PHYSIOLOGICAL APPROACHES FOR DROUGHT TOLERANCE IN SUGARCANE (*Saccharum officinarum* L.)

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I. INTRODUCTION

Sugarcane (*Saccharum officinarum* L.) is one of the important commercial crops of the world and its cultivation being restricted to tropical and subtropical countries. It is grown in a wide range of temperature (18-40°C) and temperature requirement varies with growth stages. There are 102 countries in the world growing sugarcane over an area of about 19.2 m ha producing 1214 m tons of sugarcane with an average production of 63.3 tons per ha (Anon, 2008). Sugarcane contributes to 60 per cent of the total sugar production in the world and the remaining 40 per cent is contributed by sugarbeet.

Brazil stands first in the world with respect to area (4.8 m ha) and production (324 m tons) followed by India, Cuba, Pakistan and China. It is an important commercial crop grown in almost all the states in India except North-Eastern states. India stands second in the world both in area (4.2 m ha) and production (314 m tons). Uttar Pradesh, Maharashtra, Karnataka, Tamil Nadu and Andhra Pradesh are the important sugarcane growing states in India. Uttar Pradesh alone occupies 50 per cent of the sugarcane area and contributes to 30 per cent of the production. Tamil Nadu stands first in productivity (110 t/ha) followed by Karnataka (85 t/ha). Generally, the area between latitude 10° to 20° North or South represents the best climate for productivity of sugarcane in respect of both yield and sugar recovery, as this region enjoys higher temperatures and higher humidity during the grand growth period.

Climate plays a major role in influencing the growth rate of sugarcane crop. Increase in soil temperature enhances the rate of mineralization in the soil and the rate of absorption of nutrients by the plants. On the other hand, higher temperatures increase the rate of transpiration through leaves.

Sugarcane is cultivated over a large area under rainfed or irrigated conditions in India and the crop suffers from moisture stress at one or the other stage of crop growth. Usually moisture stress occurs during summer months (February-June). The annual rainfall and its distribution plays a major role in influencing the irrigation requirement of sugarcane crop. It has certain stages in its life cycle, where the application of water pays large dividends. The initiation of tillering, commencement of internode elongation and grand growth periods are the phases where the crop must be supplemented with adequate water through irrigation, if the rains do not meet the crop needs.

While planning for economic water use and better crop growth under water stress conditions, one has to pay maximum attention to increasing moisture content of the soil, minimizing the loss of soil moisture through surface evaporation and transpiration, to train crop artificially to face drought conditions (hardening effect), to efficient use of available water in the soil and adoption of suitable crop management practices.

The adverse effects of water stress manifest themselves through high mortality of tillers, stunted growth, reduction in cane height, reduced internodal length, cane weight, millable plant population, cane yield, juice quantity, ion contents in leaves, transpiration rates, stomatal conductance, stomatal size, chlorophyll stability index, root activity and nutrient supply in the soil or its uptake by the plants (Bendigeri and Hapse, 1987). If all these parameters are affected simultaneously, the effect on cane growth or cane yield is very drastic. In addition, there is a possibility of reduction in the activity of specific enzymes involved in various processes (Naik and Somashekar, 1989).

Opening and closing of stomata has a direct bearing on the water loss through transpiration under water stress conditions. Moisture stress associated with high dry temperature causes poor growth and higher tiller mortality in both tropical and subtropical conditions and the yield loss has been estimated to be 50-70 per cent based on the degree of water stress.

Work pertaining to drought tolerance and the avenues to overcome water stress through physiological approaches in sugarcane are very meager. Understanding of the mechanisms involved in this matter help desire solution to the associated problems effectively. With this background, the present investigation was planned with the following objectives.

1. To study the biochemical and biophysical changes during moisture stress in sugarcane.
2. To know the effect of different treatments on morpho-physiological, yield attributes and quality parameters in sugarcane.
3. To find out the appropriate crop technology to overcome drought in sugarcane.

An extensive review on the key determinant morpho-physiological processes, biophysical and biochemical parameters and their relations to growth and yield processes in relation to sugarcane is presented in the following chapter.

II. REVIEW OF LITERATURE

The main aim of this literature review is to abstract and synthesize the existing knowledge on morpho-physiological processes, biophysical and biochemical parameters and their relations to growth and yield processes of sugarcane under adequate water and water scarce situations. In addition this review will provide evidence for different objectives that have been formulated and to be tested in two years of field experiments. This review has been organized into four main parts. The first part deals with understanding the growth and yield processes in sugarcane under water scarce situations. The major focus is on mechanisms underlying processes under different agro-techniques and practices. The second part deals with biophysical parameters and the major attention has been placed on stomatal traits that are responsible for variations in drought resistance mechanisms. The third part deals with biochemical parameters influencing various processes under water scarce conditions. The fourth part focuses on yield and quality attributes as regulated by different practices in sugarcane.

In its widest context, the water stress environment is one of the major factors responsible for the current global map of distribution pattern of various crops. The water stress is critical by way of affecting plant phenology, developmental phases, growth rates, yield components and the final yield. In the present review, an attempt has been made to present relevant literature on the changes in growth parameters, yield, biophysical parameters viz., transpiration rate, diffusive resistance and leaf temperature, physiological and biochemical parameters viz., chlorophyll content, proline accumulation, nitrate reductase activity, potassium and sugar contents in leaf during water stress in sugarcane.

2.1 GROWTH AND DEVELOPMENT

Water stress is one of the important environmental factors which affects plant growth and development. In sugarcane, hot weather favours plant growth and development and cool temperatures enhance the sugar production. In sugarcane several agro-techniques have found to improve morpho-physiological characters (Pawar *et al*., 2003; Chetti and Pawar, 1997). Some of them are soil application of K_2O (Kathiresan and Balasubramanian, 1991) foliar application of K_2O (Parameshwaran *et al*., 1987), seed hardening with chemicals (Bhatia and Rathore, 1986; Pawar *et al*., 2003), mulching (Kannappan *et al*., 1994), anti-transpirants (Parameshwaran *et al*., 1987; Salunke *et al*., 1998). These practices have been reviewed in this sub-section. Gill (1962) reported that tillering and growth are adversely affected by deficient irrigation, but the cane yield was not greatly influenced by the frequency of irrigation.

Higher survival of shoots by potassium chloride spray was reported by Mohan Naidu and Srinivasan (1978). Among different sprays, kaolin recorded significantly higher number of cane formed shoots and was on par with potassium chloride, but superior to control. Kaolin spray registered an increase in the survival of shoots closely followed by potassium chloride. This is in confirmity with the findings of Kathiresan and Balasubramanian (1991) who reported that KCl spray registered higher survival of shoots under drought conditions. In plants sprayed with diammonium phosphate, there was 70.3 per cent survival of shoots at 150th day of planting and 4.39 per cent higher economic shoots than the control.

Growth, yield and quality were adversely affected due to moisture stress. A significant reduction in shoot population was noticed due to soil moisture tension, but the magnitude varied with the varieties (Johari *et al*., 1998). They also observed a significant reduction in millable canes. In the experiment of Kathiresan and Balasubramanian (1991), consisting of trash mulch, soil application of 60 kg per ha K_2O, kaoline spray (12.5 kg/ha) and combination of trash mulch and additional dose of K_2O, beneficial effects in terms of maximum number of tillers, economic shoots and maximum number of millable canes were recorded with trash mulch with additional dose of K_2O as compared to other treatments.

Water stress reduces the number of tillers produced or the kill the number of tillers. The direct effects of water stress are difficult to distinguish from the secondary ones. Almost all the processes of plant require sufficient amount of water and its deficit in any process adversely affect the growth and development as most of the processes are interlinked. Bendigeri *et al.* (1986) conducted an experiment by giving 20 days and 40 days irrigation intervals with different varieties and observed that loss in weight and commercial cane sugar due to moisture stress when all other conditions were favourable for the remaining period of growth. The loss in yield was mostly due to reduction in plant population at harvest. The number of internodes remained constant, while the length of internodes was reduced due to water stress. They also evaluated the contribution of different plant parts (leaf, stem, sheath and dry leaves) towards dry matter production and found considerable difference between different parts depending upon the response of a particular variety to moisture stress. It was further observed that there was a reduction in RGR, NAR and CGR during stress period.

Parameshwaran *et al.* (1987) evaluated the performance of sugarcane with different treatments like spray of kaolin, potassium chloride and DAP @ 12.5 kg per ha during moisture stress condition and indicated that potassium chloride spray had significantly higher millable canes and it was on par with kaolin and diammonium phosphate sprays. The per cent tillers converted into millable canes was higher with potassium chloride spray followed by kaoline and diammonium phosphate spray. The conversion rate of economic shoots into millable canes was higher with potassium chloride spray over other sprays and control. They further observed that the height of the cane stalk was more in all the chemicals than the control throughout the crop period. Though kaolin spray registered maximum height, it was on par with potassium chloride spray. The anti-transparant and reflectant action of kaolin would have contributed for higher retention of moisture in plants resulting in better growth. Similarly, potassium chloride might have reduced the transpirational loss of moisture due to the regulation of stomata and favoured growth.

Naik *et al.* (1993) observed significant reduction in plant height and leaf area due to drought in all the three cultivars (COC-671, CO-7402 and CO-7219) studied. Reduction in cell growth appears to be the most sensitive indication of water stress, since cell growth is quantitatively related to cell turgor which varies with the degree of dehydration (Levitt, 1980).

Ali *et al.* (1994) observed non-significant difference in millable cane between K applied and without K under moisture stress situation. They further observed a slight increase in weight of 10 canes due to K treatment compared to without K under moisture stress condition. With proper drought management practices, on an average, production was increased by 9.11% and number of millable canes by 4.33% over control (Mukund Rao *et al.*, 2002).

Varsha and Lakhidive (1997) studied the effect of trash management, use of anti-transpirants, additional dose of K_2O and application of manganese sulphate individually and in combination under water stress on growth and development of sugarcane and observed maximum number of millable canes in normal irrigation and 26.7 per cent reduction in millable canes due to water stress.

Teulat *et al.* (1997) evaluated number of leaves on the main tiller, number of tillers and total biomass in the treatments of well watered and stressed plot having 14 per cent field capacity in barley genotypes. They observed negative phenotypic correlation between relative water content (RWC) and growth parameters in both the treatments.

Ramesh and Mahadevswamy (2000) conducted field experiments at Coimbatore during 1996 and 1997 using four commercial sugarcane varieties to study the effect of three levels of drought (severe, moderate and control). They observed that the dry matter was reduced by 60.8, 52.4 and 25.9 per cent under severe drought; 46.3, 36.3 and 15.1 per cent in moderate drought at the end of the formative, grand growth and maturity phases, respectively. In addition to this net assimilation rate, relative growth rate, leaf area index and leaf area duration were also reduced under drought compared to normal irrigation.

Ramesh and Mahadevaswamy (2000) studied on the effect of of drought during formative phase and reported reductions in the total number of shoots and their conversion to millable canes at harvest, cane length and number of internodes. In another study, increased cane yield in irrigated plots over the stressed plot was observed due to increased cane length, girth and cane weight (Dineshkumar *et al.*, 1995).

Several studies have demonstrated the effects of water stress on physiological processes (Inman-Bomber, 2004) and canopy development (Smith *et al.*, 2005). Cell division and elongation responsible for leaf extension and leaf appearance were restricted relatively soon after the irrigation was withheld (Inman-Bomber, 2004). He also observed that leaf senescence in sugarcane was rapid when soil water deficit exceeded 100 mm.

Smith *et al.* (2005) reported in a study, the effect of water stress on canopy development of two sugarcane cultivars N22 and NC0376. They observed that water stress caused simultaneous reduction in leaf appearance rate and increase in leaf senescence and consequently reduced green leaf number in both the cultivars.

Height of the cane stalks was more in kaolin sprays than the control through the anti-transpirant and reflectant action of kaolin, due to which there was higher retention of moisture in plants through reduced transpirational loss and regulation of stomata which further favoured growth (Sinha, 1978). He also reported that foliar application of potassium induced stomatal adjustments and contributed to higher growth and yield.

Inman-Bomber (2004) observed that the specific leaf area (SLA) was lower in the dry than in the wet treatment. Water stress had greater effect on expansive growth of lamina than its dry mass. The reduction in leaf area index (LAI) under water stress was due to reduced leaf area and to a lesser extent to reduced number of green leaves per stalk.

The importance of potassium fertilization under water stress conditions remains often obscure where this nutrient is not particularly limiting in the soil. Nonetheless, it seems that adequate potassium availability contributes much towards growth and yield improvement under drought conditions. Nutrient availability from the soil is the principal contributing factor for growth reduction under water stress condition.

Mohan Naidu *et al.* (1976) and Manoharan *et al.* (1992) have reported that soaking the sets in saturated lime water coupled with trash mulching was beneficial and was able to overcome the drought conditions and resulted in higher cane yield.

Jayabal and Chockalingam (1990) reported highest cane population per hectare by the foliar application of potassium sulphate at 2.5 per cent over control. Further, the application of Kaolin (6%) and additional dose of 75 kg/ha muriate of potash (MOP) were also equally important in reducing the transpiration rate and increasing cane population. Spraying of urea (2.5%) with potash (2.5%) gave the maximum cane yield (113 t/ha), which was superior to kaolin (108.1 t/ha) and water spray (103.1 t/ha). Urea enhances the absorption of potassium in the leaf tissue thereby, causing beneficial influence on shoot population and final cane production (Manoharan *et al.*, 1992).

Subramanian *et al.* (1992) conducted experiments with graded levels of potassium like 0, 125, 175 kg/ha K_2O and 125 kg/ha K_2O + KCl (1%) spray at different growth stages during different moisture stress periods and recorded reduced plant height at critical stages of crop growth. While, irrigation levels and K levels influenced the growth significantly. Highest values of plant height were recorded with the treatment of optimal irrigation. Subramanian *et al.* (1991) reported higher dry matter production with the application of K_2O @ 125 kg per ha + KCl (1%) foliar spray. A linear response of dry matter for K application was also recorded by Rani Perumal *et al.* (1989). A higher tiller count was registered under optimal moisture regimes with application of graded levels of potassium. Economic shoot population at 270 DAP was also significantly influenced by irrigation and potassium application.

In an attempt to evolve suitable management practices to over come ill effects of moisture stress during summer, field experiments were conducted by Hunshal *et al.* (1996) and they reported that relative water content (RWC) decreased as the stress levels increased. Further, they opined that among various treatments viz., set hardening with 2% $CaCl_2$, application of K_2O @ 50 kg/ha as extra dosage at last irrigation, foliar spray of MOP (2.5%) and MOP (2.5%) spray along with urea (2%) resulted in significantly taller plants, thicker stalks, more number of internodes and maximum single cane weight over no irrigation during stress period.

In another study it was found that spraying of urea (2.5%) + KCl (2.5%) enhanced the leaf area and this increased leaf area was maintained during water stress which ultimately helped in increased cane yield (Mukundarao *et al.*, 2002). Similar findings in sugarcane were also observed under moisture stress conditions (Mohan Naidu *et al.,* 1983 and Sundara, 1998).

Kannappan *et al.* (1994) conducted an experiment to know the method of alleviating the ill-effects of drought in sugarcane and indicated that the application of 125 kg per ha MOP over recommended dose and spraying kaolin (2.5%) solution and spreading trash mulch along the ridges resulted in maintenance of maximum plant population.

Bhatia and Rathore (1986) found that drought resistance in sorghum could be improved by seed hardening with $CaCl_2$ (2%) in the ratio of 1:1 (seed : solution) when soaked for four hours. Eshanna and Kulkarni (1990) revealed that seed treatment with $CaCl_2$ in the ratio of 1:3 (seed : solution) recorded significantly higher plant height, LAI, NAR and total dry matter at different growth stages in maize over untreated control. Pawar (1996) reported that the application of 2 per cent ethanol significantly increased the dry matter production, leaf area, LAI, LAD, NAR and SLA in sorghum genotypes. Similarly, Koppar (1997) revealed that the foliar spray of methanol at different levels (1-2%) significantly increased the plant height, number of green leaves, LAI, LAD, NAR, SLA, SLW and CGR in wheat.

Significantly higher leaf sheath moisture content was noticed in potash applied crop at the end of the formative and grand growth periods, which might be due to increased osmotic potential as a result of K absorption by the root cells. Potassium is known to help in regulating opening and closure of stomata leading to higher moisture retention in the tissues (Jamuna *et al*., 1994 and Rajkumar and Kambar, 1999). Mohan Naidu *et al.* (1983) reported that the utilization of foliar applied potash is better when combined with urea. They further observed that maximum number of millable canes at harvest in the treatment with the foliar application of KCl (25%) at 60, 90 and 120 days compared to stressed crop.

Chetti and Pawar (1997) observed that plant height, number of leaves, total dry matter and grain yield increased with an increase in concentration of ethanol spray upto 30 per cent in sorghum. Salunke *et al.* (1998) observed that foliar spray of methanol upto 20 per cent in wheat caused gradual increase in the plant height, number of tillers and total dry weight of the plant. On the other hand, in cotton, Abdel-Al (1998) reported that foliar sprays of methanol solutions at 10, 20 and 30 per cent significantly increased the plant height, leaf area, dry weight, shoot-root ratio and number of bolls per plant.

Kumar *et al.* (1999) indicated the reflection of enhanced photosynthetic activity on the total dry matter accumulation in cotton. Further, they reported that there was an increase in photosynthetic activity with the foliar spray of 20 and 30 per cent methanol in cotton. The results revealed by Patil *et al.* (1999) indicated that the height of groundnut plant, number of branches, leaf area and dry matter production increased with an increase in the concentration of methanol upto 20 per cent and decreased at higher concentrations.

Govindan and Thirumurugan (2000) revealed that the growth parameters like plant height, LAI and dry matter production in greengram were significantly higher with the foliar spray of KCl (1%). Dwivedi *et al.* (2001) observed that the application of 20 per cent methanol caused short staturedness by reducing the plant height and increased total and effective nodules in soybean.

Annadurai *et al.* (2001) observed that soil application of 168 kg/ha K_2O and foliar spray of 2.5 per cent KCl at 45, 75 and 105 days after planting recorded higher dry matter production, LAI and cane yield in sugarcane. Pawar *et al.* (2003) revealed that seed hardening with 2 per cent $CaCl_2$ resulted in significantly higher plant height, total dry matter and grain yield in sunflower as compared control. Ombose *et al.* (2003) noticed that the foliar spray of methanol upto 20 per cent concentration increased the plant height, number of branches and number of leaves per plant in groundnut.

2.2 BIOPHYSICAL PARAMETERS

Barrs (1968) suggested that relative water content (RWC) under stress could also be used as a measures of tolerance to stress and could be used in varietal screening programme.

Anandrao *et al.* (1988) studied biophysical parameters in eight sugarcane varieties subjected to water stress and noticed that there was an increase in leaf temperature but reduction in transpiration rate and stomatal conductance when the crop was forced to face drought conditions. Similar results of reduction in stomatal size, transpiration rate and stomatal conductance were reported by Bendigeri and Hapse (1987) who further observed that better performance of CO-740 may be due to higher plant population, narrow chlorophyll stability index and maximum number of closed stomata per unit area and maximum dry weight of roots.

It is known that potassium increases the guard cell turgidity resulting in opening of stomata which may result in higher transpiration rate. Sudamsingh *et al.* (1997) conducted experiments with two cane varieties by applying 80 kg/ha potash which resulted in an increased stomatal resistance and decreased transpiration rate. Nelson (1982) and Edwards (1982) also reported that with the adequate potassium, stomata close rapidly under drought conditions. This also results in increase of sucrose per cent in juice, which may be due to increased tissue moisture status resulting in better translocation of assimilates from leaf to stem. The beneficial effect of potassium on juice quality has also been reported by Barua (1970), Golden (1982), Kathiresan and Balasubramanian, (1991) and Varsha and Lakhdiv (1997).

The stomatal behaviour in terms of stomatal diffusive resistance and transpiration rate are useful parameters for selecting drought resistant varieties. The moisture stress conditions exhibit greater stomatal diffusive resistance (SDR) and less transpiration rate (Srivastava *et al.,* 1996).

Du *et al.* (1996) noticed that during water stress, carbon exchange rate and stomatal conductance decreased in a non-linear way. Chlorophyll content and total soluble proteins decreased linearly with decreasing leaf water potential. The changes of stomatal conductance, chlorophyll content and total soluble proteins were highly related to the changes in carbon exchange rate.

Srivastava *et al.* (1997) reported that the varieties which possessed higher stomatal diffusive resistance (SDR) and lower transpiration rate and minimum reduction in leaf water potential during stress were and after rewatering the crop showed lower SDR and higher transpiration rate along with higher leaf water potential for faster recovery proved to be drought tolerant. Similar results were also observed by Venkataraman *et al.* (1986) and Singh and Srivastava (1992).

2.3 BIOCHEMICAL PARAMETERS

Crop yield is mainly dependent on the interplay of various physiological and biochemical functions of the plant in addition to the impact of the environment. Reduced nutrient availability from the soil is the principal contributing factor for growth reduction under water stress condition (Vasadia and Waisely, 1967). Sevearl studies indicated the beneficial effect of foliar application of potassium. Favourable effect of foliar application of potassium under moisture stress conditions with respect to stomatal adjustment, higher growth and yield has been obtained with 2.5 per cent and the effect was more pronounced when combined with urea (2.5%) (Sinha, 1978). Parthsarathy (1983) indicated that potassium increased the succulence and helped to retain more moisture which mitigated drought in sugarcane. Srinivasan (1981) reported that to overcome drought, potassium was applied before the commencement of soil moisture stress and got encouraging results.

Rajagopalan *et al.* (1977) found diurnal changes in RWC, nitrate reductase activity and proline content in water stressed and non-stressed wheat crop. Unirrigated wheat crop showed less nitrate reductase and more proline accumulation. Sucrose content increased due to increased sucrose phosphosynthatase activities and concomittant increase in the activities of phospoenolpyruate carboxylase, a major carbon assimilating enzyme in C_4 photosynthetic cells. On the other hand, nitrogen assimilating enzyme, nitrate reductase was decreased during drought periods. Accumulation of free proline in leaves has been shown to be an adaptive mechanism for tolerance to stress. A relationship between the magnitude of free proline accumulation and drought tolerance has been shown in barley genotypes by Singh *et al.* (1972).

Clements (1977) opined that tissue moisture content is the integrator of all the factors both internal and external, affecting the crop. The higher leaf sheath moisture per cent might be responsible for better uptake of nitrogen from the soil to enable favourable growth conditions resulting in higher yield.

Significant accumulation of free proline due to moisture stress and biological stresses has been reported in sugarcane (Rao and Asokan, 1978; Singh, 1980 and Ho *et al.*, 1984). Association of proline accumulation with dry matter production was evident, especially under stress conditions. High proline and its further accumulation under stress is known to act as a storage compound for carbon and nitrogen (Bernett and Naylor, 1966). Under severe water stress (-1.2 MPa leaf ψ_w) conditions, metabolites like sucrose, starch and enzyme activities decreased significantly compared to those under mild water stress in sugarcane leaves (Du *et al.*, 1998).

Shashidhar *et al.* (1981) reported that groundnut cv. RS-218 treated with 1 per cent $CaCl_2$ recorded 17 times more proline content than the control. Similarly, the seed treatment with 2 per cent $CaCl_2$ recorded higher RWC and proline content in sorghum (Patil, 1987). Amaregouda *et al.* (1994) revealed that seed treatment with $CaCl_2$ (2%) in wheat increased free proline content and RWC at both 60 and 80 DAS. This treatment also increased chlorophyll 'b' content, accumulated maximum K-content, total and reducing sugars in leaves. The application of methanol (0.25 or 0.5%) to soybean at initial pod filling stage significantly increased leaf chlorophyll content (Li *et al.*, 1995). Ghosh and Srivastava (1995) revealed that the foliar spray of *Quercus serreta* seedlings with KCl (5.0 mM) resulted in higher levels of total chlorophyll, total sugars, soluble protein and nitrate reductase activity in leaves. Pawar (1996) revealed that the application of ethanol (2%) increased total sugars, nitrate reductase activity, stem and leaf crude protein in sorghum.

It was also reported by Nelson (1982) and Edwards (1982) that water stress regulates stomatal behaviour and, stomata closed rapidly under drought conditions and minimize the transpiration rate. Increase of sucrose per cent in juice under non-stress condition may be due to increased tissue moisture status resulting in better translocation from leaf to stem. The beneficial effect of potassium on juice quality has also been reported by Barua (1970) and Golden (1982).

Perumal and Pasupathy (1984) experimented with C0 6304 sugarcane variety and obtained higher cane yield in potash supplied fields prior to the commencement of moisture stress period. The potash was supplied in two split doses and indicated that the application of higher dose of potash prior to the commencement of stress might have acted as an adaptive mechanism for drought tolerance. The earlier work by Shashidhar *et al.* (1977) in groundnut clearly indicated that the genotypes with high potassium, accumulated more proline under moisture stress condition. The higher proline accumulation was associated with higher potassium content in leaves of maize (Mukarjee, 1974).

While, the application of methanol upto 20 per cent resulted in significant increase in total chlorophyll, total sugars, wax content and nitrate reductase activity in wheat (Koppar, 1997).

Singh and Singh (1986) conducted field experiments with different varieties to study the effect of moisture stress on dry matter production and proline accumulation. The varieties BO 91, COS 767, CO-1148 and COS 802 had greater accumulation of proline compared to COS 510, COS 770 and COS 7918, especially under moisture stress conditions. The dry matter was also reduced to a greater extent under moisture stress conditions.

Zhang (1998) observed an increase the proline content in the leaves of sugarcane varieties with an increase in moisture stress. Drought stress stimulated proline accumulation in two sunflower varieties (Unyayar *et al.*, 2004). It is well known that proline accumulates in plants during the adaptation to various types of environmental stresses such as drought, high temperature, nutrient deficiency and exposure to heavy metals (Oncel *et al.*, 2000).

The pre-sowing seed hardening treatments with $CaCl_2$ (100 ppm) increased the chlorophyll content in *Pennisetum americanum* and *Sorghum bicolor* (Kedari and Hussaini, 1999).

2.4 YIELD AND QUALITY ATTRIBUTES

Cane yield is the ultimate manifestation of morphological, physiological, biochemical processes and growth parameters.

Cane yield was significantly decreased at 60, 40 and 20 per cent available soil moisture in five sugarcane varieties and found that cane yield decreased with increasing soil moisture stress. A field experiment was conducted by Dinesh Kumar *et al.* (1995) with treatments K_2O (2.5%) as foliar spray + urea (2.5%) and soil application of 40 kg/ha extra K_2O 15 days after last irrigation and observed that the application of 2.5 per cent K_2O and urea resulted in significantly higher cane yield over untreated control.

Singh and Sanjiva Reddy (1980) observed a greater reduction in sucrose per cent in juice and with increased reducing sugars under soil moisture stress conditions. Under optimum soil moisture conditions, the quality was found to be ideal as compared to stress conditions (Parameshwaran *et al.* 1987).

According to Naidu and Srinivasan (1982) application of potassium increased the moisture level of the cane and helped in drought tolerance and enhanced maturity and sugar content. Soil moisture stress at formative phase of the crop significantly increased the stomatal diffusive resistance, thereby decreased the transpiration rate, sucrose per cent in juice and cane yield (Sudam Singh *et al*., 1997).

The experiment conducted by Dighe *et al.* (1983) revealed that, among different methods of cycocel treatment, the seed treatment and foliar spray of cycocel in wheat produced higher grain yield than the application of cycocel through soil drenching.

The maximum sugar yield (7.47 t ha^{-1}) was found in the treatment with foliar spray of urea (2.5%) with potassium chloride (2.5%) at 60, 90 and 120 days as against 6.93 t ha^{-1} in control (Mohan Naidu *et al*., 1983). The cane juice was estimated for its CCS % and the data indicated that irrigation regimes and K levels influenced the quality of cane juice significantly. Optimal soil regimes recorded higher CCS % and badly affected under soil moisture condition. Spraying of potassium sulphate at 2.5 per cent concentration during the hot summer mitigated the drought and significantly increased the cane yield to 16.7 per cent over control (Jayabal and Chockalingam, 1990).

Avijit Sen and Mishra (1984) indicated that seed treatment with 0.25 per cent $CaCl_2$ prolonged the grain filling period in wheat by way of early ear head emergence and consequently increased the grain yield. Application of foliar spray of KCl (1%) increased the seed yield by 21.2 per cent over control in black gram (Chandrababu *et al*., 1985). Similarly, Masood Ali (1985) observed that foliar spray of 2 per cent KCl solution at flowering stage significantly increased grain yield over control (stressed plot) in chickpea.

Srinivasan (1986) evaluated soaking setts in saturated lime water for 2 hours and soaking setts in CCC (200 ppm) and found significant differences of cane yield between the treatments. The foliar spray of CCC (200 ppm) resulted in higher cane yield over control. However, sucrose (%) in juice did not differ due to treatments.

Srinivasan *et al.* (1987) evaluated the effect of foliar spray of some anti-transpirants like phenylmercuric acetate (PMA) @ 20 ppm, atrazine and kaolin (6%) on yield and juice quality of sugarcane during moisture stress conditions at formative stage (60-120 DAP). They observed maximum cane yield with kaolin (6%) spray followed by PMA (20 ppm) in sandy soil but in loamy soil, maximum cane yield (95.3 t/ha) was recorded with PMA foliar spray (20 ppm) over control (87.2 t ha^{-1}). They further analysed the sucrose per cent in juice and CCS (%) and maximum CCS % was found with the foliar spray of atrazine (100 ppm).

Patil (1987) opined that seed treatment with 2 per cent $CaCl_2$ for four hours increased drought resistance in sorghum and also increased the grain yield by 10 per cent over control under dryland conditions. Arjunan and Srinivasan (1989) indicated that the seed hardening groundnut with $CaCl_2$ (1%) significantly increased the mean pod yield by 20 per cent over untreated control under stress condition.

Potassium influences the water economy and crop growth through its effect on water uptake, root growth, maintenance of turgor, transpiration and stomatal regulation (Nelson, 1982). Chalapati (1989) experimented with COC 671 variety of sugarcane with the foliar spray of K_2O (2.5%) and urea (2.5%), on 30^{th}, 60^{th} days after planting and 40 kg/ha K_2O before last two irrigations and found that there was a significant improvement in the yield over water stressed plot).

Chalapati (1989) tried seven different treatments on COC 671 sugarcane variety to evade moisture stress during summer. Preliminary results showed that the treatment i.e., regular irrigation during summer (stress period) ranked first (105 t/ha) in cane yield. The treatment i.e. application of 40 kg K_2O/ha before last two irrigations, spraying of 2.5 per cent K_2O before last two irrigations, spraying of 2.5 per cent K_2O + 2.5 per cent urea before last two irrigations gave maximum yield (85 t/ha) as against control treatment (56 t/ha).

The yield of cane was markedly improved by 24.9 per cent over control by the application of 75 kg/ha K_2O (Raniperumal *et al*., 1989). Similar results of increase in cane yield with K fertilization were reported by Gupta and Shukla (1970). Hunasigi and Srivastava (1983) observed that sucrose per cent was maximum at 225 kg/ha K_2O as compared to control. Similar results of increase in CCS per cent with K fertilization were also reported by Mahamuni *et al.* (1973).

Mondharam *et al.* (1990) reported higher cane yield by soaking sets in saturated lime water or 20 ppm ethrel, spraying of urea and potash at 2.5 per cent during moisture stress period.

Kathiresan and Balasubramanian (1991) observed maximum Brix per cent, more pole per cent cane and higher CCS % in the treatment with trash mulch with additional dose of K_2O. But, maximum percentage of purity was recorded in the treatment with trash mulch coupled with kaolin spray compared to individual treatments.

Nanomura and Benson (1992) revealed that foliar spray of 10 to 30 per cent of methanol increased the growth and development of crops like sorghum, redgram and bengalgram. They also observed an increase of turgidity after several hours of foliar treatment with methanol and also indicated that ethanol or methanol serve as carbon source for plant during the water stress conditions.

Highest cane yield (121 t/ha) was recorded under unstressed condition and was reduced by 11.7 to 19.2 per cent due to stress imposed at tillering and grand growth stages (Subramanian *et al*., 1992), which was attributed to the poor performance of the crop under severe moisture stress, irrespective of stages. However, the reduction of cane yield can be brought to normal through K application @ 125 kg per ha along with one per cent KCl spray at 30, 60 and 90 DAP.

Balakrishnan *et al.* (1993) reported that foliar spray of KCl (1%) resulted in significantly higher yield than the control in brinjal. Amaregouda *et al.* (1994) observed that seed treatment with $CaCl_2$ (2%) had higher yield by 19 per cent in wheat as compared to control. The application of methanol @ 0.25 or 0.5 per cent in soybean at the beginning stage of pod filling increased seed yield significantly due to increase in photosynthetic rate and leaf chlorophyll content (Li *et al*., 1995). Chetti and Pawar (1997) reported that the sorghum grain yield increased with an increase in the concentration of ethanol.

Ali *et al.* (1994) reported that the application of potassium under moisture stress conditions had pronounced effect on cane yield compared to normal soil moisture. The juice quality was also improved by the application of potassium under both the moisture levels, the response being more under stress conditions.

It was seen that mulched treatments with soil application of potash recorded around 3 and 5 tons per hectare more cane yield than potash spray + mulch (Hunshal *et al*., 1996). There was a gradual reduction in stalk length during drought and other attributes such as internodal length, number of internodes, single cane weight and finally commercial cane sugar percentage (Ramesh and Mahadevswamy, 2000).

Varsha and Lakidev (1997) observed that the CCS per cent was significantly higher in the treatment of excess MOP (50 kg/ha) and foliar spray of kaolin over control. Perumal and Pasupathy (1984) tried to reduce the ill effects of drought by using excess K_2O application at different stages of sugarcane and found that, yield of sugarcane where potash supplied to fields prior to commencement of soil moisture stress was higher than the other two treatments (split doses) and they further opined that the application of potash prior to the commencement of moisture stress might have induced higher proline accumulation in the plant system, which in turn, might have acted as an adaptive mechanism for drought tolerance.

Mukund Rao *et al.* (2002) observed that trash mulching coupled with spraying urea (2.5%) + KCl (2.5%) at 1:1 concentration at monthly intervals and split application of potash i.e., half at basal and remaining half prior to summer season significantly improved the cane yield and sucrose content under soil moisture stress.

Annadurai *et al.* (2001) conducted an experiment to study the effect of soil and foliar application of K on quality parameters of sugarcane such as Brix, sucrose, purity, CCS (%) and sugar yield. They opined that K levels (160 kg K_2O ha^{-1}) through soil application in addition to 2.5% foliar spray at 45, 75 and 105 days after planting affected juice quality in terms of Brix, sucrose content, purity and commercial cane sugar. The K application improved sucrose content by reducing the fibre content and increased the juice extraction due to the application of K. It also increased the rate of assimilation of photosynthates and promoted transport of sugars.

Wood and Schroeder (2004) indicated that the K application in sugarcane can mitigate drought and result in a significant increase of cane yield over no K application.

Field experiments were conducted at Regional Research Station, Rudrur by Mukundrao *et al.* (2004) during 2000-01 and 2001-02 for the management of sugarcane clones under drought. Results revealed that the moisture management practices viz., sugarcane trash mulching at 30 DAP, spraying of 2.5% equal mixture of urea + KCl at monthly intervals and split application of potash i.e., half at basal and half prior to summer improved the cane yield significantly over no irrigation during formative stage. Among five sugarcane clones which were susceptible to moisture stress/drought during formative stage were tested along with susceptible check CO-8014, sugarcane clones 93R-44 and 93R747 were identified as prominent clones and can be recommended for drought prone areas with drought management practices to get higher yield. They further observed that average sucrose (%) and CCS production per hectare significantly increased.

III. MATERIAL AND METHODS

Field experiments were conducted during 2004-05 and 2005-06 to study the physiological approaches for drought tolerance in sugarcane variety CoC-671. The details of the materials used and techniques adopted during the course of investigations are described hereunder.

3.1 EXPERIMENTAL SITE

The experiments were carried out at the Research and Development Farm of the Ugar Sugar Works Ltd. Ugar Khurd, district Belgaum, Karnataka State.

3.2 CLIMATE

The Research Farm of Ugar Sugar Works Ltd. is situated in the transitional tract of Karnataka at 16°37'12" N latitude, 74° 51'30" longitude with an altitude of 556 m above mean sea level. The annual rainfall during 2004-05 was 553 mm, while during 2005-06 and 2006-07 it was 647 and 520.5 mm, respectively. The minimum and maximum temperatures and other meteorological data were collected from Meteorological Observatory, Kudachi (Belgaum district) and is presented in Table 1.

3.3 SOIL AND ITS CHARACTERISTICS

The experimental site consisted of deep black clay soil. Composite soil samples from the experimental site were analysed for various physical and chemical properties. The data of soil analysis and the methods employed are given in Table 2a.

3.4 EXPERIMENTAL DETAILS

The experiment consisted of one early maturing sugarcane variety CoC-671 and 11 treatments with two controls viz., one with normal irrigation (20 days intervals) and another one with water stress (40 days intervals).

3.4.1 Treatment details

There were 13 treatments and the experiment was laid out randomized block design with three replications. Stress management treatments were imposed during February month. The details of the treatments are given in Table 2b.

3.4.2 Plot size

Gross plot = 7.0 m length x 5.0 m width

Net plot = 6.3 m length x 4.0 m width

3.5 CULTURAL PRACTICES

3.5.1 Land preparation

The land was ploughed once with a tractor mounted disc and harrowed twice and smoothened with a wooden flank to bring it to a fine tilth so as to facilitate easy sowing. Ridges were made at a distance of 90 cm.

3.5.2 Planting

Single eye bud, disease free sets were obtained from 10 months old pure CoC-671 variety plot at Ugar Sugar Works R & D farm. Before planting, seeds were dipped in 2 per cent bavistin against fungal infection. Planting was done by end to end method with 30 cm distance between the sets. Before planting, soil was treated with malathion dusting to avoid ants and termites, out of 13 treatments, normal sets were planted in 12 plots and for one treatment, the sets were soaked in $CaCl_2$ (3%) for 2 hours for hardening and planted on first October 2004 and 2005.

Table 1. Monthly meteorological data for the year 2004-05 and 2006 of Research farm of the Ugar Sugar works Ltd. Ugarkhurd, Dist. Belgaum

Months	Rainfall (mm)			Temperature (°C)						Relative humidity (%)		
				Maximum			Minimum					
	2004	2005	2006	2004	2005	2006	2004	2005	2006	2004	2005	2006
January	-	-	-	29.00	28.93	29.87	19.48	19.09	15.96	70.87	74.51	67.54
February	-	-	-	31.47	31.35	32.64	21.94	19.61	20.03	68.72	72.96	62.67
March	-	-	41.50	36.16	35.01	35.67	26.03	21.91	23.32	71.20	70.22	67.74
April	-	75.25	-	37.80	36.21	38.57	27.42	24.56	26.36	73.72	71.30	75.13
May	-	82.75	69.50	35.16	38.50	37.75	26.29	25.27	26.52	76.12	75.96	78.67
June	131.25	91.50	71.25	30.53	33.67	30.33	24.30	23.73	25.16	87.00	87.70	87.03
July	84.75	131.50	97.75	30.16	29.96	29.18	23.87	23.86	23.54	90.41	92.00	88.90
August	71.00	60.50	162.00	28.32	29.06	28.72	23.28	22.74	22.88	91.80	91.48	90.32
September	174.50	72.25	7.50	30.16	31.16	30.50	23.60	23.13	22.00	88.96	90.66	87.50
October	92.25	133.25	71.00	30.90	31.29	31.00	23.32	23.03	22.50	78.77	8635	82.00
November	-	-	-	29.32	30.76	30.00	21.75	19.00	20.00	72.60	69.00	70.00
December	-	-	-	29.77	29.15	29.00	19.22	16.44	17.50	69.58	67.77	71.00
Total	553.70	647.00	520.5									

Table 2a. Physical and chemical properties of the soil of the experimental site

	Particulars	Value obtained	Method employed
I.	Physical properties		
	Sand (%)	15	Puri's method (Sankaram, 1966)
	Silt (%)	30	Puri's method (Sankaram, 1966)
	Clay (%)	55	Puri's method (Sankaram, 1966)
b.	Bulk density (g cc^{-1})	1.30	Core sampler method (Piper, 1966)
II.	Chemical properties		
	Available N kg ha^{-1}	160	Monofide Kjeldahl's method (Jackson, 1967)
	Available P kg ha^{-1}	10.03	Olsen's method (Jackson, 1967)
	Available K kg ha^{-1}	249	Flame photometer (Jackson, 1967)
	$CaCO_3$ %	6.4	-
	Fe ppm (DIPA Cylrakhle)	6.86	Atomic absorption spectrophotometer
	Mn ppm (DIPA Cylrakhle)	5.14	Atomic absorption spectrophotometer
	Zn ppm (DIPA Cylrakhle)	1.50	Atomic absorption spectrophotometer
	Cu ppm (DIPA Cylrakhle)	3.28	Atomic absorption spectrophotometer
	pH (soil to water ratio 1:2.5)	8.08	pH meter
	EC dS/m	0.79	EC meter
	Organic carbon (%)	0.30	Walkley and Black wet oxidation method (Jackson, 1967)

Table 2b. Treatment details

Treatments
T_1 : Control (20 days irrigation intervals)
T_2 : Water stress (40 days irrigation intervals)
T_3 : T_2 + Soil application of K_2O (75 kg/ha) before last irrigation
T_4 : T_2+ Foliar spray of KCl (3%) at 160, 200 and 240 DAP
T_5 : T_2+ Foliar spray of urea (3%) + KCl (3%) at 160, 200 and 240 DAP
T_6 : T_2+ Foliar spray of PMA (20 ppm) at 160, 200 and 240 DAP
T_7 : T_2+ Foliar spray of alachlor (200 ppm) at 160, 200 and 240 DAP
T_8 : T_2+ Foliar spray of CCC (100 ppm) at 160, 200 and 240 DAP
T_9 : T_2+ Foliar spray of china clay (6%) at 160, 200 and 240 DAP
T_{10} : T_2+ Foliar spray of kaolin (6%) at 160, 200 and 240 DAP
T_{11} : T_2 + Foliar spray of ethanol (2%) at 160, 200 and 240 DAP
T_{12} : T_2+ Foliar spray of methanol (2%) at 160, 200 and 240 DAP
T_{13} : T_2+ Set soaking with saturated lime water (2%) at the time of planting.

LEGEND

Treatments
T_1 : Control (20 days irrigation intervals)
T_2 : Water stress (40 days irrigation intervals)
T_3 : T_2 + Soil application of K_2O (75 kg/ha) before last irrigation
T_4 : T_2+ Foliar spray of KCl (3%) at 160, 200 and 240 DAP
T_5 : T_2+ Foliar spray of urea (3%) + KCl (3%) at 160, 200 and 240 DAP
T_6 : T_2+ Foliar spray of PMA (20 ppm) at 160, 200 and 240 DAP
T_7 : T_2+ Foliar spray of alachlor (200 ppm) at 160, 200 and 240 DAP
T_8 : T_2+ Foliar spray of CCC (100 ppm) at 160, 200 and 240 DAP
T_9 : T_2+ Foliar spray of china clay (6%) at 160, 200 and 240 DAP
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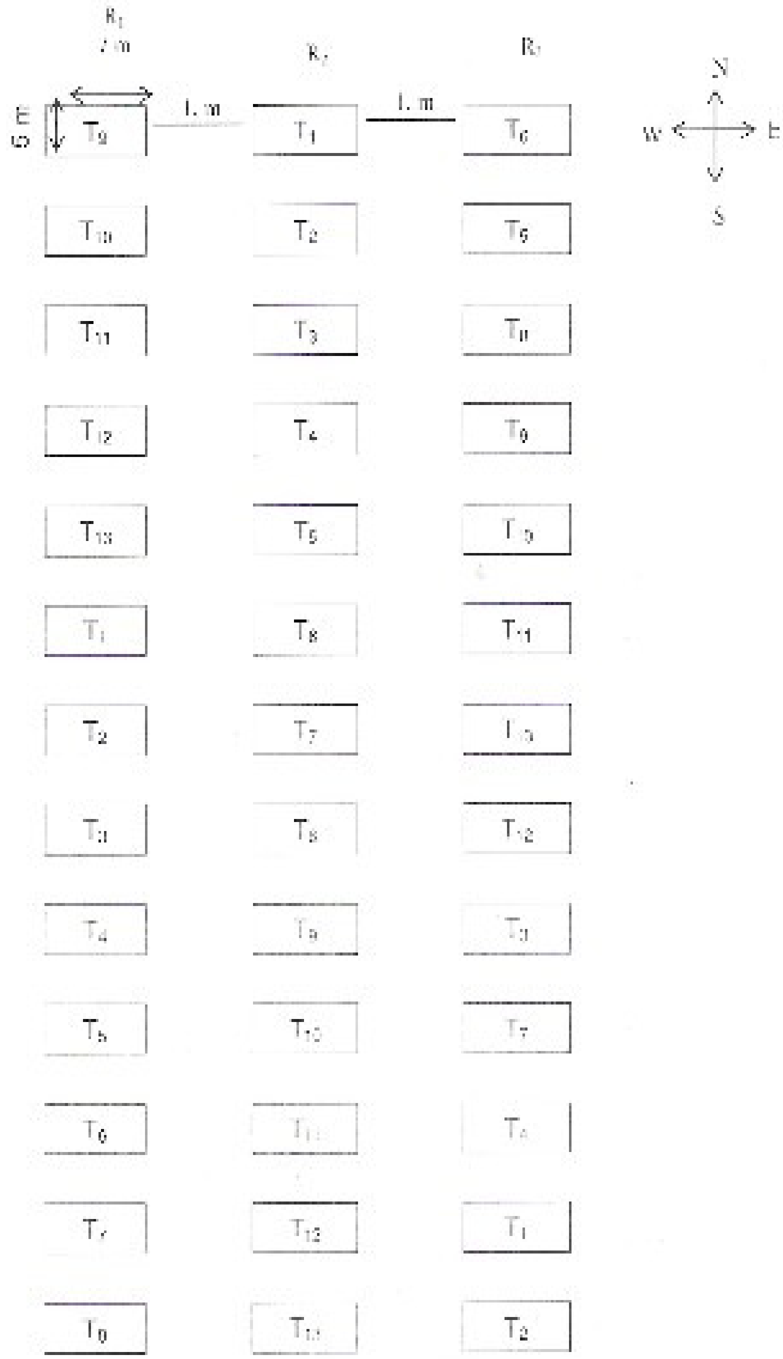

Fig. 1. **Plan of Layout of the experiment**

Fig.1: Plan of Layout of the experiment

3.5.3 Fertilizer application

Recommended fertilizer dose of 250:100:175 kg N, P_2O_5 and K_2O per ha was applied. Out of the total dose, 25 per cent of N, 50 per cent P_2O_5 and K_2O were applied at the time of planting and the rest of the fertilizer was applied in two split doses within 3 months. 75 kg muriate of potash was applied on 1st February 2005 i.e., before last irrigation as per treatment No. 3.

3.5.4 After care

Two hand weedings were done at 3rd and 6th week after planting. There was no pest and disease incidence hence no plant protection measures were taken up. Earthing up was done at 110 days after planting. Till first February 2005, normal irrigation was given to all the treatments. From first February 2005 onwards, irrigation intervals i.e., 20 days irrigation intervals (NI) and 40 days irrigation intervals (stress period) to 12 treatments in each replication were given. Treatments were imposed as per the plan given in Table 2b.

Second experiment was also conducted in same field number at 20 m. away from the first experiment. All the agronomic practices were followed as of first experiment.

3.6 COLLECTION OF EXPERIMENTAL DATA

Plants from each hill were taken randomly in each treatment after 160, 200 and 240 days after planting (DAP) and at harvest for recording the following morphological and physiological parameters, yield and yield attributes.

3.6.1 Morphological characteristics

3.6.1.1 Number of tillers per hill

Three hills in each treatment were used for counting the number of tillers at 160, 200 and 240 DAP and at harvest. Number of tillers per hill was computed by taking the average of three hills.

3.6.1.2 Plant height

Plant height was measured from the base of the plant to the top fully opened leaf of the main shoot at 160, 200, 240 DAP and at harvest. Measurements were taken for the main shoots in each treatment tagged earlier and average height of the single plant was calculated and expressed in cm.

3.6.1.3 Number of internodes

Number of internodes on the main shoot was counted from three hills in each treatment at 160, 200, 240 DAP and at harvest and the average of three main hills was calculated as number of internodes per plant.

3.6.1.4 Leaf area

Leaf area was computed by using index leaf method of Stickler *et al.* (1961) as given below ;

Leaf area = L x W x F

where, L = Maximum length (cm)

W = Maximum width (cm)

F = Factor (0.76).

3.6.1.5 Total dry matter production

For this purpose, plants from three hills at random were cut at the base and separated into leaf, stem and were dried at 80°C to a constant weight at 160, 200, 240 DAP and at harvest. The data was expressed on per hill basis in g.

3.6.1.6 Cane girth

Girth of the middle internode was measured by using Vernier calipers and expressed in cm.

3.6.1.7 Internodal length

Length of middle internode was measured by using scale and expressed in cm.

3.6.1.8 Single cane weight

Single cane was selected from five clumps in each plot and naked whole cane was weighed and expressed in kg/cane.

3.6.2 Growth Parameters

Various growth parameters were calculated from the data obtained from dry weights of different plant parts and leaf area as described below. 3.6.2.1 Leaf area duration (LAD) (days)

3.6.2.1 Leaf area duration (LAD) (days)

Leaf area duration is the integral of leaf area index over the growth period (Watson, 1952). LAD for various growth periods was worked out as per the formula of Power *et al.* (1967).

$$LAD = \frac{L_i + (L_{(i+1)})}{2} \times (t_2 - t_1)$$

where,

L_i = LAI at i^{th} stage

L_{i+1} = LAI at $(i+1)^{th}$ stage

$t_2 - t_1$ = Time interval between i and (i + 1)th stage (days)

3.6.2.2 Leaf area index (LAI)

The LAI per hill was calculated by dividing the leaf area per hill by the land area occupied by the hill (Sestak *et al.*, 1971),

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

3.6.2.3 Specific leaf weight (SLW)

The specific leaf weight indicates the leaf thickness and was determined by the method of Radford (1967).

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

3.6.2.4 Specific leaf area (SLA)

The inverse of specific leaf weight is the specific leaf area and was calculated by using the following formula.

$$SLA = \frac{\text{Leaf area (dm}^2\text{)}}{\text{Leaf dry weight (g)}} \text{ dm}^2 \text{ g}^{-1}$$

3.6.2.5 Absolute growth rate (AGR)

Absolute growth rate was calculated by using the formula given by Radford (1967).

$$AGR = \frac{(W_2 - W_1)}{(t_2 - t_1)} \quad g\ day^{-1}$$

where,

W_2 and W_1 are the dry weights of the plant per hill at time t_1 and t_2, respectively

3.6.2.6 Relative growth rate (RGR)

It is the rate of increase in the dry weight per unit dry weight already present and was calculated by using the formula of Blackman (1919).

$$RGR = \frac{(\log_e W_2 - \log_e W_1)}{(t_2 - t_1)} \quad g\ g^{-1}\ day^{-1}$$

where,

W_1 = Dry weight of the plant at time t_1

W_2 = Dry weight of the plant at time t_2

3.6.2.7 Crop growth rate (CGR)

Crop growth rate is the rate of dry matter production per unit ground area per unit time (Watson, 1952). It was calculated by using the formula,

$$CGR = \frac{(W_2 - W_1)}{(t_2 - t_1)} \times \frac{1}{A} \quad g\ m^{-2}\ day^{-1}$$

where,

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

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

A = Land area (m^2)

3.6.2.8 Net assimilation rate (NAR)

Net assimilation rate is the rate of dry weight increase per unit leaf area per unit time (Watson, 1952). It was calculated by following the formula of Radford (1967).

$$NAR = \frac{(W_2 - W_1)}{(t_2 - t_1)} \times \frac{(\log_e L_2 - \log_e L_1)}{(L_2 - L_1)} \quad g\ dm^{-2}\ day^{-1}$$

where,

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

L_2 and W_2 = Leaf area (dm^2) and dry weight of plant (g), at time t_2

3.6.2.9 Harvest index (HI)

It was calculated by using the formula given by Donald (1967) and expressed in per cent.

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

3.6.3 Biophysical Studies

Measurements of various biophysical parameters viz., stomatal resistance for CO_2 and water vapour exchange, transpiration rate and leaf temperature were made on the abaxial surface of the top fully expanded leaf at 160, 200 and 240 DAP using steady state porometer (LICOR model LI 1600, USA). These measurements were made between 10.00 AM to 12.00 noon on all sampling dates. Stomatal resistance was expressed as s cm^{-1}, whereas, the transpiration rate and leaf temperatures were expressed in terms of µg cm^{-2} s^{-1} and °C, respectively.

The transpiration rate (µg cm^{-2} s^{-1}) was measured directly from the same leaf used for measuring stomatal conductance by the porometer. The leaf temperature (°C) was recorded using the built in thermocouple of the steady state porometer pressed against the abaxial surface of the leaf. The leaves used for measuring stomatal conductance and transpiration rate were simultaneously used for recording the leaf temperature.

3.6.3.1 Relative water content (%)

The relative water content was estimated by the method prescribed by Barrs and Weatherly (1962). Ten discs from the leaves of three hills were collected randomly in each treatment and weighed accurately upto fourth decimal on an electrically operated single pan analytical balance. This was considered as the fresh weight. The weighed leaf discs were allowed to float on distilled water in a Petri dish and allowed to absorb water for four hours. After four hours, the leaf discs were taken out and their surface was blotted gently and weighed. This was referred to as turgid weight after drying these leaf discs in an oven at 70°C for 48 hours, the dry weight was recorded and designated as dry weight. The RWC was calculated by the following formula.

$$RWC(\%) = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Turgid weight} - \text{Dry weight}} \times 100$$

3.6.3.2 Estimation of leaf sheath moisture content

Five leaves were collected from the main plants from each treatment in three replications and leaf sheaths were separated from the leaves. Fresh weight of the leaf sheath was taken and the samples were oven dried at 80^0C and the dry weight of the sample was taken. The per cent leaf sheath moisture was calculated by using the formula.

$$\text{Leaf sheath moisture}(\%) = \frac{\text{Fresh weight - dry weight}}{\text{Dry weight}} \times 100$$

3.6.4 Biochemical Parameters

3.6.4.1 Estimation of chlorophyll content

Total chlorophyll, Chlorophyll ‘a’ and Chlorophyll ‘b’ contents were determined following the method of Arnon (1949) at 160 and 240 DAP.

Fresh leaves from top of the canopy were brought in an ice box from the field and were cut into small pieces. Approximately 250 mg of leaves were weighed from each sample and were homogenized with acetone. The extract was filtered through Whatman No. 1 filter paper and washed twice with 80 per cent acetone. The final volume of the extract was made to 25 ml. The absorbance of the extract was measured at 645, 652 and 663 nm in ultra-spec double beam spectrophotometer (model CL-54). The total chlorophyll, chlorophyll ‘a’ and chlorophyll ‘b’ contents were calculated using the following formulae,

$$\text{Total chlorophyll} = \frac{(20.2 \times A_{645}) + (8.02 \times A_{663})}{a \times 1000 \times W} \times V \quad \text{mg g}^{-1} \text{ fr.wt.}$$

$$\text{Chlorophyll ‘a’} = \frac{(12.7 \times A_{663}) - (2.69 \times A_{645})}{a \times 1000 \times W} \times V \quad \text{mg g}^{-1} \text{ fr.wt.}$$

$$\text{Chlorophyll ‘b’} = \frac{(22.9 \times A_{645}) - (4.68 \times A_{663})}{a \times 1000 \times W} \times V \quad \text{mg g}^{-1} \text{ fr.wt.}$$

where,

A_{645} = Absorbance of the extract at 645 nm

A_{663} = Absorbance of the extract at 663 nm

a = Path length of light in the cuvette (1 cm)

V = Volume of the extract (25 ml)

W = Fresh weight of the sample (0.25 g).

3.6.4.2 Estimation of nitrate reductase activity

Nitrate reductase activity *in vivo* was assayed in leaves by the method of Sardhambal et al (1978). Leaves were cut in to small pieces, weighed and suspended in 25ml flasks containing 0.1 M phosphate buffer (pH 7.6,) 0.02 M $KN0_3$ propanal (5%) and two drops of chloramphenical (0.5 mg/ml) was added. The flasks were incubated at 30°C for 30 minutes. After that, the reaction was terminated by adding 1 ml of 1.0 M zinc acetate and 1.9 ml of 70% ethanol. The contents were centrifuged at 3000g for 10 minutes. Nitrate formed was determined in an aliquot of the supernatant by adding 1 ml of sulphanilamide (1%) in 1.0 M, HCI and 1 ml of N-1 naphthy1-ethelene diamine dihydrochloride (0.02%). The absorbance of the developed pink colour was measured at 540 nm after 20 minutes. The activity of nitrate reductase was determined from a standard curve of $KN0_2$ and expressed as nmoles $N0_2$ formed g fresh weight/hour.

3.6.4.3 Determination of free proline content

Proline content was estimated by the method of Bates *et al.* (1973).

Reagents

1. Aqueous sulfosalicylic acid (3%)
2. Glacial acetic acid
3. Toluene
4. Acid ninhydrin: 1.25 g of ninhydrin was dissolved in a warm mixture of 30 ml of glacial acetic acid and 20 ml of 6 M phosphoric acid.

Procedure

Fresh leaf samples (0.5 g) were collected, ground well in a mortar using pestle and extracted in 10 ml of three per cent sulphosalicylic acid. The extract was filtered through Whatman No. 1 filter paper and the filtrate was used for proline estimation.

An aliquot of 2.0 ml from each sample was taken in separate test tubes and to each test tube, 2.0 ml of acid ninhydrin reagent and 2.0 ml of glacial acetic acid were added and boiled on hot water bath for an hour. Then the test tubes were transferred to ice water bath for cooling and the contents of each test tube were transferred to a separating funnel. To this, 4.0 ml of toluene was added, shaken thoroughly and allowed to form two separate layers.

The upper toluene layer containing the colour complex due to proline-ninhydrin interaction was taken into a separate test tube and the colour was read in ultra-spec double beam spectrophotometer (model CL-54) at 520 nm. The proline concentration was determined from a standard curve prepared using proline and expressed on dry weight basis.

3.6.4.4 Estimation of total soluble sugars

The amount of total soluble sugars present in the extract was estimated by anthrone method (Dobois *et al*., 1951).

Reagents

1. Ethanol (80%)
2. Anthrone reagent: 0.29 g of anthrone was dissolved in 100 ml of concentrated sulphuric acid.

Procedure

1. Extraction of plant sample

Fresh leaf samples were collected randomly from each plot, washed and 1.0 g of the sample was homogenized with 80 per cent ethanol. Homogenised leaf extract was allowed to boil for 2-3 minutes on hot water bath and filtered through Whatman No.1 filter paper. The residue was once again boiled in alcohol for 2-3 minutes and filtered through Whatman No. 1 filter paper. The extraction process was repeated three to four times. Extracted alcohol was used for the estimation of total soluble sugars by using anthrone reagent.

Estimation of sugars

One ml of alcohol extract was taken in a test tube and 4.0 ml of anthrone reagent was allowed to run down the sides of the test tube by keeping the test tubes in an ice bath. The samples were boiled on hot water bath for 10 minutes and allowed to cool at room temperature. The absorbance of the blue green solution was measured at 625 nm and the amount of sugars present in the sample was calculated by using the standard curve prepared from glucose.

3.6.5 Chemical Studies

3.6.5.1 Determination of potassium content in leaves

Procedure

Sample digestion

Usually triacid digestion method was used for estimation of potassium in plant samples. The mixture of concentrated HNO_3, H_2SO_4 and $HClO_4$ was used in the ratio of 10:1:4. Transferred 1 g of dried sample to a 100 ml conical flask and added 5 ml of conc. HNO_3. Glass funnel was kept on the flask, placed it on a water bath and was heated at 100℃ for 30 minutes.

Shifted the flask on hot plate and heated at 180-200℃. Boiling was continued until nearer to dryness. Cooled and added 5 ml of triacid mixture. Again it was heated at 180-200℃ until the dense white fumes are evolved. Continued the digestion until the mixture is largely volatilized. The flask was removed when only moist clear and white contents were left. So entire quantity of $HClO_4$ was volatilized by this stage. Cooled and added about 50 ml distilled water filtered into a 100 ml flask given washing to make the volume to 100 ml. and finally the filtrate was used for analysis.

Estimation of potassium

Known quantity of plant digest was transferred to 50 ml volumetric flask and made up the volume with distilled water. This gave required dilution factor (0.5 ml made upto 50 ml gives 100 times dilution factor) Adjusted the flame photometer reading to zero with 0 ppm K standard solution and 100 with 10 ppm K or 5 ppm K standard solution. Fed the diluted solutions of plant digest and recorded the flame photometer reading. Drawn K standard curve by plotting flame photometer readings on Y axis and concentration of K on X axis found out the concentration of K in diluted plant digest by referring to standard curve, percentage of K was calculated by using the formula.

$$\% K = \frac{\text{ppm from graph}}{10^6} \times \frac{\text{Vol. of digest}}{\text{Wt of plant sample}} \times \text{Dilution factor} \times 100$$

3.6.6 Yield and yield components

Various yield and yield components were estimated as indicated below.

3.6.6.1 Number of millable canes

All the canes from each net plot were cut, dressed, counted and recorded as the number of millable cane per plot. These were expressed as thousands of millable canes per hectare.

3.6.6.2 Single cane weight (kg)

The weight of the millable canes was recorded at harvest and the average of these was workedout and expressed as weight of millable cane in kilograms per cane.

3.6.6.3 Cane yield

All the canes in the plot were cut close to the ground level at 350 DAP. The tops and fresh were removed and cane yield per plot was recorded. The cane yield was expressed in tonnes per hectare.

3.6.7 Quality parameters of sugarcane

3.6.7.1 Brix reading

Brix reading was recorded by using Brix hydrometer. Corrected Brix reading were worked out by noting the room temperature at the time of observation with the help of bur standards.

3.6.7.2 Purity (%)

It is the ratio between sucrose per cent and the corrected brix value expressed as per cent purity of juice.

$$\text{Purity percentage (\%)} = \frac{\text{Sucrose per cent}}{\text{Corrected Brix}} \times 100$$

3.6.7.3 Commercial cane sugar percentage

The commercial cane sugar percentage (CCS%) is the amount of white sugar commercially obtained from cane juice after removing total soluble solids. It was calculated by using the formula.

CCS (%) = {Sucrose % - (brix % - Sucrose%) x 0.40} x 0.75

CCS percentage is converted into tonnes per hectare.

3.7 STATISTICAL ANALYSIS

Fischer’s method of analysis of variance was applied for the analysis of the data and interpretation of results as suggested by Panse and Sukhatme (1967). The level of significance used in 'F' and 't' test was P = 0.05. Critical difference (CD) values were calculated at 5 per cent probability level, wherever 'F' test was significant.

IV. EXPERIMENTAL RESULTS

Field experiments were conducted during 2004-05 and 2005-06 at Research and Development Farm of Ugar Sugar Works Ltd., UgarKhurd to study the influence of different stress mitigating treatments on various morpho-physiological, growth, biochemical and yield parameters in sugarcane (Cv. CoC-671). The results obtained from the investigation are presented in this chapter.

4.1 MORPHOLOGICAL PARAMETERS

4.1.1 Plant height (cm)

The data on plant height presented in Table 3 indicated that it increased continuously from 160 days after planting (DAP) until harvest or maturity in all the treatments and the treatments differed significantly at all the stages. It was further observed that the plant height almost doubled between 240 DAP and harvest. At 160 DAP, T_1 had significantly higher plant height over all other treatments. Similarly, T_{11} and T_{12} had similar plant height and were also maximum but less than the control. However, no significant differences were observed between T_4, T_5, T_{10}, T_{11}, T_{12} and T_{13} at this stage. Significantly a lower plant height was observed in T_2 compared to all other treatments. A similar trend continued at 200 and 240 DAP with T_1 having significantly taller plant and T_2 having significantly the least plant height over all other treatments.

At harvest, control treatment with irrigation at 20 days continued to maintain significantly higher plant height. However, significantly a lower plant height was recorded in T_2 compared to all other treatments. The treatments T_3, T_4, T_5, T_7 and T_8 did not differ significantly among themselves. Similarly, the treatments T_6 and T_2 were on par with each other.

4.1.2 Number of tillers

The data on number of tillers per hill presented in Table 4 indicated that the tillers were maximum at 160 days after planting (DAP) in all the treatments. The maximum number of tillers was noticed in control treatment with irrigation at 20 days intervals. The treatments T_{10}, T_{12} and T_{13} were on par with each other and also with control. At 200 DAP, there was a reduction in tiller number compared to 160 DAP in all the treatments. These trends continued even at 240 DAP and harvest.

At harvest, treatment T_{12} had significantly more number of tillers over all other treatments, except control. While, T_3, T_8 and T_{11} had the same number of tillers but were on par with T_5, T_6, T_7, T_9 and T_{13} treatments.

4.1.3 Length of the internodes

The length of internodes increased from 160 days after planting (DAP) until harvest in all the treatments (Table 5). At 160 DAP, maximum internodal length was recorded in control which was significantly superior over T_2, T_4, T_7, T_8, T_{10} and T_{12} treatments. Significantly a shorter internodal length was recorded in T_2 compared to all other treatments. The treatments T_7, T_8 and T_{10} had the same internodal length and were significantly lower over control. While, T_3, T_5, T_6, T_9 and T_{13} were on par with each other.

At 200 DAP, irrigation at 20 days interval (T_1) recorded maximum internodal length which was significantly superior over all other treatments. While, irrigation at 40 days interval (T_2) had the least internodal length and was found to be significantly lower over all other treatments. A similar trend continued at 240 DAP and among the treatments, maximum internodal length was observed in T_{13} followed by T_4 and T_{10}. While, T_5 and T_7 had the same internodal length.

At harvest, T_1 had significantly a maximum internodal length over all other treatments. The treatment T_2 continued to maintain significantly lower internodal length over all other treatments, except T_4, T_5, T_{10} and T_{12}.

Table 3.Influence of agrochemicals on plant height (cm) at different stages in sugarcane (pooled)

Treatments	Days after planting			
	160	200	240	At harvest
T_1 – Control*	140.2	179.9	204.1	387.7
T_2 – Water stress**	115.1	146.1	165.4	335.8
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	131.1	167.5	188.9	363.7
T_4 - T_2+ Foliar spray of KCl (3%)	134.8	160.8	179.0	362.4
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	135.2	172.2	186.6	355.5
T_6 - T_2+ Foliar spray of PMA (20 ppm)	133.7	161.3	181.2	338.3
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	129.3	171.0	180.8	359.0
T_8 - T_2+ Foliar spray of CCC (100 ppm)	132.6	164.7	181.3	359.1
T_9 - T_2+ Foliar spray of china clay (6%)	134.0	162.0	181.0	346.6
T_{10} - T_2+ Foliar spray of kaolin (6%)	135.2	158.5	182.2	345.9
T_{11} - T_2 + Foliar spray of ethanol (2%)	136.3	168.1	180.4	355.0
T_{12} - T_2+ Foliar spray of methanol (2%)	136.3	160.0	178.0	349.1
T_{13} - T_2+ Set soaking with saturated lime water (2%)	134.7	169.1	175.1	344.7
Mean	132.9	164.7	181.7	354.1
S.Em ($\pm$)	3.53	2.09	2.95	3.63
CD (5%)	10.15	6.00	8.49	10.45

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Table 4. Influence of agrochemicals on number of tillers/hill at different stages in sugarcane (pooled)

Treatments	Days after planting			
	160	200	240	At harvest
T_1 – Control*	8.5	7.8	5.9	5.1
T_2 – Water stress**	6.7	7.0	4.1	4.1
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	7.3	6.7	4.7	4.6
T_4 - T_2+ Foliar spray of KCl (3%)	7.2	6.5	4.5	4.4
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	7.0	5.8	4.8	4.5
T_6 - T_2+ Foliar spray of PMA (20 ppm)	7.5	5.8	4.9	4.5
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	7.5	6.3	4.8	4.4
T_8 - T_2+ Foliar spray of CCC (100 ppm)	7.8	6.0	5.0	4.6
T_9 - T_2+ Foliar spray of china clay (6%)	7.3	6.2	4.5	4.4
T_{10} - T_2+ Foliar spray of kaolin (6%)	8.0	6.7	4.8	4.8
T_{11} - T_2 + Foliar spray of ethanol (2%)	7.7	5.5	4.6	4.6
T_{12} - T_2+ Foliar spray of methanol (2%)	8.0	5.0	5.0	5.4
T_{13} – T_2+ Set soaking with saturated lime water (2%)	8.2	5.5	4.8	4.7
Mean	7.6	6.2	4.8	4.4
S.Em (±)	0.37	0.30	0.17	0.20
CD (5%)	1.05	0.85	0.55	0.56

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate
** - Crop was irrigated at 40 days int

4.1.4 Girth of internodes

Girth of internodes was slightly lower than the length of the internodes at all the stages (Table 6). At 160 days after planting (DAP), control had significantly higher girth of internodes over all other treatments. Among the treatments, T_5, T_{11} and T_{12} had the same girth of internodes and were on par with T_3, T_4 and T_7 treatments. At 200 DAP, again control recorded significantly higher girth of internodes over all other treatments. The treatments T_5, T_6 and T_{11} were found to have similar values (8.0 cm) and did not differ significantly with T_9, T_{11} and T_{13} treatments. It was T_3 which had the maximum girth of internodes. A similar trend was also found at 240 DAP.

At harvest, the treatment T_2 had significantly lower girth of internodes over T_1 and T_4, but did not differ significantly with rest of the treatments. The treatments T_7 and T_{13} had the same values (8.8 cm) and did not differ significantly with T_{11} and T_{12} treatments.

4.1.5 Leaf area

The data on leaf area per hill at different stages as influenced by different agrochemicals presented in Table 7 indicated that it was more in control at all the stages. Treatments differed significantly at all the stages and it increased continuously from 160 DAP to harvest. At 160 DAP, control had significantly higher leaf area over all other treatments. Among other treatments, T_9 had maximum leaf area which was significantly higher over all other treatments except T_3, T_5 and T_7.

At 200 DAP also T_2 recorded significantly lower leaf area over all other treatments. The treatment T_{11} and T_{12} had same leaf area and were on par with T_{10}, T_{12}. At 240 DAP, control continued to maintain significantly higher leaf area over all other treatments. However, the treatments T_5, T_7, T_8, T_{10} and T_{12} were on par with each other.

At harvest, control continued to maintain significantly higher leaf area over all other treatments. While, the treatments T_6, T_{10}, T_{11}, T_{12} and T_{13} were the next best treatments after T_1 and were found to be on par with each other and significantly lower compared to control.

4.1.6 Total dry matter

The total dry matter was found to increase from 160 DAP till harvest in all the treatments and the treatments differed significantly at all the stages (Table 8). At 160 DAP, control treatment recorded significantly higher total dry matter over all other treatments. Among other treatments, T_6 was shown to have maximum total dry matter and was significantly superior over T_2, T_3 and T_7. At 200 DAP, T_2 had significantly lower total dry matter and T_1 recorded significantly higher total dry matter over all other treatments. At 240 DAP, control continued to maintain significantly higher total dry matter over all other treatments.

At harvest, T_2 had significantly lower total dry matter over all other treatments. Among other treatments, T_3 had the maximum total dry matter and was significantly higher over all other treatments except T_4, T_9 and T_{10}. The treatments T_7, T_9 and T_{13} were on par with each other.

4.2 BIOPHYSICAL PARAMETERS

4.2.1 Leaf sheath moisture content

The data on leaf sheath moisture indicated that it decreased from 160 days after planting (DAP) to 240 DAP (Table 9). The treatments differed significantly at both the stages. At 140 DAP, T_7 recorded significantly higher leaf sheath moisture content over all other treatments except T_1, T_4, T_5, T_6 and T_{11}. While, the treatments T_3, T_8, T_{12} and T_{13} were found to be on par with each other.

At 240 DAP, the leaf sheath moisture content was significantly superior in T_1 over other treatments except T_3, T_5, T_7 and T_8. While, the rest of the treatments were on par with each other except T_2. The treatment T_2 had significantly lower leaf sheath moisture content over all other treatments.

Table 5. Influence of agrochemicals on length of the internodes (cm) at different stages in sugarcane (pooled)

Treatments	Days after planting			
	160	200	240	At harvest
T_1 – Control*	8.5	10.2	11.3	12.2
T_2 – Water stress**	6.4	6.6	7.5	9.6
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	7.8	8.6	8.9	10.9
T_4 - T_2+ Foliar spray of KCl (3%)	7.3	8.1	9.5	10.3
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	7.8	8.2	8.8	10.3
T_6 - T_2+ Foliar spray of PMA (20 ppm)	7.9	8.1	9.3	10.7
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	7.5	8.1	8.8	10.7
T_8 - T_2+ Foliar spray of CCC (100 ppm)	7.5	8.3	8.7	10.2
T_9 - T_2+ Foliar spray of china clay (6%)	7.9	8.4	8.6	10.8
T_{10} - T_2+ Foliar spray of kaolin (6%)	7.5	8.5	9.5	9.9
T_{11} - T_2 + Foliar spray of ethanol (2%)	8.0	8.5	9.2	10.6
T_{12} - T_2+ Foliar spray of methanol (2%)	7.7	8.3	9.4	10.1
T_{13} - T_2+ Set soaking with saturated lime water (2%)	7.9	8.5	9.6	10.4
Mean	7.7	8.3	9.2	10.6
S.Em (±)	0.25	0.25	0.24	0.25
CD (5%)	0.73	0.71	0.70	0.71

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Table 6. Influence of agrochemicals on girth of the internodes (cm) at different stages in sugarcane (pooled)

Treatments	Days after planting			
	160	200	240	At harvest
T_1 – Control*	8.2	10.2	10.7	11.2
T_2 – Water stress**	6.2	6.6	7.5	8.1
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	7.1	8.7	8.8	9.4
T_4 - T_2+ Foliar spray of KCl (3%)	7.1	8.6	9.4	9.7
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	7.3	8.0	8.3	9.3
T_6 - T_2+ Foliar spray of PMA (20 ppm)	7.0	8.0	8.5	9.0
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	7.2	7.6	8.0	8.8
T_8 - T_2+ Foliar spray of CCC (100 ppm)	7.1	8.6	8.3	9.3
T_9 - T_2+ Foliar spray of china clay (6%)	7.0	8.2	8.2	9.2
T_{10} - T_2+ Foliar spray of kaolin (6%)	6.9	7.8	8.5	9.4
T_{11} - T_2 + Foliar spray of ethanol (2%)	7.3	8.0	8.3	8.9
T_{12} - T_2+ Foliar spray of methanol (2%)	7.3	7.8	7.8	8.6
T_{13} - T_2+ Set soaking with saturated lime water (2%)	7.5	7.9	7.7	8.8
Mean	7.2	8.1	8.5	9.2
S.Em ($\pm$)	0.16	0.23	0.14	0.49
CD (5%)	0.47	0.66	0.41	1.42

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Table 7. Influence of agrochemicals on leaf area (dm^2/hill) at different stages in sugarcane (pooled)

Treatments	Days after planting			
	160	200	240	At harvest
T_1 – Control*	14.2	31.6	38.0	41.4
T_2 – Water stress**	8.4	23.3	27.4	30.3
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	12.4	28.4	30.9	33.5
T_4 - T_2+ Foliar spray of KCl (3%)	10.4	27.5	30.7	32.2
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	11.8	28.7	32.5	33.5
T_6 - T_2+ Foliar spray of PMA (20 ppm)	10.4	28.5	31.6	35.7
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	12.3	29.0	32.6	32.9
T_8 - T_2+ Foliar spray of CCC (100 ppm)	10.8	29.5	31.5	33.6
T_9 - T_2+ Foliar spray of china clay (6%)	13.2	30.1	32.4	34.8
T_{10} - T_2+ Foliar spray of kaolin (6%)	11.0	29.7	32.3	35.2
T_{11} - T_2 + Foliar spray of ethanol (2%)	9.9	29.8	32.2	35.8
T_{12} - T_2+ Foliar spray of methanol (2%)	9.7	29.7	32.0	35.2
T_{13} - T_2+ Set soaking with saturated lime water (2%)	10.4	29.8	33.1	36.3
Mean	11.2	28.8	32.1	34.6
S.Em (±)	0.30	0.54	0.37	0.56
CD (5%)	0.85	1.55	1.06	1.61

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.

** - Crop was irrigated at 40 days interval

Table 8. Influence of agrochemicals on total dry matter (g/hill) at different stages in sugarcane (pooled)

Treatments	Days after planting			
	160	200	240	At harvest
T_1 – Control*	286.5	585.5	895.6	1531.1
T_2 – Water stress**	207.3	443.2	613.5	1031.1
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	249.3	511.3	762.5	1271.7
T_4 - T_2+ Foliar spray of KCl (3%)	266.5	514.5	776.5	1165.6
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	258.4	544.6	763.6	1223.6
T_6 - T_2+ Foliar spray of PMA (20 ppm)	266.9	551.8	772.0	1215.1
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	248.1	545.7	817.3	1177.0
T_8 - T_2+ Foliar spray of CCC (100 ppm)	255.4	538.3	731.6	1213.2
T_9 - T_2+ Foliar spray of china clay (6%)	261.3	541.6	777.5	1161.6
T_{10} - T_2+ Foliar spray of kaolin (6%)	257.0	534.2	787.5	1175.1
T_{11} - T_2 + Foliar spray of ethanol (2%)	256.6	538.8	846.5	1198.3
T_{12} - T_2+ Foliar spray of methanol (2%)	251.6	544.6	840.5	1188.2
T_{13} - T_2+ Set soaking with saturated lime water (2%)	259.5	538.5	767.5	1177.6
Mean	256.9	533.2	775.5	1209.0
S.Em (±)	5.620	12.93	20.23	33.29
CD (5%)	16.150	37.162	58.43	95.66

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.

** - Crop was irrigated at 40 days interval

4.2.2 Relative water content

The data on relative water content presented in Table 10 increased from 160 to 240 DAP and differed significantly between the treatments at both the stages. It was found to be maximum (92.4%) in T_{13} but differed significantly only with T_1, T_2, T_4 and T_{12} and was on par with rest of the treatments at 160 DAP. At 240 DAP, the relative water content was higher in T_5 and T_{10} which had the similar values (77.4%) followed by T_7 (77.2) and T_3 (76.1). The treatment T_{12} had the lower relative water content of 69.7 per cent but did not differ significantly with T_2, T_1, T_4, T_6, T_{11} and T_{13}. The relative water content was almost declined by 10 per cent on an average from 160 to 240 DAP.

4.2.3 Diffusive resistance

The diffusive resistance was found to increase from 160 to 240 DAP in all the treatments and it almost doubled between 160 and 200 DAP (Table 11).

The treatments differed significantly at all the stages with control recording significantly lower diffusive resistance over all other treatments. At 160 DAP, significantly higher diffusive resistance was recorded in T_2 compared to all other treatments. The treatments T_7 and T_8 had the lower diffusive resistance to all other treatments except T_1 but were on par with each other.

At 200 DAP, T_8 recorded significantly higher diffusive resistance over all other treatments, even it was higher compared to T_2. The other treatments also differed significantly among themselves. While, at 240 DAP, T_2 had significantly higher diffusive resistance compared to all other treatments followed by T_7 and T_6. Significant difference between other treatments was evident. However, the treatments T_6 and T_{13}; T_{11} and T_{12}; T_5, T_7 and T_{10} were on par among themselves.

4.2.4 Transpiration rate

The transpiration rate decreased continuously from 160 to 240 DAP in all the treatments with T_2 consistently recording significantly lower transpiration rate over all other treatments at all the stages (Table 12).

The treatments also differed significantly at all the stages. At 160 DAP, T_7 recorded significantly higher transpiration rate (68.71 $\mu g/cm^2/s$) followed by T_8 (66.75 $\mu g/cm^2/s$) over all other treatments and they did not differ significantly among themselves. Similarly, the treatments T_1, T_3, T_4, T_5, T_6 and T_{12} were on par with each other. At 200 DAP, the maximum transpiration rate was recorded in T_1 which was significantly superior over rest of the treatments. However, the treatments T_3, T_4, T_5, T_6 and T_{10}; T_{12} and T_{13} were on par with each other. Similar trends continued even at 240 DAP with T_1 recording significantly higher transpiration rate over all other treatments. While, the treatments T_3, T_4 and T_{10}; T_6 and T_7; T_5, T_8, T_{10}, T_{12} and T_{13} were on par among themselves.

4.2.5 Leaf temperature

The data on leaf temperature presented in Table 13 indicated that it increased from 160 days after planting (DAP) until 240 DAP and the treatments differed significantly at 200 and 240 DAP. Although at 160 DAP, no significant differences were observed between the treatments, T_3, T_5, T_8 and T_{10} had the maximum leaf temperature and were same. At 200 DAP, T_2 showed maximum temperature, but it was significantly higher over all other treatments except T_5. At 240 DAP, T_4 recorded significantly higher leaf temperature compared to T_5, T_8, T_{11} and T_{12} treatments. However, no significant differences were observed between T_3, T_4, T_6, T_7, T_9, T_{10} and T_{13} treatments.

4.3 GROWTH PARAMETERS

4.3.1 Leaf area index

Leaf area index was found to increase from 160 DAP until harvest (Table 14). At 160 DAP, control recorded significantly higher LAI over all other treatments, except T_9. Among other treatments, T_3 and T_7 had the same LAI (3.7) and were on par with T_5 and T_9 treatments. The treatment T_2 had significantly lower LAI over all other treatments. At 200 DAP, control recorded significantly higher LAI compared to all other treatments, except T_8 and

Table 9. Influence of agrochemicals on leaf sheath moisture content (%) at different stages in sugarcane (pooled)

Treatments	Days after planting	
	160	240
T_1 – Control*	74.1	73.8
T_2 – Water stress**	66.8	61.6
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	68.2	70.8
T_4 - T_2+ Foliar spray of KCl (3%)	74.6	69.6
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	72.8	71.4
T_6 - T_2+ Foliar spray of PMA (20 ppm)	73.7	70.7
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	75.0	71.4
T_8 - T_2+ Foliar spray of CCC (100 ppm)	68.4	70.9
T_9 - T_2+ Foliar spray of china clay (6%)	66.8	67.4
T_{10} - T_2+ Foliar spray of kaolin (6%)	63.4	66.8
T_{11} - T_2 + Foliar spray of ethanol (2%)	74.1	70.6
T_{12} - T_2+ Foliar spray of methanol (2%)	68.0	67.5
T_{13} - T_2+ Set soaking with saturated lime water (2%)	68.4	69.3
Mean	70.4	69.4
S.Em ($\pm$)	1.49	1.56
CD (5%)	4.29	4.48

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.

** - Crop was irrigated at 40 days interval

Table 10. Influence of agrochemicals on relative water content (%) at different stages in sugarcane (pooled)

Treatments	Days after planting	
	160	240
T_1 – Control*	69.3	73.8
T_2 – Water stress**	82.9	72.0
T_3 – T_2+ Soil application of K_2O (75 kg/ha)	90.2	76.1
T_4 - T_2+ Foliar spray of KCl (3%)	80.8	72.9
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	83.4	77.4
T_6 - T_2+ Foliar spray of PMA (20 ppm)	86.3	73.9
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	91.2	77.2
T_8 - T_2+ Foliar spray of CCC (100 ppm)	86.4	75.3
T_9 - T_2+ Foliar spray of china clay (6%)	87.7	75.3
T_{10} - T_2+ Foliar spray of kaolin (6%)	88.4	77.4
T_{11} - T_2 + Foliar spray of ethanol (2%)	88.6	74.6
T_{12} - T_2+ Foliar spray of methanol (2%)	82.5	69.7
T_{13} - T_2+ Set soaking with saturated lime water (2%)	92.4	73.7
Mean	85.4	74.5
S.Em (±)	3.36	1.74
CD (5%)	9.64	5.00

* - Crop was irrigated at 20 days interval   PMA - Phenyl mercuric acetate.

** - Crop was irrigated at 40 days interval

Table 11. Influence of agrochemicals on diffusive resistance (DR, s cm^{-1}) at different stages in sugarcane (pooled)

Treatments	Days after planting		
	160	200	240
T_1 – Control*	0.321	0.673	0.742
T_2 – Water stress**	1.422	1.327	1.995
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	0.678	1.004	1.043
T_4 - T_2+ Foliar spray of KCl (3%)	0.614	1.020	1.071
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	0.622	1.376	1.210
T_6 - T_2+ Foliar spray of PMA (20 ppm)	0.654	1.391	1.665
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	0.526	1.451	1.745
T_8 - T_2+ Foliar spray of CCC (100 ppm)	0.543	1.535	1.294
T_9 - T_2+ Foliar spray of china clay (6%)	0.648	1.192	1.321
T_{10} - T_2+ Foliar spray of kaolin (6%)	0.636	1.140	1.252
T_{11} - T_2 + Foliar spray of ethanol (2%)	0.688	1.012	1.175
T_{12} - T_2+ Foliar spray of methanol (2%)	0.650	1.054	1.195
T_{13} - T_2+ Set soaking with saturated lime water (2%)	0.632	1.215	1.670
Mean	0.670	1.180	1.315
S.Em (±)	0.03	0.02	0.04
CD (5%)	0.08	0.06	0.10

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Table 12. Influence of agrochemicals on transpiration rate (TR, $\mu g cm^{-2} s^{-1}$) at different stages in sugarcane (pooled)

Treatments	Days after planting		
	160	200	240
T_1 – Control*	59.67	56.00	51.36
T_2 – Water stress**	34.89	20.78	16.50
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	58.72	32.05	29.97
T_4 - T_2+ Foliar spray of KCl (3%)	59.79	33.42	28.67
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	57.99	30.75	26.11
T_6 - T_2+ Foliar spray of PMA (20 ppm)	58.54	32.12	21.57
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	68.71	34.43	22.40
T_8 - T_2+ Foliar spray of CCC (100 ppm)	66.75	34.40	26.72
T_9 - T_2+ Foliar spray of china clay (6%)	54.65	40.96	25.60
T_{10} - T_2+ Foliar spray of kaolin (6%)	52.87	31.31	26.39
T_{11} - T_2 + Foliar spray of ethanol (2%)	50.20	48.39	27.32
T_{12} - T_2+ Foliar spray of methanol (2%)	57.91	37.20	26.85
T_{13} - T_2+ Set soaking with saturated lime water (2%)	60.02	37.87	26.21
Mean	56.56	36.13	27.36
S.Em (±)	1.30	1.04	0.98
CD (5%)	3.72	2.98	2.81

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Table 13. Influence of agrochemicals on leaf temperature (°C) at different stages in sugarcane (pooled)

Treatments	Days after planting		
	160	200	240
T_1 – Control*	30.8	33.1	34.0
T_2 – Water stress**	30.6	32.0	34.4
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	30.9	32.2	34.0
T_4 - T_2+ Foliar spray of KCl (3%)	30.8	33.0	34.7
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	30.9	32.9	33.4
T_6 - T_2+ Foliar spray of PMA (20 ppm)	30.7	32.4	34.6
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	30.5	32.2	34.6
T_8 - T_2+ Foliar spray of CCC (100 ppm)	30.9	32.3	33.9
T_9 - T_2+ Foliar spray of china clay (6%)	30.6	32.3	34.0
T_{10} - T_2+ Foliar spray of kaolin (6%)	30.9	32.7	34.2
T_{11} - T_2 + Foliar spray of ethanol (2%)	30.8	32.4	33.5
T_{12} - T_2+ Foliar spray of methanol (2%)	30.7	31.5	33.4
T_{13} - T_2+ Set soaking with saturated lime water (2%)	30.7	32.8	34.3
Mean	30.8	32.4	34.2
S.Em (±)	0.37	0.46	0.41
CD (5%)	NS	0.91	0.78

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

T_9 treatments. While, the treatments T_3, T_5, T_6 and T_{11} were on par with each other. Same trend was observed even at 240 DAP, wherein T_7, T_{10} and T_{12} had the same LAI (9.67) and were on par with T_5, T_8, T_9 and T_{11} treatments.

At harvest, control continued to maintain significantly higher LAI compared to all other treatments, while T_2 had significantly lower LAI over all other treatments. The treatments T_{10} and T_{12} had the same LAI (10.60) and were on par with T_5, T_6, T_9, T_{11} and T_{13} treatments.

4.3.2 Leaf area duration

The data on leaf area duration (LAD) presented in Table 15 indicated that it increased from 160 - 200 DAP to 240 DAP-harvest. At 160 – 200 DAP, control treatment recorded significantly higher LAD (271.4 days) over all other treatments except T_9. Whereas, T_2 had significantly lower LAD (186.0 days) over all other treatments.

At 200 – 240 DAP, the treatments T_5, T_6, T_7, T_8, T_{10}, T_{11} and T_{12} were on par with each other. While, the treatment T_2 showed the least LAD (298.6 days) but significant differences were observed over all other treatments. Among the treatments T_{13} had the maximum LAD (379.2 days) but was on par with T_7, T_8, T_9, T_{10}, T_{11} and T_{12} treatments.

At 240 DAP-harvest, control recorded significantly higher LAD over all other treatments. Among the treatments T_{13} recorded maximum LAD but on par with the treatments T_6, T_9, T_{10}, T_{11} and T_{12}.

4.3.3 Specific leaf weight

Specific leaf weight (SLW) was found to increase from 160 DAP to harvest (Table 16). At 160 DAP, control recorded significantly lower SLW compared to all other treatments except T_3, T_7, T_8 and T_9 treatments. The treatment T_2 recorded significantly higher SLW compared to all other treatments. Same trend was observed even at 200 DAP. At 240 DAP, the treatments T_8 and T_{10} had the same SLW (8.0 g/dm^2) and were found to have non-significant differences over all other treatments, except control.

At harvest, control recorded significantly higher SLW compared to all other treatments, except T_2 and T_3 treatments. The treatments T_5 and T_{11} had the same SLW and were on par with all other treatments except T_1 and T_{13}.

4.3.4 Specific leaf area

The data on specific leaf area (SLA) presented in Table 17 indicated that it decreased from 160 days after planting (DAP) until harvest. At 160 DAP, the treatments T_3 and T_9 had same SLA and were significantly superior over all other treatments except T_1, T_7 and T_8. Same trend was observed even at 200 DAP. At 240 DAP, T_2 recorded significantly higher SLA over all other treatments. The treatments T_6, T_9 and control had the same SLA (0.125 dm^2/g) and were on par with T_4, T_5, T_7, T_8, T_{10}, T_{11}, T_{12} and T_{13} treatments.

At harvest, T_{10} recorded significantly higher SLA over all other treatments. While, control had the least SLA and was significantly lower over all other treatments.

4.3.5 Absolute growth rate

Absolute growth rate (AGR) was found to decrease from 160-200 days after planting (DAP) until 240 DAP-harvest. At 160-200 DAP, control treatment was on par with T_5, T_6, T_7, T_8, T_9, T_{10}, T_{11}, T_{12} and T_{13} treatments.

The treatment, T_2 had significantly lower AGR over all other treatments except T_3 and T_4 treatments. Among the treatments, T_7 had the maximum AGR but was on par with all other treatments except T_2 and T_4. At 200-240 DAP, T_{11} had the maximum AGR among the treatments, but was on par with T_7, T_{12} and control. The treatments T_3, T_4, T_7, T_9, T_{10} and T_{13} showed non-significant differences among themselves.

At 240-harvest, control continued to maintain significantly higher AGR compared to all other treatments. The treatments T_2, T_4, T_6, T_9, T_{10} and T_{13} were on par with each other. Among the treatments, T_{12} recorded significantly lower AGR over all other treatments, except T_7 T_9, T_{10} and T_{11} treatments.

Table 14. Influence of agrochemicals on leaf area index (LAI) at different stages in sugarcane (pooled)

Treatments	Days after planting			
	160	200	240	At harvest
T_1 – Control*	4.07	9.50	11.43	12.43
T_2 – Water stress**	2.60	6.70	8.23	9.10
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	3.70	8.57	9.20	10.10
T_4 - T_2+ Foliar spray of KCl (3%)	3.13	8.40	8.87	9.77
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	3.53	8.50	9.60	10.40
T_6 - T_2+ Foliar spray of PMA (20 ppm)	3.10	8.73	9.43	10.70
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	3.70	8.92	9.67	10.00
T_8 - T_2+ Foliar spray of CCC (100 ppm)	3.27	9.17	9.57	10.10
T_9 - T_2+ Foliar spray of china clay (6%)	3.97	9.13	9.80	10.53
T_{10} - T_2+ Foliar spray of kaolin (6%)	3.33	8.82	9.67	10.60
T_{11} - T_2 + Foliar spray of ethanol (2%)	2.97	8.77	9.77	10.57
T_{12} - T_2+ Foliar spray of methanol (2%)	2.90	8.93	9.67	10.60
T_{13} - T_2+ Set soaking with saturated lime water (2%)	3.07	9.03	9.93	10.67
Mean	3.33	8.71	9.60	10.43
S.Em ($\pm$)	0.10	0.13	0.11	0.13
CD (5%)	0.29	0.38	0.31	0.38

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Table 15. Influence of agrochemicals on leaf area duration (LAD, days) at different stages in sugarcane (pooled)

Treatments	Days after planting		
	160-200	200-240	240-harvest
T_1 – Control*	271.2	418.6	1073.7
T_2 – Water stress**	186.0	298.6	779.8
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	240.1	355.4	868.5
T_4 - T_2+ Foliar spray of KCl (3%)	230.6	345.4	838.8
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	240.6	362.0	900.0
T_6 - T_2+ Foliar spray of PMA (20 ppm)	236.6	363.2	905.8
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	252.4	371.8	885.2
T_8 - T_2+ Foliar spray of CCC (100 ppm)	248.8	374.8	885.2
T_9 - T_2+ Foliar spray of china clay (6%)	262.0	378.6	914.8
T_{10} - T_2+ Foliar spray of kaolin (6%)	243.0	369.8	912.2
T_{11} - T_2 + Foliar spray of ethanol (2%)	234.8	370.8	915.2
T_{12} - T_2+ Foliar spray of methanol (2%)	236.6	372.00	912.2
T_{13} - T_2+ Set soaking with saturated lime water (2%)	242.0	379.2	927.7
Mean	240.38	355.1	901.4
S.Em (±)	4.65	5.41	7.25
CD (5%)	13.37	15.55	22.5

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Table 16. Influence of agrochemicals on specific leaf weight (SLW, g dm^{-2}) at different stages in sugarcane (pooled)

Treatments	Days after planting			
	160	200	240	At harvest
T_1 – Control*	6.63	7.40	8.53	10.07
T_2 – Water stress**	8.73	8.33	7.53	9.73
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	6.67	6.93	7.85	9.67
T_4 - T_2+ Foliar spray of KCl (3%)	7.27	7.53	8.27	9.23
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	7.50	7.50	7.90	9.40
T_6 - T_2+ Foliar spray of PMA (20 ppm)	7.37	7.37	8.07	9.30
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	6.83	6.87	8.13	9.17
T_8 - T_2+ Foliar spray of CCC (100 ppm)	6.67	6.87	8.00	9.20
T_9 - T_2+ Foliar spray of china clay (6%)	6.40	7.00	7.73	9.27
T_{10} - T_2+ Foliar spray of kaolin (6%)	7.40	7.17	8.00	9.00
T_{11} - T_2 + Foliar spray of ethanol (2%)	7.23	7.33	7.57	9.40
T_{12} - T_2+ Foliar spray of methanol (2%)	7.47	7.23	7.77	9.13
T_{13} - T_2+ Set soaking with saturated lime water (2%)	7.30	7.10	7.96	8.77
Mean	7.19	7.28	7.90	9.33
S.Em ($\pm$)	0.17	0.08	0.18	0.21
CD (5%)	0.48	0.24	0.50	0.62

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.

** - Crop was irrigated at 40 days interval

4.3.6 Relative growth rate

The data on relative growth rate (RGR) presented in Table 18 indicated that it decreased from 160 – 200 DAP to 240 – harvest. At 160 – 200 DAP, non-significant differences were observed between the treatments. At 200 – 240 DAP, the treatments T_{11} and T_{12} had the same RGR (0.0047 g/g/day) and were maximum but did not differ significantly with other treatments, except T_2, T_5, T_8 and T_{13} treatments. While, T_3, T_4, T_6, T_7, T_9 and T_{10} were on par with each other.

At 240 – harvest, control treatment was significantly superior over T_3, T_4, T_7, T_9, T_{11}, T_{12} and T_{13} treatments. However, non-significant differences were observed between T_2, T_5, T_6, T_8, T_9 and T_{10} treatments. Among the treatments, T_8 and T_{10} had the same RGR (0.0033 g/g/day) and were the maximum.

4.3.7 Crop growth rate

The data on crop growth rate presented in Table 20 was found to decrease from 160-200 DAP until 240 DAP -harvest. At 160-200 DAP, control treatment recorded significantly higher CGR (2.56 g/dm^2/day) compared to all other treatments, except T_6, T_7, T_8, T_9, T_{10}, T_{11} and T_{13} treatments. Among the treatments, T_6 and T_7 had the same CGR and were the maximum, but were on par with T_3, T_4, T_5, T_8, T_9, T_{10}, T_{11}, T_{12} and T_{13} treatments. At 200-240 DAP, control treatment recorded significantly higher CGR over all other treatments, except T_{11} and T_{12}. The treatment T_2 recorded significantly lower CGR (1.41 g/dm^2/day) compared to all other treatments.

At 240 - harvest, control treatment continued to maintain significantly higher CGR compared to all other treatments. Among the treatments T_{11} was found to have lower CGR (1.29 g/dm^2/day), but on par with T_4, T_7, T_9 and T_{12} treatments. The treatment T_2 recorded significantly lower CGR over all other treatments, except T_5, T_6 and T_8 treatments.

4.3.8 Net assimilation rate

It was observed that net assimilation rate (NAR) decreased from 160-200 DAP, 240 DAP-harvest (Table 21). At 160-200 DAP, T_{11} recorded the maximum NAR, but was on par with all other treatments, except the treatment T_3. The treatments, T_2 and T_4 had the same NAR (0.165 g/dm^2/day) and were found to be non-significant with other treatments including control. At 200-240 DAP, control treatment recorded significantly higher NAR (0.108 g/dm^2/day) over all other treatments except T_3, T_5, T_7, T_{10}, T_{11}, T_{12} and T_{13} treatments. However, T_7, T_{10} and T_{12} had the same NAR and were maximum, but on par with T_3, T_5, T_7, T_8, T_9, T_{10}, T_{11}, T_{12} and T_{13} treatments.

At 240-harvest, T_2 had the maximum NAR and was found to be significantly higher compared to all other treatments, except T_8 treatment. The treatments T_3, T_4, T_5, T_6, T_7, T_9, T_{10} and T_{13} were found to be non-significant among themselves. The treatments T_7 and T_{13} had the same NAR (0.059 g/dm^2/day), but were on par with T_3, T_4 and T_7 treatments. The treatment T_{11} had significantly lower NAR compared to all other treatments, except T_4, T_7, T_9, T_{10}, T_{12} and T_{13} treatments.

4.4 BIOCHEMICAL PARAMETERS

4.4.1 Chlorophyll ‘a’ content

The data on chlorophyll ‘a’ content at different stages presented in Table 22 indicated that at 160 DAP control treatment had significantly higher chlorophyll content (0.970 mg/g fr. wt.) over all other treatments. Among the treatments, T_8 recorded significantly lower chlorophyll content (0.550 mg/g fr. wt.) compared to all other treatments, except T_2 treatment. The treatments T_4, T_7, T_9, T_{10}, T_{12} and T_{13} were found to be non significant among themselves. The treatments T_{10} and T_{12} had the same chlorophyll ‘a’ content (0.683 mg g^{-1}/fr.wt) but were on par with T_4, T_7, T_9 and T_{13} treatments.

At 200 DAP, T_2 had significantly lower chlorophyll ‘a’ content compared to all other treatments, except T_{11}. The treatment T_3 had the maximum chlorophyll ‘a’ content but was on par with T_5, T_6 and T_7 treatments. The treatments T_7 and T_{12} had the same chlorophyll ‘a’

Table 17. Influence of agrochemicals on specific leaf area (SLA, $dm^2\ g^{-1}$) at different stages in sugarcane (pooled)

Treatments	Days after planting			
	160	200	240	At harvest
T_1 – Control*	0.147	0.133	0.125	0.010
T_2 – Water stress**	0.112	0.118	0.145	0.101
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	0.153	0.143	0.129	0.102
T_4 - T_2+ Foliar spray of KCl (3%)	0.138	0.130	0.115	0.108
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	0.129	0.132	0.116	0.105
T_6 - T_2+ Foliar spray of PMA (20 ppm)	0.134	0.122	0.125	0.104
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	0.145	0.137	0.122	0.106
T_8 - T_2+ Foliar spray of CCC (100 ppm)	0.146	0.142	0.123	0.105
T_9 - T_2+ Foliar spray of china clay (6%)	0.153	0.140	0.125	0.107
T_{10} - T_2+ Foliar spray of kaolin (6%)	0.133	0.137	0.129	0.109
T_{11} - T_2 + Foliar spray of ethanol (2%)	0.136	0.138	0.131	0.105
T_{12} - T_2+ Foliar spray of methanol (2%)	0.133	0.137	0.127	0.106
T_{13} - T_2+ Set soaking with saturated lime water (2%)	0.139	0.145	0.131	0.106
Mean	0.138	0.135	0.126	0.106
S.Em (±)	0.001	0.001	0.001	0.001
CD (5%)	0.010	0.010	0.010	0.0011

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

content (0.803 mg/g fr. wt.) but were found to be non-significant with T_3, T_4, T_5, T_6, T_8 and T_{13} treatments.

Table 18. Influence of agrochemicals on absolute growth rate (AGR, g day^{-1}) at different stages in sugarcane (pooled)

Treatments	Days after planting		
	160-200	200 –240	240-harvest
T_1 – Control*	7.47	7.75	7.07
T_2 – Water stress**	5.89	4.25	4.64
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	6.55	4.53	4.57
T_4 - T_2+ Foliar spray of KCl (3%)	6.20	6.55	4.32
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	7.15	5.47	5.11
T_6 - T_2+ Foliar spray of PMA (20 ppm)	7.12	5.50	4.92
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	7.44	6.79	3.99
T_8 - T_2+ Foliar spray of CCC (100 ppm)	7.07	4.83	5.35
T_9 - T_2+ Foliar spray of china clay (6%)	7.01	5.89	4.26
T_{10} - T_2+ Foliar spray of kaolin (6%)	6.93	6.33	4.30
T_{11} - T_2 + Foliar spray of ethanol (2%)	7.05	7.69	3.90
T_{12} - T_2+ Foliar spray of methanol (2%)	7.32	7.52	3.86
T_{13} - T_2+ Set soaking with saturated lime water (2%)	6.97	5.72	4.55
Mean	6.93	6.05	4.67
S.Em ($\pm$)	0.31	0.34	0.16
CD (5%)	0.89	0.97	0.46

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Table 19. Influence of Agrochemicals on relative growth rate (RGR, g g^{-1} day^{-1}) at different stages in sugarcane (pooled)

Treatments	Days after planting		
	160-200	200-240	240- harvest
T_1 – Control*	0.0086	0.0045	0.0039
T_2 – Water stress**	0.0073	0.0034	0.0035
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	0.0077	0.0042	0.0028
T_4 - T_2+ Foliar spray of KCl (3%)	0.0074	0.0041	0.0027
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	0.0078	0.0036	0.0032
T_6 - T_2+ Foliar spray of PMA (20 ppm)	0.0067	0.0041	0.0030
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	0.0084	0.0044	0.0025
T_8 - T_2+ Foliar spray of CCC (100 ppm)	0.0081	0.0032	0.0033
T_9 - T_2+ Foliar spray of china clay (6%)	0.0078	0.0038	0.0028
T_{10} - T_2+ Foliar spray of kaolin (6%)	0.0079	0.0040	0.0033
T_{11} - T_2 + Foliar spray of ethanol (2%)	0.0082	0.0047	0.0023
T_{12} - T_2+ Foliar spray of methanol (2%)	0.0082	0.0047	0.0025
T_{13} - T_2+ Set soaking with saturated lime water (2%)	0.0078	0.0037	0.0027
Mean	0.0078	0.0040	0.0029
S.Em (±)	0.0001	0.0001	0.0001
CD (5%)	NS	0.0010	0.0010

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Table 20. Influence of agrochemicals on crop growth rate (CGR, g dm^{-2} day^{-1}) at different stages in sugarcane (pooled)

Treatments	Days after planting		
	160-200	200-240	240-harvest
T_1 – Control*	2.56	2.58	2.35
T_2 – Water stress**	1.84	1.41	1.78
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	2.17	2.15	1.52
T_4 - T_2+ Foliar spray of KCl (3%)	2.27	1.69	1.43
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	2.24	1.76	1.75
T_6 - T_2+ Foliar spray of PMA (20 ppm)	2.43	1.78	1.63
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	2.43	2.26	1.33
T_8 - T_2+ Foliar spray of CCC (100 ppm)	2.32	1.63	1.77
T_9 - T_2+ Foliar spray of china clay (6%)	2.36	1.94	1.44
T_{10} - T_2+ Foliar spray of kaolin (6%)	2.31	2.04	1.45
T_{11} - T_2 + Foliar spray of ethanol (2%)	2.42	2.56	1.29
T_{12} - T_2+ Foliar spray of methanol (2%)	2.28	2.50	1.28
T_{13} - T_2+ Set soaking with saturated lime water (2%)	2.37	1.92	1.48
Mean	2.31	2.02	1.58
S.Em ($\pm$)	0.09	0.07	0.05
CD (5%)	0.26	0.20	0.15

* - Crop was irrigated at 20 days interval   PMA - Phenyl mercuric acetate.

** - Crop was irrigated at 40 days interval

Table 20. Influence of agrochemicals on crop growth rate (CGR, g m^2 day^{-1}) at different stages in sugarcane (pooled)

Treatments	Days after planting		
	160-200	200-240	240-harvest
T_1 – Control*	27.65	28.70	26.18
T_2 – Water stress**	21.10	15.74	17.18
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	24.25	16.77	23.81
T_4 - T_2+ Foliar spray of KCl (3%)	22.96	24.25	16.00
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	26.48	20.25	18.92
T_6 - T_2+ Foliar spray of PMA (20 ppm)	26.37	20.37	18.22
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	27.55	25.14	14.77
T_8 - T_2+ Foliar spray of CCC (100 ppm)	26.18	17.88	19.81
T_9 - T_2+ Foliar spray of china clay (6%)	25.96	21.81	15.77
T_{10} - T_2+ Foliar spray of kaolin (6%)	25.66	23.44	15.92
T_{11} - T_2 + Foliar spray of ethanol (2%)	26.11	28.48	14.44
T_{12} - T_2+ Foliar spray of methanol (2%)	27.11	27.37	14.30
T_{13} - T_2+ Set soaking with saturated lime water (2%)	25.81	21.18	16.85
Mean	25.66	22.40	17.85
S.Em ($\pm$)	0.64	0.48	0.42
CD (5%)	1.83	1.50	1.30

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Table 21. Influence of agrochemicals on net assimilation rate (NAR, g dm^{-2} day^{-1}) at different stages in sugarcane (pooled)

Treatments	Days after planting		
	160-200	200-240	240-harvest
T_1 – Control*	0.154	0.108	0.076
T_2 – Water stress**	0.165	0.068	0.079
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	0.147	0.091	0.061
T_4 - T_2+ Foliar spray of KCl (3%)	0.165	0.072	0.058
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	0.161	0.084	0.068
T_6 - T_2+ Foliar spray of PMA (20 ppm)	0.163	0.071	0.064
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	0.161	0.105	0.059
T_8 - T_2+ Foliar spray of CCC (100 ppm)	0.162	0.076	0.071
T_9 - T_2+ Foliar spray of china clay (6%)	0.156	0.078	0.055
T_{10} - T_2+ Foliar spray of kaolin (6%)	0.167	0.105	0.056
T_{11} - T_2 + Foliar spray of ethanol (2%)	0.173	0.104	0.049
T_{12} - T_2+ Foliar spray of methanol (2%)	0.167	0.105	0.050
T_{13} - T_2+ Set soaking with saturated lime water (2%)	0.164	0.079	0.059
Mean	0.160	0.092	0.061
S.Em (±)	0.01	0.01	0.00
CD (5%)	0.02	0.03	0.01

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval.

4.4.2 Chlorophyll ‘b’ content

The data on chlorophyll ‘b’ content presented in Table 23 indicated that at 160 DAP, the treatment T_6 recorded significantly higher chlorophyll ‘b’ content (0.646 mg/g fr. wt.) over all other treatments except T_3, T_5. While, the treatment, T_9 had significantly lower chlorophyll ‘b’ content compared to all other treatments except T_2, T_{11} and T_{12}. Non-significant differences were also found between T_3, T_4, T_5, T_6 and T_7 treatments.

At 240 DAP, T_4 recorded significantly higher chlorophyll ‘b’ content as compared to all other treatments, except T_4 and T_7 treatments. However, non significant differences were observed between T_3, T_4, T_5, T_6, T_7 and T_9 treatments.

4.4.3 Total chlorophyll content

The data on total chlorophyll content as influenced by different agrochemicals presented in Table 24 indicated that at 160 DAP, the treatment control recorded significantly higher total chlorophyll content (1.603 mg/g fr. wt.) over all other treatments, except T_3. Whereas, T_{10} recorded significantly lower total chlorophyll content (1.016 mg/g fr. wt.) compared to all other treatments, except T_{12} and T_{13}.

In general, the total chlorophyll content slightly increased at 240 DAP, compared to 160 DAP. At this stage, T_3 recorded the maximum total chlorophyll content (1.480 mg/g fr. wt.) and was found to have non significant differences with other treatments, except T_9, T_{11}, T_{12} and T_{13}. Among the treatments, T_3, T_4, T_5, T_6, T_7, T_8, T_9 and T_{10} were on par with each other.

4.4.4 Nitrate-reductase activity

The data on nitrate reductase activity (NRA) presented in Table 25 indicated that control had significantly higher NRA as compared to all other treatments except T_{12} at 160 DAP. Among other treatments, T_{12} recorded significantly higher NRA (981.1 nmol/g fr. wt.) over all other treatments except T_{13}. The treatments, T_2, T_4, T_6, T_7 and T_{11} were on par with each other.

At 240 DAP also control continued to maintain significantly higher NRA (966.5 nmol/g fr. wt.) and T_2 had significantly lower NRA over all other treatments. Among other treatments, T_8 recorded the maximum NRA, but was on par with T_5, T_6, T_7 and T_{13} treatments. However, no significant differences were observed between T_3, T_4, T_6, T_7, T_9, T_{10}, T_{11} and T_{12} treatments.

4.4.5 Proline content

The data on proline content at different stages indicated that control had significantly lower proline content as compared all other treatments at 160 DAP (Table 26). Among the treatments, T_2 had the maximum proline content (168.27 mg/g fr. wt.) but was on par with T_5, T_7 treatments. The non-significant differences were observed between T_3, T_6, T_8, T_9, T_{10}, T_{11}, T_{12} and T_{13} treatments.

At 240 DAP, control recorded significantly lower proline content over all other treatments. However, non significant differences were also found between T_4, T_6, T_7, T_8, T_9, T_{10}, T_{11}, T_{12} and T_{13} treatments. The treatment T_2 had significantly higher proline content as compared to all other treatments.

4.4.6 Total sugar content

The data on total sugar content indicated significant differences between the treatments at both the stages (Table 27). At 160 DAP the maximum total sugar content (19.7 mg/g fr. wt.) in leaves was found in control which was significantly higher over all other treatments. Among other treatments, T_{13} had the maximum total sugar content (17.97 mg/g fr. wt.) but was on par with T_7, T_8, T_{10} and T_{12} treatments.

At 240 DAP, T_2 recorded significantly lower total sugar content over all other treatments. The treatments T_7 and T_{10} had the same total sugar content (18.00 mg/g fr. wt.) and were significantly higher total sugar content over all other treatments except T_3, T_9, T_{11}, T_{12} and T_{13}. The treatments T_3, T_4, T_5, T_6, T_9 and T_{13} were on par with each other.

Table 22. Influence of agrochemicals on chlorophyll 'a' content (mg g^{-1} fr. wt.) at different stages in sugarcane (pooled)

Treatments	Days after planting	
	160	240
T_1 – Control*	0.970	0.980
T_2 – Water stress**	0.576	0.656
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	0.806	0.813
T_4 - T_2+ Foliar spray of KCl (3%)	0.660	0.770
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	0.910	0.790
T_6 - T_2+ Foliar spray of PMA (20 ppm)	0.800	0.806
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	0.650	0.803
T_8 - T_2+ Foliar spray of CCC (100 ppm)	0.550	0.760
T_9 - T_2+ Foliar spray of china clay (6%)	0.643	0.740
T_{10} - T_2+ Foliar spray of kaolin (6%)	0.683	0.716
T_{11} - T_2 + Foliar spray of ethanol (2%)	0.620	0.693
T_{12} - T_2+ Foliar spray of methanol (2%)	0.683	0.803
T_{13} - T_2+ Set soaking with saturated lime water (2%)	0.693	0.756
Mean	0.711	0.775
S.Em (±)	0.021	0.020
CD (5%)	0.050	0.050

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.

** - Crop was irrigated at 40 days interval

Table 23. Influence of agrochemicals on chlorophyll 'b' content (mg g^{-1} fr. wt.) at different stages in sugarcane (pooled)

Treatments	Days after planting	
	160	240
T_1 – Control*	0.643	0.640
T_2 – Water stress**	0.326	0.590
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	0.593	0.670
T_4 - T_2+ Foliar spray of KCl (3%)	0.540	0.690
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	0.596	0.610
T_6 - T_2+ Foliar spray of PMA (20 ppm)	0.646	0.640
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	0.560	0.680
T_8 - T_2+ Foliar spray of CCC (100 ppm)	0.400	0.546
T_9 - T_2+ Foliar spray of china clay (6%)	0.320	0.626
T_{10} - T_2+ Foliar spray of kaolin (6%)	0.426	0.600
T_{11} - T_2 + Foliar spray of ethanol (2%)	0.376	0.603
T_{12} - T_2+ Foliar spray of methanol (2%)	0.373	0.400
T_{13} - T_2+ Set soaking with saturated lime water (2%)	0.406	0.460
Mean	0.480	0.596
S.Em (±)	0.021	0.030
CD (5%)	0.061	0.080

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Table 24. Influence of agrochemicals on total chlorophyll content (mg g^{-1} fr. wt.) at different stages in sugarcane (pooled)

Treatments	Days after planting	
	160	240
T_1 – Control*	1.603	1.620
T_2 – Water stress**	1.323	1.260
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	1.506	1.480
T_4 - T_2+ Foliar spray of KCl (3%)	1.236	1.473
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	1.450	1.420
T_6 - T_2+ Foliar spray of PMA (20 ppm)	1.396	1.470
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	1.190	1.370
T_8 - T_2+ Foliar spray of CCC (100 ppm)	1.320	1.440
T_9 - T_2+ Foliar spray of china clay (6%)	1.390	1.330
T_{10} - T_2+ Foliar spray of kaolin (6%)	1.016	1.413
T_{11} - T_2 + Foliar spray of ethanol (2%)	1.410	1.196
T_{12} - T_2+ Foliar spray of methanol (2%)	1.066	1.313
T_{13} - T_2+ Set soaking with saturated lime water (2%)	1.086	1.303
Mean	1. 307	1.392
S.Em (±)	0.050	0.038
CD (5%)	0.151	0.112

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Table 25. Influence of agrochemicals on nitrate reductase activity (nmol g^{-1} fr. wt. hr^{-1}) at different stages in sugarcane (pooled)

Treatments	Days after planting	
	160	240
T_1 – Control*	1026.0	966.5
T_2 – Water stress**	852.8	634.0
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	921.0	722.5
T_4 - T_2+ Foliar spray of KCl (3%)	874.6	694.0
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	907.6	750.0
T_6 - T_2+ Foliar spray of PMA (20 ppm)	853.6	739.0
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	871.6	746.0
T_8 - T_2+ Foliar spray of CCC (100 ppm)	911.1	778.0
T_9 - T_2+ Foliar spray of china clay (6%)	890.9	712.5
T_{10} - T_2+ Foliar spray of kaolin (6%)	897.3	707.5
T_{11} - T_2 + Foliar spray of ethanol (2%)	869.6	708.0
T_{12} - T_2+ Foliar spray of methanol (2%)	981.1	709.0
T_{13} – T_2+ Set soaking with saturated lime water (2%)	956.8	772.0
Mean	908.8	741.6
S.Em ($\pm$)	15.25	17.24
CD (5%)	46.72	51.21

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Table 26. Influence of agrochemicals on proline content (mg g^{-1} fr. wt.) at different stages in sugarcane (pooled)

Treatments	Days after planting	
	160	240
T_1 – Control*	112.57	111.50
T_2 – Water stress**	168.27	179.42
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	150.97	139.18
T_4 - T_2+ Foliar spray of KCl (3%)	159.95	157.98
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	162.18	168.67
T_6 - T_2+ Foliar spray of PMA (20 ppm)	153.67	163.39
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	161.45	166.65
T_8 - T_2+ Foliar spray of CCC (100 ppm)	152.03	162.89
T_9 - T_2+ Foliar spray of china clay (6%)	155.02	161.28
T_{10} - T_2+ Foliar spray of kaolin (6%)	155.98	161.33
T_{11} - T_2 + Foliar spray of ethanol (2%)	157.10	164.82
T_{12} - T_2+ Foliar spray of methanol (2%)	152.18	165.85
T_{13} - T_2+ Set soaking with saturated lime water (2%)	154.53	160.33
Mean	153.53	158.72
S.Em ($\pm$)	2.87	4.01
CD (5%)	8.24	11.51

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

4.5 CHEMICAL PARAMETERS

4.5.1 Potassium content

The potassium content in control was found to be significantly higher at 160 DAP (Table 28) over all other treatments except T_7 and T_{11} treatments. The treatment T_2 recorded significantly lower potassium content compared to all other treatments, but it was on par with the treatments T_3, T_4, T_5, T_6 and T_{12}. Among the treatments, T_4 and T_6 had the same potassium content but had non-significant differences with T_2, T_3, T_5, T_6, T_8 and T_{12} treatments.

At 240 DAP, the non-significant differences were observed between T_2, T_3, T_4, T_6, T_7, T_8, T_9, T_{11}, T_{12} and T_{13} treatments. However, control recorded significantly higher potassium content compared to all other treatments, except T_3. The same percentage of potassium content was observed between T_6 and T_{12} (1.28%) and T_8 and T_9 (1.32%) treatments. The treatment T_5 had significantly lower potassium content compared to all other treatments, except T_4 and T_7.

4.6 YIELD AND YIELD COMPONENTS

4.6.1 Net millable canes

Net millable canes presented in Table 29 indicated that it was significantly higher in control compared to all other treatments. The treatments T_6, T_7, T_9, T_{10} and T_{13} were almost had the same number of millable canes, but had non significant differences with T_2, T_4, T_5, T_8 and T_{11} treatments. Among other treatments, T_3 (97.30) and T_{12} (97.65) had maximum number of millable canes and T_2 had the minimum number of millable canes (81.67).

4.6.2 Yield

It was observed that the cane yield was significantly higher in control (113.6 t/ha) as compared to all other treatments. While, the treatment T_2 recorded significantly lower cane yield (76.2 t/ha) over all other treatments. Among treatments, T_3 and T_{10} almost had the same yield but were on par with T_4, T_5, T_6, T_7, T_8, T_{12} and T_{13} treatments.

4.6.3 Single cane weight

The data on single cane weight presented in Table 29 indicated that it was significantly higher in control (1.06 kg) over all other treatments, except T_2, T_5, T_9 and T_{12}. However, the treatments T_6 and T_8 (0.98 kg); T3, T_{11} and T_{13} (0.97 kg) had the same single cane weight but was on par with each other.

4.6.4 Fibre content

It was found that control did not differ significantly with other treatments, except T_7 and T_{11} (Table 30). Among other treatments, T_7 and T_{11} had same fibre content (16.17%) and had non significant differences with all other treatments, except T_3 and T_6 treatments. The treatments T_2, T_5, T_{12} and T_{13} had same fibre content but on par with all other treatments.

4.6.5 Commercial cane sugar (CCS %)

The control recorded significantly higher commercial cane sugar (CCS) over all other treatments, except T_9 and T_{11} treatments (Table 30). However, T_5 and T_7 had same CCS (11.29%), but were on par with all other treatments. The treatment T_{11} had least CCS and it was significantly lower over T_1, T_6 and T_8 and was on par with the rest of the treatments.

4.6.6 Sugar production per hectare

Data on sugar production per hectare (Table 30) indicated that control treatment had significantly higher values over all other treatments. The treatment T_2 had the lowest sugar production over all other treatments. Among other treatments, T_3 had the maximum sugar production (10.62 t/ha), but was on par with other treatments, except T_2. The treatments T_4 and T_5 had same sugar production and were found significantly lower over control.

Table 27. Influence of agrochemicals on total sugar content in leaves (mg g^{-1} dry wt.) at different stages in sugarcane (pooled)

Treatments	Days after planting	
	160	240
T_1 – Control*	19.70	21.57
T_2 – Water stress**	13.40	14.60
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	15.97	16.83
T_4 - T_2+ Foliar spray of KCl (3%)	14.87	16.43
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	16.52	16.42
T_6 - T_2+ Foliar spray of PMA (20 ppm)	17.07	16.43
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	16.47	18.00
T_8 - T_2+ Foliar spray of CCC (100 ppm)	16.83	18.43
T_9 - T_2+ Foliar spray of china clay (6%)	15.33	16.93
T_{10} - T_2+ Foliar spray of kaolin (6%)	16.40	18.00
T_{11} - T_2 + Foliar spray of ethanol (2%)	15.60	17.23
T_{12} - T_2+ Foliar spray of methanol (2%)	16.23	17.22
T_{13} - T_2+ Set soaking with saturated lime water (2%)	17.97	16.62
Mean	16.33	17.29
S.Em ($\pm$)	0.64	0.48
CD (5%)	1.83	1.38

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Table 28. Influence of agrochemicals on potassium content (%) in leaves at different stages in sugarcane (pooled)

Treatments	Days after planting	
	160	240
T_1 – Control*	1.58	1.44
T_2 – Water stress**	1.28	1.24
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	1.39	1.33
T_4 - T_2+ Foliar spray of KCl (3%)	1.31	1.21
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	1.35	1.14
T_6 - T_2+ Foliar spray of PMA (20 ppm)	1.31	1.28
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	1.54	1.23
T_8 - T_2+ Foliar spray of CCC (100 ppm)	1.40	1.32
T_9 - T_2+ Foliar spray of china clay (6%)	1.44	1.32
T_{10} - T_2+ Foliar spray of kaolin (6%)	1.43	1.26
T_{11} - T_2 + Foliar spray of ethanol (2%)	1.51	1.24
T_{12} - T_2+ Foliar spray of methanol (2%)	1.35	1.28
T_{13} - T_2+ Set soaking with saturated lime water (2%)	1.38	1.27
Mean	1.41	1.27
S.Em (+)	0.04	0.04
CD (5%)	0.11	0.11

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.

** - Crop was irrigated at 40 days interval

Table 29. Influence of agrochemicals on net millable cane (000 ha^{-1}), yield (t ha^{-1}) and single cane weight (kg) in sugarcane (pooled)

Treatments	Days after planting		
	NMC (000 ha^{-1})	Yield (t ha^{-1})	Single cane weight (kg)
T_1 – Control*	106.60	113.6	1.06
T_2 – Water stress**	81.67	76.2	0.93
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	97.30	94.4	0.97
T_4 - T_2+ Foliar spray of KCl (3%)	90.30	93.9	1.03
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	95.60	90.6	0.94
T_6 - T_2+ Foliar spray of PMA (20 ppm)	89.57	87.6	0.98
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	89.30	88.3	0.99
T_8 - T_2+ Foliar spray of CCC (100 ppm)	90.93	89.3	0.98
T_9 - T_2+ Foliar spray of china clay (6%)	89.44	85.8	0.96
T_{10} - T_2+ Foliar spray of kaolin (6%)	89.44	94.7	1.05
T_{11} - T_2 + Foliar spray of ethanol (2%)	88.61	86.1	0.97
T_{12} - T_2+ Foliar spray of methanol (2%)	97.65	89.2	0.91
T_{13} - T_2+ Set soaking with saturated lime water (2%)	89.65	86.8	0.97
Mean	91.66	90.5	0.98
S.Em (±)	2.44	4.621	0.058
CD (5%)	7.00	8.245	0.100

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Table 30. Influence of agrochemicals on fibre content (%) and CCS (%) and sugar production ($q\ ha^{-1}$) in sugarcane (pooled)

Treatments	Fibre (%)	CCS (%)	Sugar production ($t\ ha^{-1}$)
T_1 – Control*	14.67	11.84	13.40
T_2 – Water stress**	15.50	11.09	8.45
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	14.83	11.26	10.62
T_4 - T_2+ Foliar spray of KCl (3%)	15.00	11.02	10.34
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	15.50	11.29	10.32
T_6 - T_2+ Foliar spray of PMA (20 ppm)	14.67	11.63	10.18
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	16.17	11.29	9.97
T_8 - T_2+ Foliar spray of CCC (100 ppm)	15.67	11.48	10.52
T_9 - T_2+ Foliar spray of china clay (6%)	15.00	11.01	9.45
T_{10} - T_2+ Foliar spray of kaolin (6%)	15.33	11.17	10.59
T_{11} - T_2 + Foliar spray of ethanol (2%)	16.17	10.49	9.04
T_{12} - T_2+ Foliar spray of methanol (2%)	15.50	11.31	10.08
T_{13} - T_2+ Set soaking with saturated lime water (2%)	15.50	11.15	9.68
Mean	15.35	11.23	10.19
S.Em ($\pm$)	0.45	0.29	6.245
CD (5%)	1.30	0.83	16.50

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

4.6.7 Brix value (%)

The data on brix value presented in Table 31 indicated that the control treatment did not differ significantly with all other treatments, except T_2, T_{10}, T_{11} and T_{13} treatments. Among the treatments, T_{11} had the lower brix content which was found significantly lower over all other treatments except T_{10}. The treatments, T_7, T_8 and T_{12} had almost same brix content but did not differ significantly with other treatments.

4.6.8 Pole in cane

It was observed that the control treatment had the maximum pole in cane per cent over all other treatments except T_{11} (Table 31). The treatments T_2 and T_{13} had the same pole in cane (18.01%) but did not differ significantly with all other treatments. Among other treatments, T_{11} recorded significantly lower pole in cane compared to all other treatments.

4.6.9 Purity

The data on purity per cent presented in Table 31 indicated that it was maximum (86.97%) in $T_{8,}$ but was on par with all other treatments, except T_6, T_{11} and T_{13} treatments. However, significantly lower purity was recorded in T_2 over all other treatments, except T_3, T_5, T_6, T_{10}, T_{11}, T_{12} and T_{13} treatments.

Table 31. Influence of agrochemicals on Brix (%), purity (%) and pole in cane (%) in sugarcane (pooled)

Treatments	Brix (%)	Pole in cane (%)	Purity (%)
T_1 – Control*	22.51	18.88	86.40
T_2 – Water stress**	21.04	18.01	84.30
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	22.18	18.33	85.35
T_4 - T_2+ Foliar spray of KCl (3%)	21.19	18.02	85.86
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	21.25	18.40	85.49
T_6 - T_2+ Foliar spray of PMA (20 ppm)	22.13	18.09	85.08
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	21.58	18.17	86.00
T_8 - T_2+ Foliar spray of CCC (100 ppm)	21.56	18.52	86.97
T_9 - T_2+ Foliar spray of china clay (6%)	21.41	18.31	86.21
T_{10} - T_2+ Foliar spray of kaolin (6%)	20.45	17.95	85.36
T_{11} - T_2 + Foliar spray of ethanol (2%)	19.23	17.21	85.27
T_{12} - T_2+ Foliar spray of methanol (2%)	21.59	18.33	85.73
T_{13} - T_2+ Set soaking with saturated lime water (2%)	20.74	18.01	85.18
Mean	21.30	18.17	85.63
S.Em ($\pm$)	0.49	0.43	0.53
CD (5%)	1.41	1.25	1.54

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Table 32. Correlation coefficient of growth, biophysical and biochemical parameters with yield

Correlation coefficients	Yield	Significant
TDM at harvest	0.8089	**
Leaf area at harvest	0.7396	**
Tillers/hill at 160 DAP	0.6104	**
Length of internode at harvest	0.7682	**
Girth of internode at harvest	0.9515	**
Plant height at harvest	0.8627	**
SLW at harvest	0.4085	**
AGR at harvest	0.4254	**
CGR at harvest	0.4459	**
NAR at harvest	-0.4346	**
LAI at harvest	0.7958	**
LAD at harvest	0.7901	**
Total chlorophyll at 160 DAP	0.8135	**
Proline at 200 DAP	-0.9132	**
Total sugar at 200 DAP	0.8591	**
Potassium at 200 DAP	0.5424	**
NRA at 200 DAP	0.6899	**
Leaf sheath moisture at 160 DAP	0.2767	NS
RWC (%) at 160 DAP	-0.6333	**
DR at 240 DAP	-0.7991	**
TR at 240 DAP	0.9407	**

NS – Non significant.
** Significant at 1% level of probability @ p = 0.05.

V. DISCUSSION

Concern over water for irrigation is mounting in many countries where water supplies are limited and communities are becoming more conscious of the impact of irrigation on the environment and on the sustainability of their livelihoods, particularly in rural areas. During years of drought this awareness is heightened and the pressure on irrigators to defend or improve their farming practices can be quite severe.

Sugarcane (*Saccharum officinarum* L.) is cultivated as an annual irrigated crop in both tropics and subtropics of India. High yielding/ high sucrose cane varieties and the environment in which these varieties are cultivated generally determine sugarcane productivity in India. In India, sugarcane is grown under widely divergent agro-climatic conditions, frequently facing drought or water logging. This would account largely for low productivity. Moisture stress associated with high day temperature causes poor growth and high tiller mortality in both tropical and sub-tropical conditions.

Sugarcane being a long duration crop requires needful water management. Low atmospheric humidity at formative stage (April-June) of the crop affects the crop adversely. Among the three types of drought i.e., soil, atmospheric and physiological, the first one is more deleterious caused by the deficiency of soil moisture condition. Sugarcane requires about 2200 mm of water in its life cycle; half of it is met through rains and the rest is given through irrigation. About 10-12 cm water in 5-6 times of irrigation found satisfactory for the growth of sugarcane (Singh and Singh, 1974). Any water imbalance in plant tissues reduces the growth and yield of sugarcane (Singh and Singh, 1974; Srivastava *et al.*, 1994, 1995, 1996). It was therefore, considered desirable to find out some promising sugarcane varieties for general cultivation under deficient moisture condition.

Sugarcane is favourably adaptable to a wide range of agricultural situations, but its productivity is generally limited by abiotic stress factors. Although improved cultural practices and use of high yielding varieties substantially contributed for growth in sugar industry. The per hectare yields and general productivity remained relatively low, primarily due to the expansion of cane cultivation into relatively less fertile marginal soils which are characterized by various stresses. Drought in combination with high temperature during summer months is known to influence the cane yields in both tropical and sub-tropical climates. Accordingly, evolution of sugarcane varieties for drought resistance and search for genotypes, which possess inherent capabilities of drought tolerance has been on the threshold of sugarcane varietal improvement.

It has been found that the amount of water utilized by the sugarcane crop has a linear relationship with the final yield produced. It has been estimated that for the production of 1 kg dry matter in cane (excluding leaves, sheaths and roots), about 380 kg of water is utilized by the crop. That is to say about 125 tons of water (including rainfall) is needed to produce one ton of cane or about 1350 tons of water are necessary to produce a ton of sugar (Prasada Rao, 1983).

Various attempts have been consistently made to define specific physiological characteristics that are indicative of drought resistance in crop plants.

Many important physiological and morphological processes, such as leaf enlargement, stomatal opening and associated photosynthesis are directly affected by the reduction of leaf turgor potential which accompanies the loss of water from leaf tissue. Recent evidence suggest that stress pre-conditioning alters the relationship between leaf water potential and leaf turgor potential so that plants with a previous history of water deficits have a lower leaf water potential at zero turgor (Brown *et al.*, 1976; Elson *et al.*, 1976 and Tunstal and Conners, 1975). This in turn lowers the critical leaf water potential for stomatal closure (Brown *et al.*, 1976, McCree, 1974, Miller *et al.*, 1971 and Thomas *et al.*, 1976).

The results of the field study are discussed in this chapter through an analysis of yield forming traits and estimates of drought tolerance in sugarcane to explain the relative contribution of various treatments under stressed and unstressed field conditions. The issues pertaining to influence on morphological characters, biophysical, growth parameters, biochemical characters and chemical parameters will be dealt with in detail to elucidate physiological mechanisms regulating drought tolerance in sugarcane. The present study was undertaken with a view to elucidate physiological approaches for drought tolerance studies in sugarcane and the results obtained are discussed in the chapter.

5.1 MORPHOLOGICAL CHARACTERS

Various morphological characters, such as plant height, leaf area, number of tillers, internodal length, girth of internodes and dry matter production showed significant differences due to stress treatments. The present investigation consisted of various treatments comprising both foliar spray as well as soil application of different agrochemicals mainly to reduce the water losses.

In the present study significant differences between the treatments were noticed in plant height. Among the treatments, soil application of K_2O registered significantly higher plant height followed by foliar spray of KCl and alachlor as compared to other treatments. Significantly lower plant height was recorded in water stress treatments. However, higher plant height was observed in normal irrigation.

Though, plant height is basically a genetically controlled character, it is being influenced by environmental conditions and management practices. Present results are in confirmity with the findings of Sinha (1978), Subramaniam *et al.* (1991) and Naik *et al*. (1993) who opined that increase in plant height was due to reflectant action of antitranspirants thereby leading to higher retention of moisture and the regulation of the stomata. In sugarcane, plant height is an important character and showed positive association with cane yield.

It was noticed that number of tillers decreased from 160 DAP to harvest and this decrease was due to mortality of tillers at later stages of the growth. Among the treatments, foliar spray of methanol registered significantly higher number of tillers followed by foliar spray of kaolin. Significantly lower number of tillers was observed in water stress treatment. These results are in the line with the findings of Kathiresan and Balasubramanian (1991) who stated that trash mulch, soil application of K_2O at 60 kg, kaolin spray and combination of these are more beneficial in increasing the number of tillers. The number of tillers recorded was also more in the treatment with kaolin spray (Parameswaran *et al*., 1987).

Internodal length is an important yield contributing character in sugarcane. It was noticed in the present investigation that the internodal length increased from 160 DAP to harvest. Among the treatments, the internodal length was significantly higher with the soil application of K_2O followed by foliar spray of China clay, PMA and alachlor. Significantly lower internodal length was observed in water stress treatment. However, the maximum internodal length was observed in normal irrigation (control). Similarly Hunshal *et al.* (1996) reported that the foliar spray of potash + urea, soil application of K_2O and set hardening with $CaCl_2$ (2%) registered higher internodal length in sugarcane. Adequate potash availability contributes much towards growth and yield improvement, it also facilitates higher water uptake by roots even at high soil moisture tensions and reduces the transpirational losses (Srinivasan, 1987).

Girth of internodes is also an important yield contributing character in sugarcane. Generally, the girth of the internodes is adversely affected by water stress condition. In the present investigation the girth of the internodes increased from 160 DAP to harvest, but among the treatments significantly higher girth was found with the foliar spray of KCl (3%) followed by soil application of K_2O (75 kg/ha) and foliar spray of kaolin (6%). Significantly lower girth of internodes was seen with the water stress treatment. Our results are in agreement with the findings of Dineshkumar *et al.* (1995) who reported that the application of K with mulch and alone registered maximum girth of internodes.

Leaf area fairly gives a good idea of the photosynthetic capacity of the plant. Among several morphological characters associated with yield, maintenance of functional leaf and higher leaf area, particularly during later growth stages seem to be most important. In the present investigation, leaf area increased from 160 DAP to harvest. Significantly higher leaf area was found in the treatment of set soaking with saturated lime water followed by foliar spray of ethanol as compared to stress treatment. These results are in confirmity with the findings of Mukundarao *et al.* (2002) and Ali *et al.* (1994) who indicated that maximum leaf area was with soil application of K_2O (120 kg/ha) under drought condition. Sinha (1978) obtained favourable effect of leaf area under moisture stress condition which induced stomatal adjustment and resulted in improvement of growth and yield in sugarcane.

The amount of total dry matter produced in an indication of the overall efficiency of utilization of resources and better light interception. The data pertaining total dry matter production indicated that it increased from 160 DAP to harvest. Among various treatments, the foliar spray of urea (3%) and KCl (3%) recorded significantly higher total dry matter followed by foliar application of PMA (20 ppm). While, lower total dry matter was observed in stress treatment. Similar results were also obtained by Mohan Naidu and Srinivasan (1978), Dineshkumar *et al.* (1995) and Varsha and Lakhidev (1997). Increased dry matter accumulation by the application of K_2O was mainly due to increased succulence and helped to retain moisture which mitigated drought in sugarcane (Parthasarathy, 1983 and Jaybal and Chakalingam, 1990).

Morphological parameters like the total dry matter, leaf area and tillers number, length of internodes, girth of internodes and plant height are significantly correlated with yield in sugarcane (Table 32).

5.2 BIOPHYSICAL PARAMETERS

Stomatas are the minute pores present on the epidermal leaf surface and are important since the metabolism of crop plants depends to a larger extent on the diffusion of gases and water vapour through these pores. The arrangement and frequency of stomata vary widely among the species and within the species.

The resistance to diffusion of CO_2 and water vapour between the leaf and atmosphere is a function of stomatal frequency and the degree of opening. A change in stomatal resistance has a greater effect on transpiration than on photosynthesis, because it constitutes a relatively larger proportion of the total resistance to water vapour diffusion than to CO_2 diffusion (Gaastra, 1959).

Plant regulation of water utilization and loss is important in determining the drought tolerance in crop plants. There is a considerable range among species in their stomatal sensitivity to water stress. In addition to stomatal conductance, stomatal frequency also plays an important role in determining the leaf conductance and transpiration rate.

Barrs (1968) suggested that RWC under stress could also be used as a measure of tolerance to stress and could be used in screening programme. In the present investigation the leaf sheath moisture (LSM) content decreased with advancement in crop age. Among the treatments, stress treatment showed lower LSM and higher LSM was recorded with the foliar spray of urea (3%) + KCl (3%) followed by alachlor (200 ppm).

The relative water content (RWC) is another important parameter considered in determining the drought resistance in the crops. However, RWC was found higher in foliar spray of urea (3%) + KCl (3%) followed by kaolin (6%). These results are in confirmity with the findings of Hunshal *et al.* (1996). Jamuna *et al.* (1994) also noticed higher LSM in potash applied treatments compared to no potash. This might be due to increased osmotic potential as a result of K absorption by the root cells which help in regulating opening and closure of stomata leading to higher moisture in the index tissues.

Diffusive resistance (DR) was found to be significantly higher in water stress treatments and at the same time transpiration rate was lower at 160 DAP in stressed treatments. At later stages (240 DAP) the diffusive resistance increased in all the treatments but found more in water stress treatments and obviously transpiration rate was decreased. These results are in the line with the findings of Srivastav *et al.* (1996) who observed greater stomatal diffusive resistance and less transpiration rate under soil moisture stress conditions. In the present study, DR was negatively correlated with yield ($r = 0.080$). Anti-transpirants and the reflectant action of kaolin might have contributed for higher retention of moisture in plants resulting in reduced transpirational loss of moisture due to regulation of stomata and might have favoured growth (Sinha, 1978).

Leaf temperature is one of the important parameters in assessing the drought status of the plant. The leaf temperature should be lower than the air temperature for getting higher productivity.

In this study, leaf temperature was more in water stress treatments. Among the treatments, the leaf temperature was relatively higher in foliar spray of KCl (3%) followed by

PMA (20 ppm) and alachlor (200 ppm) and these treatments were on par with each other. However, in control treatment (normal irrigation) the leaf temperature was less.

5.3 GROWTH PARAMETERS

It is well established fact that the plant infrastructure is decided by the growth parameters such as, leaf area index (LAI), leaf area duration (LAD), crop growth rate (CGR), relative growth rate (RGR), net assimilation rate (NAR), specific leaf weight (SLW), specific leaf area (SLA) and biomass duration (BMD). This concept not only involves the final crop yield and its components, but also probes into the physiological events that have occurred early in the growth stages causing variation in yield potential.

In the present investigation, the LAI was significantly higher in the foliar spray of PMA (20 ppm) followed by set hardening in saturated lime water and foliar spray of kaolin (6%) as compared to water stress treatment. However, the LAI was more in normal irrigation schedule. Lower values are found with the foliar spray of KCl (3%). Thus it is very clear that the use of antitranspirants are more helpful in the retention of moisture in plant tissues. Apart from this, set hardening also plays an important role. Similarly, Maitra *et al*. (1998) reported that seed hardening with 2 per cent $CaCl_2$ recorded significantly higher LAI as compared to control in finger millet. Govindan and Thirumurugan (2000) revealed that foliar spray of KCl (1%) increased the LAI over control in greengram.

Leaf area duration (LAD) is a useful growth parameter not only in depicting the efficiency of photosynthetic system, but also in showing a linear relationship with dry matter accumulation (Chetti and Sirohi, 1995).

In the present study, significant differences were found in the LAD due to various treatments. In general, it increased from 160 DAP to harvest and among the treatments, maximum LAD was observed in set hardening with 2 per cent saturated lime water followed by foliar spray of ethanol (2%) and kaolin (6%) and China clay (6%). Significantly lower LAD was observed in water stress treatment. However, control treatment maintained maximum LAD (1073.7 days at harvest). These results are in agreement with the findings of Govindan and Thirumurugan (2000) who revealed that the growth parameters like plant height, LAI, LAD and dry matter production in greengram are significantly higher with the foliar spray of KCl (1%). Eshanna and Kulkarni (1990) reported that seed treatment with $CaCl_2$ in the ratio of 1:3 (seed : solution) recorded significantly higher plant height, LAI, NAR, LAD and total dry matter at different growth stages in maize as compared to control. In this study, LAD had significantly positive correlation with yield (r = 0.79).

Specific leaf weight is the measure of leaf thickness; it increases with the age of the crop. The increase in SLW is due to stacking of palisade cells. Since sugarcane is C_4 plant photosynthetic efficiency per unit leaf area is more and thus increases leaf thickness which could probably enhance the photosynthetic efficiency due to stacking of mesophyll and bundle sheath cells thereby recapturing the CO_2 released in photorespiratory process and leading to an increased TDM. The SLW increased from 160 DAP to harvest. The SLW was significantly higher in water stress treatment followed by soil application of K_2O and foliar spray of KCl (3%) as compared to other stress treatments. It is evident that imposition of stress increased the SLW and is one of the important parameters for drought tolerance.

SLA is another important growth parameter which influences the yield potential in sugarcane. SLA decreased from 160 DAP to harvest in all the treatments. Among various stress treatments, foliar spray of kaolin (6%) showed significantly higher value followed by foliar spray of KCl (3%) and foliar spray of kaolin (6%) as compared to rest of the stress treatments. Similarly, Koppar (1997) revealed that foliar spray of methanol at different levels (1-20%) increased the SLA in wheat.

It is very difficult to account for yield variation in terms of growth and development, since it involves the effect of both intrinsic and extrinsic factors in all the physiological processes of plant. Various empirical relationships such as CGR, RGR, NAR, SLW and SLA describe the connections between the end point of a long chain of interdependent processes in the environment and the plant (Watson, 1952). The RGR is an important physiological parameter which reflects the ability of the plant to produce dry matter per unit of dry matter already existing. In the present investigation, the RGR decreased from 160 DAP to harvest. Among the treatments, significantly higher RGR was found in water stress treatment followed by foliar spray of CCC (100 ppm) and kaolin (6%). However, maximum RGR was noticed in the control treatment.

Growth parameters such as CGR, RGR, NAR and BMD indicate the development of crop in a logical sequence and elucidate the causes for differences in yield through the events that have occurred earlier in the growth. CGR is influenced by LAD, leaf photosynthetic rate and leaf angle and is an index of the light intercepted. Present study indicated that the CGR in general increased upto harvest. Significantly higher CGR was observed in the treatment with soil application of K_2O (75 kg/ha) followed by foliar spray of urea (3%) + KCl (3%). These results are in the line with the findings of Govindan and Tirumurgan (2000) who revealed that the growth parameters like plant height, LAI, CGR and dry matter production in greengram are significantly higher with the foliar spray of KCl (1%). Annadurai *et al.* (2001) observed that soil application of 168 K_2O kg per ha recorded more dry matter production, LAI, CGR and cane yield in sugarcane.

Net assimilation rate (NAR) refers to a capacity of green leaves to produce dry matter and it depends on leaf area and the rate of photosynthesis. In the present investigation, NAR decreased from 160 DAP to harvest. Among the treatments, significantly higher NAR was recorded in water stress treatment (0.079 g dm^{-2} day^{-1}) followed by foliar spray of CCC (100 ppm) and foliar spray of KCl (3%) + urea (3%). However, control treatment (normal irrigation) also showed higher NAR (0.076 g dm^{-2} day^{-1}). These results are in conformity with the findings of Pawar (1996) who reported that foliar application of 2 per cent ethanol significantly increased the dry matter production, leaf area, LAI, LAD, NAR and SLA in sorghum genotypes.

Significant correlation of yield with SLW, AGR, CGR, NAR, LAI in sugarcane was observed.

5.4 BIOCHEMICAL CHARACTERS

Crop yield is mainly dependent on the interplay of various physiological and biochemical functions of the plant in addition to the impact of the environment. The cause and effect relationship is necessary to understand the interplay of several processes and functions affecting crop yield.

Higher photosynthetic rate is one of the factors for realising higher productivity because, it is expected to provide the raw material and the energy required for growth and development. Murthy and Murthy (1977) reported that variations in photosynthesis are associated with leaf protein content, nitrogen, leaf thickness and chlorophyll content per unit area. However, chlorophyll has not always been shown to have a strong relationship with photosynethetic rate under normal conditions. But at lower light intensity, it becomes a deciding factor (Janardhan, 1977).

Chlorophyll and carotenoids are the major pigments which have extremely important in biological functions. The chlorophyll is of paramount importance in photosynthesis. Among chlorophylls, chlorophyll a and b are predominant in higher plants and the ratio of chlorophyll a and b is usually 3:1 and it is an important biochemical parameter. The ratio also varies with growth conditions and environmental factors. It has already been found that chlorophyll a is more rapidly degraded than chlorophyll b. Consequently, the chlorophyll a/b ratio is continuously shifted to lower values during leaf senescence.

In the present investigation, chlorophyll 'a' was found to be more at later stage (240 DAP) compared to early stage (160 DAP). Among the treatments, soil application of K_2O (75 kg/ha) showed significantly higher chlorophyll 'a' content followed by foliar spray of PMA (20 ppm), alachlor (200 ppm) and methanol (2%). Chlorophyll 'b' content was found maximum in the foliar spray of KCl (3%) and finally the total chlorophyll was significantly higher in soil application of K_2O (75 kg/ha) followed by foliar spray of KCl (3%) and PMA (20 ppm). However, the control treatment (normal irrigation) showed maximum total chlorophyll content. These results are in agreement with the findings of Amaregouda *et al.* (1994), Li *et al.* (1995) and Kedari and Hussaini (1999) who reported that pre-sowing seed hardening with $CaCl_2$ (2%) and foliar spray of methanol upto 20 per cent increased the chlorophyll content under drought condition.

The nitrate reductase, which is the key enzyme in nitrogen metabolism, is known to be regulated by various environmental factors apart from its own substrate, nitrate. It is also believed that the reduction of nitrate to nitrite by nitrate reductase is the rate limiting process for the utilization of nitrogen in the form of nitrate. The peak activity of nitrate reductase coincided with the maximum chlorophyll content, thereby complementing the carbon-nitrogen balance in plants.

In the present investigation, the NRA was found to be more at early stage and reduced slightly at 240 DAP. The NRA activity was observed to be maximum with the foliar spray of CCC (100 ppm) followed by set hardening with saturated lime water (2%) and foliar spray of urea (3%) + KCl (3%). However, lower NRA values were recorded in water stress treatment. These readings are in conformity with the findings of Ghosh and Srivastava (1995) who revealed that the foliar spray of *Quereus serreta* seedlings with 5.0 mM KCl resulted in higher levels of NRA in leaves. Pawar (1996) reported that the application of ethanol (2%) increased NRA in sorghum, and further the application of methanol upto 20 per cent resulted increased in NRA activity in wheat (Koppar, 1997).

Accumulation of proline in leaves has been shown to be an adaptive mechanism for tolerance to stress. Also a relationship between the magnitude of free proline accumulation and drought tolerance has been shown in barley genotypes (Singh *et al*., 1972). Significant accumulation of free proline due to moisture and biological stresses has been reported in sugarcane (Rao and Ashokan, 1978; Singh, 1980 and Ho *et al*., 1984). Association of proline accumulation with dry matter production was evident especially under stress condition.

In the present studies, proline content increased in the stress treatments. Among the treatments, significantly higher proline content was recorded in the water stress treatment followed by foliar spray of urea (3%) + KCl (3%), alachlor (200 ppm) and foliar spray of methanol (2%). These results are similar with the findings of Shashidhar *et al.* (1977) who observed that the genotypes with high potassium accumulation had higher proline content under moisture stress condition in groundnut. The higher proline accumulation was associated with higher potassium content as observed in maize (Mukarjee, 1974). High proline and its further accumulation under stress is known to act as storage compound for carbon and nitrogen (Bernett and Naylor, 1966). Rajgopal *et al.* (1977) observed that in unirrigated wheat crop, there was less NRA activity and more proline accumulation.

It was found that the total sugar content in the leaves was higher at later stages. Significantly higher sugar content was recorded in the control treatment (normal irrigation). Among the stress treatments, foliar spray of CCC (100 ppm) showed maximum total sugar content followed by foliar application of alachlor (100 ppm) and kaolin (6%). However, water stress treatment was found to possess lower sugar content compared to other treatments. These results are in agreement with the findings of Shashidhar *et al.* (1981) and Amaregouda *et al.* (1994) who reported that seed treatment with $CaCl_2$ (1%) enhanced the accumulation of total sugar content in sorghum leaves. This accumulation of sugar helps in the retention of water by osmotic adjustment in the plant cells.

Biochemical parameters like total sugar, potassium and total chlorophyll were significantly correlated with yield (Table 32).

5.5 CHEMICAL PARAMETERS

The importance of potassium fertilization under water stress conditions remain often obscure where this nutrient is not particularly limiting in the soil. Nevertheless, adequate supply of ‘K’ is necessary towards growth and yield improvements under drought condition (Mohan Naidu *et al.,* 1981). Parthasarathy (1983) indicated that potassium content increased the succulence and helped to retain more moisture which mitigated drought in sugarcane. In the present investigation, the K content was more at early stages (160 DAP) and decreased slightly at later stages (240 DAP). Among the treatments, significantly higher K content was found with the soil application of K_2O (75 kg/ha) followed by foliar application of CCC (100 ppm) and china clay (6%). However, normal irrigation treatment recorded maximum K content in leaves.

5.6 YIELD AND YIELD COMPONENTS

Net millable cane is most important yield contributing parameter for final yield and it depends on number of tillers converted into economic shoots. In the present studies, maximum net millable canes was observed with the foliar spray of methanol followed by soil application of K_2O (75 kg/ha) and urea (3%) + KCl (3%). These results are in the line with the findings of Mohan Naidu *et al.* (1983). Manoharan *et al.* (1992) and Ali *et al.* (1994) who evaluated the net millable canes by the application of 120 kg per ha K_2O, soil application and foliar spray of 2.5 per cent KCl and KCl (2.5%) + urea (2.5%) reported significant improvement of net millable canes.

Application of K had favourable effects on leaf area under moisture stress conditions and induced stomatal adjustment and contribute to higher growth and yield. Potassium influences the water economy and crop growth through its effect on water uptake, root growth, maintenance of turgor, transpiration and stomatal regulation (Nelson, 1980). Moreover, potassium nutrition helps in increasing crop tolerance to water stress and promotes root growth that results into better uptake of nutrients and water (Polizoto, 1986).

Single cane weight is another important parameter for evaluating the final yield in sugarcane. Optimum millable canes and maximum single cane weight will decide the final yield. In the present investigation, among the treatments, maximum single cane weight was recorded in the foliar spray of kaolin (6%) followed by KCl (3%) foliar spray. These results are in agreement with the findings of Hunshal *et al.* (1996) who confirmed with their experiment that the application of muriate of potash spray (2.5%) and foliar spray of muriate of potash (2.0%)+ urea (2.0%) recorded maximum single cane weight.

In the present investigation, it is observed that cane yield was significantly higher (113.6 t/ha) in the control treatment (normal irrigation) while stress treatments recorded lower cane yield. Among the stress treatments, maximum cane yield was found with the foliar spray of kaolin (6%) followed by soil application of K_2O (75 kg/ha) and foliar spray of KCl (3%). These results are in conformity with the findings of Kathiresan and Balsubramanian (1991). Kannapan *et al.* (1994) noticed maximum cane yield with soil application of K_2O and foliar spray of KCl (2.5%). The higher cane yield was attributed to the conservation of soil moisture and as such the nutrient uptake by the crop was more and this lead to the vigorous growth of the crop.

Reduction of yield can be brought to normal through K application @ 125 kg per ha along with one per cent KCl spray at different stages showing the involvement of K in stomatal regulation to reduce the transpiration rate without affecting the biomass production (Subramanian *et al.*, 1992).

Commercial cane sugar (CCS) per hectare is an important parameter and it depends on the net recovery of the sugar from cane and total cane yield. The sugar production per hectare was calculated in the present investigation and found that it was more with the soil application of K_2O (75 kg/ha) followed by foliar spray of kaolin (6%), CCC (100 ppm) and of KCl (3%). These results are in line with the findings of Kannappan *et al.* (1994) who noticed maximum sugar yield with the soil application of K_2O and foliar spray of kaolin (6%). Similar results were also obtained by Kathiresan and Balasubramanian (1991).

Pol per cent juice is determined after clarifying the juice sample with lead sub-acetate and taking the pol reading in a saccharimeter or sucromat. In the estimation of sugar recovery per cent in cane, pol per cent juice is taken as sugar per cent juice, by assuming the presence of equal quantities of glucose and fructose. In reality, pol per cent in juice is not the sugar per cent juice due to the presence of other dextro-rotatory compounds like tartaric acid, dextran, etc. In the present investigation, significantly maximum pol per cent cane was noticed with the foliar spray of CCC followed by foliar spray of urea (3%) + KCl (3%) and methanol. These results are in agreement with the findings of Kathiresan and Balsubramanian (1991) and Dinesh kumar *et al.* (1995) who noticed the application of overdose K (40 kg/ha) increased the pol per cent cane.

Purity is a ratio between pol per cent juice and Brix per cent juice. During ripening of sugarcane, there will be increase in the Brix values along with pol per cent and higher juice purity. Under water stress conditions, significantly lower values were noticed in Brix values due to impaired photosynthetic process and thus the purity remains low. A cane crop considered mature if it has attained a minimum of 16 per cent sucrose with 85 per cent purity. Brix (%) was maximum with the soil application of K_2O (75 kg/ha) followed by foliar spray of

PMA (20 ppm). However, higher Brix per cent was noticed in control treatment (normal irrigation).

In the present investigation, fibre content was maximum with the foliar spray of alachlor (200 ppm) followed by ethanol (2%). Lower values of fibre per cent in cane was found in control treatment followed by soil application of K_2O and foliar spray of PMA (20 ppm).

Based on the above discussion, it is clear that the cane yield was more in the treatments with the foliar spray of kaolin (6%) followed by soil application of K_2O (75 kg/ha) and foliar application of KCl (3%). The yield improvement was due to increase in plant height, number of tillers, girth of internodes, relative water content, transpiration rate, LAI, LAD, SLW, AGR, RGR, CGR, chlorophyll 'a', total chlorophyll, total sugar content in leaves, 'K' content, net millable canes, single cane weight and Brix values.

Practical utility

1. Among the various treatments the foliar spray of kaolin (6%), soil application of K_2O (3%) and foliar application of KCl (3%) were found to be the best stress mitigating compounds in sugarcane.
2. Among these, soil application of K_2O is practically easier in sugarcane cultivation.

Future line of work

The main finding of this study showed that physiological approaches to drought management such as foliar and soil application of muriate of potash emerges as an important component of crop management practices in sugarcane. Measurement of root traits across sampling stages were beyond the scope of the present study, as other above-ground traits were assessed in the field experiments across samplings.

Methodological considerations in recording the water use in the field need to be revisited. It is very important that the growing conditions and timing of drought are properly defined because any small variation in these conditions would increase the residual variance and result in lower precision. The studies relating to drought tailored to specific phenophases in sugarcane needs further study. Gas-exchange measurements for this kind experiments is time consuming and difficult to measure. Hence there is a need to develop faster screening methods to estimate stomatal aperture traits. Following are the broader areas of research that are needed towards understanding better the physiological processes that determine yield in stress environment.

1. There is a need to identify promising physiological traits under water stress in sugarcane.
2. Comprehensive study on biochemical parameters related to moisture stress situation is to be taken up.
3. It is worthwhile to study the morpho-physiological changes brought out by different stress mitigating treatments.

VI. SUMMARY

Field experiments were conducted during 2004-05 and 2005-06 to study the physiological approaches for drought tolerance in sugarcane variety CoC-671. The experiments were carried out at the Research and Development Farm of the Ugar Sugar Works Ltd., Ugarkhurd, Belgaum district. The experiment consisted of 13 treatments with two controls viz., one with normal irrigation (20 days interval) and another one with water stress (40 days intervals) and experiment was laid out in randomized block design with three replications. Water stress treatments were imposed during February. The salient features of the findings are summarized in this chapter.

1. Due to variation in irrigation interval, the crop showed significant differences between the treatments for different morphological, physiological, biophysical, biochemical changes, cane yield and quality attributes.

2. Morphological parameters like plant height, number of tillers and girth of internodes showed better performance with the foliar application of kaolin (6%) and soil application of K_2O (75 kg/ha).

3. Biophysical parameters like diffusive resistance and transpiration rate showed significant differences between the treatments. Maximum values for diffusive resistance was found in the stressed treatment, while the normal irrigation recorded minimum values.

4. The results of various growth parameters viz., LAI, LAD, SLW, AGR and CGR indicated significant differences between the treatments and were higher with the treatments of soil application of K_2O (75 kg/ha) and foliar spray of KCl (3%) whereas, a significant decrease in NAR and SLA was observed under stressed treatment compared to non-stressed plots.

5. Total chlorophyll content decreased due to water stress treatments. The soil application of K_2O (75 kg/ha) recorded significantly higher values followed by foliar spray of urea (3%) and KCl (3%). Same trend was also observed with chlorophyll 'a' and 'b' contents.

6. The nitrate reductase activity increased in the normal irrigation and lower values were found in water stress treatment. Maximum NRA was observed with the foliar spray of methanol (2%) followed by set soaking in saturated lime water (2%).

7. The proline content significantly increased in water stress treatments. The lower proline content was observed in the normal irrigation. Among various treatments, the foliar spray of urea (3%) + KCl (3%) showed maximum proline content.

8. Sugar content was found to be maximum in set soaking with saturated lime water (2%) followed by foliar spray of PMA (20 ppm). However, significantly higher sugar content was recorded in the normal irrigation treatment.

9. The yield and quality attributes showed significantly higher values in normal irrigation. Among various treatments, maximum millable canes were observed with the soil application of K_2O (75 kg/ha) followed by foliar application of urea (3%) + KCl (3%). The cane yield was found to be more with the foliar spray of kaolin (6%) and soil application of K_2O (75 kg/ha). The same trend was found with respect to single cane weight.

10. Net recovery was significantly higher with the normal irrigation. Among treatments, the net recovery was significantly higher with the soil application of K_2O (75 kg/ha) followed by foliar application of urea (3%) + KCl (3%).

11. There was a significant increase in Brix (%) under normal irrigation. Among other treatments, significantly higher Brix (%) was found with the soil application of K_2O (75

kg/ha) followed by foliar spray of PMA (20 ppm). Pole in cane (%) was significantly higher with the foliar spray of CCC and foliar spray of urea (3%) and KCl (3%).

In the present investigation, it is observed that cane yield was significantly higher (113.6 t/ha) in the control treatment (normal irrigation) while stress treatments recorded lower cane yield. Among the stress treatments, maximum cane yield was found with the foliar spray of kaolin (6%) followed by soil application of K_2O (75 kg/ha) and foliar spray of KCl (3%).

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APPENDIX

Appendix 1. Influence of agrochemicals on plant height (cm) at different stages in sugarcane (2004)

Treatments	Days after planting			
	160	200	240	At harvest
T_1 – Control*	143.1	183.0	209.7	391.1
T_2 – Water stress**	117.5	146.3	162.8	336.1
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	135.9	167.0	191.0	357.1
T_4 - T_2+ Foliar spray of KCl (3%)	139.6	159.3	173.8	363.1
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	136.8	172.8	191.3	345.5
T_6 - T_2+ Foliar spray of PMA (20 ppm)	132.9	162.8	180.8	328.1
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	132.1	172.7	186.0	366.9
T_8 - T_2+ Foliar spray of CCC (100 ppm)	135.2	165.0	180.5	369.1
T_9 - T_2+ Foliar spray of china clay (6%)	136.2	161.7	181.0	341.1
T_{10} - T_2+ Foliar spray of kaolin (6%)	135.0	157.7	176.6	342.6
T_{11} - T_2 + Foliar spray of ethanol (2%)	141.1	169.5	177.7	355.5
T_{12} - T_2+ Foliar spray of methanol (2%)	138.4	159.7	174.8	343.5
T_{13} - T_2+ Set soaking with saturated lime water (2%)	135.8	171.8	173.0	340.5
Mean	135.3	165.3	181.5	352.3
S.Em ($\pm$)	4.827	4.482	4.669	13.629
CD (5%)	NS	4.326	13.629	NS

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.

** - Crop was irrigated at 40 days interval

Appendix 2. Influence of agrochemicals on number of tillers/hill at different stages in sugarcane (2004)

Treatments	Days after planting			
	160	200	240	At harvest
T_1 – Control*	9.0	8.3	5.9	4.3
T_2 – Water stress**	6.3	6.0	4.2	4.2
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	7.3	7.3	4.3	4.2
T_4 - T_2+ Foliar spray of KCl (3%)	7.3	6.3	4.8	4.7
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	6.7	6.0	4.8	4.7
T_6 - T_2+ Foliar spray of PMA (20 ppm)	7.3	7.0	5.1	4.5
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	7.7	6.7	5.2	4.7
T_8 - T_2+ Foliar spray of CCC (100 ppm)	7.3	6.0	5.2	4.6
T_9 - T_2+ Foliar spray of china clay (6%)	7.7	6.3	4.5	4.6
T_{10} – T_2+ Foliar spray of kaolin (6%)	9.0	7.7	4.9	5.0
T_{11} – T_2 + Foliar spray of ethanol (2%)	8.0	6.3	4.7	4.8
T_{12} – T_2+ Foliar spray of methanol (2%)	8.7	5.3	4.7	5.5
T_{13} – T_2+ Set soaking with saturated lime water (2%)	8.0	5.7	4.3	4.8
Mean	7.7	6.5	4.8	4.3
S.Em ($\pm$)	0.471	0.742	0.276	0.353
CD (5%)	1.374	NS	0.807	NS

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Appendix 3. Influence of agrochemicals on length of the internodes (cm) at different stages in sugarcane (2004)

Treatments	Days after planting			
	160	200	240	At harvest
T_1 – Control*	8.9	11.3	11.8	12.9
T_2 – Water stress**	6.6	6.9	6.9	10.3
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	8.1	9.1	9.4	11.8
T_4 - T_2+ Foliar spray of KCl (3%)	7.4	9.9	9.9	10.7
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	8.1	8.8	9.0	107
T_6 - T_2+ Foliar spray of PMA (20 ppm)	8.3	8.6	9.9	11.2
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	7.7	8.6	8.9	11.5
T_8 - T_2+ Foliar spray of CCC (100 ppm)	7.7	7.9	8.5	11.9
T_9 - T_2+ Foliar spray of china clay (6%)	8.2	8.6	8.7	11.2
T_{10} - T_2+ Foliar spray of kaolin (6%)	7.7	9.4	9.7	9.4
T_{11} - T_2 + Foliar spray of ethanol (2%)	8.2	8.7	9.8	11.6
T_{12} - T_2+ Foliar spray of methanol (2%)	7.9	8.6	9.6	10.1
T_{13} - T_2+ Set soaking with saturated lime water (2%)	8.0	8.9	9.5	10.5
Mean	7.9	8.9	9.4	11.1
S.Em ($\pm$)	0.220	0.303	0.274	0.288
CD (5%)	0.641	0.884	0.801	0.840

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.

** - Crop was irrigated at 40 days interval

Appendix 4. Influence of agrochemicals on girth of the internodes (cm) at different stages in sugarcane (2004)

Treatments	Days after planting			
	160	200	240	At harvest
T_1 – Control*	8.5	11.6	10.7	11.7
T_2 – Water stress**	5.9	7.1	7.4	7.7
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	7.0	9.8	8.51	10.0
T_4 - T_2+ Foliar spray of KCl (3%)	6.6	9.9	9.3	10.0
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	7.2	8.4	8.5	8.7
T_6 - T_2+ Foliar spray of PMA (20 ppm)	7.0	8.5	8.4	8.5
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	7.8	7.8	7.6	8.3
T_8 - T_2+ Foliar spray of CCC (100 ppm)	7.3	8.6	8.7	8.7
T_9 - T_2+ Foliar spray of china clay (6%)	6.6	8.4	8.3	9.0
T_{10} - T_2+ Foliar spray of kaolin (6%)	7.0	8.4	8.7	8.9
T_{11} - T_2 + Foliar spray of ethanol (2%)	7.2	7.9	7.8	8.0
T_{12} - T_2+ Foliar spray of methanol (2%)	7.4	7.9	7.7	8.0
T_{13} - T_2+ Set soaking with saturated lime water (2%)	7.5	7.9	7.5	8.1
Mean	7.1	8.6	8.4	8.9
S.Em ($\pm$)	0.257	0.333	0.773	0.845
CD (5%)	0.749	0.973	0.256	NS

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Appendix 5. Influence of agrochemicals on leaf area (dm^2/hill) at different stages in sugarcane (2004)

Treatments	Days after planting			
	160	200	240	At harvest
T_1 – Control*	14.0	34.1	39.3	43.0
T_2 – Water stress**	7.2	23.0	28.2	31.0
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	12.6	27.9	31.2	33.5
T_4 - T_2+ Foliar spray of KCl (3%)	9.6	25.8	30.2	33.9
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	11.4	28.0	32.7	34.0
T_6 - T_2+ Foliar spray of PMA (20 ppm)	9.5	29.8	32.2	35.4
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	11.1	30.2	32.0	33.9
T_8 - T_2+ Foliar spray of CCC (100 ppm)	8.2	30.5	32.4	34.2
T_9 - T_2+ Foliar spray of china clay (6%)	13.4	32.2	34.4	37.5
T_{10} - T_2+ Foliar spray of kaolin (6%)	10.6	30.0	32.2	35.3
T_{11} - T_2 + Foliar spray of ethanol (2%)	8.8	30.2	32.6	36.5
T_{12} - T_2+ Foliar spray of methanol (2%)	8.5	30.6	33.2	37.3
T_{13} - T_2+ Set soaking with saturated lime water (2%)	10.0	30.5	31.6	36.1
Mean	10.4	29.4	32.5	35.6
S.Em (±)	0.034	0.064	0.077	0.068
CD (5%)	0.100	0.187	0.210	0.200

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.

** - Crop was irrigated at 40 days interval

Appendix 6. Influence of agrochemicals on total dry matter (g/hill) at different stages in sugarcane (2004)

Treatments	Days after planting			
	160	200	240	At harvest
T_1 – Control*	290.6	602.0	924.6	1632.2
T_2 – Water stress**	193.3	443.1	625.2	1042.1
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	227.7	504.3	741.0	1373.3
T_4 - T_2+ Foliar spray of KCl (3%)	264.2	544.0	794.3	1201.2
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	242.0	548.3	755.0	1247.1
T_6 - T_2+ Foliar spray of PMA (20 ppm)	268.0	586.0	840.2	1250.2
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	227.4	653.3	876.0	1214.0
T_8 - T_2+ Foliar spray of CCC (100 ppm)	240.2	541.6	800.0	1236.3
T_9 - T_2+ Foliar spray of china clay (6%)	257.0	562.3	790.0	1183.2
T_{10} - T_2+ Foliar spray of kaolin (6%)	243.3	545.3	786.6	1250.2
T_{11} - T_2 + Foliar spray of ethanol (2%)	243.0	561.3	558.6	1256.4
T_{12} - T_2+ Foliar spray of methanol (2%)	230.3	551.0	908.0	1266.5
T_{13} - T_2+ Set soaking with saturated lime water (2%)	245.0	549.0	761.6	1235.2
Mean	244.0	546.3	781.5	1260.6
S.Em ($\pm$)	7.305	20.240	20.23	58.35
CD (5%)	21.322	59.079	59.069	170.23

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Appendix 7. Influence of agrochemicals on leaf sheath moisture content (%) at different stages in sugarcane (2004)

Treatments	Days after planting	
	160	240
T_1 – Control*	73.7	75.6
T_2 – Water stress**	56.0	61.1
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	68.7	69.6
T_4 - T_2+ Foliar spray of KCl (3%)	78.0	68.4
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	73.8	75.7
T_6 - T_2+ Foliar spray of PMA (20 ppm)	73.3	72.4
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	75.0	71.5
T_8 - T_2+ Foliar spray of CCC (100 ppm)	66.0	72.7
T_9 - T_2+ Foliar spray of china clay (6%)	65.1	68.3
T_{10} - T_2+ Foliar spray of kaolin (6%)	61.1	66.9
T_{11} - T_2 + Foliar spray of ethanol (2%)	77.3	74.1
T_{12} - T_2+ Foliar spray of methanol (2%)	70.8	68.2
T_{13} - T_2+ Set soaking with saturated lime water (2%)	72.5	67.8
Mean	70.1	70.2
S.Em ($\pm$)	1.812	1.892
CD (5%)	5.289	5.523

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Appendix 8 : Influence of agrochemicals on relative water content (%) at different stages in sugarcane (2004)

Treatments	Days after planting	
	160	240
T_1 – Control*	71.8	78.9
T_2 – Water stress**	77.0	72.7
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	91.6	84.7
T_4 - T_2+ Foliar spray of KCl (3%)	80.9	77.6
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	79.7	85.3
T_6 - T_2+ Foliar spray of PMA (20 ppm)	89.5	80.5
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	93.4	82.9
T_8 - T_2+ Foliar spray of CCC (100 ppm)	85.2	82.5
T_9 - T_2+ Foliar spray of china clay (6%)	93.6	80.1
T_{10} - T_2+ Foliar spray of kaolin (6%)	88.1	81.5
T_{11} - T_2 + Foliar spray of ethanol (2%)	88.6	73.5
T_{12} - T_2+ Foliar spray of methanol (2%)	81.9	73.5
T_{13} - T_2+ Set soaking with saturated lime water (2%)	94.0	78.9
Mean	85.79	79.43
S.Em ($\pm$)	3.452	2.347
CD (5%)	10.075	6.832

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Appendix 9. Influence of agrochemicals on diffusive resistance (DR, s cm^{-1}) at different stages in sugarcane (2004)

Treatments	Days after planting		
	160	200	240
T_1 – Control*	0.150	0.217	0.153
T_2 – Water stress**	0.430	2.220	1.627
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	0.215	0.693	0.667
T_4 - T_2+ Foliar spray of KCl (3%)	0.185	0.647	0.650
T_5 - T_2+ Foliar Spray of urea (3%) + KCl (3%)	0.265	1.360	0.890
T_6 - T_2+ Foliar spray of PMA (20 ppm)	0.217	1.517	1.750
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	0.122	1.683	1.909
T_8 - T_2+ Foliar spray of CCC (100 ppm)	0.145	1.767	0.980
T_9 - T_2+ Foliar spray of china clay (6%)	0.153	0.957	1.103
T_{10} - T_2+ Foliar spray of kaolin (6%)	0.220	1.00	1.025
T_{11} - T_2 + Foliar spray of ethanol (2%)	0.415	0.667	0.930
T_{12} - T_2+ Foliar spray of methanol (2%)	0.310	0.747	1.008
T_{13} - T_2+ Set soaking with saturated lime water (2%)	0.222	1.142	1.800
Mean	0.234	1.124	1.074
S.Em ($\pm$)	0.010	0.176	0.097
CD (5%)	0.029	0.514	0.284

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Appendix 10. Influence of agrochemicals on transpiration rate (TR, µg m^{-2} s^{-1}) at different stages in sugarcane (2004)

Treatments	Days after planting		
	160	200	240
T_1 – Control*	92.01	60.40	72.66
T_2 – Water stress**	48.94	20.46	14.33
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	81.33	27.96	31.16
T_4 - T_2+ Foliar spray of KCl (3%)	82.17	29.55	31.33
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	77.73	23.50	25.33
T_6 - T_2+ Foliar spray of PMA (20 ppm)	80.33	27.46	16.83
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	81.15	24.93	18.50
T_8 - T_2+ Foliar spray of CCC (100 ppm)	90.20	25.00	26.98
T_9 - T_2+ Foliar spray of china clay (6%)	69.90	40.92	23.80
T_{10} – T_2+ Foliar spray of kaolin (6%)	66.65	23.53	24.95
T_{11} – T_2 + Foliar spray of ethanol (2%)	48.92	54.70	26.56
T_{12} – T_2+ Foliar spray of methanol (2%)	75.83	33.70	25.13
T_{13} - T_2+ Set soaking with saturated lime water (2%)	81.05	36.40	25.75
Mean	75.80	33.12	27.96
S.Em (±)	2.303	1.001	1.430
CD (5%)	6.724	2.923	4.173

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Appendix 11. Influence of agrochemicals on leaf temperature (^{0}C) at different stages in sugarcane (2004)

Treatments	Days After Planting		
	160	200	240
T_1 – Control*	30.0	33.9	34.6
T_2 – Water stress**	30.6	33.4	34.9
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	30.7	33.0	34.5
T_4 - T_2+ Foliar spray of KCl (3%)	30.1	33.7	35.6
T_5 - T_2+ foliar spray of urea (3%) + KCl (3%)	31.2	34.3	33.0
T_6 - T_2+ Foliar spray of PMA (20 ppm)	30.4	33.7	35.6
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	30.8	32.9	35.9
T_8 - T_2+ Foliar spray of CCC (100 ppm)	31.5	33.3	34.2
T_9 - T_2+ Foliar spray of china clay (6%)	30.9	32.4	34.2
T_{10} - T_2+ Foliar spray of kaolin (6%)	30.9	33.6	34.6
T_{11} - T_2 + Foliar spray of ethanol (2%)	31.2	33.1	33.0
T_{12} - T_2+ Foliar spray of methanol (2%)	31.3	32.9	33.5
T_{13} - T_2+ Set soaking with saturated lime water (2%)	31.0	34.2	34.7
Mean	30.8	33.4	34.6
S.Em (+)	0.275	0.456	0.565
CD (5%)	0.802	NS	1.650

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Appendix 12. Influence of agrochemicals on leaf area index (LAI) at different stages in sugarcane (2004)

Treatments	Days after planting			
	160	200	240	At harvest
T_1 – Control*	3.90	10.25	11.8	12.92
T_2 – Water stress**	2.18	6.91	8.50	9.37
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	3.79	8.49	9.18	10.08
T_4 - T_2+ Foliar spray of KCl (3%)	2.89	8.77	8.88	10.04
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	3.42	8.74	9.65	10.02
T_6 - T_2+ Foliar spray of PMA (20 ppm)	2.79	8.91	9.61	11.24
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	3.32	9.05	9.71	10.18
T_8 - T_2+ Foliar spray of CCC (100 ppm)	2.47	9.33	9.72	10.26
T_9 - T_2+ Foliar spray of china clay (6%)	4.02	9.65	10.32	11.27
T_{10} - T_2+ Foliar spray of kaolin (6%)	3.18	9.04	9.49	10.61
T_{11} - T_2 + Foliar spray of ethanol (2%)	2.61	8.57	9.79	10.85
T_{12} - T_2+ Foliar spray of methanol (2%)	2.57	9.19	10.08	11.19
T_{13} - T_2+ Set soaking with saturated lime water (2%)	3.20	9.03	9.96	10.84
Mean	3.10	8.91	9.70	10.68
S.Em ($\pm$)	0.174	0.180	0.875	0.189
CD (5%)	0.507	0.525	NS	0.551

* - Crop was irrigated at 20 days interval   PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Appendix 13. Influence of agrochemicals on leaf area duration (LAD, days) at different stages in sugarcane (2004)

Treatments	Days after planting		
	160-200	200-240	240-harvest
T_1 – Control*	125.2	31.0	50.9
T_2 – Water stress**	114.6	40.4	36.9
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	91.6	20.3	32.4
T_4 - T_2+ Foliar spray of KCl (3%)	110.6	23.6	44.4
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	113.1	21.6	27.4
T_6 - T_2+ Foliar spray of PMA (20 ppm)	124.0	20.6	70.5
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	114.6	15.9	31.0
T_8 - T_2+ Foliar spray of CCC (100 ppm)	137.2	7.8	24.3
T_9 - T_2+ Foliar spray of china clay (6%)	113.2	20.0	42.7
T_{10} - T_2+ Foliar spray of kaolin (6%)	116.4	14.8	50.4
T_{11} - T_2 + Foliar spray of ethanol (2%)	124.6	29.2	40.9
T_{12} - T_2+ Foliar spray of methanol (2%)	132.4	26.6	55.3
T_{13} - T_2+ Set soaking with saturated lime water (2%)	127.5	25.6	39.6
Mean	118.8	22.9	42.06
S.Em (+)	7.658	9.66	10.38
CD (5%)	22.354	NS	NS

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Appendix 14. Influence of agrochemicals on specific leaf weight (SLW, g dm^{-2}) at different stages in sugarcane (2004)

Treatments	Days after planting			
	160	200	240	At harvest
T_1 – Control*	6.37	7.27	8.26	10.40
T_2 – Water stress**	8.62	7.48	7.12	9.68
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	5.83	6.50	7.44	9.68
T_4 - T_2+ Foliar spray of KCl (3%)	6.50	7.44	7.79	9.41
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	7.54	7.42	7.34	9.71
T_6 - T_2+ Foliar spray of PMA (20 ppm)	6.85	7.21	7.92	9.61
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	6.80	6.85	8.08	9.56
T_8 - T_2+ Foliar spray of CCC (100 ppm)	6.60	6.82	7.42	9.29
T_9 - T_2+ Foliar spray of china clay (6%)	6.04	6.96	7.50	9.10
T_{10} - T_2+ Foliar spray of kaolin (6%)	7.17	7.13	7.42	9.59
T_{11} - T_2 + Foliar spray of ethanol (2%)	6.30	7.48	7.17	9.59
T_{12} - T_2+ Foliar spray of methanol (2%)	6.70	7.46	7.50	9.46
T_{13} - T_2+ Set soaking with saturated lime water (2%)	6.03	7.21	7.92	9.77
Mean	6.72	7.16	7.60	9.58
S.Em ($\pm$)	0.241	0.145	0.160	0.192
CD (5%)	0.703	0.423	0.480	0.559

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Appendix 15. Influence of agrochemicals on specific leaf area (SLA, $dm^2\ g^{-1}$) at different stages in sugarcane (2004)

Treatments	Days after planting			
	160	200	240	At harvest
T_1 – Control*	0.150	0.130	0.130	0.100
T_2 – Water stress**	0.110	0.150	0.140	0.100
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	0.170	0.140	0.130	0.101
T_4 - T_2+ Foliar spray of KCl (3%)	0.150	0.130	0.120	0.100
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	0.130	0.130	0.140	0.103
T_6 - T_2+ Foliar spray of PMA (20 ppm)	0.140	0.140	0.120	0.103
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	0.150	0.120	0.120	0.104
T_8 - T_2+ Foliar spray of CCC (100 ppm)	0.150	0.140	0.140	0.106
T_9 - T_2+ Foliar spray of china clay (6%)	0.160	0.140	0.130	0.108
T_{10} - T_2+ Foliar spray of kaolin (6%)	0.140	0.140	0.140	0.103
T_{11} - T_2 + Foliar spray of ethanol (2%)	0.160	0.130	0.140	0.104
T_{12} - T_2+ Foliar spray of methanol (2%)	0.150	0.140	0.130	0.104
T_{13} - T_2+ Set soaking with saturated lime water (2%)	0.160	0.130	0.140	0.102
Mean	0.146	0.137	0.132	0.103
S.Em ($\pm$)	0.004	0.006	0.005	0.002
CD (5%)	0.011	NS	NS	NS

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.

** - Crop was irrigated at 40 days interval

Appendix 16. Influence of agrochemicals on absolute growth rate (AGR, g day^{-1}) at different stages in sugarcane (2004)

Treatments	Days after planting		
	160-200	200 –240	240-harvest
T_1 – Control*	7.63	8.13	7.85
T_2 – Water stress**	5.56	3.23	4.10
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	6.90	4.46	4.80
T_4 - T_2+ Foliar spray of KCl (3%)	6.21	6.30	4.50
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	7.65	4.71	5.38
T_6 - T_2+ Foliar spray of PMA (20 ppm)	7.94	5.21	5.09
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	8.39	7.60	3.78
T_8 - T_2+ Foliar spray of CCC (100 ppm)	7.54	4.68	5.63
T_9 - T_2+ Foliar spray of china clay (6%)	7.34	5.77	4.31
T_{10} - T_2+ Foliar spray of kaolin (6%)	7.54	6.43	4.92
T_{11} - T_2 + Foliar spray of ethanol (2%)	7.74	8.10	4.11
T_{12} - T_2+ Foliar spray of methanol (2%)	7.34	8.93	3.97
T_{13} - T_2+ Set soaking with saturated lime water (2%)	7.59	5.31	5.61
Mean	7.33	6.06	4.92
S.Em (±)	0.565	0.718	0.225
CD (5%)	NS	2.091	0.657

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Appendix 17. Influence of Agrochemicals on relative growth rate (RGR, g g^{-1} day^{-1}) at different stages in sugarcane (2004)

Treatments	Days after planting		
	160-200	200-240	240- harvest
T_1 – Control*	0.0080	0.0032	0.0040
T_2 – Water stress**	0.0091	0.0030	0.0032
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	0.0092	0.0032	0.0030
T_4 - T_2+ Foliar spray of KCl (3%)	0.0081	0.0041	0.0026
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	0.0091	0.0030	0.0032
T_6 - T_2+ Foliar spray of PMA (20 ppm)	0.0082	0.0031	0.0023
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	0.0102	0.0040	0.0024
T_8 - T_2+ Foliar spray of CCC (100 ppm)	0.0091	0.0042	0.0034
T_9 - T_2+ Foliar spray of china clay (6%)	0.0082	0.0040	0.0024
T_{10} - T_2+ Foliar spray of kaolin (6%)	0.0091	0.0052	0.0022
T_{11} - T_2 + Foliar spray of ethanol (2%)	0.0094	0.0051	0.0023
T_{12} - T_2+ Foliar spray of methanol (2%)	0.0092	0.0042	0.0030
T_{13} - T_2+ Set soaking with saturated lime water (2%)	0.0096	0.0032	0.0020
Mean	0.0086	0.0038	0.0028
S.Em (±)	0.001	0.001	0.00
CD (5%)	NS	NS	0.001

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.

** - Crop was irrigated at 40 days interval

Appendix 18. Influence of agrochemicals on crop growth rate (CGR g dm^{-2} day^{-1}) in sugarcane (2004)

Treatments	Days after planting		
	160-200	200-240	240-harvest
T_1 – Control*	28.23	30.13	15.17
T_2 – Water stress**	20.57	11.95	17.76
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	25.53	16.50	16.65
T_4 - T_2+ Foliar spray of KCl (3%)	22.97	23.31	19.90
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	28.30	17.43	18.83
T_6 - T_2+ Foliar spray of PMA (20 ppm)	29.38	19.28	13.98
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	31.04	27.75	20.83
T_8 - T_2+ Foliar spray of CCC (100 ppm)	27.89	17.32	15.94
T_9 - T_2+ Foliar spray of china clay (6%)	27.89	21.34	18.20
T_{10} - T_2+ Foliar spray of kaolin (6%)	27.15	23.80	15.20
T_{11} - T_2 + Foliar spray of ethanol (2%)	27.89	30.00	14.68
T_{12} - T_2+ Foliar spray of methanol (2%)	27.15	33.04	20.75
T_{13} - T_2+ Set soaking with saturated lime water (2%)	28.08	19.64	20.75
Mean	27.12	22.41	17.58
S.Em (±)	0.182	0.206	0.74
CD (5%)	NS	0.601	0.217

* - Crop was irrigated at 20 days interval

** - Crop was irrigated at 40 days interval

PMA - Phenyl mercuric acetate.

Appendix 19. Influence of agrochemicals on net assimilation rate (NAR, g dm^{-2} day^{-1}) at different stages in sugarcane (2004)

Treatments	Days after planting		
	160-200	200-240	240-harvest
T_1 – Control*	0.174	0.120	0.083
T_2 – Water stress**	0.194	0.041	0.080
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	0.143	0.048	0.064
T_4 - T_2+ Foliar spray of KCl (3%)	0.164	0.058	0.062
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	0.177	0.082	0.076
T_6 - T_2+ Foliar spray of PMA (20 ppm)	0.196	0.056	0.063
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	0.162	0.124	0.049
T_8 - T_2+ Foliar spray of CCC (100 ppm)	0.195	0.077	0.073
T_9 - T_2+ Foliar spray of china clay (6%)	0.186	0.070	0.054
T_{10} - T_2+ Foliar spray of kaolin (6%)	0.187	0.125	0.065
T_{11} - T_2 + Foliar spray of ethanol (2%)	0.164	0.113	0.052
T_{12} - T_2+ Foliar spray of methanol (2%)	0.109	0.114	0.049
T_{13} - T_2+ Set soaking with saturated lime water (2%)	0.190	0.073	0.066
Mean	0.173	0.092	0.064
S.Em ($\pm$)	0.022	0.096	0.002
CD (5%)	NS	NS	0.007

* - Crop was irrigated at 20 days interval

** - Crop was irrigated at 40 days interval

PMA - Phenyl mercuric acetate.

Appendix 20. Influence of agrochemicals on chlorophyll 'a' content (mg g^{-1} fr. wt.) at different stages in sugarcane (2004)

Treatments	Days after planting	
	160	200
T_1 – Control*	0.89	0.855
T_2 – Water stress**	0.370	0.582
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	0.772	0.806
T_4 - T_2+ Foliar spray of KCl (3%)	0.490	0.750
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	0.936	0.820
T_6 - T_2+ Foliar spray of PMA (20 ppm)	0.717	0.805
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	0.424	0.849
T_8 - T_2+ Foliar spray of CCC (100 ppm)	0.190	0.773
T_9 - T_2+ Foliar spray of china clay (6%)	0.428	0.755
T_{10} - T_2+ Foliar spray of kaolin (6%)	0.500	0.639
T_{11} - T_2 + Foliar spray of ethanol (2%)	0.344	0.623
T_{12} - T_2+ Foliar spray of methanol (2%)	0.470	0.739
T_{13} - T_2+ Set soaking with saturated lime water (2%)	0.490	0.660
Mean	0.540	0.742
S.Em (±)	0.032	0.025
CD (5%)	0.094	0.072

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Appendix 21. Influence of agrochemicals on chlorophyll ‘b’ content (mg g^{-1} fr. wt.) at different stages in sugarcane (2004)

Treatments	Days after planting	
	160	200
T_1 – Control*	0.466	0.690
T_2 – Water stress**	0.175	0.517
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	0.662	0.610
T_4 - T_2+ Foliar spray of KCl (3%)	0.490	0.700
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	0.590	0.567
T_6 - T_2+ Foliar spray of PMA (20 ppm)	0.566	0.567
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	0.470	0.732
T_8 - T_2+ Foliar spray of CCC (100 ppm)	0.162	0.636
T_9 - T_2+ Foliar spray of china clay (6%)	0.183	0.612
T_{10} - T_2+ Foliar spray of kaolin (6%)	0.295	0.644
T_{11} - T_2 + Foliar spray of ethanol (2%)	0.189	0.592
T_{12} - T_2+ Foliar spray of methanol (2%)	0.231	0.222
T_{13} - T_2+ Set soaking with saturated lime water (2%)	0.217	0.502
Mean	0.361	0.583
S.Em (±)	0.028	0.021
CD (5%)	0.082	0.062

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Appendix 22. Influence of agrochemicals on total chlorophyll content (mg g^{-1} fr. wt.) at different stages in sugarcane (2004)

Treatments	Days after planting	
	160	200
T_1 – Control*	1.502	1.421
T_2 – Water stress**	1.350	1.126
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	1.635	1.400
T_4 - T_2+ Foliar spray of KCl (3%)	0.994	1.481
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	1.397	1.420
T_6 - T_2+ Foliar spray of PMA (20 ppm)	1.192	1.430
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	0.890	1.470
T_8 - T_2+ Foliar spray of CCC (100 ppm)	1.123	1.600
T_9 - T_2+ Foliar spray of china clay (6%)	1.573	1.170
T_{10} - T_2+ Foliar spray of kaolin (6%)	0.602	1.345
T_{11} - T_2 + Foliar spray of ethanol (2%)	1.353	0.942
T_{12} - T_2+ Foliar spray of methanol (2%)	0.709	1.196
T_{13} - T_2+ Set soaking with saturated lime water (2%)	0.795	1.166
Mean	1.161	1.321
S.Em ($\pm$)	0.096	0.045
CD (5%)	0.279	0.131

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Appendix 23. Influence of agrochemicals on nitrate reductase activity (nmol g^{-1} fr. wt. hr^{-1}) at different stages in sugarcane (2004)

Treatments	Days after planting	
	160	240
T_1 – Control*	1043.0	930.0
T_2 – Water stress**	812.2	500.0
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	938.0	540.0
T_4 - T_2+ Foliar spray of KCl (3%)	865.0	570.0
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	913.3	600.0
T_6 - T_2+ Foliar spray of PMA (20 ppm)	860.0	650.0
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	850.0	680.0
T_8 - T_2+ Foliar spray of CCC (100 ppm)	911.6	740.0
T_9 - T_2+ Foliar spray of china clay (6%)	896.6	575.0
T_{10} - T_2+ Foliar spray of kaolin (6%)	895.0	570.0
T_{11} - T_2 + Foliar spray of ethanol (2%)	863.3	578.0
T_{12} - T_2+ Foliar spray of methanol (2%)	971.6	510.0
T_{13} - T_2+ Set soaking with saturated lime water (2%)	928.0	650.0
Mean	903.3	622.5
S.Em ($\pm$)	19.67	18.46
CD (5%)	57.415	53.87

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.

** - Crop was irrigated at 40 days interval

Appendix 24. Influence of agrochemicals on proline content (mg g^{-1} fr. wt.) at different stages in sugarcane (2004)

Treatments	Days after planting	
	160	240
T_1 – Control*	108.69	123.50
T_2 – Water stress**	159.40	149.30
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	150.35	150.06
T_4 - T_2+ Foliar spray of KCl (3%)	148.50	153.90
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	150.35	163.86
T_6 - T_2+ Foliar spray of PMA (20 ppm)	135.81	170.26
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	141.32	162.06
T_8 - T_2+ Foliar spray of CCC (100 ppm)	144.56	160.68
T_9 - T_2+ Foliar spray of china clay (6%)	144.19	160.85
T_{10} - T_2+ Foliar spray of kaolin (6%)	146.72	167.90
T_{11} - T_2 + Foliar spray of ethanol (2%)	148.54	163.33
T_{12} - T_2+ Foliar spray of methanol (2%)	150.35	168.81
T_{13} - T_2+ Set soaking with saturated lime water (2%)	151.44	167.36
Mean	144.50	158.61
S.Em (±)	3.217	12.281
CD (5%)	9.389	NS

* - Crop was irrigated at 20 days interval

** - Crop was irrigated at 40 days interval

PMA - Phenyl mercuric acetate.

Appendix 25. Influence of agrochemicals on total sugar content in leaves (mg g^{-1} dry wt.) at different stages in sugarcane (2004)

Treatments	Days after planting	
	160	240
T_1 – Control*	21.46	20.57
T_2 – Water stress**	13.70	14.58
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	16.15	17.46
T_4 - T_2+ Foliar spray of KCl (3%)	15.70	17.45
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	15.83	16.33
T_6 - T_2+ Foliar spray of PMA (20 ppm)	16.89	16.61
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	17.00	19.25
T_8 - T_2+ Foliar spray of CCC (100 ppm)	18.30	20.96
T_9 - T_2+ Foliar spray of china clay (6%)	13.66	14.66
T_{10} - T_2+ Foliar spray of kaolin (6%)	16.46	17.66
T_{11} - T_2 + Foliar spray of ethanol (2%)	16.53	17.25
T_{12} - T_2+ Foliar spray of methanol (2%)	17.00	17.50
T_{13} - T_2+ Set soaking with saturated lime water (2%)	17.50	18.40
Mean	16.80	17.01
S.Em ($\pm$)	0.638	1.151
CD (5%)	1.862	3.361

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Appendix 26. Influence of agrochemicals on potassium content (%) in leaves at different stages in sugarcane (2004)

Treatments	Days after planting	
	160	240
T_1 – Control*	1.59	1.42
T_2 – Water stress**	1.30	1.30
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	1.42	1.28
T_4 - T_2+ Foliar spray of KCl (3%)	1.25	1.15
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	1.28	1.10
T_6 - T_2+ Foliar spray of PMA (20 ppm)	1.28	1.26
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	1.68	1.19
T_8 - T_2+ Foliar spray of CCC (100 ppm)	1.45	1.32
T_9 - T_2+ Foliar spray of china clay (6%)	1.48	1.35
T_{10} - T_2+ Foliar spray of kaolin (6%)	1.50	1.15
T_{11} - T_2 + Foliar spray of ethanol (2%)	1.57	1.17
T_{12} - T_2+ Foliar spray of methanol (2%)	1.26	1.35
T_{13} - T_2+ Set soaking with saturated lime water (2%)	1.42	1.25
Mean	1.42	1.14
S.Em (±)	0.050	0.064
CD (5%)	1.145	0.186

* - Crop was irrigated at 20 days interval
** - Crop was irrigated at 40 days interval

PMA - Phenyl mercuric acetate.

Appendix 27. Influence of agrochemicals on net millable canes (000 ha^{-1}), yield (t/ha) and single cane weight (kg) in sugarcane (2005)

Treatments	Days after planting		
	Net Millable cane (000 ha^{-1})	Yield (t ha^{-1})	Single cane weight (kg)
T_1 – Control*	104.66	106.40	1.01
T_2 – Water stress**	84.65	75.90	0.92
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	93.99	94.99	0.95
T_4 - T_2+ Foliar spray of KCl (3%)	98.66	92.74	0.94
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	98.70	91.32	1.00
T_6 - T_2+ Foliar spray of PMA (20 ppm)	94.62	88.94	0.94
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	94.65	84.23	0.89
T_8 - T_2+ Foliar spray of CCC (100 ppm)	98.60	93.71	0.95
T_9 - T_2+ Foliar spray of china clay (6%)	90.32	83.99	0.93
T_{10} - T_2+ Foliar spray of kaolin (6%)	92.29	92.38	0.99
T_{11} - T_2 + Foliar spray of ethanol (2%)	93.99	86.47	0.92
T_{12} - T_2+ Foliar spray of methanol (2%)	103.32	90.92	0.88
T_{13} - T_2+ Set soaking with saturated lime water (2%)	93.32	88.68	0.95
Mean	95.51	90.05	0.94
S.Em (±)	8.894	1.760	0.053
CD (5%)	NS	5.137	0.154

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.

** - Crop was irrigated at 40 days interval

Appendix 28. Influence of agrochemicals on fibre content (%), net recovery (%) and sugar production (q ha^{-1}) in sugarcane (2004)

Treatments	Fibre (%)	Net recovery (%)	Sugar production (q ha^{-1})
T_1 – Control*	15.33	11.87	135.55
T_2 – Water stress**	16.00	11.27	85.65
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	14.33	11.34	111.94
T_4 - T_2+ Foliar spray of KCl (3%)	14.33	10.94	103.71
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	15.00	11.58	108.8
T_6 - T_2+ Foliar spray of PMA (20 ppm)	15.00	11.86	101.52
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	16.00	11.42	105.34
T_8 - T_2+ Foliar spray of CCC (100 ppm)	15.66	11.66	98.92
T_9 - T_2+ Foliar spray of china clay (6%)	15.00	11.50	38.89
T_{10} - T_2+ Foliar spray of kaolin (6%)	15.00	10.80	101.58
T_{11} - T_2 + Foliar spray of ethanol (2%)	15.66	9.81	84.05
T_{12} - T_2+ Foliar spray of methanol (2%)	15.33	11.30	98.61
T_{13} - T_2+ Set soaking with saturated lime water (2%)	15.00	10.90	92.70
Mean	15.23	11.25	92.48
S.Em ($\pm$)	0.628	0.535	54.87
CD (5%)	NS	NS	160.17

* - Crop was irrigated at 20 days interval

** - Crop was irrigated at 40 days interval

PMA - Phenyl mercuric acetate.

Appendix 29. Influence of agrochemicals on Brix (%), purity (%) and pole in cane (%) in sugarcane (2004)

Treatments	Brix (%)	Pole in cane (%)	Purity (%)
T_1 – Control*	22.22	19.66	86.13
T_2 – Water stress**	21.43	18.36	84.67
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	21.76	18.18	84.78
T_4 - T_2+ Foliar spray of KCl (3%)	20.97	17.92	85.40
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	21.92	18.77	85.64
T_6 - T_2+ Foliar spray of PMA (20 ppm)	22.76	18.48	84.17
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	21.58	18.56	85.76
T_8 - T_2+ Foliar spray of CCC (100 ppm)	21.79	18.88	86.72
T_9 - T_2+ Foliar spray of china clay (6%)	21.67	18.65	86.00
T_{10} - T_2+ Foliar spray of kaolin (6%)	20.74	17.73	85.34
T_{11} - T_2 + Foliar spray of ethanol (2%)	19.23	16.42	85.20
T_{12} - T_2+ Foliar spray of methanol (2%)	21.60	18.40	25.29
T_{13} - T_2+ Set soaking with saturated lime water (2%)	21.00	17.87	25.07
Mean	21.43	18.28	85.38
S.Em (+)	0.769	0.738	0.817
CD (5%)	NS	NS	NS

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Appendix 1. Influence of agrochemicals on plant height (cm) at different stages in sugarcane (2005)

Treatments	Days after planting			
	160	200	240	At harvest
T_1 – Control*	137.3	177.1	199.2	392.3
T_2 – Water stress**	112.6	146.3	168.0	333.9
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	128.0	168.0	185.2	369.7
T_4 - T_2+ Foliar spray of KCl (3%)	130.0	162.1	182.3	360.4
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	133.6	172.2	185.2	366.3
T_6 - T_2+ Foliar spray of PMA (20 ppm)	134.3	160.0	182.2	345.8
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	126.6	169.0	173.8	351.2
T_8 - T_2+ Foliar spray of CCC (100 ppm)	130.0	164.1	180.3	354.9
T_9 - T_2+ Foliar spray of china clay (6%)	131.6	162.0	179.7	355.4
T_{10} - T_2+ Foliar spray of kaolin (6%)	135.3	160.1	187.8	345.2
T_{11} - T_2 + Foliar spray of ethanol (2%)	131.6	167.1	182.3	345.7
T_{12} - T_2+ Foliar spray of methanol (2%)	134.3	160.1	182.5	356.2
T_{13} - T_2+ Set soaking with saturated lime water (2%)	133.3	167.0	177.2	348.3
Mean	130.6	164.1	181.9	355.7
S.Em (±)	2.97	4.20	4.09	6.19
CD (5%)	8.69	12.26	11.92	18.09

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Appendix 2. Influence of agrochemicals on number of tillers/hill at different stages in sugarcane (2005)

Treatments	Days after planting			
	160	200	240	At harvest
T_1 – Control*	8.0	7.3	5.9	5.9
T_2 – Water stress**	7.0	8.0	4.1	4.0
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	7.3	6.0	5.1	4.9
T_4 - T_2+ Foliar spray of KCl (3%)	7.0	6.7	4.2	4.1
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	7.3	5.7	4.8	4.1
T_6 - T_2+ Foliar spray of PMA (20 ppm)	7.7	5.3	4.7	4.5
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	7.3	6.0	4.4	4.3
T_8 - T_2+ Foliar spray of CCC (100 ppm)	8.0	6.0	4.9	4.5
T_9 - T_2+ Foliar spray of china clay (6%)	7.0	6.0	4.5	4.2
T_{10} - T_2+ Foliar spray of kaolin (6%)	7.0	6.0	4.8	4.6
T_{11} - T_2 + Foliar spray of ethanol (2%)	7.3	4.7	4.7	4.4
T_{12} - T_2+ Foliar spray of methanol (2%)	7.3	4.7	5.4	5.3
T_{13} - T_2+ Set soaking with saturated lime water (2%)	8.3	5.3	4.8	4.6
Mean	7.4	5.9	4.7	4.5
S.Em ($\pm$)	0.481	0.439	0.353	0.310
CD (5%)	NS	1.280	NS	NS

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.

** - Crop was irrigated at 40 days interval

Appendix 3. Influence of agrochemicals on length of the internode (cm) at different stages in sugarcane (2005)

Treatments	Days after planting			
	160	200	240	At harvest
T_1 – Control*	8.16	8.99	10.90	11.94
T_2 – Water stress**	6.48	6.66	7.98	8.89
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	7.41	7.66	8.75	10.11
T_4 - T_2+ Foliar spray of KCl (3%)	7.18	7.33	9.08	10.33
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	7.46	7.55	8.58	10.00
T_6 - T_2+ Foliar spray of PMA (20 ppm)	7.50	7.66	9.41	10.33
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	7.38	7.55	8.58	10.00
T_8 - T_2+ Foliar spray of CCC (100 ppm)	7.35	8.77	8.91	10.66
T_9 - T_2+ Foliar spray of china clay (6%)	7.76	8.11	8.58	10.50
T_{10} - T_2+ Foliar spray of kaolin (6%)	7.45	7.55	9.25	10.38
T_{11} - T_2 + Foliar spray of ethanol (2%)	7.83	8.33	8.58	9.99
T_{12} - T_2+ Foliar spray of methanol (2%)	7.41	7.99	9.25	10.16
T_{13} - T_2+ Set soaking with saturated lime water (2%)	7.75	8.11	9.75	10.33
Mean	7.40	7.86	9.10	10.28
S.Em ($\pm$)	0.207	0.205	0.263	0.177
CD (5%)	0.605	0.650	0.767	0.518

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.

** - Crop was irrigated at 40 days interval

Appendix 4. Influence of agrochemicals on girth of internodes (cm) at different stages in sugarcane (2005)

Treatments	Days after planting			
	160	200	240	At harvest
T_1 – Control*	7.9	8.7	10.7	10.7
T_2 – Water stress**	6.5	6.1	7.4	8.3
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	7.2	7.6	9.2	8.8
T_4 - T_2+ Foliar spray of KCl (3%)	7.5	7.2	9.5	9.4
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	7.4	7.5	8.2	9.6
T_6 - T_2+ Foliar spray of PMA (20 ppm)	7.0	7.6	8.8	9.4
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	7.1	7.4	8.5	9.3
T_8 - T_2+ Foliar spray of CCC (100 ppm)	7.3	8.6	9.0	9.9
T_9 - T_2+ Foliar spray of china clay (6%)	7.3	7.9	8.2	9.4
T_{10} - T_2+ Foliar spray of kaolin (6%)	7.0	7.2	8.2	9.8
T_{11} - T_2 + Foliar spray of ethanol (2%)	7.4	8.4	9.0	9.9
T_{12} - T_2+ Foliar spray of methanol (2%)	7.3	7.7	8.0	9.3
T_{13} - T_2+ Set soaking with saturated lime water (2%)	7.4	7.9	7.9	9.4
Mean	7.2	7.7	8.6	9.5
S.Em ($\pm$)	0.17	0.160	0.206	0.190
CD (5%)	0.492	0.458	0.601	0.554

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Appendix 5. Influence of agrochemicals on leaf area (LA, dm^2 $hill^{-1}$) at different stages in sugarcane (2005)

Treatments	Days after planting			
	160	200	240	At harvest
T_1 - Control	14.3	29.2	36.8	39.9
T_2 – Water stress	9.6	21.6	26.6	30.0
T_3 - T_2+ soil application of K_2O (75 kg/ha)	12.0	28.8	30.7	33.3
T_4 - T_2+ Foliar Spray of KCl (3%)	11.2	26.9	31.1	31.5
T_5 - T_2+ foliar Spray of urea (3%) + KCl (3%)	12.1	28.3	33.7	33.9
T_6 - T_2+ Foliar spray of PMA (20 ppm)	11.4	27.3	30.9	34.0
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	13.6	27.9	32.0	31.8
T_8 - T_2+ Foliar spray of CCC (100 ppm)	13.4	27.9	30.9	33.1
T_9 - T_2+ Foliar spray of China clay (6%)	13.1	28.7	30.9	32.3
T_{10} - T_2+ Foliar spray of kaolin (6%)	11.4	29.5	32.9	35.5
T_{11} - T_2 + Foliar spray of ethanol (2%)	10.9	29.9	32.5	34.1
T_{12} - T_2+ Foliar spray of methanol (2%)	10.8	28.8	30.8	32.6
T_{13} - T_2+ Set soaking with saturated lime water (2%)	10.6	23.6	33.1	37.2
Mean	11.9	27.6	31.8	33.8
S.Em (±)	0.406	1.93	0.619	0.791
CD (5%)	1.158	NS	1.806	2.310

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Appendix 6. Influence of agrochemicals on total dry matter (g/hill) at different stages in sugarcane (2005)

Treatments	Days after planting			
	160	200	240	At harvest
T_1 – Control*	282.6	571.7	866.0	1430.00
T_2 – Water stress**	221.3	445.2	601.8	1020.00
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	271.8	518.4	644.3	1170.00
T_4 - T_2+ Foliar spray of KCl (3%)	269.2	519.8	756.7	1130.00
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	274.8	523.5	778.0	1200.00
T_6 - T_2+ Foliar spray of PMA (20 ppm)	264.8	531.4	761.3	1180.00
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	268.9	520.2	759.0	1140.00
T_8 - T_2+ Foliar spray of CCC (100 ppm)	270.6	538.5	741.7	1190.00
T_9 - T_2+ Foliar spray of china clay (6%)	265.7	524.5	767.3	1140.00
T_{10} – T_2+ Foliar spray of kaolin (6%)	270.7	526.5	773.7	1100.00
T_{11} – T_2 + Foliar spray of ethanol (2%)	270.1	535.0	807.3	1140.00
T_{12} – T_2+ Foliar spray of methanol (2%)	271.9	530.3	772.7	1110.00
T_{13} - T_2+ Set soaking with saturated lime water (2%)	274.1	525.0	773.3	1120.00
Mean	268.0	523.8	754.1	1159.20
S.Em (+)	6.459	5.208	7.546	20.632
CD (5%)	NS	15.202	22.027	60.222

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.

** - Crop was irrigated at 40 days interval

Appendix 7. Influence of agrochemicals on leaf sheath moisture content (%) at different stages in sugarcane (2005)

Treatments	Days after planting	
	160	240
T_1 – Control*	74.2	72.0
T_2 – Water stress**	77.5	62.1
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	67.8	72.0
T_4 - T_2+ Foliar spray of KCl (3%)	71.2	67.3
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	71.8	67.7
T_6 - T_2+ Foliar spray of PMA (20 ppm)	74.1	68.4
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	75.0	71.3
T_8 - T_2+ Foliar spray of CCC (100 ppm)	70.8	69.1
T_9 - T_2+ Foliar spray of china clay (6%)	68.5	66.5
T_{10} - T_2+ Foliar spray of kaolin (6%)	65.7	67.0
T_{11} - T_2 + Foliar spray of ethanol (2%)	70.8	67.1
T_{12} - T_2+ Foliar spray of methanol (2%)	65.2	66.8
T_{13} - T_2+ Set soaking with saturated lime water (2%)	64.3	70.8
Mean	70.5	68.06
S.Em (±)	1.436	1.796
CD (5%)	4.192	5.241

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.

** - Crop was irrigated at 40 days interval

Appendix 8. Influence of agrochemicals on relative water content (%) at different stages in sugar cane (2005)

Treatments	Days after planting	
	160	200
T_1 – Control*	66.80	68.9
T_2 – Water stress**	88.80	71.3
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	88.80	67.5
T_4 - T_2+ Foliar spray of KCl (3%)	80.70	68.2
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	87.10	69.5
T_6 - T_2+ Foliar spray of PMA (20 ppm)	83.10	67.3
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	89.60	71.5
T_8 - T_2+ Foliar spray of CCC (100 ppm)	87.60	68.1
T_9 - T_2+ Foliar spray of china clay (6%)	81.80	70.5
T_{10} - T_2+ Foliar spray of kaolin (6%)	88.70	73.3
T_{11} - T_2 + Foliar spray of ethanol (2%)	88.60	82.3
T_{12} - T_2+ Foliar spray of methanol (2%)	83.10	65.9
T_{13} - T_2+ Set soaking with saturated lime water (2%)	90.80	68.5
Mean	84.60	70.29
S.Em (±)	1.264	1.168
CD (5%)	3.689	3.411

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.

** - Crop was irrigated at 40 days interval

Appendix 9. Influence of agrochemicals on diffusive resistance (DR, s cm^{-1}) at different stages in sugarcane (2005)

Treatments	Days after planting		
	160	200	240
T_1 – Control*	0.493	1.130	1.332
T_2 – Water stress**	2.413	1.488	2.363
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	1.140	1.315	1.420
T_4 - T_2+ Foliar spray of KCl (3%)	1.043	1.393	1.492
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	0.980	1.393	1.530
T_6 - T_2+ Foliar spray of PMA (20 ppm)	1.090	1.266	1.580
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	0.930	1.220	1.581
T_8 - T_2+ Foliar spray of CCC (100 ppm)	0.942	1.303	1.612
T_9 - T_2+ Foliar spray of china clay (6%)	1.143	1.428	1.540
T_{10} - T_2+ Foliar spray of kaolin (6%)	1.052	1.283	1.480
T_{11} - T_2 + Foliar spray of ethanol (2%)	0.961	1.356	1.421
T_{12} - T_2+ Foliar spray of methanol (2%)	0.990	1.361	1.382
T_{13} - T_2+ Set soaking with saturated lime water (2%)	1.042	1.288	1.531
Mean	1.117	1.236	1.558
S.Em (±)	0.066	0.054	0.039
CD (5%)	0.192	0.158	0.113

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Appendix 10. Influence of agrochemicals on transpiration rate (TR, µg m^{-2} s^{-1}) at different stages in sugarcane (2005)

Treatments	Days after planting		
	160	200	240
T_1 – Control*	27.33	51.60	28.92
T_2 – Water stress**	20.85	21.10	18.64
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	36.12	36.14	28.77
T_4 - T_2+ Foliar spray of KCl (3%)	37.41	34.49	26.96
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	38.25	38.00	26.88
T_6 - T_2+ Foliar spray of PMA (20 ppm)	36.75	36.78	26.30
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	44.25	43.93	26.30
T_8 - T_2+ Foliar spray of CCC (100 ppm)	43.83	43.80	26.45
T_9 - T_2+ Foliar spray of china clay (6%)	39.41	41.00	27.40
T_{10} - T_2+ Foliar spray of kaolin (6%)	39.09	39.09	27.83
T_{11} - T_2 + Foliar spray of ethanol (2%)	42.08	42.08	28.05
T_{12} - T_2+ Foliar spray of methanol (2%)	40.00	40.70	28.60
T_{13} - T_2+ Set soaking with saturated lime water (2%)	39.00	39.34	26.50
Mean	37.32	39.29	26.80
S.Em (±)	2.303	1.001	1.430
CD (5%)	6.724	2.923	4.173

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.

** - Crop was irrigated at 40 days interval

Appendix 11. Influence of agrochemicals on leaf temperature (^{0}C) at different stages in sugarcane (2005)

Treatments	Days after planting		
	160	200	240
T_1 – Control*	30.0	28.3	31.5
T_2 – Water stress**	31.6	30.60	34.05
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	31.1	31.50	33.48
T_4 - T_2+ Foliar spray of KCl (3%)	31.5	32.22	33.90
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	30.7	31.50	33.95
T_6 - T_2+ Foliar spray of PMA (20 ppm)	31.1	31.20	33.66
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	30.3	31.50	33.43
T_8 - T_2+ Foliar spray of CCC (100 ppm)	30.4	31.25	33.59
T_9 - T_2+ Foliar spray of china clay (6%)	30.4	32.20	33.75
T_{10} - T_2+ Foliar spray of kaolin (6%)	30.9	31.90	33.96
T_{11} – T_2 + Foliar spray of ethanol (2%)	30.4	32.00	34.00
T_{12} – T_2+ Foliar spray of methanol (2%)	30.1	30.25	33.43
T_{13} - T_2+ Set soaking with saturated lime water (2%)	30.6	31.75	33.95
Mean	30.8	31.40	33.80
S.Em (±)	0.425	0.390	0.301
CD (5%)	1.301	1.420	1.31

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.

** - Crop was irrigated at 40 days interval

Appendix 12. Influence of agrochemicals on leaf area index (LAI) at different stages in sugarcane (2005)

Treatments	Days after planting			
	160	200	240	At harvest
T_1 - Control	4.16	8.76	11.04	11.92
T_2 – Water stress	2.99	6.49	7.97	8.89
T_3 - T_2+ soil application of K_2O (75 kg/ha)	3.64	8.65	9.22	10.14
T_4 - T_2+ Foliar Spray of KCl (3%)	3.34	8.03	8.86	9.56
T_5 - T_2+ foliar Spray of urea (3%) + KCl (3%)	3.63	8.26	9.55	10.77
T_6 - T_2+ Foliar spray of PMA (20 ppm)	3.43	8.50	9.25	10.18
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	4.09	8.78	9.63	9.95
T_8 - T_2+ Foliar spray of CCC (100 ppm)	4.01	8.97	9.37	9.94
T_9 - T_2+ Foliar spray of China clay (6%)	3.92	8.58	9.27	9.80
T_{10} - T_2+ Foliar spray of kaolin (6%)	3.44	8.68	9.88	10.61
T_{11} - T_2 + Foliar spray of ethanol (2%)	3.27	8.97	9.75	10.31
T_{12} - T_2+ Foliar spray of methanol (2%)	3.19	8.64	9.26	10.02
T_{13} - T_2+ Set soaking with saturated lime water (2%)	3.19	9.01	9.93	10.49
Mean	3.56	8.52	9.46	10.19
S.Em ($\pm$)	0.096	0.143	0.174	0.200
CD (5%)	0.282	0.418	0.508	0.584

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Appendix 13. Influence of agrochemicals on leaf area duration (LAD, days) at different stages in sugarcane (2005)

Treatments	Days after planting		
	160-200	200-240	At harvest
T_1 - Control	259.4	396.2	1035.0
T_2 – Water stress	190.4	289.2	755.4
T_3 – T_2+ soil application of K_2O (75 kg/ha)	234.7	357.4	870.3
T_4 – T_2+ Foliar Spray of KCl (3%)	228.0	337.8	826.2
T_5 – T_2+ foliar Spray of urea (3%) + KCl (3%)	238.0	356.2	914.8
T_6 – T_2+ Foliar spray of PMA (20 ppm)	238.3	355.4	673.4
T_7 – T_2+ Foliar spray of alachlor (200 ppm)	257.4	368.4	875.3
T_8 – T_2+ Foliar spray of CCC (100 ppm)	261.6	368.6	871.3
T_9 – T_2+ Foliar spray of China clay (6%)	250.6	357.8	858.1
T_{10} - T_2+ Foliar spray of kaolin (6%)	241.6	369.0	919.9
T_{11} - T_2 + Foliar spray of ethanol (2%)	246.0	374.4	901.6
T_{12} - T_2+ Foliar spray of methanol (2%)	238.0	358.6	867.2
T_{13} - T_2+ Set soaking with saturated lime water (2%)	239.7	379.6	919.4
Mean	240.3	336.9	883.7
S.Em ($\pm$)	3.146	5.100	12.517
CD (5%)	9.182	14.886	NS

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Appendix 14. Influence of agrochemicals on specific leaf weight (SLW. g dm^{-2}) at different stages in sugar cane (2005)

Treatments	Days After planting			
	160	200	240	At harvest
T_1 - Control	6.78	7.57	8.15	9.82
T_2 – Water stress	8.87	9.24	7.94	9.78
T_3 - T_2+ soil application of K_2O (75 kg/ha)	7.49	7.38	7.88	9.65
T_4 - T_2+ Foliar Spray of KCl (3%)	8.10	7.64	8.74	9.04
T_5 - T_2+ foliar Spray of urea (3%) + KCl (3%)	7.50	7.56	8.44	9.16
T_6 - T_2+ Foliar spray of PMA (20 ppm)	7.89	7.51	8.21	8.98
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	6.89	6.97	8.20	8.79
T_8 - T_2+ Foliar spray of CCC (100 ppm)	6.80	7.01	8.05	9.09
T_9 - T_2+ Foliar spray of China clay (6%)	6.80	7.08	7.96	9.38
T_{10} - T_2+ Foliar spray of kaolin (6%)	7.61	7.15	7.96	8.32
T_{11} - T_2 + Foliar spray of ethanol (2%)	8.13	7.17	8.07	9.19
T_{12} - T_2+ Foliar spray of methanol (2%)	8.33	7.23	8.05	8.82
T_{13} - T_2+ Set soaking with saturated lime water (2%)	8.58	7.01	7.90	7.78
Mean	7.67	7.42	8.11	9.13
S.Em (+)	0.250	0.108	0.086	0.269
CD (5%)	0.730	NS	NS	NS

* - Crop was irrigated at 20 days interval   PMA - Phenyl mercuric acetate.

** - Crop was irrigated at 40 days interval

Appendix 15. Influence of agrochemicals on specific leaf area (SLA, $dm^2\ g^{-1}$) at different stages in sugarcane (2005)

Treatments	Days after planting			
	160	200	240	At harvest
T_1 – Control*	0.146	0.121	0.122	0.101
T_2 – Water stress**	0.112	0.107	0.124	0.102
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	0.133	0.134	0.126	0.103
T_4 - T_2+ Foliar spray of KCl (3%)	0.124	0.131	0.129	0.110
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	0.133	0.131	0.118	0.109
T_6 - T_2+ Foliar spray of PMA (20 ppm)	0.126	0.133	0.121	0.111
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	0.145	0.142	0.121	0.113
T_8 - T_2+ Foliar spray of CCC (100 ppm)	0.147	0.142	0.124	0.110
T_9 - T_2+ Foliar spray of china clay (6%)	0.147	0.140	0.125	0.106
T_{10} - T_2+ Foliar spray of kaolin (6%)	0.131	0.139	0.125	0.120
T_{11} - T_2 + Foliar spray of ethanol (2%)	0.122	0.139	0.123	0.108
T_{12} - T_2+ Foliar spray of methanol (2%)	0.116	0.138	0.123	0.113
T_{13} - T_2+ Set soaking with saturated lime water (2%)	0.116	0.142	0.126	0.128
Mean	0.131	0.133	0.124	0.110
S.Em (±)	0.003	0.004	0.003	0.0014
CD (5%)	0.010	0.012	0.0015	0.1100

* - Crop was irrigated at 20 days interval   PMA - Phenyl mercuric acetate.

** - Crop was irrigated at 40 days interval

Appendix 16. Influence of agrochemicals on absolute growth rate (AGR g day^{-1}) at different stages in sugarcane (2005)

Treatments	Days after planting		
	160-200	200-240	240-harvest
T_1 - Control	7.31	7.37	6.29
T_2 – Water stress	6.22	5.27	5.18
T_3 - T_2+ soil application of K_2O (75 kg/ha)	6.20	4.60	4.35
T_4 - T_2+ Foliar Spray of KCl (3%)	6.19	6.80	4.14
T_5 - T_2+ foliar Spray of urea (3%) + KCl (3%)	6.65	6.23	4.84
T_6 - T_2+ Foliar spray of PMA (20 ppm)	6.31	5.79	4.75
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	6.47	5.98	4.20
T_8 - T_2+ Foliar spray of CCC (100 ppm)	6.60	4.98	5.05
T_9 - T_2+ Foliar spray of China clay (6%)	6.68	6.01	4.21
T_{10} - T_2+ Foliar spray of kaolin (6%)	6.32	6.23	3.68
T_{11} - T_2 + Foliar spray of ethanol (2%)	6.36	7.28	3.69
T_{12} - T_2+ Foliar spray of methanol (2%)	7.30	6.11	3.79
T_{13} - T_2+ Set soaking with saturated lime water (2%)	6.37	6.13	3.49
Mean	6.53	6.06	4.43
S.Em (±)	0.393	0.215	0.259
CD (5%)	NS	0.629	0.755

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Appendix 17. Influence of agrochemicals on relative growth rate (RGR g gr^{-1} day^{-1}) at different stages in sugarcane (2005)

Treatments	Days after planting		
	160-200	200-240	240- harvest
T_1 – Control*	0.0080	0.004	0.0040
T_2 – Water stress**	0.0060	0.004	0.0040
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	0.0070	0.0040	0.0040
T_4 - T_2+ Foliar spray of KCl (3%)	0.0070	0.0041	0.0032
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	0.0070	0.0040	0.0040
T_6 - T_2+ Foliar spray of PMA (20 ppm)	0.0070	0.0041	0.0040
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	0.0050	0.0041	0.0040
T_8 - T_2+ Foliar spray of CCC (100 ppm)	0.0070	0.0030	0.0040
T_9 - T_2+ Foliar spray of china clay (6%)	0.0070	0.0042	0.0041
T_{10} - T_2+ Foliar spray of kaolin (6%)	0.0070	0.0040	0.0030
T_{11} - T_2 + Foliar spray of ethanol (2%)	0.0070	0.0051	0.0030
T_{12} - T_2+ Foliar spray of methanol (2%)	0.0070	0.0042	0.0030
T_{13} - T_2+ Set soaking with saturated lime water (2%)	0.0070	0.0040	0.0030
Mean	0.0070	0.0042	0.0033
S.Em (±)	0.0010	0.0003	0.000
CD (5%)	NS	0.0202	0.001

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.

** - Crop was irrigated at 40 days interval

Appendix 18. Influence of agrochemicals on crop growth rate (CGR, g dm^{-2} day^{-1}) at different stages in sugarcane (2005)

Treatments	Days after planting		
	160-200	200-240	240-harvest
T_1 - Control	27.04	27.27	23.27
T_2 – Water stress	23.01	19.53	19.17
T_3 - T_2+ soil application of K_2O (75 kg/ha)	22.94	17.04	16.09
T_4 - T_2+ Foliar Spray of KCl (3%)	22.90	25.19	15.31
T_5 - T_2+ foliar Spray of urea (3%) + KCl (3%)	24.60	23.07	17.90
T_6 - T_2+ Foliar spray of PMA (20 ppm)	23.35	21.46	17.58
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	23.94	22.53	15.54
T_8 - T_2+ Foliar spray of CCC (100 ppm)	24.42	18.44	18.68
T_9 - T_2+ Foliar spray of China clay (6%)	24.71	22.28	15.57
T_{10} - T_2+ Foliar spray of kaolin (6%)	23.38	23.08	13.61
T_{11} - T_2 + Foliar spray of ethanol (2%)	23.52	26.96	13.65
T_{12} - T_2+ Foliar spray of methanol (2%)	26.01	21.76	14.02
T_{13} - T_2+ Set soaking with saturated lime water (2%)	23.56	22.72	12.91
Mean	24.20	22.39	16.39
S.Em (±)	0.141	0.073	0.087
CD (5%)	NS	0.212	0.253

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Appendix 19. Influence of agrochemicals on net assimilation rate (NAR, g dm^2 day^{-1}) at different stages in sugarcane (2005)

Treatments	Days after planting		
	160-200	200-240	240-harvest
T_1 – Control*	0.159	0.097	0.071
T_2 – Water stress**	0.101	0.095	0.080
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	0.139	0.094	0.059
T_4 - T_2+ Foliar spray of KCl (3%)	0.155	0.088	0.058
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	0.141	0.087	0.062
T_6 - T_2+ Foliar spray of PMA (20 ppm)	0.157	0.087	0.045
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	0.135	0.087	0.072
T_8 - T_2+ Foliar spray of CCC (100 ppm)	0.147	0.075	0.069
T_9 - T_2+ Foliar spray of china clay (6%)	0.147	0.087	0.058
T_{10} - T_2+ Foliar spray of kaolin (6%)	0.145	0.087	0.047
T_{11} - T_2 + Foliar spray of ethanol (2%)	0.152	0.095	0.047
T_{12} - T_2+ Foliar spray of methanol (2%)	0.151	0.089	0.052
T_{13} - T_2+ Set soaking with saturated lime water (2%)	0.147	0.087	0.047
Mean	0.144	0.089	0.059
S.Em (+)	0.014	0.003	0.008
CD (5%)	NS	0.010	NS

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.

** - Crop was irrigated at 40 days interval

Appendix 20. Influence of agrochemicals on chlorophyll 'a' content (mg g^{-1} fr. wt.) at different stages in sugarcane (2005)

Treatments	Days after planting	
	160	200
T_1 – Control*	1.050	1.105
T_2 – Water stress**	0.790	0.730
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	0.840	0.817
T_4 - T_2+ Foliar spray of KCl (3%)	0.826	0.790
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	0.884	0.770
T_6 - T_2+ Foliar spray of PMA (20 ppm)	0.883	0.807
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	0.876	0.757
T_8 - T_2+ Foliar spray of CCC (100 ppm)	0.908	0.747
T_9 - T_2+ Foliar spray of china clay (6%)	0.858	0.725
T_{10} - T_2+ Foliar spray of kaolin (6%)	0.877	0.793
T_{11} - T_2 + Foliar spray of ethanol (2%)	0.896	0.763
T_{12} - T_2+ Foliar spray of methanol (2%)	0.896	0.867
T_{13} - T_2+ Set soaking with saturated lime water (2%)	0.896	0.852
Mean	0.883	0.809
S.Em (±)	0.014	0.083
CD (5%)	0.041	NS

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Appendix 21. Influence of agrochemicals on chlorophyll 'b' content (mg gr^{-1} fr. wt.) at different stages in sugarcane (2005)

Treatments	Days after planting	
	160	200
T_1 – Control*	0.820	0.590
T_2 – Water stress**	0.477	0.663
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	0.524	0.730
T_4 - T_2+ Foliar spray of KCl (3%)	0.590	0.683
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	0.602	0.653
T_6 - T_2+ Foliar spray of PMA (20 ppm)	0.726	0.713
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	0.651	0.628
T_8 - T_2+ Foliar spray of CCC (100 ppm)	0.638	0.456
T_9 - T_2+ Foliar spray of china clay (6%)	0.458	0.640
T_{10} - T_2+ Foliar spray of kaolin (6%)	0.557	0.556
T_{11} - T_2 + Foliar spray of ethanol (2%)	0.563	0.614
T_{12} - T_2+ Foliar spray of methanol (2%)	0.515	0.578
T_{13} - T_2+ Set soaking with saturated lime water (2%)	0.595	0.418
Mean	0.594	0.609
S.Em (±)	0.027	0.077
CD (5%)	0.079	NS

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.

** - Crop was irrigated at 40 days interval

Appendix 22. Influence of agrochemicals on total chlorophyll content (mg gr^{-1} fr. wt.) at different stages in sugarcane (2005)

Treatments	Days after planting	
	160	200
T_1 – Control*	1.702	1.819
T_2 – Water stress**	1.293	1.410
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	1.377	1.560
T_4 - T_2+ Foliar spray of KCl (3%)	1.478	1.465
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	1.503	1.420
T_6 - T_2+ Foliar spray of PMA (20 ppm)	1.600	1.510
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	1.490	1.270
T_8 - T_2+ Foliar spray of CCC (100 ppm)	1.517	1.280
T_9 - T_2+ Foliar spray of china clay (6%)	1.207	1.490
T_{10} - T_2+ Foliar spray of kaolin (6%)	1.430	1.480
T_{11} - T_2 + Foliar spray of ethanol (2%)	1.467	1.450
T_{12} - T_2+ Foliar spray of methanol (2%)	1.423	1.430
T_{13} - T_2+ Set soaking with saturated lime water (2%)	1.377	1.440
Mean	1.451	1.463
S.Em (+)	0.069	0.038
CD (5%)	0.201	0.112

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Appendix 23. Influence of agrochemicals on nitrate reductase activity (nmoles gr^{-1} fr. wt. hr^{-1}) at different stages in sugarcane (2005)

Treatments	Days after planting	
	160	240
T_1 – Control*	1009.0	1003.0
T_2 – Water stress**	893.5	768.0
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	904.0	905.0
T_4 - T_2+ Foliar spray of KCl (3%)	884.3	818.0
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	902.0	900.0
T_6 - T_2+ Foliar spray of PMA (20 ppm)	847.3	828.0
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	893.3	812.0
T_8 - T_2+ Foliar spray of CCC (100 ppm)	910.6	816.0
T_9 - T_2+ Foliar spray of china clay (6%)	885.3	850.0
T_{10} – T_2+ Foliar spray of kaolin (6%)	899.6	845.0
T_{11} – T_2 + Foliar spray of ethanol (2%)	876.0	838.0
T_{12} – T_2+ Foliar spray of methanol (2%)	990.6	908.0
T_{13} – T_2+ Set soaking with saturated lime water (2%)	985.6	894.0
Mean	998.6	860.4
S.Em ($\pm$)	16.610	18.456
CD (5%)	48.483	53.872

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.

** - Crop was irrigated at 40 days interval

Appendix 24. Influence of agrochemicals on proline content in leaves (mg gr^{-1} fr. wt.) at different stages in sugarcane (2005)

Treatments	Days after planting	
	160	240
T_1 - Control	112.10	113.40
T_2 – Water stress	172.09	176.80
T_3 - T_2+ soil application of K_2O (75 kg/ha)	144.92	147.00
T_4 - T_2+ Foliar Spray of KCl (3%)	166.66	162.50
T_5 - T_2+ foliar Spray of urea (3%) + KCl (3%)	173.90	158.60
T_6 - T_2+ Foliar spray of PMA (20 ppm)	168.40	160.33
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	177.53	171.16
T_8 - T_2+ Foliar spray of CCC (100 ppm)	157.60	162.33
T_9 - T_2+ Foliar spray of China clay (6%)	164.85	165.33
T_{10} - T_2+ Foliar spray of kaolin (6%)	157.60	161.08
T_{11} - T_2 + Foliar spray of ethanol (2%)	170.30	161.66
T_{12} - T_2+ Foliar spray of methanol (2%)	184.77	162.50
T_{13} - T_2+ Set soaking with saturated lime water (2%)	175.72	160.00
Mean	163.50	158.20
S.Em (±)	4.611	4.355
CD (5%)	13.47	12.711

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Appendix 25. Influence of agrochemicals on total sugar content (mg gr^{-1} dry weight) in leaves at different stages in sugarcane (2005)

Treatments	Days after planting	
	160	240
T_1 - Control	17.94	22.57
T_2 – Water stress	13.10	14.62
T_3 - T_2+ soil application of K_2O (75 kg/ha)	15.79	16.20
T_4 - T_2+ Foliar Spray of KCl (3%)	14.04	15.41
T_5 - T_2+ foliar Spray of urea (3%) + KCl (3%)	16.03	16.51
T_6 - T_2+ Foliar spray of PMA (20 ppm)	15.54	16.25
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	15.94	16.75
T_8 - T_2+ Foliar spray of CCC (100 ppm)	15.36	15.90
T_9 - T_2+ Foliar spray of China clay (6%)	17.00	19.20
T_{10} - T_2+ Foliar spray of kaolin (6%)	16.34	18.34
T_{11} - T_2 + Foliar spray of ethanol (2%)	14.67	17.16
T_{12} - T_2+ Foliar spray of methanol (2%)	17.50	15.00
T_{13} - T_2+ Set soaking with saturated lime water (2%)	15.75	17.50
Mean	15.76	19.52
S.Em (+)	0.842	1.032
CD (5%)	2.457	NS

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Appendix 26. Influence of agrochemicals on potassium content (%) in leaves at different stages in sugarcane (2005)

Treatments	Days After Planting	
	160	240
T_1 – Control*	1.57	1.46
T_2 – Water stress**	1.26	1.18
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	1.36	1.38
T_4 - T_2+ Foliar spray of KCl (3%)	1.37	1.27
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	1.42	1.18
T_6 - T_2+ Foliar spray of PMA (20 ppm)	1.34	1.30
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	1.40	1.27
T_8 - T_2+ Foliar spray of CCC (100 ppm)	1.35	1.32
T_9 - T_2+ Foliar spray of china clay (6%)	1.40	1.29
T_{10} - T_2+ Foliar spray of kaolin (6%)	1.36	1.37
T_{11} - T_2 + Foliar spray of ethanol (2%)	1.45	1.31
T_{12} - T_2+ Foliar spray of methanol (2%)	1.29	1.21
T_{13} - T_2+ Set soaking with saturated lime water (2%)	1.44	1.29
Mean	1.38	1.29
S.Em (±)	0.061	0.082
CD (5%)	NS	0.120

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.
** - Crop was irrigated at 40 days interval

Appendix 27. Influence of agrochemicals on net millable canes (000 ha^{-1}), yield (t/ha) and single cane weight (kg) in sugarcane (2005)

Treatments	Days after planting		
	Net Millable cane (000 ha^{-1})	Yield (t ha^{-1})	Single cane weight (kg)
T_1 – Control*	104.66	106.40	1.01
T_2 – Water stress**	84.65	75.90	0.92
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	93.99	94.99	0.95
T_4 - T_2+ Foliar spray of KCl (3%)	98.66	92.74	0.94
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	98.70	91.32	1.00
T_6 - T_2+ Foliar spray of PMA (20 ppm)	94.62	88.94	0.94
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	94.65	84.23	0.89
T_8 - T_2+ Foliar spray of CCC (100 ppm)	98.60	93.71	0.95
T_9 - T_2+ Foliar spray of china clay (6%)	90.32	83.99	0.93
T_{10} - T_2+ Foliar spray of kaolin (6%)	92.29	92.38	0.99
T_{11} - T_2 + Foliar spray of ethanol (2%)	93.99	86.47	0.92
T_{12} - T_2+ Foliar spray of methanol (2%)	103.32	90.92	0.88
T_{13} - T_2+ Set soaking with saturated lime water (2%)	93.32	88.68	0.95
Mean	95.51	90.05	0.94
S.Em (±)	8.894	1.760	0.053
CD (5%)	NS	5.137	0.154

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.

** - Crop was irrigated at 40 days interval

Appendix 28. Influence of agrochemicals on fibre content (%), net recovery (NR, %) and sugar production (q ha^{-1}) in sugarcane (2005)

Treatments	Fibre (%)	Net Recovery	Sugar production (q ha^{-1})
T_1 - Control	14.00	11.81	124.71
T_2 – Water stress	15.00	10.90	84.87
T_3 - T_2+ soil application of K_2O (75 kg/ha)	15.37	11.17	106.10
T_4 - T_2+ Foliar Spray of KCl (3%)	15.66	11.09	102.84
T_5 - T_2+ foliar Spray of urea (3%) + KCl (3%)	16.00	10.99	100.36
T_6 - T_2+ Foliar spray of PMA (20 ppm)	14.33	11.40	101.39
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	16.66	11.15	93.91
T_8 - T_2+ Foliar spray of CCC (100 ppm)	15.66	11.25	105.42
T_9 - T_2+ Foliar spray of China clay (6%)	14.33	11.18	93.90
T_{10} - T_2+ Foliar spray of kaolin (6%)	15.66	11.53	106.51
T_{11} - T_2 + Foliar spray of ethanol (2%)	16.66	11.16	96.50
T_{12} - T_2+ Foliar spray of methanol (2%)	15.66	11.31	102.83
T_{13} - T_2+ Set soaking with saturated lime water (2%)	16.00	11.39	100.97
Mean	15.46	11.25	101.55
S.Em (±)	0.625	0.103	45.250
CD (5%)	NS	0.301	130.715

* - Crop was irrigated at 20 days interval

** - Crop was irrigated at 40 days interval

PMA - Phenyl mercuric acetate.

Appendix 29. Influence of agrochemicals on in Brix (%), pole in cane (%) and purity (%) in sugarcane (2005)

Treatment	Brix (%)	Pole in cane (%)	Purity
T_1 – Control*	22.81	18.55	86.66
T_2 – Water stress**	20.65	17.86	84.25
T_3 - T_2+ Soil application of K_2O (75 kg/ha)	21.93	18.48	85.91
T_4 - T_2+ Foliar spray of KCl (3%)	21.41	18.12	86.25
T_5 - T_2+ Foliar spray of urea (3%) + KCl (3%)	20.56	12.05	85.33
T_6 - T_2+ Foliar spray of PMA (20 ppm)	21.50	17.70	86.00
T_7 - T_2+ Foliar spray of alachlor (200 ppm)	21.58	17.78	86.23
T_8 - T_2+ Foliar spray of CCC (100 ppm)	21.33	18.15	87.21
T_9 - T_2+ Foliar spray of china clay (6%)	21.05	17.96	86.33
T_{10} - T_2+ Foliar spray of kaolin (6%)	20.16	18.16	85.38
T_{11} - T_2 + Foliar spray of ethanol (2%)	19.23	18.06	85.33
T_{12} - T_2+ Foliar spray of methanol (2%)	21.58	18.26	86.16
T_{13} - T_2+ Set soaking with saturated lime water (2%)	20.47	18.13	85.30
Mean	21.101	18.101	85.86
S.Em (+)	0.370	0.214	0.59
CD (5%)	1.079	NS	NS

* - Crop was irrigated at 20 days interval PMA - Phenyl mercuric acetate.

** - Crop was irrigated at 40 days interval

PHYSIOLOGICAL APPROACHES FOR DROUGHT TOLERANCE IN SUGARCANE (*Saccharum officinarum* L.)

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ABSTRACT

Field experiments were conducted at Research and Development Farm of the Ugar Sugar Works Ltd., Ugarkhurd (Belgaum District), Karnataka during 2004-05 and 2005-06 to study the influence of different agro-chemicals on various morpho-physiological, biochemical and yield and yield components in sugarcane under moisture stress conditions. The experiments were laid out in randomized block design with 13 treatments and three replications.

The morphological parameters, *viz*., plant height, length and girth of internodes were significantly higher with the soil application of K2O (75 kg/ha) followed by foliar spray of KCl (3%) and foliar spray of KCl (3%) + urea (3%) compared to control. Significantly higher number of tillers per hill were observed with the foliar spray of methanol (2%) compared to all other treatments.

Among various biochemical parameters, chlorophyll ‘a’, chlorophyll ‘b’ and total chlorophyll contents were found to be significantly higher with the soil application of K_2O (75 kg/ha) followed by foliar spray of PMA (20 ppm) and foliar spray of methanol (2%) compared to moisture stress treatments. Whereas, praline content was significantly higher in water stress treatments compared to all other treatments. While, the NRA was found to be significantly lower in water stress treatment compared to other treatments.

Among various growth parameters, LAI was found to be significantly higher in the foliar spray of PMA (20 ppm) compared to all other treatments. Whereas, LAD, SLW, AGR were found to be maximum in normal irrigation compared to all other stress treatments. Net millable canes were found significantly higher in foliar spray of methanol (2%) followed by soil application of K_2O (75 kg/ha) and foliar spray of KCl (3%) + urea (3%) compared to control (water stress). Sugar production (t/ha) was significantly higher with the soil application of K_2O (75 kg/ha) compared to all other treatments.