P)	0.1	NS	0.7	NS	0.8	NS
Agrochemicals (S)	0.1	NS	0.2	0.5	0.2	0.6
P x S at same S	0.1	NS	0.4	NS	0.5	NS
P x S at same or different S	0.1	NS	0.8	NS	0.9	NS

Table 5: Influence of plant population and agrochemicals on leaf area (cm^2/plant) at different stages in compact cotton

Treatments	Days after sowing							
	75		100		125		150	
Main treatment (P = Plant population)								
P1-83,333 (60 x 20)	1376.6		1905.9		2047.8		532.4	
P2- 1,11,111 (60 x 15)	1340.9		1856.4		2010.3		513.1	
P3-1,66,666 (60 x 10)	1262.2		1747.5		1869.9		461.4	
P4-1,48,148 (45 x 15)	1187.0		1643.4		1761.5		437.6	
P5-2,22,222 (45 x 10)	1083.1		1499.5		1593.5		376.3	
Sub treatment (S = Agrochemicals)								
S1-Control	1264.0		1957.6		2110.6		884.0	
S2- MC 100 ppm (90 DAS)	1281.8		1670.8		1791.0		828.9	
S3- MC 100 ppm (90DAS) + Ethrel 2000 ppm (140 DAS)	1246.2		1483.1		1575.4		76.2	
S4- Ethrel 2000 ppm (140 DAS)	1207.8		1810.6		1949.5		67.5	
Interaction (P x S)								
P1S1	1382.7		2122.0		2295.2		999.6	
P1S2	1371.9		1795.5		1926.1		953.4	
P1S3	1383.3		1672.9		1767.8		90.7	
P1S4	1368.6		2033.2		2202.1		86.0	
P2S1	1354.9		2083.5		2276.1		978.3	
P2S2	1432.1		1878.9		2040.0		903.4	
P2S3	1269.8		1515.8		1621.2		87.3	
P2S4	1306.6		1947.5		2104.0		83.3	
P3S1	1245.6		1932.2		2079.2		875.5	
P3S2	1357.6		1775.7		1905.0		827.1	
P3S3	1214.4		1439.0		1513.9		79.7	
P3S4	1231.1		1843.0		1981.4		63.5	
P4S1	1240.9		1925.7		2068.1		837.5	
P4S2	1186.4		1538.7		1640.5		786.9	
P4S3	1245.4		1481.9		1593.5		65.7	
P4S4	1075.4		1627.3		1743.9		60.4	
P5S1	1095.7		1724.6		1834.3		729.1	
P5S2	1061.2		1365.3		1443.3		673.8	
P5S3	1118.3		1305.9		1380.5		57.8	
P5S4	1057.3		1602.3		1716.2		44.3	
Grand mean	**1250.0**		**1730.5**		**1856.6**		**464.2**	
For comparing means of	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**
Plant population (P)	28.9	94.1	34.7	113.1	37.3	121.7	17.4	56.6
Agrochemicals (S)	56.0	NS	36.5	105.3	39.2	113.1	26.2	75.6
P x S at same S	125.2	NS	81.6	NS	87.6	NS	58.5	NS
P x S at same or different S	112.2	NS	78.7	NS	84.5	NS	53.6	NS

However, number of days required for 50 per cent squaring (55.67 days) and 50 per cent flowering (82.77 days) was less in 45 x 10 cm spacing than the others.

The data on 50 per cent boll opening and for maturity as influenced by plant spacing was non significant. Among the agrochemicals, number of days to 50 per cent boll opening (137.48 days) and maturity (157.04 days) was significantly less in Ethrel 2000 ppm sprayed at 140 DAS. The interaction of plant spacing with agrochemicals for all these phenological characters was non significant.

4.3 Growth parameters

4.3.1 Leaf dry weight (g/plant)

The data on leaf dry weight per plant recorded at different plant growth stages as influenced by agrochemicals foliar spray under different spacing is presented in Table 8. At 75 DAS, significantly higher leaf dry weight (4.76 g/plant) was recorded in 60 x 20 cm spacing followed by (4.61 g/plant) 60 x 15 cm spacing as compared to (3.88 g/plant) in 45 x 15 cm spacing and (3.44 g/plant) 45 x 10 cm spacing. Foliar spray of agrochemical and their interaction effect on leaf dry weight was non significant.

At 100 DAS, 60 x 20 cm spacing recorded significantly higher leaf dry weight (7.25 g/plant) as compared to 60 x 10 cm, 45 X15 cm and 45 x 10cm spacing (6.43, 5.91 and 5.23 g/plant respectively). While 60 x 15 cm spacing recorded 7.02 g/plant which was on par with 60 x 20 cm spacing. Among the agrochemicals control with no spray recorded significantly higher leaf dry weight (7.12 g/plant) as compared to Mepiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS (5.58 g/plant). The interaction effect for leaf dry weight was non significant.

Similarly at 125 DAS, significantly higher leaf dry weight of 10.58 g/plant was recorded in 60 x 20 cm spacing followed by 10.31 g/plant in 60 x 15 cm spacing as compared to 9.42, 8.71 and 7.68 g/plant in 60 x 10 cm, 45 X15 cm and 45 x 10 cm spacing respectively. Among the agrochemicals control with no spray recorded significantly higher leaf dry weight (10.56 g/plant) as compared to Mepiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS (8.06 g/plant). While the Ethrel 2000 ppm sprayed at 140 DAS (9.39 g/plant) and Mepiquat chloride 100 ppm sprayed at 90 DAS (9.35 g/plant) were on par with the control. The interaction effect for leaf dry weight was non significant.

At 150 DAS, leaf dry weight was higher in 60 x 20 cm spacing (2.25 g/plant) followed by 60 x 15 cm spacing (2.17 g/plant) which were significantly higher compared to 60 x 10 cm, 45 x 15 cm and 45 x 10 cm spacing(1.92, 1.80 and 1.51 g/plant respectively). Among the agrochemicals, Ethrel 2000 ppm sprayed at 140 DAS (0.27 g/plant) and Mepiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS (0.32 g/plant) significantly reduced the leaf dry weight as compare to Mapiquat chloride 100 ppm sprayed at 90 DAS (3.51 g/plant) and control with no spray (3.62 g/plant). No significant difference was recorded for interaction. However, all the treatment combination of different plant spacing with the foliar spray of Ethrel 2000 ppm sprayed at 140 DAS either alone or Mepiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS recorded lower leaf dry weight than the others.

4.3.2 Stem dry weight (g/plant)

The data on stem dry weight recorded at different growth stages as influenced by foliar spray of agrochemicals under different plant spacing is presented in Table 9. In general, stem dry weight increased with the age of the crop till harvest. Stem dry weight differed significantly in all growth stages (ie., at 75, 100 ,125 and 150 DAS) under different plant spacing and except at 75 DAS in foliar spray of agrochemicals. However, the interaction effects of agrochemicals foliar spray and different plant spacing was not significant.

At 75 DAS, stem dry weight was higher (5.19 g/plant) in 60 x 20 cm spacing followed by 60 x 15 cm, 60 x 10 cm and 45 x 15 cm spacing (5.02, 4.60 and 4.22 g/plant respectively) which were significantly higher as compared to 45 x 10 cm spacing (3.74 g/plant). Among the foliar spray of agrochemicals, higher (4.89 g/plant) and lower (4.27 g/plant) stem dry weight was recorded in control with no spray and in Mepiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS respectively.

At 100 DAS, significantly higher stem dry weight of 8.20 g/plant was recorded in 60 x 20 cm spacing followed by 7.93 and 7.27 g/plant in 60 x 15 cm and 60 x 10 cm spacing respectively as compared to 6.68 and 5.91 g/plant in 45 x 15 cm and 45 x 10 cm spacing respectively. Among the

Table 7: Influence of plant population and agrochemicals on phenological characters in compact cotton

Treatments	Number of days to 50% Squaring		50% Flowering		50%Boll opening		Maturity	
Main treatment (P = Plant population)								
P1-83,333 (60 x 20)	58.58		84.86		144.33		167.30	
P2- 1,11,111 (60 x 15)	58.33		84.64		143.50		166.13	
P3-1,66,666 (60 x 10)	57.50		84.04		142.00		163.35	
P4-1,48,148 (45 x 15)	56.75		83.40		140.25		160.78	
P5-2,22,222 (45 x 10)	55.67		82.77		138.15		157.33	
Sub treatment (S = Agrochemicals)								
S1-Control	57.00		83.60		140.74		161.46	
S2- MC 100 ppm (90 DAS)	59.00		85.13		145.20		168.20	
S3- MC 100 ppm (90DAS) + Ethrel 2000 ppm (140 DAS)	58.00		84.42		143.16		165.20	
S4- Ethrel 2000 ppm (140 DAS)	55.47		82.62		137.48		157.04	
Interaction (P x S)								
P1S1	58.0		84.2		142.80		164.70	
P1S2	60.0		86.0		147.20		171.80	
P1S3	59.3		85.6		146.10		170.90	
P1S4	57.0		83.6		141.20		161.80	
P2S1	58.7		84.7		144.20		166.10	
P2S2	59.7		85.7		146.70		171.00	
P2S3	59.3		85.5		145.70		169.60	
P2S4	55.7		82.7		137.40		157.80	
P3S1	57.7		84.1		142.30		163.60	
P3S2	59.0		85.2		145.30		168.50	
P3S3	58.3		84.6		143.70		165.80	
P3S4	55.0		82.3		136.70		155.50	
P4S1	56.0		82.8		138.60		158.90	
P4S2	59.0		85.0		144.90		167.30	
P4S3	56.7		83.3		140.50		160.50	
P4S4	55.3		82.5		137.00		156.40	
P5S1	54.7		82.2		135.80		154.00	
P5S2	57.3		83.8		141.90		162.40	
P5S3	56.3		83.1		139.80		159.20	
P5S4	54.3		82.0		135.10		153.70	
Grand mean	**57.37**		**83.94**		**141.65**		**162.98**	
For comparing means of	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**
Plant population (P)	1.2	NS	1.7	NS	7.1	NS	8.1	NS
Agrochemicals (S)	1.2	NS	1.7	NS	1.8	5.3	2.1	6.1
P x S at same S	2.7	NS	3.9	NS	4.1	NS	4.7	NS
P x S at same or different S	2.6	NS	3.8	NS	7.9	NS	9.1	NS

Table 8: Influence of plant population and agrochemicals on leaf dry weight (g/plant) at different stages in compact cotton

Treatments	Days after sowing			
	75	100	125	150
Main treatment (P = Plant population)				
P1-83,333 (60 x 20)	4.76	7.25	10.58	2.25
P2- 1,11,111 (60 x 15)	4.61	7.02	10.31	2.17
P3-1,66,666 (60 x 10)	4.22	6.43	9.42	1.92
P4-1,48,148 (45 x 15)	3.88	5.91	8.71	1.80
P5-2,22,222 (45 x 10)	3.44	5.23	7.68	1.51
Sub treatment (S = Agrochemicals)				
S1-Control	4.43	7.12	10.56	3.62
S2- MC 100 ppm (90 DAS)	4.24	6.47	9.35	3.51
S3- MC 100 ppm (90DAS) + Ethrel 2000 ppm (140 DAS)	3.94	5.58	8.06	0.32
S4- Ethrel 2000 ppm (140 DAS)	4.12	6.31	9.39	0.27
Interaction (P x S)				
P1S1	4.98	7.92	11.75	4.14
P1S2	4.64	7.14	10.21	4.11
P1S3	4.55	6.58	9.32	0.39
P1S4	4.88	7.38	11.04	0.35
P2S1	4.87	7.91	11.77	4.10
P2S2	4.93	7.45	10.79	3.88
P2S3	4.02	5.91	8.51	0.37
P2S4	4.62	6.80	10.16	0.33
P3S1	4.36	7.14	10.58	3.60
P3S2	4.55	6.86	9.93	3.50
P3S3	3.77	5.42	7.78	0.33
P3S4	4.20	6.31	9.38	0.25
P4S1	4.31	6.79	10.08	3.38
P4S2	3.80	5.90	8.50	3.31
P4S3	3.91	5.33	7.92	0.27
P4S4	3.51	5.63	8.34	0.24
P5S1	3.64	5.85	8.60	2.88
P5S2	3.27	5.00	7.30	2.76
P5S3	3.43	4.65	6.79	0.23
P5S4	3.42	5.42	8.01	0.17
Grand mean	**4.18**	**6.37**	**9.34**	**1.93**

For comparing means of	SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%
Plant population (P)	0.09	0.31	0.14	0.46	0.21	0.68	0.07	0.24
Agrochemicals (S)	0.19	NS	0.29	0.84	0.43	1.23	0.11	0.32
P x S at same S	0.42	NS	0.65	NS	0.95	NS	0.25	NS
P x S at same or different S	0.38	NS	0.58	NS	0.85	NS	0.23	NS

Table 9: Influence of plant population and agrochemicals on stem dry weight (g/plant) at different stages in compact cotton

Treatments	Days after sowing							
	75		100		125		150	
Main treatment (P = Plant population)								
P1-83,333 (60 x 20)	5.19		8.20		12.20		15.37	
P2- 1,11,111 (60 x 15)	5.02		7.93		11.88		14.97	
P3-1,66,666 (60 x 10)	4.60		7.27		10.86		13.68	
P4-1,48,148 (45 x 15)	4.22		6.68		10.04		12.65	
P5-2,22,222 (45 x 10)	3.74		5.91		8.85		11.15	
Sub treatment (S = Agrochemicals)								
S1-Control	4.89		8.05		12.17		15.34	
S2- MC 100 ppm (90 DAS)	4.33		7.31		10.78		13.58	
S3- MC 100 ppm (90DAS) + Ethrel 2000 ppm (140 DAS)	4.27		6.30		9.30		11.71	
S4- Ethrel 2000 ppm (140 DAS)	4.73		7.13		10.82		13.64	
Interaction (P x S)								
P1S1	5.51		8.94		13.55		17.07	
P1S2	4.76		8.07		11.77		14.83	
P1S3	4.91		7.43		10.74		13.53	
P1S4	5.57		8.34		12.73		16.04	
P2S1	5.38		8.94		13.57		17.10	
P2S2	5.07		8.42		12.44		15.68	
P2S3	4.36		6.68		9.81		12.36	
P2S4	5.28		7.69		11.71		14.75	
P3S1	4.82		8.07		12.20		15.37	
P3S2	4.66		7.76		11.44		14.42	
P3S3	4.10		6.12		8.97		11.30	
P3S4	4.82		7.14		10.82		13.63	
P4S1	4.75		7.68		11.62		14.64	
P4S2	3.86		6.66		9.80		12.35	
P4S3	4.24		6.02		9.13		11.50	
P4S4	4.05		6.36		9.61		12.11	
P5S1	4.00		6.61		9.91		12.49	
P5S2	3.29		5.65		8.42		10.61	
P5S3	3.74		5.26		7.83		9.87	
P5S4	3.94		6.12		9.24		11.64	
Grand mean	**4.56**		**7.20**		**10.77**		**13.57**	
For comparing means of	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**
Plant population (P)	0.10	0.33	0.16	0.52	0.24	0.78	0.30	0.98
Agrochemicals (S)	0.21	NS	0.33	0.95	0.49	1.42	0.62	1.78
P x S at same S	0.46	NS	0.73	NS	1.10	NS	1.38	NS
P x S at same or different S	0.41	NS	0.66	NS	0.98	NS	1.23	NS

foliar spray of agrochemicals control with no spray (8.05 g/plant) followed by (7.31 g/plant) Mepiquat chloride 100 ppm sprayed at 90 DAS recorded significantly higher stem dry weight as compared to (6.30 g/plant) Mepiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS. The interaction effects between foliar spray of agrochemicals with different plant spacing was not significant.

At 125 and 150 DAS, significantly higher stem dry weight of 12.20 and 15.37 g/plant was recorded in 60 x 20 cm spacing followed by 11.88 and 14.97 g/plant in 60 x 15 cm spacing as compared to 10.86 and 13.68 g/plant in 60 x 10 cm, 10.04 and 12.65 g/plant in 45 x 15 cm and 8.85 and 11.15 g/plant in 45 x 10 cm spacing at 125 and 150 DAS respectively. Among the foliar spray of agrochemicals, significantly higher stem dry weight was recorded in control with no spray as compared to in Mepiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS (12.17 and 9.30 g/plant at 125 DAS and 15.34 and 11.71 g/plant at 150 DAS respectively). However, no significant difference was observed for interaction of agrochemicals foliar spray with different plant spacing.

4.3.3 Reproductive parts dry weight (g/plant)

The data on reproductive parts dry weight per plant recorded at different plant growth stages as influenced by agrochemicals foliar spray under different spacing is presented in Table 10. At 75 DAS, no significant difference was observed for spacing, agrochemicals and also for their interaction.

At 100 DAS, 60 x 20 cm followed by 60 x 15cm spacing recorded significantly higher reproductive part dry weight (5.13 and 5.09 g/plant respectively) as compared to 60 x 10 cm, 45 X15 cm and 45 x 10 cm spacing (4.94, 4.82 and 4.67 g/plant respectively). Among the agrochemicals Mapiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS (5.19 g/plant) followed by Mapiquat chloride 100 ppm sprayed at 90 DAS (5.03 g/plant) recorded significantly higher reproductive part dry weight as compared to Ethrel 2000 ppm sprayed at 140 DAS (4.86 g/plant) and control with no spray (4.64 g/plant). The interaction effect for reproductive part dry weight was non significant.

Similarly at 125 and 150 DAS, significantly higher reproductive part dry weight of 9.69 and 13.64 g/plant was recorded in 60 x 20 cm spacing followed by 9.60 and 13.52 g/plant in 60 x 15 cm spacing and 9.32 and 13.13 g/plant in 60 x 10 cm spacing as compared to 8.81 and 12.40 g/plant in 45 x 10 cm spacing. Among the agrochemicals Mapiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS (9.80 and 13.80 g/plant at 125 and 150 DAS respectively) recorded significantly higher reproductive part dry weight as compared to Ethrel 2000 ppm sprayed at 140 DAS (9.16 and 12.91 g/plant at 125 and 150 DAS respectively) and control with no spray (8.75 and 12.33 g/plant at 125 and 150 DAS respectively). At both 125 and 150 DAS the interaction effect for reproductive part dry weight was non significant.

4.3.4 Total dry weight (g/plant)

The data on total dry weight per plant as influenced by agrochemicals foliar spray under different spacing recorded at different plant growth stages is presented in Table 11. At 75 DAS, significantly higher total dry weight (11.75 g/plant) was recorded in 60 x 20 cm spacing followed by (11.41 g/plant) in 60 x 15 cm spacing as compared to (9.79 g/plant) 45 x 15 cm spacing and (8.82 g/plant) 45 x 10 cm spacing. Foliar spray of agrochemical and their interaction effect on total dry weight was non significant.

At 100 DAS, significantly higher total dry weight of 20.58 g/plant was observed in 60 x 20 cm followed by 20.04 g/plant in 60 x 10 cm spacing as compared to 45 X15 cm and 45 x 10 cm spacing (17.41 and 15.81 g/plant respectively). Among the agrochemicals control with no spray (19.81 g/plant) and Mepiquat chloride 100 ppm sprayed at 90 DAS (18.81 g/plant) recorded significantly higher total dry weight as compared to Mapiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS (17.07 g/plant).

At 125 DAS, 60 x 20 cm spacing recorded significantly higher total dry weight of 32.46 g/plant as compared to 60 x 10 cm, 45 x 15 cm and 45 x 10 cm spacing (29.60, 27.84 and 25.34 g/plant respectively). While 60 x 15 cm spacing recorded 31.79 g/plant which was on par with 60 x 20 cm spacing. Among the agrochemicals control with no spray (31.48 g/plant) recorded significantly higher total dry weight as compared to Mepiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS (27.16 g/plant) while the other treatments were on par with each other.

Table 10: Influence of plant population and agrochemicals on reproductive parts dry weight (g/plant) at different stages in compact cotton

Treatments	Days after sowing							
	75		100		125		150	
Main treatment (P = Plant population)								
P1-83,333 (60 x 20)	1.80		5.13		9.69		13.64	
P2- 1,11,111 (60 x 15)	1.78		5.09		9.60		13.52	
P3-1,66,666 (60 x 10)	1.73		4.94		9.32		13.13	
P4-1,48,148 (45 x 15)	1.69		4.82		9.10		12.81	
P5-2,22,222 (45 x 10)	1.63		4.67		8.81		12.40	
Sub treatment (S = Agrochemicals)								
S1-Control	1.62		4.64		8.75		12.33	
S2- MC 100 ppm (90 DAS)	1.76		5.03		9.49		13.37	
S3- MC 100 ppm (90DAS) + Ethrel 2000 ppm (140 DAS)	1.82		5.19		9.80		13.80	
S4- Ethrel 2000 ppm (140 DAS)	1.70		4.86		9.16		12.91	
Interaction (P x S)								
P1S1	1.70		4.85		9.16		12.90	
P1S2	1.85		5.29		9.98		14.06	
P1S3	1.89		5.39		10.17		14.32	
P1S4	1.75		5.00		9.43		13.28	
P2S1	1.63		4.67		8.81		12.40	
P2S2	1.83		5.24		9.89		13.93	
P2S3	1.87		5.34		10.08		14.19	
P2S4	1.78		5.10		9.61		13.54	
P3S1	1.60		4.57		8.63		12.15	
P3S2	1.77		5.05		9.52		13.41	
P3S3	1.82		5.19		9.80		13.80	
P3S4	1.73		4.95		9.34		13.16	
P4S1	1.62		4.62		8.72		12.28	
P4S2	1.68		4.81		9.07		12.78	
P4S3	1.80		5.14		9.71		13.67	
P4S4	1.65		4.71		8.89		12.53	
P5S1	1.57		4.48		8.45		11.91	
P5S2	1.67		4.76		8.98		12.65	
P5S3	1.72		4.90		9.25		13.03	
P5S4	1.58		4.53		8.54		12.03	
Grand mean	**1.73**		**4.93**		**9.30**		**13.10**	
For comparing means of	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**
Plant population (P)	0.04	NS	0.08	0.25	0.14	0.47	0.20	0.66
Agrochemicals (S)	0.08	NS	0.08	0.24	0.15	0.45	0.22	0.63
P x S at same S	0.17	NS	0.18	NS	0.35	NS	0.49	NS
P x S at same or different S	0.16	NS	0.18	NS	0.33	NS	0.47	NS

Table 11: Influence of plant population and agrochemicals on total dry weight (g/plant) at different stages in compact cotton

Treatments	Days after sowing							
	75		100		125		150	
Main treatment (P = Plant population)								
P1-83,333 (60 x 20)	11.75		20.58		32.46		31.26	
P2- 1,11,111 (60 x 15)	11.41		20.04		31.79		30.66	
P3-1,66,666 (60 x 10)	10.55		18.65		29.60		28.73	
P4-1,48,148 (45 x 15)	9.79		17.41		27.84		27.26	
P5-2,22,222 (45 x 10)	8.82		15.81		25.34		25.07	
Sub treatment (S = Agrochemicals)								
S1-Control	10.95		19.81		31.48		31.28	
S2- MC 100 ppm (90 DAS)	10.32		18.81		29.61		30.45	
S3- MC 100 ppm (90DAS) + Ethrel 2000 ppm (140 DAS)	10.03		17.07		27.16		25.83	
S4- Ethrel 2000 ppm (140 DAS)	10.56		18.29		29.37		26.81	
Interaction (P x S)								
P1S1	12.19		21.72		34.46		34.11	
P1S2	11.25		20.51		31.96		33.00	
P1S3	11.35		19.40		30.23		28.24	
P1S4	12.20		20.71		33.20		29.67	
P2S1	11.88		21.52		34.14		33.60	
P2S2	11.83		21.12		33.12		33.48	
P2S3	10.25		17.93		28.40		26.93	
P2S4	11.69		19.59		31.48		28.63	
P3S1	10.78		19.79		31.41		31.13	
P3S2	10.98		19.67		30.89		31.33	
P3S3	9.70		16.73		26.55		25.44	
P3S4	10.75		18.40		29.54		27.04	
P4S1	10.68		19.09		30.42		30.30	
P4S2	9.33		17.37		27.37		28.43	
P4S3	9.95		16.49		26.75		25.44	
P4S4	9.20		16.71		26.84		24.88	
P5S1	9.21		16.94		26.96		27.28	
P5S2	8.22		15.41		24.71		26.02	
P5S3	8.88		14.81		23.87		23.13	
P5S4	8.95		16.06		25.80		23.85	
Grand mean	**10.46**		**18.50**		**29.41**		**28.60**	
For comparing means of	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**
Plant population (P)	0.24	0.78	0.54	1.75	0.85	2.78	0.85	2.77
Agrochemicals (S)	0.47	NS	0.58	1.67	0.92	2.65	0.89	2.58
P x S at same S	1.06	NS	1.29	NS	2.05	NS	1.99	NS
P x S at same or different S	0.94	NS	1.24	NS	1.97	NS	1.93	NS

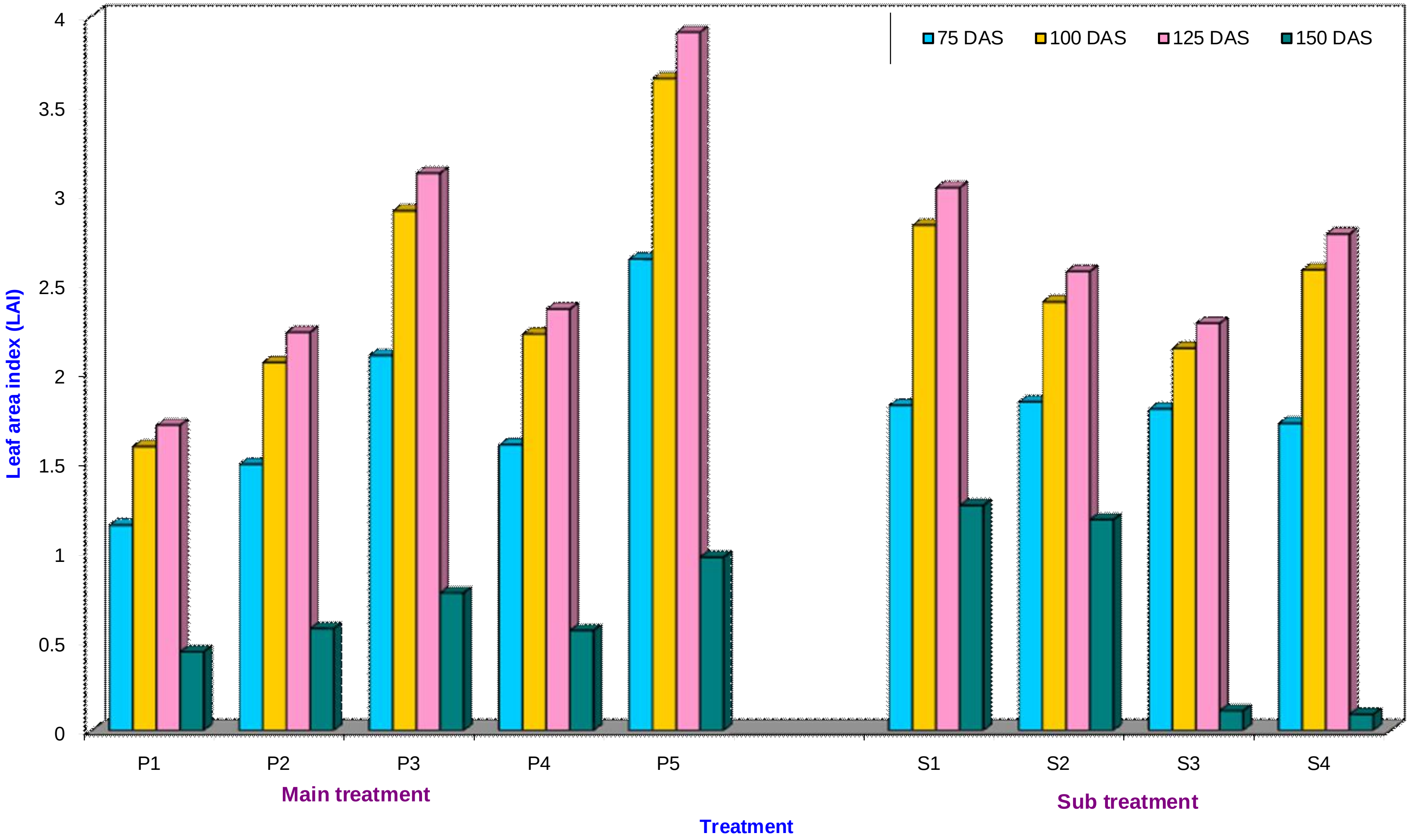

Fig. 3: Influence of plant population and agrochemicals on leaf area index (LAI) at different stages in compact cotton

The total dry weight at 150 DAS was significantly higher (31.26 g/plant) in 60 x 20 cm followed by (30.66 g/plant) 60 x 15 cm spacing as compared to (27.26 g/plant) 45 x 15 cm and (25.07 g/plant) 45 x 10 cm spacing. Control with no spray (31.28 g/plant) followed by Mapiquat chloride 100 ppm sprayed at 90 DAS (30.45 g/plant) recorded significantly higher total dry weight as compared to Mapiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS (25.83 g/plant) and Ethrel 2000 ppm sprayed at 140 DAS (26.81 g/plant). The interaction effect of plant spacing and foliar spray of agrochemicals for total dry weight was non significant at all the stages (ie., at 75, 100, 125 and 150 DAS).

4.3.5 Leaf area index (LAI)

The data on leaf area index at different stages of plant growth as influenced by agrochemicals foliar spray under different spacing is presented in Table 12. In general, leaf area index increased up to 125 DAS and decreased thereafter. At 75 DAS, significantly higher leaf area index was recorded in 45 x 10 cm spacing(2.64) as compared to all other plant spacing i.e., 60 x 20 cm (1.15), 60 x 15 cm (1.49) 60 x 10 cm (2.10) and 45 x 15 cm spacing (1.60). Foliar spray of agrochemical and their interaction effect on leaf dry weight was non significant.

Similarly, at 100 and 125 DAS, leaf area index was significantly higher in 45 x 10 cm spacing (3.65 and 3.91) than all other plant spacing. Among the agrochemicals control with no spray(2.83 and 3.04) recorded significantly higher leaf area index as compared to (2.14 and 2.28) Mapiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS and (2.40 and 2.57) Mapiquat chloride 100 ppm sprayed at 90 DAS. The interaction effect for reproductive part dry weight was non significant.

At 150 DAS, significantly higher leaf area index was recorded in 45 x 10 cm spacing (0.97) as compared to all other plant spacing ie., 60 x 20 cm (0.44), 60 x 15 cm (0.57) 60 x 10 cm (0.77) and 45 x 15 cm spacing (0.57). Among the agrochemicals control with no spray (1.26) followed by (1.18) Mapiquat chloride 100 ppm sprayed at 90 DAS recorded significantly higher leaf area index as compared to (0.11) Mapiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS and (0.09) Ethrel 2000 ppm sprayed at 140 DAS. The interaction of plant spacing with agrochemicals spray was found significant. Wherein, Ethrel 2000 ppm sprayed at 140 DAS either alone or Mapiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS significantly reduced the leaf area index in all the treatment combination with plant spacing.

4.3.6 Specific leaf weight (SLW, mg/cm^2)

The data on specific leaf weight recorded at different plant growth stages as influenced by agrochemicals foliar spray under different spacing is presented in Table 13. At 75 DAS, no significant difference was observed for spacing, agrochemicals and also for their interaction.

At 100 DAS, specific leaf weight was significantly higher in 60 x 20 cm spacing (3.82 mg/cm^2) followed by 60 x 15 cm spacing (3.79 mg/cm^2)as compared to 45 x 10 cm spacing (3.50 mg/cm^2). Among the agrochemicals foliar spray of Mepiquat chloride 100 ppm sprayed at 90 DAS (3.86 mg/cm^2) followed by (3.75 mg/cm^2) Mapiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS recorded significantly higher specific leaf weight than Ethrel 2000 ppm sprayed at 140 DAS. The interaction effect of agrochemicals foliar spray with different plant spacing on specific leaf weight was non significant.

At 125 DAS, influence of plant spacing on specific leaf weight was non significant and among the agrochemical foliar spray, Mepiquat chloride 100 ppm sprayed at 90 DAS (5.21 mg/cm^2) followed by (5.11 mg/cm^2) Mepiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS recorded significantly higher specific leaf weight than Ethrel 2000 ppm sprayed at 140 DAS. However, no significant difference was noticed for agrochemicals foliar spray and plant spacing. At 150 DAS, no significant difference for specific leaf weight was observed for spacing, agrochemicals and also for their interaction.

4.3.7 Leaf area duration (LAD, days)

The data on leaf area duration recorded at different plant growth stages as influenced by agrochemicals foliar spray under different spacing is presented in Table 14. In general, leaf area duration increased from 75-100 DAS to 100-125 DAS and decreased thereafter at 125-150 DAS.

At 75-100 DAS, significantly higher leaf area duration was recorded in 45 x 10 cm spacing (78.6 days) as compared to all other plant spacing i.e., 60 x 20 cm (34.2 days), 60 x 15 cm (44.4

Table 12: Influence of plant population and agrochemicals on leaf area index (LAI) at different stages in compact cotton

Treatments	Days after sowing							
	75		100		125		150	
Main treatment (P = Plant population)								
P1-83,333 (60 x 20)	1.15		1.59		1.71		0.44	
P2- 1,11,111 (60 x 15)	1.49		2.06		2.23		0.57	
P3-1,66,666 (60 x 10)	2.10		2.91		3.12		0.77	
P4-1,48,148 (45 x 15)	1.60		2.22		2.36		0.56	
P5-2,22,222 (45 x 10)	2.64		3.65		3.91		0.97	
Sub treatment (S = Agrochemicals)								
S1-Control	1.82		2.83		3.04		1.26	
S2- MC 100 ppm (90 DAS)	1.84		2.40		2.57		1.18	
S3- MC 100 ppm (90DAS) + Ethrel 2000 ppm (140 DAS)	1.80		2.14		2.28		0.11	
S4- Ethrel 2000 ppm (140 DAS)	1.72		2.58		2.78		0.09	
Interaction (P x S)								
P1S1	1.15		1.77		1.91		0.83	
P1S2	1.14		1.50		1.61		0.79	
P1S3	1.15		1.39		1.47		0.08	
P1S4	1.14		1.69		1.84		0.07	
P2S1	1.51		2.32		2.53		1.09	
P2S2	1.59		2.09		2.27		1.00	
P2S3	1.41		1.68		1.80		0.10	
P2S4	1.45		2.16		2.34		0.09	
P3S1	2.08		3.22		3.47		1.46	
P3S2	2.26		2.96		3.18		1.38	
P3S3	2.02		2.40		2.52		0.13	
P3S4	2.05		3.07		3.30		0.11	
P4S1	2.76		4.28		4.60		1.86	
P4S2	2.64		3.42		3.65		1.75	
P4S3	2.77		3.29		3.54		0.15	
P4S4	2.39		3.62		3.88		0.13	
P5S1	1.62		2.56		2.72		1.08	
P5S2	1.57		2.02		2.14		1.00	
P5S3	1.66		1.93		2.05		0.09	
P5S4	1.57		2.37		2.54		0.07	
Grand mean	**1.80**		**2.49**		**2.67**		**0.66**	
For comparing means of	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**
Plant population (P)	0.04	0.14	0.06	0.19	0.06	0.21	0.03	0.09
Agrochemicals (S)	0.07	NS	0.10	0.30	0.11	0.32	0.03	0.10
P x S at same S	0.17	NS	0.23	NS	0.25	NS	0.08	0.22
P x S at same or different S	0.15	NS	0.21	NS	0.22	NS	0.07	0.20

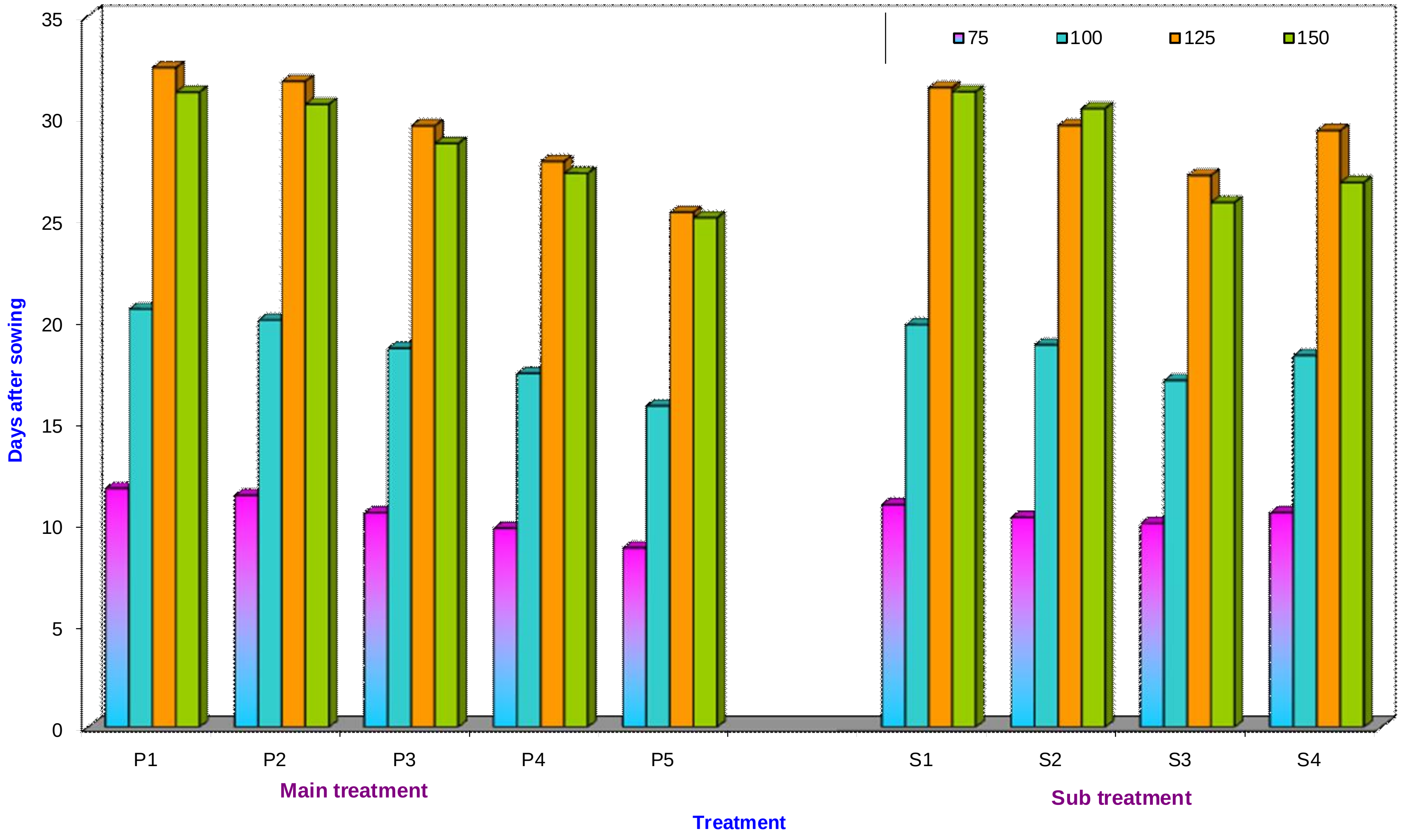

Fig. 4: Influence of plant population and agrochemicals on total dry weight (g/plant) at different stages in compact cotton

Table 13: Influence of plant population and agrochemicals on specific leaf weight (SLW, mg /cm^2) at different stages in compact cotton

Treatments	Days after sowing							
	75		100		125		150	
Main treatment (P = Plant population)								
P1-83,333 (60 x 20)	3.46		3.82		5.18		4.20	
P2- 1,11,111 (60 x 15)	3.43		3.79		5.13		4.18	
P3-1,66,666 (60 x 10)	3.34		3.69		5.04		4.12	
P4-1,48,148 (45 x 15)	3.27		3.60		4.95		4.07	
P5-2,22,222 (45 x 10)	3.18		3.50		4.83		4.00	
Sub treatment (S = Agrochemicals)								
S1-Control	3.50		3.63		4.99		4.08	
S2- MC 100 ppm (90 DAS)	3.29		3.86		5.21		4.23	
S3- MC 100 ppm (90DAS) + Ethrel 2000 ppm (140 DAS)	3.15		3.75		5.11		4.15	
S4- Ethrel 2000 ppm (140 DAS)	3.40		3.48		4.81		3.99	
Interaction (P x S)								
P1S1	3.60		3.73		5.12		4.14	
P1S2	3.38		3.98		5.30		4.31	
P1S3	3.29		3.93		5.27		4.26	
P1S4	3.56		3.63		5.01		4.08	
P2S1	3.59		3.80		5.17		4.19	
P2S2	3.44		3.97		5.29		4.29	
P2S3	3.17		3.90		5.25		4.24	
P2S4	3.53		3.49		4.83		4.01	
P3S1	3.50		3.70		5.09		4.11	
P3S2	3.35		3.87		5.21		4.23	
P3S3	3.11		3.76		5.14		4.17	
P3S4	3.41		3.43		4.73		3.97	
P4S1	3.47		3.53		4.87		4.03	
P4S2	3.20		3.83		5.18		4.21	
P4S3	3.14		3.59		4.97		4.06	
P4S4	3.26		3.46		4.78		3.98	
P5S1	3.32		3.39		4.69		3.95	
P5S2	3.08		3.66		5.06		4.09	
P5S3	3.07		3.56		4.92		4.04	
P5S4	3.23		3.38		4.67		3.91	
Grand mean	**3.34**		**3.68**		**5.03**		**4.11**	
For comparing means of	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**
Plant population (P)	0.08	NS	0.06	0.19	0.08	NS	0.06	NS
Agrochemicals (S)	0.15	NS	0.06	0.18	0.08	0.24	0.07	NS
P x S at same S	0.33	NS	0.14	NS	0.19	NS	0.15	NS
P x S at same or different S	0.30	NS	0.13	NS	0.18	NS	0.15	NS

days) 60 x 10 cm (62.7 days) and 45 x 15 cm spacing (47.8 days). Among the agrochemical foliar spray, leaf area duration was significantly higher (58.1 days) in control with no spray recorded than (49.3 days) Mapiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS.

At 100-125 DAS, significantly higher and lower leaf area duration was noticed in 45 x 10 cm spacing (94.6 days) and 60 x 20 cm spacing (41.2 days) respectively as compared to all other plant spacing. Among the agrochemical foliar spray, leaf area duration was significantly higher in control with no spray (73.4 days) recorded than Mapiquat chloride 100 ppm sprayed at 90 DAS (62.0 days) and Mapiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS (55.2 days). Similar trend was observed at 125-150 DAS and in all the three stages of crop growth the interaction effect of agrochemicals foliar spray with plant spacing on leaf area duration was non significant.

4.3.8 Absolute growth rate (AGR, g/day)

The data on absolute growth rate recorded at different plant growth stages as influenced by agrochemicals foliar spray under different spacing is presented in Table 15.

At 75-100 DAS, higher absolute growth rate was recorded in 60 x 20 cm (0.354 g/day) followed by 60 x 15 cm spacing (0.345 g/day) and were significantly higher than 45 x 15 cm (0.305 g/day) and 45 x 10 cm spacing (0.280 g/day). The foliar spray of agrochemical and also the interaction effect was non significant.

At 100-125 DAS, absolute growth rate was significantly higher in 60 x 20 cm (0.475g/day) and 60 x 15 cm spacing (0.470 g/day) as compared to 45 x 10 cm (0.417 g/day) and 45 x 10 cm spacing (0.381). Among the agrochemical foliar spray, control with no spray recorded significantly higher (0.467 g/day) absolute growth rate than Mapiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS (0.403 g/day). While, Mapiquat chloride 100 ppm sprayed at 90 DAS (0.432 g/day) was on par with control. However, the interaction effect was non significant.

4.3.8 Crop growth rate (CGR, $g/m^2/day$)

The data on crop growth rate recorded at different plant growth stages as influenced by agrochemicals foliar spray under different spacing is presented in Table 15. At 75-100 DAS, 45 x 10 cm (6.77 $g/m^2/day$) and 60 x 20 cm spacing (2.95 $g/m^2/day$) recorded significantly higher and lower crop growth rate as compared to all other spacing. Among the agrochemical foliar spray, control with no spray (5.10 $g/m^2/day$) recorded significantly higher crop growth rate than Mepiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS (4.02 $g/m^2/day$). While, Mapiquat chloride 100 ppm sprayed at 90 DAS (4.88 $g/m^2/day$) and Ethrel 2000 ppm sprayed at 140 DAS (4.47 $g/m^2/day$) were on par with control. Similar trend was recorded at 100-125 DAS for both plant spacing and agrochemical foliar spray. The interaction effect at both 75-100 and 100-125 DAS was non significant.

4.3.9 Relative growth rate (RGR, g/g/day)

The data on relative growth rate recorded at different plant growth stages as influenced by agrochemicals foliar spray under different spacing is presented in Table 16. At 75-100 DAS, relative growth rate was higher in 45 x 10 cm spacing (0.0363 g/g/day) was significantly higher than all other spacing. Among the agrochemical foliar spray, Mepiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS recorded significantly higher (0.0330 g/g/day) relative growth rate than (0.0293 g/g/day) control with no spray. While, Mepiquat chloride 100 ppm sprayed at 90 DAS (0.0312 g/g/day) was on par with each other. The interaction effect was non significant.

Similarly, at 100-125 DAS, 45 x 10 cm spacing (0.0216 g/g/day) was significantly higher than all other spacing and among the agrochemical foliar spray also same trend was followed as that of 75-100 DAS. The effect of plant spacing and foliar spray interaction was non significant.

4.3.10 Net assimilation rate (NAR, g/dm^2leaf area/day)

The data on net assimilation rate recorded at different plant growth stages as influenced by agrochemicals foliar spray under different spacing is presented in Table 16.

Both at 75-100 and 100-125 DAS, the data recorded on net assimilation rate was non significant for spacing, agrochemicals and also for their interaction. However, higher (0.095 and 0.108) and lower (0.094 and 0.105) net assimilation rate values were recorded in 45 x 10 cm and 60 x

Table 14: Influence of plant population and agrochemicals on leaf area duration (LAD, days) at different stages in compact cotton

Treatments	Days after sowing					
	75-100		100-125		125-150	
Main treatment (P = Plant population)						
P1-83,333 (60 x 20)	34.2		41.2		26.9	
P2- 1,11,111 (60 x 15)	44.4		53.7		35.0	
P3-1,66,666 (60 x 10)	62.7		75.4		48.6	
P4-1,48,148 (45 x 15)	47.8		57.3		36.5	
P5-2,22,222 (45 x 10)	78.6		94.6		61.1	
Sub treatment (S = Agrochemicals)						
S1-Control	58.1		73.4		53.9	
S2- MC 100 ppm (90 DAS)	53.0		62.0		46.9	
S3- MC 100 ppm (90DAS) + Ethrel 2000 ppm (140 DAS)	49.3		55.2		29.8	
S4- Ethrel 2000 ppm (140 DAS)	53.8		67.0		35.9	
Interaction (P x S)						
P1S1	36.5		46.0		34.3	
P1S2	33.0		38.8		30.0	
P1S3	31.8		35.8		19.4	
P1S4	35.4		44.1		23.8	
P2S1	47.8		60.6		45.2	
P2S2	46.0		54.4		40.9	
P2S3	38.7		43.6		23.7	
P2S4	45.2		56.3		30.4	
P3S1	66.2		83.6		61.6	
P3S2	65.3		76.7		56.9	
P3S3	55.3		61.5		33.2	
P3S4	64.0		79.7		42.6	
P4S1	88.0		110.9		80.7	
P4S2	75.7		88.3		67.4	
P4S3	75.8		85.4		46.1	
P4S4	75.1		93.6		50.1	
P5S1	52.2		65.9		47.5	
P5S2	44.9		52.0		39.2	
P5S3	44.9		49.7		26.6	
P5S4	49.3		61.5		32.6	
Grand mean	**53.5**		**64.4**		**41.6**	
For comparing means of	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**
Plant population (P)	1.3	4.2	1.5	5.0	0.9	3.0
Agrochemicals (S)	2.2	NS	2.7	7.7	1.7	5.0
P x S at same S	4.9	NS	5.9	NS	3.9	NS
P x S at same or different S	4.5	NS	5.4	NS	3.5	NS

Table 15: Influence of plant population and agrochemicals on absolute growth rate (AGR, g/day) and crop growth rate (CGR, g/m2/day) at different stages in compact cotton

Treatments	Absolute growth rate (AGR, g/day)				Crop growth rate (CGR, g/m2/day)			
	75-100		100-125		75-100		100-125	
Main treatment (P = Plant population)								
P1-83,333 (60 x 20)	0.354		0.475		2.95		3.96	
P2- 1,11,111 (60 x 15)	0.345		0.470		3.83		5.22	
P3-1,66,666 (60 x 10)	0.324		0.438		5.40		7.30	
P4-1,48,148 (45 x 15)	0.305		0.417		4.15		5.65	
P5-2,22,222 (45 x 10)	0.280		0.381		6.78		9.27	
Sub treatment (S = Agrochemicals)								
S1-Control	0.354		0.467		5.10		6.72	
S2- MC 100 ppm (90 DAS)	0.340		0.432		4.88		6.21	
S3- MC 100 ppm (90DAS) + Ethrel 2000 ppm (140 DAS)	0.282		0.403		4.02		5.86	
S4- Ethrel 2000 ppm (140 DAS)	0.309		0.443		4.47		6.33	
Interaction (P x S)								
P1S1	0.381		0.510		3.17		4.25	
P1S2	0.370		0.458		3.09		3.82	
P1S3	0.322		0.433		2.69		3.61	
P1S4	0.341		0.500		2.84		4.16	
P2S1	0.385		0.505		4.28		5.61	
P2S2	0.371		0.480		4.13		5.34	
P2S3	0.307		0.419		3.41		4.65	
P2S4	0.316		0.476		3.51		5.29	
P3S1	0.360		0.465		6.00		7.75	
P3S2	0.348		0.449		5.79		7.48	
P3S3	0.281		0.393		4.69		6.55	
P3S4	0.306		0.445		5.10		7.42	
P4S1	0.336		0.453		7.47		10.07	
P4S2	0.321		0.400		7.14		8.89	
P4S3	0.262		0.410		5.81		9.12	
P4S4	0.300		0.405		6.67		9.01	
P5S1	0.309		0.401		4.58		5.94	
P5S2	0.287		0.372		4.26		5.51	
P5S3	0.237		0.363		3.51		5.37	
P5S4	0.285		0.389		4.22		5.77	
Grand mean	**0.321**		**0.436**		**4.62**		**6.28**	
For comparing means of	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**
Plant population (P)	0.008	0.025	0.013	0.041	0.12	0.38	0.22	0.73
Agrochemicals (S)	0.015	NS	0.014	0.039	0.20	0.57	0.19	0.56
P x S at same S	0.033	NS	0.030	NS	0.44	NS	0.43	NS
P x S at same or different S	0.029	NS	0.029	NS	0.40	NS	0.43	NS

Table 16: Influence of plant population and agrochemicals on relative growth rate (RGR, g/g/plant) and net assimilation rate (NAR, g/dm^2/day) at different stages in compact cotton

Treatments	Relative growth rate (RGR, g/g/plant)		Net assimilation rate (NAR, g/dm^2/day)	
	75-100	**100-125**	**75-100**	**100-125**
Main treatment (P = Plant population)				
P1-83,333 (60 x 20)	0.0276	0.0167	0.094	0.105
P2- 1,11,111 (60 x 15)	0.0285	0.0171	0.095	0.106
P3-1,66,666 (60 x 10)	0.0307	0.0184	0.094	0.106
P4-1,48,148 (45 x 15)	0.0329	0.0196	0.095	0.107
P5-2,22,222 (45 x 10)	0.0363	0.0216	0.095	0.108
Sub treatment (S = Agrochemicals)				
S1-Control	0.0293	0.0174	0.097	0.100
S2- MC 100 ppm (90 DAS)	0.0312	0.0185	0.101	0.109
S3- MC 100 ppm (90DAS) + Ethrel 2000 ppm (140 DAS)	0.0330	0.0201	0.090	0.115
S4- Ethrel 2000 ppm (140 DAS)	0.0312	0.0187	0.091	0.102
Interaction (P x S)				
P1S1	0.0263	0.0157	0.096	0.100
P1S2	0.0282	0.0168	0.102	0.107
P1S3	0.0289	0.0178	0.092	0.109
P1S4	0.0270	0.0164	0.088	0.102
P2S1	0.0268	0.0159	0.099	0.101
P2S2	0.0271	0.0163	0.098	0.107
P2S3	0.0316	0.0191	0.096	0.116
P2S4	0.0284	0.0173	0.085	0.102
P3S1	0.0293	0.0173	0.100	0.101
P3S2	0.0291	0.0175	0.097	0.106
P3S3	0.0337	0.0204	0.092	0.116
P3S4	0.0305	0.0185	0.088	0.101
P4S1	0.0300	0.0179	0.094	0.099
P4S2	0.0336	0.0198	0.103	0.109
P4S3	0.0335	0.0205	0.084	0.116
P4S4	0.0345	0.0203	0.098	0.105
P5S1	0.0342	0.0201	0.097	0.098
P5S2	0.0379	0.0221	0.103	0.115
P5S3	0.0375	0.0229	0.085	0.117
P5S4	0.0357	0.0211	0.094	0.102
Grand mean	**0.0312**	**0.0187**	**0.095**	**0.106**

For comparing means of	SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%
Plant population (P)	0.0010	0.0032	0.0006	0.0019	0.003	NS	0.003	NS
Agrochemicals (S)	0.0009	0.0027	0.0006	0.0016	0.004	0.013	0.005	NS
P x S at same S	0.0021	NS	0.0013	NS	0.010	NS	0.011	NS
P x S at same or different S	0.0021	NS	0.0012	NS	0.009	NS	0.010	NS

20 cm spacing respectively in both the stages. Among agrochemicals, at 75-100 and at 100-125 DAS higher (0.101 and 0.109) net assimilation rate was recorded in Mepiquat chloride 100 ppm sprayed at 90 DAS and Mepiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS (0.090 and 0.115) respectively and lower in Mepiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS and in control respectively.

4.4 Biophysical Parameters

4.4.1 Rate of photosynthesis (µ mol of CO_2/m^2/sec)

The data on rate of photosynthesis recorded at different growth stages as influenced by foliar spray of agrochemicals under different plant spacing is presented in Table 17. In general, rate of photosynthesis increased from 75 to 100 DAS and decreased thereafter in125 and 150 DAS. Rate of photosynthesis differed significantly in all growth stages (i.e., at 75, 100, 125 and 150 DAS) under different plant spacing except at 100 DAS and in foliar spray of agrochemicals except at 75 DAS. The interaction effects of agrochemicals foliar spray and different plant spacing was not significant in all the stages except at 150 DAS.

At 75 DAS, rate of photosynthesis was significantly higher (21.70) in 60 x 20 cm spacing as compared to 45 x 15 cm and 45 x 10 cm spacing (20.58 and 20.82 respectively). Among the foliar spray of agrochemicals, higher (21.40) and lower (20.98) rate of photosynthesis was recorded in Mepiquat chloride 100 ppm sprayed at 90 DAS and in Ethrel 2000 ppm sprayed at 140 DAS respectively.

At 100 DAS, rate of photosynthesis was more in 60 x 20 cm spacing followed by 60 x 15 cm spacing while it was less in 45 x 10 cm spacing. Among the foliar spray of agrochemicals Mepiquat chloride 100 ppm sprayed at 90 DAS (26.59) recorded significantly higher rate of photosynthesis as compared to control with no spray (25.89) and Ethrel 2000 ppm sprayed at 140 DAS (25.51). The interaction effects between foliar spray of agrochemicals with different plant spacing was not significant.

At 125 DAS, rate of photosynthesis was significantly higher (24.16) in 60 x 20 cm spacing followed by (24.13) 60 x 15 cm spacing as compared to (22.84) 45 x 10 cm spacing. Among the agrochemicals foliar spray of Mapiquat chloride 100 ppm sprayed at 90 DAS (24.34) followed by Mapiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS (24.05) recorded significantly higher rate of photosynthesis than Ethrel 2000 ppm sprayed at 140 DAS (22.82). The interaction effect of agrochemicals foliar spray with different plant spacing on specific leaf weight was non significant.

4.4.2 Stomatal conductance (µ mol /m^2/sec)

The data on stomatal conductance recorded at different growth stages as influenced by foliar spray of agrochemicals under different plant spacing is presented in Table 18. At 75 DAS, stomatal conductance was significantly higher (0.545) in 60 x 20 cm followed by (0.534) 60 x 15 cm and (0.517) 60 x 10 cm spacing as compared to (0.466) 45 x 10 cm spacing. The difference on stomatal conductance for agrochemicals foliar spray and also the interaction effect was non significant.

At 100 DAS, stomatal conductance was significantly higher in 60 x 20 cm spacing (0.540) followed by 60 x 15 cm spacing (0.526) as compared to 45 x 15 cm spacing (0.490) and 45 x 10 cm spacing (0.473). Among the foliar spray of agrochemicals Mapiquat chloride 100 ppm sprayed at 90 DAS (0.547) recorded significantly higher stomatal conductance as compared to control with no spray (0.494) and Ethrel 2000 ppm sprayed at 140 DAS (0.466). The interaction effect on stomatal conductance was non significant.

At 125 DAS, 60 x 20 cm spacing (0.463) followed by 60 x 15 cm spacing (0.450) recorded significantly higher stomatal conductance as compare to 45 x 15 cm (0.359) and 45 x 10 cm (0.302) spacing. Among the agrochemicals, Mapiquat chloride 100 ppm sprayed at 90 DAS (0.488) recorded significantly higher stomatal conductance as compared to Ethrel 2000 ppm sprayed at 140 DAS (0.300). In both the stages, the interaction effect on stomatal conductance for plant spacing and agrochemicals foliar spray was significant.

4.4.3 Rate of transpiration (m mol of H_2O /m^2/sec)

The data on rate of transpiration recorded at different growth stages as influenced by foliar spray of agrochemicals under different plant spacing is presented in Table 19. At 75 DAS, significantly

Table 17: Influence of plant population and agrochemicals on rate of photosynthesis (μmol/m²/sec) at different stages in compact cotton

Treatments	Days after sowing					
	75		100		125	
Main treatment (P = Plant population)						
P1-83,333 (60 x 20)	21.70		26.56		24.16	
P2- 1,11,111 (60 x 15)	21.56		26.23		24.13	
P3-1,66,666 (60 x 10)	21.14		25.97		23.76	
P4-1,48,148 (45 x 15)	20.82		25.87		23.52	
P5-2,22,222 (45 x 10)	20.58		25.49		22.84	
Sub treatment (S = Agrochemicals)						
S1-Control	21.08		25.89		23.52	
S2- MC 100 ppm (90 DAS)	21.40		26.59		24.34	
S3- MC 100 ppm (90DAS) + Ethrel 2000 ppm (140 DAS)	21.17		26.12		24.05	
S4- Ethrel 2000 ppm (140 DAS)	20.98		25.51		22.82	
Interaction (P x S)						
P1S1	21.31		26.10		23.89	
P1S2	22.36		27.81		24.65	
P1S3	22.24		26.46		24.46	
P1S4	20.88		25.89		23.64	
P2S1	21.43		26.26		24.35	
P2S2	22.24		26.60		24.61	
P2S3	22.04		26.38		24.41	
P2S4	20.53		25.70		23.14	
P3S1	21.27		25.99		23.88	
P3S2	21.53		26.36		24.40	
P3S3	21.32		26.17		24.19	
P3S4	20.42		25.38		22.56	
P4S1	20.58		25.79		23.16	
P4S2	21.43		26.28		24.39	
P4S3	20.82		25.81		23.62	
P4S4	20.43		25.61		22.94	
P5S1	20.28		25.31		22.31	
P5S2	21.07		25.89		23.67	
P5S3	20.78		25.79		23.58	
P5S4	20.21		24.98		21.81	
Grand mean	**21.16**		**26.03**		**23.68**	
For comparing means of	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**
Plant population (P)	0.20	0.64	0.25	NS	0.23	0.74
Agrochemicals (S)	0.20	NS	0.24	0.69	0.22	0.63
P x S at same S	0.44	NS	0.54	NS	0.49	NS
P x S at same or different S	0.43	NS	0.53	NS	0.48	NS

Table 18: Influence of plant population and agrochemicals on stomatal conductance (µmol/m^2/sec) at different stages in compact cotton

Treatments	Days after sowing					
	75		100		125	
Main treatment (P = Plant population)						
P1-83,333 (60 x 20)	0.545		0.540		0.463	
P2- 1,11,111 (60 x 15)	0.534		0.526		0.450	
P3-1,66,666 (60 x 10)	0.517		0.509		0.397	
P4-1,48,148 (45 x 15)	0.507		0.490		0.359	
P5-2,22,222 (45 x 10)	0.466		0.473		0.302	
Sub treatment (S = Agrochemicals)						
S1-Control	0.502		0.494		0.375	
S2- MC 100 ppm (90 DAS)	0.530		0.547		0.488	
S3- MC 100 ppm (90DAS) + Ethrel 2000 ppm (140 DAS)	0.526		0.524		0.414	
S4- Ethrel 2000 ppm (140 DAS)	0.498		0.466		0.300	
Interaction (P x S)						
P1S1	0.517		0.514		0.424	
P1S2	0.598		0.580		0.590	
P1S3	0.561		0.556		0.495	
P1S4	0.502		0.508		0.344	
P2S1	0.524		0.526		0.459	
P2S2	0.572		0.560		0.540	
P2S3	0.545		0.554		0.485	
P2S4	0.493		0.464		0.318	
P3S1	0.517		0.513		0.388	
P3S2	0.544		0.551		0.476	
P3S3	0.519		0.515		0.427	
P3S4	0.490		0.457		0.298	
P4S1	0.496		0.469		0.325	
P4S2	0.540		0.533		0.467	
P4S3	0.500		0.499		0.334	
P4S4	0.492		0.460		0.308	
P5S1	0.459		0.447		0.278	
P5S2	0.503		0.510		0.368	
P5S3	0.498		0.495		0.327	
P5S4	0.406		0.439		0.234	
Grand mean	**21.16**		**26.03**		**23.68**	
For comparing means of	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**
Plant population (P)	0.010	0.034	0.012	0.037	0.008	0.026
Agrochemicals (S)	0.011	NS	0.013	0.040	0.009	0.025
P x S at same S	0.024	NS	0.028	NS	0.019	0.056
P x S at same or different S	0.023	NS	0.027	NS	0.019	0.053

Table 19: Influence of plant population and agrochemicals on rate of transpiration (m mol/m²/sec) at different stages in compact cotton

Treatments	Days after sowing					
	75		100		125	
Main treatment (P = Plant population)						
P1-83,333 (60 x 20)	4.752		4.140		3.841	
P2- 1,11,111 (60 x 15)	4.949		4.233		3.871	
P3-1,66,666 (60 x 10)	5.120		4.693		4.700	
P4-1,48,148 (45 x 15)	5.197		4.927		4.974	
P5-2,22,222 (45 x 10)	5.393		5.154		5.635	
Sub treatment (S = Agrochemicals)						
S1-Control	5.190		4.893		5.195	
S2- MC 100 ppm (90 DAS)	4.938		4.022		3.336	
S3- MC 100 ppm (90DAS) + Ethrel 2000 ppm (140 DAS)	4.985		4.427		4.232	
S4- Ethrel 2000 ppm (140 DAS)	5.215		5.175		5.655	
Interaction (P x S)						
P1S1	5.016		4.760		5.044	
P1S2	4.059		3.224		2.294	
P1S3	4.743		3.707		2.826	
P1S4	5.188		4.869		5.202	
P2S1	4.986		4.674		4.510	
P2S2	4.743		3.431		2.541	
P2S3	4.770		3.815		2.895	
P2S4	5.299		5.012		5.539	
P3S1	5.098		4.822		5.063	
P3S2	4.852		3.964		3.231	
P3S3	4.990		4.756		4.679	
P3S4	5.538		5.232		5.828	
P4S1	5.288		4.975		5.523	
P4S2	4.923		4.666		3.441	
P4S3	5.211		4.885		5.267	
P4S4	5.366		5.183		5.666	
P5S1	5.563		5.235		5.836	
P5S2	5.114		4.828		5.171	
P5S3	5.212		4.973		5.493	
P5S4	5.685		5.582		6.040	
Grand mean	**5.082**		**4.630**		**4.604**	
For comparing means of	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**
Plant population (P)	0.105	0.343	0.096	0.313	0.098	0.321
Agrochemicals (S)	0.104	NS	0.094	0.273	0.096	0.276
P x S at same S	0.232	NS	0.211	NS	0.214	0.617
P x S at same or different S	0.227	NS	0.206	NS	0.210	0.605

Table 20: Influence of plant population and agrochemicals on leaf temperature (^{0}C) at different stages in compact cotton

Treatments	Days after sowing					
	75		100		125	
Main treatment (P = Plant population)						
P1-83,333 (60 x 20)	27.1		29.0		29.6	
P2- 1,11,111 (60 x 15)	26.9		29.0		29.8	
P3-1,66,666 (60 x 10)	27.1		29.3		31.0	
P4-1,48,148 (45 x 15)	27.3		30.2		30.8	
P5-2,22,222 (45 x 10)	27.2		30.4		31.9	
Sub treatment (S = Agrochemicals)						
S1-Control	27.4		30.6		31.8	
S2- MC 100 ppm (90 DAS)	27.1		29.7		30.0	
S3- MC 100 ppm (90DAS) + Ethrel 2000 ppm (140 DAS)	26.9		28.4		29.3	
S4- Ethrel 2000 ppm (140 DAS)	27.1		29.6		31.5	
Interaction (P x S)						
P1S1	27.4		30.3		30.8	
P1S2	27.2		28.6		28.3	
P1S3	26.8		27.9		28.0	
P1S4	27.0		29.1		31.3	
P2S1	27.2		30.6		31.9	
P2S2	26.8		28.9		29.0	
P2S3	26.8		28.0		28.1	
P2S4	26.8		28.4		30.4	
P3S1	27.6		30.7		32.5	
P3S2	27.0		28.7		30.7	
P3S3	26.8		28.6		29.4	
P3S4	27.1		29.2		31.5	
P4S1	27.6		30.8		31.2	
P4S2	27.4		31.0		30.8	
P4S3	26.7		28.4		29.7	
P4S4	27.3		30.7		31.7	
P5S1	27.2		30.7		32.5	
P5S2	27.2		31.1		31.3	
P5S3	27.2		29.2		31.4	
P5S4	27.3		30.7		32.5	
Grand mean	**5.082**		**4.630**		**4.604**	
For comparing means of	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**
Plant population (P)	0.550	NS	0.607	NS	0.631	NS
Agrochemicals (S)	0.558	NS	0.606	NS	0.626	NS
P x S at same S	1.247	NS	1.356	NS	1.400	NS
P x S at same or different S	1.212	NS	1.322	NS	1.367	NS

higher rate of transpiration was observed in 45 x 10 cm (5.393) followed by 45 x 15 cm (5.197) spacing as compared to 60 x 20 cm (4.752) spacing. The difference on rate of transpiration for agrochemicals foliar spray and also the interaction effect was non significant.

At 100 DAS, 45 x 10 cm (5.154) followed by 45 x 15 cm (4.927) spacing recorded significantly higher rate transpiration as compared to 60 x 15 cm (4.233) and 60 x 20 cm (4.140) spacing. Among the foliar spray of agrochemicals Ethrel 2000 ppm sprayed at 140 DAS (5.175) recorded significantly higher rate of transpiration as compared to all other foliar spray. The interaction effect on rate of transpiration was non significant.

At 125 DAS, significantly higher and lower rate of transpiration was recorded in 45 x 10 cm and 60 x 20 cm spacing (5.635 and 3.841 respectively). Among the foliar spray of agrochemicals significantly higher and lower rate of transpiration was recorded in Ethrel 2000 ppm sprayed at 140 DAS (5.655) and Mapiquat chloride 100 ppm sprayed at 90 DAS (3.336) as compared to all other foliar spray. The interaction effect on rate of transpiration was significant.

4.4.4 Leaf temperature (°C)

The data on leaf temperature recorded at different plant growth stages as influenced by foliar spray of agrochemicals under different plant spacing is presented in Table 20. In general leaf temperature increased from 75 DAS to 125 DAS and decreased thereafter. At all the stages of crop growth (75, 100, 125 and 150 DAS) the data on leaf temperature was non significant for spacing, agrochemicals and also for their interaction.

Among the different spacing, 45 x 15 cm (27.3) at 75 DAS, 45 x 10 cm (30.4) and (31.9) at 100 and 125 DAS and among the agrochemicals, control with no spray (27.4), (30.6) and (31.8) at 75,100 and 125 DAS and Mepiquat chloride 100 ppm sprayed at 90 DAS recorded higher leaf temperature.

4.4.5 Light transmission rate (%)

The data on light transmission rate recorded at 100, 125 and 150 DAS as influenced by foliar spray of agrochemicals under different plant spacing is presented in Table 21a, 21b and 21c respectively. In general, the data on light transmission rate in all the stages was higher in the top of the canopy followed by middle and was least in bottom of the canopy. Light transmission rate differed significantly in middle and bottom of the canopy at 100, 125 and 150 DAS under different plant spacing and at 150 DAS in foliar spray of agrochemicals. However, in all the stages the light transmission data on top of the canopy was non significant for both spacing and foliar spray and the interaction effects of agrochemical foliar spray and different plant spacing was also not significant.

At 100 DAS, significantly higher light transmission rate in middle and bottom of the canopy was recorded in 60 x 20 cm spacing (73.87 and 67.85) followed by 60 x 15 cm spacing (73.74 and 67.49) as compared to 45 x 10 cm spacing (68.15 and 59.72). The difference on light transmission rate for agrochemicals foliar spray and also the interaction effect was non significant (Table 21a).

Same trend was observed at 125 DAS where in, 60 x 20 cm spacing (63.08 and 54.44) followed by 60 x 15 cm spacing (62.97 and 54.34) recorded significantly higher light transmission rate as compared to 45 x 10 cm spacing (57.47 and 50.33) in middle and bottom of the canopy respectively. While, the foliar spray and the interaction effect for light transmission rate was non significant (Table 21b).

At 150 DAS, among the plant spacing light transmission rate was significantly higher in 60 x 20 cm spacing (88.36 and 86.53) followed by 60 x 15 cm spacing (87.68 and 85.86) as compared to 45 x 10 cm spacing (82.75 and 80.92) and 45 x 15 cm spacing (82.79 and 81.05) and among the foliar spray of agrochemicals, Ethrel 2000 ppm sprayed at 140 DAS (88.26 and 86.38) followed by Mapiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS (86.25 and 84.42) recorded significantly higher light transmission rate as compared to control with no spray (82.14 and 80.40) in middle and bottom of the canopy respectively. The interaction effect for light transmission rate was non significant (Table 21c).

Table 21a: Influence of plant population and agrochemicals on light transmission rate (%) at 100 days in compact cotton

Treatments	100 DAS					
	Top		Middle		Bottom	
Main treatment (P = Plant population)						
P1-83,333 (60 x 20)	93.43		73.87		67.85	
P2- 1,11,111 (60 x 15)	93.26		73.74		67.49	
P3-1,66,666 (60 x 10)	92.96		70.50		63.07	
P4-1,48,148 (45 x 15)	92.09		71.81		63.89	
P5-2,22,222 (45 x 10)	92.52		68.15		59.72	
Sub treatment (S = Agrochemicals)						
S1-Control	93.62		72.22		65.39	
S2- MC 100 ppm (90 DAS)	93.12		71.47		64.23	
S3- MC 100 ppm (90DAS) + Ethrel 2000 ppm (140 DAS)	92.02		70.93		62.99	
S4- Ethrel 2000 ppm (140 DAS)	92.65		71.83		64.99	
Interaction (P x S)						
P1S1	94.05		74.36		68.30	
P1S2	93.85		73.66		67.66	
P1S3	92.64		73.24		67.28	
P1S4	93.16		74.20		68.16	
P2S1	93.92		74.26		68.20	
P2S2	93.69		73.84		67.82	
P2S3	92.06		72.79		65.90	
P2S4	93.39		74.07		68.04	
P3S1	93.61		71.01		63.98	
P3S2	93.26		70.63		63.63	
P3S3	91.86		69.63		60.93	
P3S4	93.12		70.73		63.72	
P4S1	93.53		68.95		60.92	
P4S2	92.48		67.83		59.38	
P4S3	91.96		67.71		58.41	
P4S4	92.12		68.12		60.16	
P5S1	93.01		72.53		65.54	
P5S2	92.33		71.42		62.69	
P5S3	91.59		71.29		62.45	
P5S4	91.44		72.00		64.86	
Grand mean	**92.85**		**73.41**		**67.00**	
For comparing means of	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**
Plant population (P)	1.88	NS	1.10	3.59	1.28	4.17
Agrochemicals (S)	1.91	NS	1.19	NS	1.34	NS
P x S at same S	4.28	NS	2.66	NS	2.99	NS
P x S at same or different S	4.16	NS	2.55	NS	2.89	NS

Table 21b: Influence of plant population and agrochemicals on light transmission rate (%) at 125 days in compact cotton

Treatments	125 DAS					
	Top		Middle		Bottom	
Main treatment (P = Plant population)						
P1-83,333 (60 x 20)	95.18		63.08		54.44	
P2- 1,11,111 (60 x 15)	95.02		62.97		54.34	
P3-1,66,666 (60 x 10)	94.71		59.77		52.00	
P4-1,48,148 (45 x 15)	93.82		60.56		51.64	
P5-2,22,222 (45 x 10)	94.26		57.47		50.33	
Sub treatment (S = Agrochemicals)						
S1-Control	95.38		61.31		53.15	
S2- MC 100 ppm (90 DAS)	94.87		60.67		52.42	
S3- MC 100 ppm (90DAS) + Ethrel 2000 ppm (140 DAS)	93.76		60.12		51.77	
S4- Ethrel 2000 ppm (140 DAS)	94.39		60.97		52.86	
Interaction (P x S)						
P1S1	95.82		63.50		54.80	
P1S2	95.62		62.90		54.28	
P1S3	94.38		62.55		53.98	
P1S4	94.92		63.37		54.68	
P2S1	95.69		63.41		54.72	
P2S2	95.45		63.05		54.41	
P2S3	93.80		62.16		53.64	
P2S4	95.15		63.25		54.59	
P3S1	95.37		60.20		52.55	
P3S2	95.01		59.87		52.26	
P3S3	93.59		59.02		50.87	
P3S4	94.88		59.96		52.34	
P4S1	95.29		58.15		51.00	
P4S2	94.22		57.19		50.17	
P4S3	93.69		57.09		49.76	
P4S4	93.85		57.44		50.39	
P5S1	94.76		61.29		52.69	
P5S2	94.07		60.34		50.98	
P5S3	93.32		59.76		50.60	
P5S4	93.16		60.84		52.30	
Grand mean	**94.60**		**62.67**		**53.95**	
For comparing means of	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**
Plant population (P)	1.91	NS	0.93	3.03	0.80	2.62
Agrochemicals (S)	1.95	NS	1.01	NS	0.87	NS
P x S at same S	4.36	NS	2.26	NS	1.95	NS
P x S at same or different S	4.24	NS	2.17	NS	1.87	NS

Table 21c: Influence of plant population and agrochemicals on light transmission rate (%) at 150 days in compact cotton

Treatments	150 DAS					
	Top		Middle		Bottom	
Main treatment (P = Plant population)						
P1-83,333 (60 x 20)	94.04		88.36		86.53	
P2- 1,11,111 (60 x 15)	93.88		87.68		85.86	
P3-1,66,666 (60 x 10)	93.58		84.82		82.98	
P4-1,48,148 (45 x 15)	92.70		82.79		81.05	
P52,22,222 (45 x 10)	93.13		82.75		80.92	
Sub treatment (S = Agrochemicals)						
S1-Control	94.24		82.14		80.40	
S2- MC 100 ppm (90 DAS)	93.73		84.47		82.67	
S3- MC 100 ppm (90DAS) + Ethrel 2000 ppm (140 DAS)	92.63		86.25		84.42	
S4- Ethrel 2000 ppm (140 DAS)	93.26		88.26		86.38	
Interaction (P x S)						
P1S1	94.67		85.06		83.29	
P1S2	94.47		86.82		85.02	
P1S3	93.25		90.05		88.18	
P1S4	93.78		91.53		89.63	
P2S1	94.54		82.84		81.12	
P2S2	94.30		87.89		86.06	
P2S3	92.67		89.46		87.60	
P2S4	94.00		90.54		88.66	
P3S1	94.23		81.16		79.39	
P3S2	93.87		84.85		83.01	
P3S3	92.47		85.83		83.97	
P3S4	93.74		87.46		85.56	
P4S1	94.14		80.74		78.96	
P4S2	93.09		81.31		79.51	
P4S3	92.57		82.49		80.66	
P4S4	92.72		86.45		84.54	
P5S1	93.62		80.93		79.23	
P5S2	92.94		81.49		79.77	
P5S3	92.20		83.42		81.66	
P5S4	92.04		85.32		83.52	
Grand mean	**93.47**		**86.08**		**81.45**	
For comparing means of	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**
Plant population (P)	1.89	NS	1.30	4.25	1.27	4.16
Agrochemicals (S)	1.93	NS	1.42	4.10	1.39	4.01
P x S at same S	4.31	NS	3.17	NS	3.10	NS
P x S at same or different S	4.18	NS	3.04	NS	2.97	NS

4.5 Biochemical parameters

4.5.1 SPAD value

The data on the SPAD value per plant recorded at different growth stages as influenced by foliar spray of agrochemicals under different plant spacing is presented in Table 22. In general SPAD value increased from 75 DAS to 125 DAS and decreased thereafter. At 75 DAS, except for spacing no significant difference was observed for agrochemicals and also for their interaction. Significantly higher SPAD value was recorded in 60 x 20 cm spacing (41.5) followed by 60 x 15 cm spacing (41.3) as compared to 45 x 15 cm spacing (37.9) and 45 x 10 cm spacing (35.4).

At 100 DAS, 60 x 20 cm spacing (44.1) followed by 60 x 15 cm spacing (43.9) recorded significantly higher SPAD value as compared to 45 x 15 cm spacing (39.8) and 45 x 10 cm spacing (38.2). Among the agrochemicals, Mepiquat chloride 100 ppm sprayed at 90 DAS (45.3) recorded significantly higher SPAD value as compared to Ethrel 2000 ppm sprayed at 140 DAS (37.5). The interaction effect for SPAD value was non significant.

Similarly at 125 DAS also, SPAD value was significantly higher in 60 x 20 cm spacing(47.2) followed by 60 x 15 cm(46.6) and 60 x 10 cm spacing(45.4) as compared to 45 x 10 cm spacing(42.9). Among the foliar spray of agrochemicals Mepiquat chloride 100 ppm sprayed at 90 DAS (47.6) recorded significantly higher SPAD value as compared to Ethrel 2000 ppm sprayed at 140 DAS (42.7) and control with no spray (44.6). The interaction effect for SPAD value was non significant.

At 140 and 145 DAS, 60 x 20 cm spacing (40.8 and 37.3) followed by 60 x 15 cm spacing (40.0 and 36.5) recorded significantly higher SPAD value as compared to 45 x 10 cm spacing (35.9 and 33.2). Among the agrochemicals, Mapiquat chloride 100 ppm sprayed at 90 DAS (41.3 and 37.6) and Mapiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS (39.7 and 36.1) recorded significantly higher SPAD value as compared to Ethrel 2000 ppm sprayed at 140 DAS (35.2 and 33.0). In both the stages, the interaction between plant spacing and foliar spray of agrochemicals was found non significant.

4.5.2 Water potential (-bars)

The data on water potential recorded at different growth stages as influenced by foliar spray of agrochemicals under different plant spacing is presented in Table 23. In general, water potential increased with the age of the crop from 75 to 150 DAS. Water potential differed significantly in all growth stages (ie., at 75, 100 ,125 and 150 DAS) under different plant spacing and except at 75 DAS in foliar spray of agrochemicals. However, the interaction effects of agrochemicals foliar spray and different plant spacing was not significant.

At 75 DAS, significantly higher water potential was recorded in 45 X 10 cm spacing (7.8) followed by 45 x 15 cm spacing (8.4) as compared to 60 x 15 cm spacing (9.4) and 60 x 10 cm spacing (9.5). The difference in water potential for agrochemicals foliar spray and also the interaction effect was non significant.

At 100 DAS, 60 x 20 cm spacing (13.0) followed by 45 X 10 cm spacing (10.8) recorded significantly higher water potential as compared to 60 X 15 cm spacing (12.7) and 60 X 10 cm spacing (13.0). Among the agrochemicals, control with no spray (13.2) recorded significantly lower water potential as compared to while, others are on par with control. The interaction effect for water potential was non significant.

At 125 and 150 DAS, water potential was non significant for plant spacing and among the foliar spray of agrochemicals, control with no spray (19.1 and 21.7) recorded significantly lesser water potential as compared to Mepiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS (16.7 and 18.3). The interaction effect for water potential was non significant.

4.6 Yield and yield components

The data on number of bolls, boll weight, yield and harvest index as influenced by foliar spray of agrochemicals under different plant spacing is presented in Table 24.

Table 22: Influence of plant population and agrochemicals on SPAD value at different stages in compact cotton

Treatments	Days after sowing									
	75		100		125		140		145	
Main treatment (P = Plant population)										
P1-83,333 (60 x 20)	41.5		44.1		47.2		40.8		37.3	
P2- 1,11,111 (60 x 15)	41.3		43.9		46.6		40.0		36.5	
P3-1,66,666 (60 x 10)	39.1		41.8		45.4		38.6		35.1	
P4-1,48,148 (45 x 15)	37.9		39.8		44.4		37.4		34.6	
P5-2,22,222 (45 x 10)	35.4		38.2		42.9		35.9		33.2	
Sub treatment (S = Agrochemicals)										
S1-Control	38.1		40.6		44.6		37.9		34.6	
S2- MC 100 ppm (90DAS)	42.3		45.3		47.6		41.3		37.6	
S3- MC 100 ppm (90DAS) + Ethrel 2000 ppm (140 DAS)	40.4		42.8		46.3		39.7		36.1	
S4- Ethrel 2000 ppm (140 DAS)	35.4		37.5		42.7		35.2		33.0	
Interaction (P x S)										
P1S1	39.7		42.6		45.8		39.6		35.4	
P1S2	44.3		47.5		49.6		43.3		40.8	
P1S3	43.5		46.5		48.6		42.0		38.1	
P1S4	38.3		39.9		44.7		38.4		34.7	
P2S1	41.3		44.2		46.5		40.1		36.5	
P2S2	44.1		47.2		48.9		42.6		38.2	
P2S3	43.4		46.3		47.8		41.4		37.9	
P2S4	36.4		37.7		43.1		35.7		33.4	
P3S1	39.6		41.7		45.7		39.5		35.0	
P3S2	42.5		45.8		47.4		41.2		37.2	
P3S3	40.4		43.0		46.2		39.8		35.7	
P3S4	34.0		36.8		42.1		34.1		32.5	
P4S1	36.8		38.2		43.5		37.0		33.7	
P4S2	41.8		44.4		46.7		40.2		37.0	
P4S3	37.5		39.2		44.6		38.0		34.5	
P4S4	35.6		37.3		42.8		34.4		33.2	
P5S1	33.2		36.4		41.5		33.5		32.4	
P5S2	38.8		41.5		45.2		39.3		34.9	
P5S3	37.2		38.8		44.2		37.5		34.1	
P5S4	32.5		35.9		40.8		33.2		31.3	
Grand mean	**39.0**		**41.5**		**45.3**		**38.5**		**35.3**	
For comparing means of	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**
Plant population (P)	1.0	3.1	1.0	3.3	0.7	2.3	0.8	2.5	0.7	2.3
Agrochemicals (S)	1.8	NS	1.9	5.4	0.8	2.2	0.8	2.3	0.7	2.1
P x S at same S	3.9	NS	4.2	NS	1.7	NS	1.8	NS	1.6	NS
P x S at same or different S	3.5	NS	3.8	NS	1.6	NS	1.7	NS	1.6	NS

Table 23: Influence of plant population and agrochemicals on water potential (- bars) at different stages in compact cotton

Treatments	Days after sowing							
	75		100		125		150	
Main treatment (P = Plant population)								
P1-83,333 (60 x 20)	9.5		13.0		18.9		20.9	
P2- 1,11,111 (60 x 15)	9.4		12.7		18.6		20.4	
P3-1,66,666 (60 x 10)	8.8		12.0		18.1		19.5	
P4-1,48,148 (45 x 15)	8.4		11.6		17.5		19.2	
P5-2,22,222 (45 x 10)	7.8		10.8		16.8		18.4	
Sub treatment (S = Agrochemicals)								
S1-Control	9.1		13.2		19.1		21.7	
S2- MC 100 ppm (90 DAS)	8.6		11.7		17.7		20.9	
S3- MC 100 ppm (90DAS) + Ethrel 2000 ppm (140 DAS)	8.4		10.7		16.7		18.3	
S4- Ethrel 2000 ppm (140 DAS)	9.0		12.5		18.4		17.9	
Interaction (P x S)								
P1S1	10.5		14.0		19.9		23.2	
P1S2	9.0		12.3		18.4		22.4	
P1S3	8.5		11.8		17.7		19.4	
P1S4	10.1		13.7		19.4		18.7	
P2S1	10.3		13.8		19.7		22.7	
P2S2	9.3		12.6		18.8		21.8	
P2S3	7.9		11.0		16.7		18.8	
P2S4	10.0		13.5		19.2		18.3	
P3S1	9.7		13.2		19.1		21.5	
P3S2	8.8		12.0		18.2		20.6	
P3S3	7.5		10.1		16.4		18.2	
P3S4	9.2		12.5		18.7		17.7	
P4S1	9.5		13.1		19.0		21.0	
P4S2	8.0		11.3		16.9		20.2	
P4S3	7.7		10.5		16.6		17.9	
P4S4	8.4		11.5		17.4		17.5	
P5S1	8.7		11.9		17.9		19.9	
P5S2	7.4		10.1		16.3		19.5	
P5S3	7.1		9.8		16.0		17.2	
P5S4	8.1		11.4		17.1		17.1	
Grand mean	**8.8**		**12.0**		**18.0**		**19.7**	
For comparing means of	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**
Plant population (P)	0.2	0.7	0.3	0.9	0.52	NS	0.59	NS
Agrochemicals (S)	0.4	NS	0.5	1.5	0.55	1.60	0.61	1.76
P x S at same S	0.9	NS	1.2	NS	1.24	NS	1.36	NS
P x S at same or different S	0.8	NS	1.1	NS	1.19	NS	1.32	NS

4.6.1 Number of bolls per plant

Among the spacing, significantly higher number of bolls per plant was recorded in 60 x 20 cm spacing (7.15) followed by 60 x 15 cm spacing (6.88) as compared to 60 x 10 cm (6.45), 45 x 15 cm (6.04) and 45 x 10 cm (6.00) spacing. In the foliar spray, significantly higher and lower number of bolls per plant was observed in Mepiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS (7.28) and Mapiquat chloride 100 ppm sprayed at 90 DAS (6.74). The interaction effect was non significant (Table 24).

4.6.2 Boll weight (g/boll)

Boll weight was significantly higher in 60 x 20 cm (2.98) followed by 60 x 15 cm (2.95) and 60 x 10 cm (2.87) spacing as compared to 45 x 10 cm (2.71) spacing. Among the foliar spray, Mepiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS recorded significantly higher boll weight (3.01) followed by Mepiquat chloride 100 ppm sprayed at 90 DAS (2.92) as compared to control with no spray (2.69). The interaction effect was non significant (Table 24).

4.6.3 Seed cotton yield (kg/ha)

The seed cotton yield differed significantly for plant spacing and foliar spray of agrochemicals. While, the interaction of spacing and foliar spray was non significant (Table 24). Among the spacing 60 x 20 cm (1326 kg/ha) followed by 60 x 15 cm (1311 kg/ha) spacing recorded significantly higher yield as compared to 45 x 10 cm (1184 kg/ha) spacing. Among the foliar spray, Mapiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS recorded significantly higher boll weight (1346 kg/ha) which was significantly higher than Mapiquat chloride 100 ppm sprayed at 90 DAS (1299 kg/ha), Ethrel 2000 ppm sprayed at 140 DAS (1234 kg/ha) and control with no spray (1178 kg/ha).

4.7 Fiber quality parameters

The data on fiber quality parameters viz., fiber length, fiber strength and micronair value as influenced by foliar spray of agrochemicals under different plant population is presented in Table 25.

4.7.1 Fiber length (mm)

Among the spacing higher fiber length (28.4) was recorded in 60 x 20 cm and 60 X15 cm spacing and was less in 45 x 10 cm spacing. In the foliar spray, higher (28.5) and lower (28.0) fiber length was recorded in Mepiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS and control with no spray.

4.7.2 Fiber strength (g/tex)

The higher fibre strength value (24.23) was recorded in 45 x 10 cm followed by (24.18) in 45 x 15 cm spacing and least (23.23) was observed in 60 x 20 cm spacing. Among the agrochemicals control with no spray recorded higher (24.0) fibre strength values as compared to Mepiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS (23.7).

4.7.3 Micronair value (μg $inch^{-1}$)

Similarly the higher micronair value (4.23) was recorded in a spacing of 45 x 10 cm and least (3.90) was recorded in 60 x 20 cm spacing and in the foliar spray of agrochemicals, higher value (4.20) was observed in control with no spray while lower micronair values was recorded (4.00) in both Mepiquat chloride 100 ppm sprayed at 90 DAS and Mepiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS treatment.

Table 24: Influence of plant population and agrochemicals on yield and yield components in compact cotton

Treatments	No. of bolls/plant		Boll wt. (g)		Yield (kg/ha)	
Main treatment (P = Plant population)						
P1-83,333 (60 x 20)	7.15		2.98		1326	
P2- 1,11,111 (60 x 15)	6.88		2.95		1311	
P3-1,66,666 (60 x 10)	6.45		2.87		1267	
P4-1,48,148 (45 x 15)	6.04		2.80		1234	
P5-2,22,222 (45 x 10)	6.00		2.71		1184	
Sub treatment (S = Agrochemicals)						
S1-Control	5.76		2.69		1178	
S2- MC 100 ppm (90 DAS)	6.74		2.92		1299	
S3- MC 100 ppm (90DAS) + Ethrel 2000 ppm (140 DAS)	7.28		3.01		1346	
S4- Ethrel 2000 ppm (140 DAS)	6.24		2.82		1234	
Interaction (P x S)						
P1S1	7.46		2.82		1240	
P1S2	6.74		3.07		1378	
P1S3	6.93		3.13		1429	
P1S4	7.47		2.90		1256	
P2S1	7.29		2.71		1179	
P2S2	5.95		3.04		1362	
P2S3	6.92		3.10		1395	
P2S4	7.35		2.96		1305	
P3S1	6.52		2.65		1162	
P3S2	5.56		2.93		1303	
P3S3	6.38		3.01		1353	
P3S4	7.35		2.87		1252	
P4S1	6.09		2.68		1177	
P4S2	5.27		2.79		1230	
P4S3	5.25		2.98		1313	
P4S4	7.29		2.73		1216	
P5S1	6.33		2.60		1132	
P5S2	5.26		2.76		1219	
P5S3	5.46		2.84		1243	
P5S4	6.92		2.63		1141	
Grand mean	**6.50**		**2.9**		**1264.3**	
For comparing means of	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**
Plant population (P)	0.11	0.34	0.04	0.14	27	89
Agrochemicals (S)	0.11	0.31	0.05	0.14	12	34
P x S at same S	0.24	NS	0.11	NS	27	NS
P x S at same or different S	0.23	NS	0.10	NS	36	NS

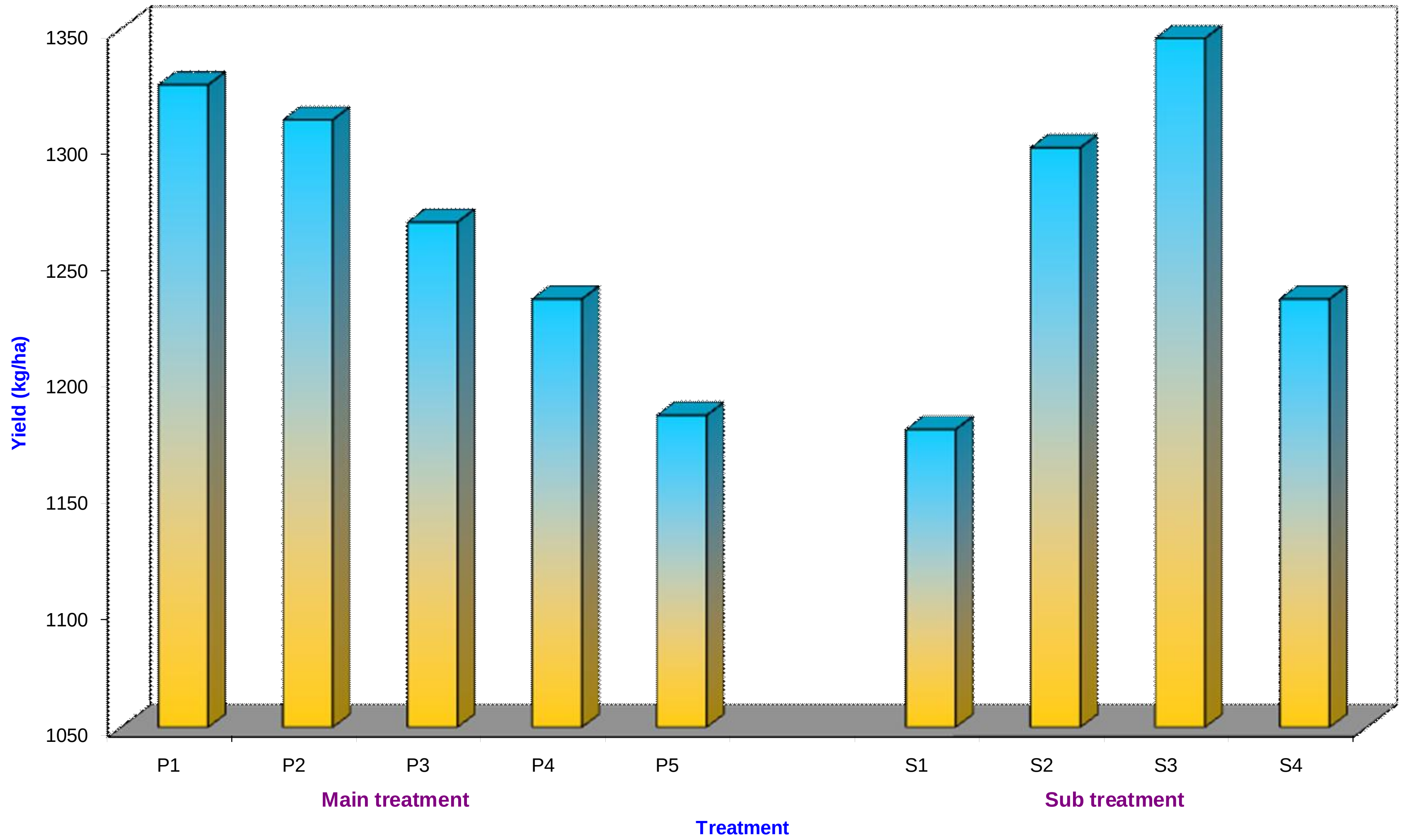

Fig. 5: Influence of plant population and agrochemicals on yield in compact cotton

60 X 20 cm

45 X 10 cm

Plate 5. Field view of compact cotton genotype at harvest

Table 25: Influence of plant population and agrochemicals on fiber quality parameters at different stages in compact cotton

Treatments	Days after sowing					
	Fibre length (mm)		Strength(g/tex)		Micronair value (µg inch-1)	
Main treatment (P = Plant population)						
P1-83,333 (60 x 20)	28.4		23.23		3.90	
P2- 1,11,111 (60 x 15)	28.4		23.43		4.03	
P3-1,66,666 (60 x 10)	28.2		24.15		4.08	
P4-1,48,148 (45 x 15)	28.1		24.18		4.15	
P5-2,22,222 (45 x 10)	28.0		24.23		4.23	
Sub treatment (S = Agrochemicals)						
S1-Control	28.0		24.0		4.2	
S2- MC 100 ppm (90 DAS)	28.2		23.8		4.0	
S3- MC 100 ppm (90DAS) + Ethrel 2000 ppm (140 DAS)	28.5		23.7		4.0	
S4- Ethrel 2000 ppm (140 DAS)	28.1		23.8		4.1	
Interaction (P x S)						
P1S1	28.2		21.7		4.1	
P1S2	28.6		23.3		3.7	
P1S3	28.2		24.2		3.8	
P1S4	28.4		23.7		4	
P2S1	28.2		24.2		4.1	
P2S2	27.8		21.8		3.8	
P2S3	29.1		23.1		4.1	
P2S4	28.3		24.6		4.1	
P3S1	28.3		25.2		3.9	
P3S2	27.4		25.5		4.2	
P3S3	29.3		23.7		4	
P3S4	27.7		22.2		4.2	
P4S1	28.2		24.8		4.2	
P4S2	28.5		23.4		4.1	
P4S3	27.8		23.8		4	
P4S4	28		24.7		4.3	
P5S1	27.3		24		4.6	
P5S2	28.6		25.2		4.3	
P5S3	28.1		23.9		4.1	
P5S4	28.1		23.8		3.9	
Grand mean	**28.2**		**23.8**		**4.1**	
For comparing means of	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**	**SEm±**	**CD at 5%**
Plant population (P)	0.56	NS	0.48	NS	0.08	NS
Agrochemicals (S)	0.58	NS	0.49	NS	0.08	NS
P x S at same S	1.30	NS	1.10	NS	0.19	NS
P x S at same or different S	1.26	NS	1.06	NS	0.18	NS

DISCUSSION

Cotton is a perennial plant with an indeterminate growth habit with both vegetative and reproductive growth occurring simultaneously. Vegetative growth is necessary to support reproductive growth however excessive vegetative growth can be detrimental. Under excessive vegetative growth, fruit abscission may increase and crop maturity may be delayed with reduced harvest.

Various techniques like high yielding varieties, maintaining suitable plant population, use of optimum dose of nutrition, growth regulators *etc.* are being used in enhancing commercial cotton productivity. Among various cultural practices, the spacing and plant population are crucial factors which influence the morphological traits and yield in cotton as in many other crops. When optimum level of plant population in cotton exceeds, yield reduction occurs due to excessive vegetative growth increased boll shedding and delayed maturity. While lower than the optimum level is also a major reason for low yield in cotton. The optimum level of plant population of cotton would however depend on the plant type, genotypes, soil moisture and management practices. Besides, spacing between the plants and within the rows has greater influence on the growth pattern. The earlier workers (Singh and Narayan, 1993) have suggested plant ideotype traits in cotton were earliness, few small thick leaves, compactness, indeterminate growth habit, spars hairs, synchronized bolling, high response to nutrients and pest resistance.

Cotton plants produce several natural growth regulators or plant hormones, which modify plant growth and divert energy allocation within the plant. Regulators are being applied to the foliage in an effort to maintain a balance between vegetative and reproductive growth. Most commonly used growth regulator in cotton is mepiquat chloride which decreases the vegetative growth by interfering in the biosynthetic path way of gibberellins. While, ethylene promotes senescence and abscission by promoting the synthesis of cell wall degrading cellulase and dehydrogenase enzymes results in synchronized boll opening and defoliation of leaves.

Very few experimental studies were carried out with compact cotton to determine the optimum plant spacing and use of growth regulators in altering the plant architecture and synchronized boll opening to facilitate mechanical harvesting. Keeping all these points, present study on effect of agrochemicals under different plant population and spacing in compact cotton (DSC-8) was undertaken and the results generated are discussed in this chapter.

5.1 Influence of agrochemicals on morphological parameters

Morphological characters such as plant height, number of leaves, leaf area, number of monopodial, sympodial branches and nodes per plant indicated significant differences due to varied plant spacing.

Plant height is an important morphological character in cotton which provides sites for nodes and internodes from where sympodial branches emerge, and thus play an important role in determining the morphological frame work relating to productivity (Patil, 1989). Significantly higher plant height (101.3 cm) was noticed in closer spacing of 45 x 10 cm with (2,22,222 plants/ha) followed by 45X 15 cm with (1,48,148 plants/ha) (100.0 cm). Higher plant height with closer spacing may be due to suppression of side growth leading to upward growth of plant. These results are in conformity with the findings of Yassen *et al.* (1990), Jain and Jain (1991) and Hussain *et al.* (2000) in cotton. Among the growth regulators, the application of mepiquat chloride 100 ppm sprayed at 90 DAS severely reduced all the morphological traits compared to control with no spray. Basically, plant height is a genetically controlled character, but, several studies have indicated that the plant height is either increased or decreased by the application of synthetic plant growth regulators. However, in the present investigation, significant differences in plant height were noticed due to the plant growth regulator treatments from 100 DAS to harvest. Application of mepiquat chloride 100 ppm sprayed at 90 DAS recorded the lowest plant height as compared to all other treatments and control. Application of mepiquat chloride decreased the plant height as compared to other treatments and this is similar to the results of Walter *et al.* (1980), Sawan and Sakr (1990), Reddy *et al.* (1996) and Brar *et al.* (2000). This mechanism of reduction in the cell elongation is because of inhibitory effect of mepiquat chloride in the biosynthetic pathway of gibberellins in the plant body (Reddy *et al.*, 1996).

Significantly more number of leaves per plant and leaf area were recorded in 60 x 20 cm spacing (80.8 and 2047.8 cm^2/plant) followed by 60 x 15 cm spacing (80.0 and 2010.3 cm^2/plant) at 125 DAS as compared to closer spacing of 45 x 10 cm (71.2 and 1593.5 cm^2/plant). This may be attributed to the fact that growth and development of leaves was suppressed by closer spacing with higher plant population. Further, area occupied by each plant was less in closer than wider spacing. Similar findings of suppression of production and expansion of leaves at higher densities was noticed by Aher *et al* (1980) and Manjappa *et al*. (1997) in cotton crop.

Though there is significant difference, no much variation was noticed for number of leaves among the foliar spray of agrochemicals except the spray of ethrel 2000 ppm at 140 DAS. But after the ethrel spray there is a drastic defoliation and at 150 DAS only 3.5 and 3.9 leaves were retained in Ethrel 2000 ppm sprayed at 140 DAS and Mepiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS treatments as compared to control (40.1). Fernandez *et al.* (1992) reported reduction in leaf area by the application of mepiquat chloride due to inhibition of leaf expansion. Mepiquat chloride is the key enzyme which inhibits the production of gibberlic acid (Rademacher, 2000). Similarly leaf area also severely reduced with ethrel spray. Senescence is the final developmental stage of the plant growth. Application of ethylene promotes senescence and abscission by promoting the synthesis of cell wall degrading enzymes like cellulase and dehydrogenase (Kader, 1985). So, the application of ethylene in the later crop growth stages results in defoliation resulting in less number of leaves and leaf area which is in conformity with the findings of Dabre *et al.* (1991) and More *et al.* (1993).

The observations on number of monopodia, sympodia and nodes per plant at harvest as influenced by foliar spray of agrochemicals under different plant spacing recorded non significant difference except sympodia for foliar spray of agrochemicals. Higher number of monopodia (1.7), sympodia (14.5) and nodes (15.8) per plant was observed in 60 x 20 cm spacing and were less in closer spacing of 45 x 10 cm and 45 x 15 cm. This may be attributed to the fact that the monopodial branches are vegetative in nature in present investigation and their growth was suppressed by closer spacing at higher plant population level. While, the sympodial branches are reproductive branches and their growth was suppressed by the dense plant population because of higher intra and inter plant competition for space, light, nutrients and moisture at higher plant population levels. Similar findings of suppression of production and development of monopodial branches at higher densities was noticed by Aher *et al* (1980), Manjappa *et al*. (1997) and Maitra *et al*. (2000) in cotton crop.

Among the foliar spray of agrochemicals more number of monopodia (1.7) was observed in Mapiquat chloride 100 ppm sprayed at 90 DAS while, significantly higher number of sympodia (14.7) and higher nodes per plant (16.0) in Mapiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS treatment. Similar observations for these parameters were made by Gadakh *et al.* (1992) and Brar *et al.* (2000).

5.2 Influence of agrochemicals on phenological characters

Plant spacing, foliar spray of agrochemicals and the interaction effect had no significant effect on 50 per cent squaring and 50 per cent flowering. However, number of days required for 50 per cent squaring (55.67 days), 50 per cent flowering (82.77 days), 50 per cent boll opening (138.15 days) and for maturity (157.33 days) was less in closer spacing of 45 x 10 cm than the others. This may be attributed to suppression of vegetative parts which helps in initiation of phonological characters early through diversion of assimilates to reproductive parts. Similar results were also reported by Sawan *et al*. (1993) and Bastia (2000). Among the agrochemicals, number of days to 50 per cent boll opening (137.48 days) and maturity (157.04 days) was significantly less in Ethrel 2000 ppm sprayed at 140 DAS. This could be due to the effect of ethylene which promotes senescence and abscission by promoting the synthesis of cell wall degrading enzymes like cellulase and dehydrogenase (Kader, 1985).

5.3 Influence of agrochemicals on growth parameters

Cotton is basically an indeterminate crop where the vegetative and reproductive phases overlap resulting in intra-plant competition for photosynthates between the developing bolls and vegetative parts (mainly stem, lateral branches and leaves). Yield improvement in any crop could be attributed to the better partitioning of photo assimilates towards reproductive/economic sinks. Cotton yield depends not only on total dry matter production but also its distribution into reproductive parts. The total dry matter is the summation of leaf, stem and reproductive parts and the higher total dry weight per plant was recorded in 60 x 20 cm and 60 x 15 cm spacing while in closer spacing of 45 x 15 cm and 45 x 10 cm there is a significant reduction in total dry matter. This may be attributed to the fact that accumulation of dry matter was hindered by closer spacing with higher plant population due to competetion for space, light, moisture and nutrients. While, wider spacing with less population receives these resources in ample and further, there is no inter plant computation. Among the agrochemicals, total dry matter accumulation was more in control while, accumulation was diminished with the spray of either of the growth regulators i.e., mepiquat chloride or ethrel. This could be due to nature of action of these chemicals as mepiquat chloride decreases the vegetative growth by interfering in the biosynthetic path way of gibberellins and ethylene promotes senescence and abscission by promoting the synthesis of cell wall degrading enzymes Bhatt (1972).

The distribution of dry matter in different plant parts showed that at early stages, leaves contributed a greater proportion to total dry matter, but at later stages, stem and reproductive parts contributed more. The amount of total dry matter produced is an indication of the overall efficiency of the utilization of resources and better light interception. At later stages of crop growth, the dry matter accumulated at a decreasing rate, which could be attributed to reduced source activity due to senescence and defoliation leading to lesser dry matter accumulation in the leaf and stem. Dry matter production, particularly of reproductive parts is an important yield contributing character and the basic vegetative phase essential for the development of reproductive organs. It is therefore, inferred that the growth regulators have profound effect not only on the production of dry matter but also its partitioning between various organs of the plant.

In the present study, irrespective of spacing with different plant populations and agrochemical treatments, leaf dry weight increased up to 125 DAS and in later stage of growth decreased due to senescence and defoliation. While, there is linear increase in dry weight of stem and reproductive parts. The total dry matter increased with the crop growth up to 125 DAS and there is a slight decline towards harvest because of reduced source activity due to senescence and defoliation. Similar observation on dry matter partitioning was made by Matolli (1981) and Nagabhushana *et al.* (1993).

Growth parameters help in understanding the importance of morpho physiological changes during the crop growth and development particularly the economic yield. Leaf area index depends on the leaf area per plant and more LAI was observed in wider plant spacing this was attributed to the better availability of growth resources like space, moisture, light and nutrients. Total dry matter production and supply of required photosynthates for the developing bolls largely depends on leaf area and leaf area index. The photosynthetic efficiency of crop plants as measured by net assimilation rate is dependent upon photosynthetic capacity expressed as leaf area index (Watson, 1952). Under field conditions, an increase in LAI may therefore improve the yield, provided such an increase is commensurate with an increased rate of dry matter production in reproductive parts. Leaf area over unit ground area gives a fairly good idea of the photosynthetic surface. LAI was influenced by spacing and in the present study LAI was significantly higher in closure spacing. The increased LAI was due to more no of plants there by more no of leaves leads to more LAI. Leaf area index increased with the age of the crop upto 125 DAS and decreased thereafter, which was due to ageing and senescence of leaves. Among the growth regulator treatments significant differences were noticed with regard to leaf area index.

Specific leaf weight (SLW) indicates the thickness of leaf and is known to have a positive correlation with photosynthetic rate (Walter *et al.,* 1980, Rasulov and Asrrorov, 1982 and Tom and Oosterhius, 1993). The results of the present study indicated that SLW increased up to 125 DAS and decreased thereafter. Significantly higher SLW was observed in wider spacing than closer spacing may be attributed to the fact that wider spacing with less population receives space, light, moisture and nutrients in ample and further, there is no inter plant competition. While closer spacing with higher plant population starve for these resources due to competition. Among the growth regulator mepiquat chloride recorded higher SLW as compared to other treatments. Increase in SLW with age of the crop might be due to either enhanced layer of mesophyll cells and/or increased thickness of conducting vessels.

Leaf area duration (LAD) is a useful concept not only depicting efficiency of photosynthetic system but also has been shown to have linear relationship with dry matter accumulation. In the present study, more LAI results in significantly higher LAD in closer spacing compared to wider spacing. However, the LAD reduced significantly in mepiquat chloride treatments due to reduced LAI.

Growth parameters like AGR, CGR, RGR and NAR have been extensively used in recent years for better understanding of physiological basis of yield variation in crop plants. Increase in yield is not associated with increase in photosynthetic rate alone and it is difficult to find out clear cut answer for improving the yield potential. The average daily increment of plant stand biomass is an important characteristic which is designated as absolute growth rate by Watson (1952). The AGR was more during early stage in both spacing and agrochemical treatments. In the present study, wider spacing and control with no spray of agrochemicals showed higher AGR at two stages of growth (75-

100 and 100-125 DAS). Similarly, CGR was also increased with crop age up to 100-125 DAS wherein closer spacing and control with no spray of agrochemicals showed higher CGR.

The RGR was more during early stages and decreased thereafter this indicates that RGR in cotton is more closely associated with vegetative growth than seed cotton yield (Coy, 1976). Net assimilation rate (NAR) expresses the rate of dry weight increase at any instant per unit leaf area and leaf representing an estimate of the size of the assimilatory surface area. In the present study, higher RGR and NAR were recorded in closer spacing and with mepiquat chloride treatment. The increase for these parameters by the application of growth retardant could be attributed to increased photosynthetic efficiency as a result of increased leaf thickness, higher chlorophyll content and efficient translocation of photosynthates (Joseph and Johnson, 2006).

5.4 Influence of agrochemicals on bio physical parameters

Leaf photosynthesis is the primary process which forms the basis for dry matter production for yield determination. In the present study, higher photosynthetic rate and conductance was maintained up to peak flowering in all the treatments. Wherein, higher rate was noticed in wider spacing and mepiquat chloride treatments. This is in agreement with Fernandez *et al.* (1992) and Reddy *et al.* (1996). Application of growth retardants enhanced the photosynthetic carbon dioxide fixation rates and RuBp carboxylase activity (Pando and Srivastava, 1985). This might be due to increased stomatal conductance and increased leaf CO_2 uptake (Kirankumar, 2001). In general, light transmission rate in all the stages was higher in the top of the canopy followed by middle and was the least in bottom canopy. Light transmission rate differed significantly in middle and bottom of the canopy at 100, 125 and 150 DAS under different plant spacing and at 150 DAS in foliar spray of agrochemicals. Light transmission rate was more in wider spacing may be due to lesser leaf number and LAI. While it was more in ethrel could be due to senescence and defoliation of leaves.

5.5 Influence of agrochemicals on biochemical parameters

Total chlorophyll content determines the photosynthetic capacity of the cotton genotypes and influences the rate of photosynthesis, dry matter production and the yield (Krasichkov *et al.,* 1989). The variation in chlorophyll content due to growth regulators may be attributed to decreased chlorophyll degradation and increased chlorophyll synthesis. In the present study, mepiquat chloride (50 ppm) recorded the maximum total chlorophyll content. This is in agreement with the results of Bhatt and Ramanujam (1971) and Reddy *et al.* (1996). Application of mepiquat chloride at different concentrations increased the leaf thickness by 29 per cent due to longer palisade and strong spongy parenchyma cells within the leaf mesophyll and had more chlorophyll per unit area in cotton. Mepiquat chloride treated plants are typically shorter, more compact and possess a characteristically darker green colour than untreated plants (Stewart, 2005). Water potential increased with the age of the crop from 75 to 150 DAS and it was more in closer spacing may be due to more competition between the plants for moisture.

5.6 Influence of agrochemicals on yield and yield components

Major factors attributed for the variation in the yield of seed cotton are the yield components like number of bolls per plant and boll weight, morphological characters like number of monopodial and sympodial branches. Crop yield depends not only on the accumulation of photosynthates during the crop growth and development, but also on the partitioning of photosynthates in storage organs. These inturn are influenced by the efficiency of metabolic processes within the plant.

Difference in spacing brought significant variation in number of bolls and boll weight. The higher number of bolls and boll weight was observed in wider spacing (60 x 20 cm) may be due to less competition for growth resources among the plants and more availability of nutrients and sunlight it ultimately resulted in better nourishment and plant growth (Krishnaswamy, 1979) there by produced bigger sized bolls with more boll weight. Similar results were also reported by Prasad and Prasad (1993), Wankhade and Bathkal (1994), Bastia (2000) and Maitra *et al.* (2000) in cotton crop.

Differences in spacing brought significant variation in the seed cotton yield. Significantly highest seed cotton yield (1326 kg/ha) was recorded at wider spacing of 60 x 20 cm followed by (1311 kg/ha) 60 x 15 cm as compared to closer spacing of 45 x 10 cm (1184) and 45 x 15 cm. This may be attributed to production of highest number of sympodial branches and boll weight. Lower seed cotton and seed yield per plant at closer spacing and dense planting was probably due to less space available for the lateral spread of the plant per unit area which lead to inter plant competition for light, moisture and nutrients. Present investigation results are in conformity with Manjappa *et al*. (1997), Maitra *et al*. (2000) and Bastia (2000).

In the present investigation, among the agro chemical treatments, more boll weight and higher yield was observed with mapiquat chloride 100 ppm sprayed at 90 DAS + ethrel 2000 ppm sprayed at 140 DAS. It was due to delayed senescence of leaves which helped in increasing the photo-assimilate supply for an extended period (to reproductive sink) by mapiquat chloride and synchronized boll opening by ethrel. Application of growth retardant and defoliant at later stage had beneficial effect on seed cotton yield and this was in conformity with the findings of Brar *et al.* (2000), Keith (2000), Joseph and Johnson (2006) and Zakaria (2006).

4.6.5 Fiber properties

Fiber properties did not show any significant difference among the treatments. More fiber length was recorded at wider spacing of 60 x 20 cm spacing as compared to closer spacing of 45 x 10 cm. Among the agro chemical treatments higher fiber length was observed with mepiquat chloride 100 ppm sprayed at 90 DAS + ethrel 2000 ppm sprayed at 140 DAS and least was recorded in control with no spray. Levis (1970) reported that plant growth hormones generally increased mean fiber length and fibre bundle strength and Nagwekar and Kairon (1978) also reported that the mean fiber length increased with application of growth regulators. Higher fibre strength and micronair values were recorded in closer spacing of 45 x 10 cm as compared to wider spacing of 60 x 20 cm. These were higher in control with no spray then growth regulator spray. Similarly, Stuart *et al.* (1984), Kerby (1985), George and William (1988) and Mehetre *et al.* (1990) reported plant growth regulators had significant effect on fiber properties.

Future line of work

1. The performance of ultra compact genotype(s) should be evaluated at normal rainfall condition
2. Different ultra compact genotype(s) should be evaluated under irrigated and rainfed condition to assess their performance

SUMMARY AND CONCLUSIONS

The results of the field experiment conducted at Agricultural Research Station, Dharwad during *kharif* 2012-13 to study the influence of agrochemicals with different plant population on various parameters pertaining to morpho-physiological, biochemical, phenology, yield and quality taken at different time intervals are summarized below.

The morphological parameters viz., plant height, number of leaves per plant, leaf area per plant, number of monopodia, sympodia and nodes per plant at harvest showed variation among different spacing and also for growth regulator treatments.

In general, the plant height increased with the age of the crop till harvest. Plant height differed significantly for different plant spacing in all growth stages (ie., at 75, 100, 125 and 150 DAS) except at 75 DAS with foliar spray of agrochemicals (as the treatments were not imposed at this stage). In all the stages closer spacing (45 x 10 and 45 x 15 cm) with higher plant population resulted in increased plant height than the wider spacing (60 x 20, 60 x 15 and 60 x 10 cm). Application of mepiquat chloride 100 ppm sprayed at 90 DAS decreased the height compared to control.

Number of leaves and leaf area were significantly higher in wider spacing than closer spacing and also in control with no spray of growth regulators. Higher number of monopodia, sympodia and nodes per plant was observed in wider spacing of 60 x 20 cm and 60 x 15 cm. Among the foliar spray of agrochemicals these parameters were higher in mepiquat chloride and ethrel treatments as compared to control with no spray.

Phenological characters viz., number of days required for 50 per cent squaring, 50 percent flowering, 50 per cent boll opening and maturity reduced in closer spacing than the wider spacing. Among the agrochemicals, number of days to 50 per cent boll opening and maturity was significantly less in ethrel 2000 ppm sprayed at 140 DAS compared to control with no spray.

Dry matter partitioning in leaf, stem, reproductive parts and total dry weight per plant recorded significant differences with agrochemicals under different spacing. Higher dry weight in all these parameters was noticed in wider spacing of 60 x 20, 60 x 15 and 60 x 10 cm spacing as compared to closer spacing (45 x 15 and 45 x 10 cm). Among the agrochemicals partitioning of dry matter in leaf, stem and also total dry weight was higher in control with no spray while, the reproductive parts weight was more in growth regulator (mepiquat chloride and ethrel) treatments.

All the growth parameters viz., LAI, LAD, CGR, RGR and NAR except SLW and AGR were higher in closer spacing (45 x 15 and 45 x 10 cm) as compared to wider spacing ie., 60 x 20, 60 x 15 and 60 x 10 cm. Among the agrochemicals LAI, LAD, AGR and CGR were higher in control with no spray While SLW, RGR and NAR were higher in growth regulator (mapiquat chloride and ethrel) treatments.

The bio physical parameters viz., rate of photosynthesis and stomatal conductance increased up to 100 DAS and decreased thereafter while, rate of transpiration decreased continuously with the age. Higher rate of photosynthesis and stomatal conductance was observed in wider spacing and in growth regulator treatments whereas rate of transpiration was more in closer spacing and in control with no spray.

In general, the data on light transmission rate in all the stages was higher in the top of the canopy followed by middle and was the least in bottom of the canopy. In all the stages i.e., 100, 125 and 150 DAS the light transmission data on top of the canopy was non significant for both spacing and foliar spray. Significantly higher light transmission rate in middle and bottom of the canopy was recorded in wider spacing (60 x 20 and 60 x 15 cm) as compared to closer spacing (45 x 10 cm). The difference on light transmission rate for agrochemicals foliar spray was non significant in both at 100 and 125 DAS and while at150 DAS application of growth regulator recorded significantly higher light transmission rate as compared to control with no spray in both middle and bottom canopy.

SPAD value increased from 75 DAS to 125 DAS and decreased thereafter. Wider spacing recorded higher SPAD value as compared to closer spacing. Among the agrochemicals, mepiquat chloride recorded higher SPAD value as compared to other treatments and control. In general, water potential increased with the age of the crop from 75 to 150 DAS and higher water potential was recorded in closer spacing and in Mepiquat chloride + Ethrel spray.

The yield components viz., number of bolls and boll weight differed significantly for different plant spacing and also for application of growth regulators. Wider spacing produced more bolls with higher weight as compared to closer spacing and among foliar spray of agrochemicals more boll number and boll weight were recorded in mapiquat chloride + Ethrel and mapiquat chloride respectively.

The highest seed cotton yield was found in the wider spacing of 60 x 20 cm (1326 kg/ha) and 60 x 15 cm (1311 kg/ha) as compared to closer spacing of 45 x 10 cm (1184 kg/ha). Among the foliar spray, mapiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS recorded higher yield (1346 kg/ha) than mapiquat chloride 100 ppm sprayed at 90 DAS (1299 kg/ha), ethrel 2000 ppm sprayed at 140 DAS (1234 kg/ha) and was lowest (1178 kg/ha) in control with no spray.

The fiber quality parameters viz., fiber length showed direct while fiber strength and micronair value showed inverse relation with seed cotton yield irrespective of spacing and agrochemical treatments. Though all the quality parameters were non significant, the fiber length was more in wider spacing and in control with no spray while, fiber strength and micronair value were higher in closer spacing and in growth regulator treatments.

Conclusions

1. Morphological parameters viz., number of leaves per plant, leaf area per plant, number of monopodia, sympodia and nodes per plant, partitioning of dry matter in leaves, stem and reproductive parts were higher in wider spacing as there is less competition for growth resources among the plants and more availability of nutrients and sunlight it ultimately resulted in better nourishment and plant growth.
2. Higher rate of photosynthesis, stomatal conductance and SPAD value (chlorophyll content), partitioning of assimilate in reproductive parts and also delayed senescence of leaves with higher LAI, LAD and SLW which helped in increasing the photo-assimilate supply for an extended period (to reproductive sink) by mepiquat chloride and synchronized boll opening by ethrel contributed for more bolls and better boll set.
3. Thus, it can be concluded that combined application of Mapiquat chloride 100 ppm sprayed at 90 DAS + Ethrel 2000 ppm sprayed at 140 DAS treatment with a spacing of 60 cm x 20 cm (83,333 plants/ ha) is optimum to get higher seed cotton yield.

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EFFECT OF AGROCHEMICALS ON PHYSIOLOGICAL TRAITS, YIELD AND FIBRE QUALITY ON COMPACT COTTON

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ABSTRACT

A field experiment was conducted to study the effect of agrochemicals under different plant population in compact cotton (DSC- 8) during *kharif* season of 2012 at Agricultural Research Station, Dharwad Farm. The experiment was laid out in split plot design with three replications consisting five main treatments (plant population / spacing) and four sub treatments. The agrochemicals included were mepiquat chloride (growth retardent) sprayed at 90 DAS to curtail vegetative growth and Ethrel (defoliant) sprayed at 140 DAS to facilitating mechanical picking.

Wider spacing recorded more number of bolls and boll weight resulting in highest seed cotton yield as compared to closer spacing. Among agrochemicals application of mapiquat chloride + Ethrel recorded more number of bolls with higher yield. The none of the quality parameters were affected due to agrochemical spray.

All the morphological parameters viz., number of leaves, leaf area, number of monopodia, sympodia and nodes per plant, partitioning of dry matter in leaves, stem and reproductive parts were higher in wider spacing (60 x 20 cm) as there is less competition for growth resources among the plants. Higher rate of photosynthesis, stomatal conductance, SPAD value (chlorophyll content), partitioning of assimilate in reproductive parts and delayed senescence of leaves with higher LAI, LAD and SLW which helped in increasing the photoassimilate supply for an extended period (to reproductive sink) by mapiquat chloride and synchronized boll opening by ethrel contributed for more number of bolls and better boll set. Thus, it is found that combined application of mapiquat chloride and ethrel treatment with a spacing of 60 cm x 20 cm (83,333 plants per ha) is optimum to get higher seed cotton yield in such compact genotypes.