CHAPTER - I

REVIEW OF LITERATURE

A. INDOL 3 ACETIC ACID (IAA)

1. INTRODUCTION

Among the five well known phytohormones auxins were perhaps the most popular among early days of plant physiology. The idea of the existence of auxins the plants was for the first time conceived by Charles Darwin in 1881. Although the classical oat coleoptile experiments of Went (1929) demonstrated the presence of this phytohormone, it was Thimann (1934) who for the first time isolated auxin from the culture filtrate of the fungus *Rhizopus suinus*. Chemically the typical auxin is Indole acetic acid. Auxins represent a class of phytohormones, which are capable of promoting longitudinal growth in coleoptile and mature plants. Auxin plays an important role in cell elongation, tropical movements, formation of adventitious roots, apical dominance, formation of parthenocarpic fruits, prevention of abscission, erradication of weeds and respiration etc.

2. RESPONSES OF SUGARCANE TO IAA

a. Germination

Sena et al. (1974) studied the effect of IAA on germination of sugarcane and found that there was decrease in the germination of sugarcane setts. On the other hand Sharma et al. (1983) found that foliar application of IAA (100 and 150 ppm) caused increase in sprouting of stubble

buds of ratoon. Bendigary et al. (1986) also noticed that there was increase in germination percentage due to IAA treatment. Castro et al. (1975) observed that germination was increased by pretreating sugarcane setts with 100 and 250 ppm IAA for about 8-12 hrs. Naik and Joshi (1981) however noticed that pretreatment of sugarcane setts with IAA inhibited the germination.

b. Vegetative Growth

Singh and Singh (1964) used five different concentration of IAA (5-80 ppm) for foliar spray and noted that the treatment of IAA enhanced the tillering. Dowson (1965) observed that pretreatment with IAA increased the tiller number in sugarcane. Sena et al. (1974) observed that pretreatment with IAA caused improved growth of aerial parts of sugarcane variety co. 740. Singh and Singh (1964) and Nimbalkar (1973) reported that pretreatment caused stalk elongation of sugarcane.

Hayashi et al. (1953) observed that IAA treated leaves were longer and hence grater total photosynthetic area was produced. Brain et al. (1954) also found that plant treated with IAA showed an increase in total photosynthetic leaf area. Yasumaisu (1967) noticed that there was decrease in the dry weight in case of IAA treated sugarcane leaves.

c. Yield and Juice Quality

The experiments of Sharma et al. (1983) at Sugarcane Research Station, Punjab Agricultural University, Jalandhar, India indicated that there is increase in the yield by 9.20% due to IAA at 150 ppm. In 1982-83 they also noticed that the IAA at 100 and 150 ppm enhanced yield by 19.50% and 16.80% respectively.

d. Metabolic Changes

i. Chlorophyll Content

Shetty (1971) reported that foliar spary of IAA caused reduction in chlorophyll content of sugarcane leaves. In contrast to above observations Nimbalkar (1973) observed that the leaves treated with IAA contained higher amount of chlorophylls.

ii. Photosynthetic Rate

Extensive studies of Nimbalkar (1973) revealed that the treatment of IAA increased the total photosynthetic rate and had a definite effect on products of photosynthesis. There is increase in the rate of 14C assimilation and there was greater stimulation of labelling of amino acids, decline in sucrose label and slight increase in ^{14}C incorporation in reducing sugars.

iii. Carbohydrates

Nimbalkar (1973) found that IAA treatment caused

changes in sugar content of leaves. He also reported that the value for reducing sugars was higher in IAA treated sugarcane leaves while starch content was reduced due to auxin treatment.

iv. Mineral Constituents

The auxins also bring about changes in inorganic constituents corresponding to the accelerated growth. Nimbalkar (1973) observed that the pretreatment with IAA caused slight fluctuation in the inorganic constituents and had different mobilizing effects on elements like P, K and Ca in sugarcane variety CO-740.

v. Enzymes

Among various enzymes, enzyme invertase occupies an important place in sugarcane metabolism as it controls the level of sucrose in sugarcane stalk tissue. The work of Sacher et al. (1963) indicated that IAA functions in regulation of activity of this enzyme.

B. GIBBERELLINS (GA)

1. INTRODUCTION

Gibberllins are diterpenoids that promote cell elongation and flowering in plants. Chemically they are gibberllic acids. The story of discovery of gibberllic acid is very interesting. Japnese Pathologists Kurosawa (1920) reported `bakanae' disease of rice plants. The disease was

caused by the fungus "*Gibberella fusikuroi*" which secretes the chemical substance bringing about excessive growth of rice plants. Yabuta and Sumiki (1938) coined the term `gibberllin' for these substance. Uptill now 84 gibberllins have been isolated from various plant species.

Gibberllins are widely distributed in all parts of the plant body. They show marked effect on stem elongation, bolting and flowering, development of parthenocarpic fruits, seed germination and dormancy. This phytohormone has wide range of application in agriculture and horticulture.

2. RESPONSES OF SUGARCANE TO GA

a. Germination

Coleman et al. (1960) reported that due to foliar spray of GA germination percentage was retarded. On the other hand in 1984 Sharma et al. found that foliar application of GA_3 enhanced sprouting in ratoon cane.

b. Vegetative Growth

Chardon (1956) reported that soaking seed pieces in 20 and 100 ppm GA increased shoot growth after germination Stowe and Yamaki (1957) admitted that the results on the effect of gibberllins on leaves are far from conclusive. The effect varied with leaf and age of plant and also possibly with season. Bates (1957) obtained slight increase in stalk length for cane treated with GA 6 weeks

before harvest. Coleman et al. (1960) showed that the growth of sugarcane was markedly increased on foliar application of GA. Bull (1964) applied aqueous GA solution (0.02 and 0.10%) weekly to the sugarcane leaf spindle. He noticed increase in stalk length, fibre content while leaf area and leaf weight were decreased due to GA treatment. The node number was not altered due to GA treatment. In 1969 Coleman et al. obtained a significant growth stimulation by presowing seed setts in GA solution. Buren et al. (1980) observed that application of GA_3 increased the stalk length in Hawaiian sugarcane. Moore and Paul (1980) noticed that the exogenous application of GA_3 at about 0, 1 and 2 mg/lit concentration increased fresh weight, total stalk length and length of individual internode. In experiments of Mc David et al. (1981) increase in fresh weight of leaves was evident due to GA_3 application. Yang (1986) conducted a field trial and came to the conclusion that application of GA at 100-200 ppm increases internodal length and stalk weight. Gonzales et al. (1986) however, found that spray of GA_3 at different concentrations did not significantly influence growth in '6' varieties of sugarcane. Yamaguchi et al. (1986) found that if the sugarcane C_v'-310 received foliar spray of 2.5 mg of GA_3 only once at 11th week, 14th week and 17th week after planting and 0.85 mg of GA_3 in the same time, stimulatory

effect on tiller production and internodal elongation after 17th week treatment was noticeable.

c. Yield and Juice Quality

Bates (1957) obtained no appreciable difference in stalk weight or juice quality following GA treatment. Vallareal and Santos (1958) reported that foliar application of GA failed to improve sugarcane yield and quality of juice. On the other hand Bull (1964) noticed that application of 0.02 and 0.10% GA to the leaf spindles of sugarcane increased the sugar content. Gonzales et al. (1980) concluded that foliar application of GA_3 at different concentrations did not influence different yield components of sugarcane. On the contrary Castro et al. (1982) reported that there is increase in cane weight by the treatment of GA_3.

Buren et al. (1980) found that GA_3 treatment improved the sugar content of sugarcane juice. But report of Mc David et al. (1981) indicates that there is decrease in sucrose percentage in cane by the treatment of GA_3. The experiments of Yang (1986) indicated that GA at 100-200 ppm increased production of sugar in Taiwan. Based on available data Nickell (1988) concluded that the application of GA increases the total dry matter production and sucrose production in sugarcane.

d. Metabolic Changes

i. Chlorophyll Content

Nimbalkar (1973) reported that there was decrease in chlorophyll content in sugarcane due to foliar spray of GA at concentration of 50 ppm.

ii. Photosynthetic Rate

Nimbalkar (1973) found acceleration in the rate of $^{14}CO_2$ uptake by GA treatment. According to him this is due to increase in photosynthetic activity per unit leaf area of sugarcane leaf. He also came to the conclusion that GA had definite effect on photosynthetic 14C incorporation and labelling was more in glucose and fructose in GA treated plants. GA treatment resulted in decrease in 14C incorporation in sucrose but increase of the same in amino acid fraction.

iii. Carbohydrates

Alexander (1968) emphasized that GA increased sugar synthesis by virtue of fact that higher sucrose level were found in GA treated leaves. Nimbalkar (1973) found that GA treatment increased the reducing sugars but the level of total sugars and carbohydrates droped down. Similarly there was also reduction in the starch level.

iv. Mineral Constituents

Nimbalkar (1973) found that GA treated sugarcane

plants had low levels of K^+ while there was increase in Ca^{++} and Si^{++} contents.

v. Enzymes

Glasziou and Bull (1965) reported that treatment of GA caused rapid stimulation of acid invertase in immature sugarcane internodes. The experiments of Sacher et al. (1963) and Alexander (1965) indicated that similar to auxine, GA is also involved in regulation of invertase activity in sugarcane and there is interaction with various compounds like glucose, glycine, nitrate and urea in this process. Cobos and Gonalez (1981) also noticed that GA treatment caused increase in the activity of soluble invertase in sugarcane.

C. CYTOKININS

1. INTRODUCTION

The presence of cell division causing substance was suspected in fruits, seeds and endosperm. The liquid endosperm of coconut (coconut milk) is rich in cell division causing factors. Skoog (1954) showed that phloem could supply cell division causing factor. Miller, Skoog and coworkers at Wisconsin University, U.S.A. in 1955 extracted for the first time this phytohormone as a degradation product of DNA by autoclaving DNA herring sperm. This substance was named as 'Kinetin'. The name 'cytokinin' was

given by Letham (1963) because of its property to activate cell division. Chemically they are isophenyl adenines.

Besides cell division, cytokinins bring about a variety of physiological effects like cell enlargement, initiation of interfascicular cambium, morphogenesis, breaking of dormancy, apical dominance, delay in senescence etc.

2. RESPONSES OF SUGARCANE TO CYTOKININS

a. Germination

Kanwar and Kanwar (1984) found that foliar application of kinetin at concentration of 20 mg/lit increased the germination percentage.

b. Vegetative Growth

Nimbalkar (1973) noticed that kinetin pretreatment caused the leaf area enhancement in var. CO-740. Kanwar and Kanwar (1984) noticed that foliar spray of kinetin at the rate of 20 mg/lit increased the plant height, milliable stalk length, stalk thickness and also stalk number of varieties Co. J. 78 and Co. J. 64.

c. Yield and Juice Quality

Moore and Harhold (1980) found that the treatment of kinetin increased the yield and enhanced the quality of sugarcane juice. Castro et al. (1982) reported that the kinetin application increased the sugar content and yield of sugarcane. Kanwar and Kanwar (1984) noticed that foliar

spary of kinetin at concentration of 20 mg/lit caused increase in yield and enhancement of juice quality, sucrose content and purity coefficient in sugarcane variety Co.J.83.

d. Metabolic Changes

i. Chlorophyll Content

Nimbalkar (1973) reported that foliar application of kinetin decreased the chlorophyll content in leaves of sugarcane var. CO-740.

ii. Photosynthetic Rate

Nimbalkar (1973) found that pretreatment of kinetin had definite effect on products of photosynthesis. In almost all cases the incorporation of 14C in total sugar fraction was reduced but synthesis of glucose was stimulated.

iii. Mineral Constituents

Nimbalkar (1973) noticed that kinetin pretreatmentstimulated K, Na and P uptake and caused decrease in Mg uptake in sugarcane variety CO-740.

iv. Enzymes

The experiments of Glasziou et al. (1966) revealed an inhibitory effect of kinetin on invertase synthesis but this happened only during long term experiments of more than 5 hours duration. These workers regarded such long term

inhibition by kinetin of invertase activity as non specific since similar kinetin effect on enzymes peroxidase and ribonuclease was also noticeable.

D. ABSCISSIC ACID (ABA)

Abscissic acid is a sesquiterpene phytohormone, which has been discovered relatively recently (Lui and Corns; 1961). It has got growth inhibiting potential and it is involved in regulation of various processes such as stomatal closure, abscission, seed dormancy and stress injury. However, responses of sugarcane to abscissic acid have not been studied except an attempt by Gayler and Glaziou (1969). These workers reported that invertase synthesis was greately increased by ABA, an effect evident even after RNA formation was blocked with 6-methyl purine. From this, they concluded that ABA is active subsequent to the formation of invertase mRNA but prior to invertase destruction.

E. ETHYLENE

1. INTRODUCTION

In contrast to other phytohormones ethylene is a gaseous phytohormone having simple unsaturated hydrocarbon nature. Russian Physiologist Neljubow (1901) for the first time showed that ethylene present in illuminating gas inhibited stem elongation, increased horizontal growth and

increased stem thickening in seedlings of pea. About fifty six chemical compounds are known which release ethylene after entry in the plant tissue and prominent among these compounds is ethephon or etherel (2 chloroethyl phosphonic acid).

2. RESPONSES OF SUGARCANE TO ETHYLENE

a. Vegetative Growth

Bischoff et al. (1967) noticed that pretreatment of sugarcane with ethephon increased shoot production but had no effect on overall growth. Doi (1983) showed that spraying the seed cane in the field with ethephon at 1 b/acer three weeks before cutting the setts and planting or dipping the setts into ethephon at 5000 ppm stimulates tillering. In 1987 Nickell reported that pretreatment of ethephon enhanced stalk fresh weight between 8-10 weeks and was active in inducing tillering at Hawaii. Nickell (1988) noticed that pretreatment of sugarcane with ethephon induces stalk elongation. Treatment of ethephon was found to promote stalk length in sugarcane variety M-442-51 (Effendi; 1991).

b. Yield, Juice Quality and Ripening

There are several reports regarding the effect of ethylene (or ethephon) on the productivity and juice quality. Yang (1986) studied the effect of plant growth regulators on sugarcane production in Taiwan. He found that

application of etherel at 1000 ppm to ratoon cane during winter increased yield by 3-12% as compared to control. Panneerselvam et al. (1991) noticed in field experiments that treatment of ethephon at concentration of 500 ppm increased yield of sugarcane. Generally ethephon increases the sugarcane yield by inhibiting the process of flowering (Nickell; 1976). Effendi (1991) studied responses of sugarcane Cv. F-154 and M. 442-51 to ethephon. He found that there was increase in stem yield in variety 442-51 after 12 month growth and sugar yield was unaffected by ethephon. Kumar and Pande (1988) observed that etherel treatment (at 1 lit ai/ha) did not show a consistent trend in juice and sucrose content of ratoon crop. Nickell (1988) reported that treatment of ethephon caused the production of greater proportion of fibres and lesser fraction of sucrose.

Ripening is one of the important aspect of sugarcane production, from both research and operational point of view. It is now very well realized that ripening is extremely complex process.

Nickell (1987) noticed that the ethylene producing compound ethephon was commercially used for ripening of sugarcane in South Africa and Rhodesia. The effectiveness of ethephon as sugarcane ripener is higher than that of

glyphosate and glyphosine in some areas of world. In 1988 he also found that treatment of ethephon increased partitioning of dry matter in favour of sucrose storage and away from fibre production. Climatic conditions appear to control this response because Rostron (1973) observed that ethylene is much more effective than polaris in Southern Africa where as reverse is true in Hawaii.

c. Flowering

Prevention of flowering is important in some crops from economic point of view. Sugarcane is one such crop as after flowering the yield and sugar percentage are considerably decreased. Moore and Osgood (1980) found that ethephon at 0-50 kg/ha was more effective in controlling flowering and also they reported that application of ethephon in early September was more effective that in mid September. Hardy et at. (1986) made use of ethephon for prevention of flowering in sugarcane in Sudan. They applied ethephon at 840 g/ha at 1-3 weeks before flowering and found excellent control of flowering in variety CO-527. Colti et al. (1986) also noticed inhibition of sugarcane flowering by ethephon in Brazil.

d. Metabolic Changes

Osgood and Teshima (1980) and Osgood et al. (1981) reported that ethephon increased the production of sucrose

per stalk by increasing the total amount of dry matter produced, with a greater portion incorporated as fiber and lesser amount as sucrose.

F. INDOL 3-BUTYRIC ACID (IBA)

1. INTRODUCTION

IBA is one of the most important compound used as growth regulator on commercial scale. It is the compound similar to IAA in many respects and it was believed for last several years that it is not naturally occouring in plants and hence synthetic auxin. But now it is very well established that IBA is an endogenous constituent of various plants and it is synthesized from IAA (Epstein and Ludwig-Muller, 1993). IBA is biologically active and commercially used as rooting medium in horticultural works.

2. RESPONSES OF SUGARCANE TO IBA

a. Yield

Yang (1986) studied the effect of plant growth regulators on sugarcane production in Taiwan and observed that treatment of IBA at concentration of about 100-200 ppm increased the yield of sugarcane.

G. NAPTHYL ACETIC ACID (NAA)

1. INTRODUCTION

NAA is one of the popular growth regulators in

horticulture. For first time in 1939 it was used in USA to prevent preharvest drop of apple. In 1942 it was applied to pineapple to induce synchronous flowering in Hawaii.

NAA is also applied to induce formation of adventitious roots in cuttings and for initiation of adventitious roots. The most popular commercial formulation of NAA is `Planofix'.

2. RESPONSES OF SUGARCANE TO NAA

a. Germination

Seno et al. (1974) noticed that there was decrease in germination of sugarcane setts due to NAA pretreatment. Naik and Joshi (1980) reported that pretreatment of NAA reduced the germination percentage of sugarcane Bischoff et al. (1988) also found that the treatment of NAA hindered the germination of sugarcane setts. Sharma et al. (1985) observed that the treatment of the ratton of sugarcane with NAA had no effect on sprouting.

b. Vegetative growth

Bischoff (1967) observed that NAA treatment increased shoot number but overall plant growth was decreased. Naik and Joshi (1980) found that the growth is stimulated in NAA treated plants on 100th day. They also found an improvement of leaf area at the 300th day after germination due to NAA pretreatment. They reported that

pretreatment with NAA improved tiller number as compared to control or untreated sugarcane setts.

c. Yield and Juice quality

Sharma et al. (1985) noticed that pretreatment with NAA at concentration of 200 ppm increased yield of sugarcane by 12.70 % and had insignificant effect on quality of ratton crop.

d. Metabolic Changes

i. Chlorophyll content

Naik and Joshi (1981) noticed that the chlorophyll content both on fresh weight and leaf area basis was maintained at higher levels in the sugarcane leaves of NAA pretreated plants. They also found that with these elevated concentration of chlorophylls, NAA treatment caused effective stimulation in $^{14}CO_2$ fixation in variety CO-740.

ii. Enzymes

Sacher and Glasziou (1962) noticed that NAA (at concentration 1.42 X 10^{-5} M) caused a three fold increase in the activity of enzyme invertase.

H. ASCORBIC ACID (AA)

1. INTRODUCTION

Ascorbic acid is popularly known as vitamin C. Although the role of this compound in animal metabolism is

well established, the same can not be said about plants. Extensive work of Chinoy and co-workers (1969) has very elegantly demonstrated that this compound has marked influence on growth and metabolism of plants.

2. RESPONSES OF SUGARCANE TO AA

a. Germination

Joshi and Naik (1980) found that the pretreatment with ascorbic acid reduced germination percentage in sugarcane. On the other hand Mohandas et al. (1984) noticed that the presowing soaking treatment with ascorbic acid at concentration of 100 ppm increased germination percentage in sugarcane by 16-52 %.

b. Vegetative growth

Nimbalkar (1973) found that pretreatment of sugarcane with ascorbic acid caused the improvement of tillering, height of plant and total leaf area. Joshi and Naik (1980) also noticed that there is increase in the leaf area and tiller number due to treatment of ascorbic acid.

c. Yield and juice quality

Nimbalkar (1973) noticed that pretreatment with ascorbic acid increased the yield of sugarcane and also improved the quality of juice.

d. Metabolic changes

i. Chlorophyll content

Nimbalkar (1973) found that pretreatment with ascorbic acid or ascorbate reduced the chlorophyll content of sugarcane leaves.

ii. Photosynthetic rate

Ascorbic acid pretreatment caused enhancement in the rate of photosynthesis (Nimbalkar; 1973) It was also noticed that ascorbic acid pretreatment diverted more carbon to the amino acid fraction.

iii. Mineral constituents

Nimbalkar (1973) noticed that pretreatment with ascorbic acid increased content of P^{+}, K^{+} and Ca^{++} in sugarcane leaf tissue and lowered the content of Mg^{++} and Si^{++}.

I. 2,4-DICHLOROPHENOXY ACETIC ACID (2,4-D)

1. INTRODUCTION

In 1942 Zimmermann and Hitchcock discovered differential herbicidal action of 2,4-D on weeds. Now it is commercially used in agriculture as weedicide Although 2,4-D was once reported, as antiauxin, it has wide applications in tissue culture technology, since very low concentration of this compound are found to influence growth and development considerably.

2. RESPONSES OF SUGARCANE TO 2,4-D

a. Germination

The experiments carried out at Sugarcane Research Station, Punjab in the year 1954-55 revealed that soaking the setts in 0.1 % solution of 2,4-D did not improve the speed or percentage of germination (Nickell, 1984). Kumar et al. (1987) noticed that the treatment of 2,4-D favoured root development during germination of sugarcane.

b. Vegetative growth

Bischoff and Martin (1988) noticed that pretreatment with 2,4-D increased shoot number of sugarcane but overall plant growth decreased.

c. Yield, Juice quality and ripening

Chacravarti et al. (1955) applied a 50 ppm solution of 2,4-D as foliar spray at the rate of 60 gallons per acer and noticed that sucrose content was increased by an average value 0.55 percent. 2,4-D was tested as foliar spray on 13 month old cane at concentration of 6 to 30 ppm by Vallance (1956). It did not show significant change in the sucrose content. Coleman and Herbert (1957) tested 2,4-D as foliar spray on Cp 36-105 at rates of 200, 600, 1000 ppm in 90 gallons of water per acer. There was no significant effect on cane quality 13 and 28 days after treatment. However, in another experiment 2,4-D at the rates of 1 to 2

pounds per acer significantly improved sugar yield 8 days after treatment. Yates and Bates (1957) also noticed that soil application of 2,4-D equivalent to 2,10 and 20 ponds per acer each increased sucrose percentage of cane.

Nickell (1984) in his review stated that 2,4-D is used as ripening agent in sugarcane. He also mentioned that it was the first compound used as ripening agent in case of sugarcane. Lugo-Lopez et al. (1953) found that the foliar spray of 2,4-D served as a ripening agent for sugarcane P.O.J. 2878 at several localities of Puerto Rico. Yates and Bates (1957) however reported inconsistent results with 2,4-D as a ripening chemical.

d. Metabolic Changes

i. Carbohydrates

Alexander (1965) studied sugar changes in greenhouse grown sugarcane variety P.R. 980 with 2,4-D at 10 weeks of age. Tissue sample were frozen and enzyme analysis was made at 1,3,9,and 27 days after treatment. It was found that leaf sucrose was increased by 3rd day and was significantly higher than control values at 9 days.

ii. Enzymes

Alexander (1965) noticed that treatment of sugarcane with 2,4-D (0.20 percent solution) caused significant

changes in different enzymes. It lowered the activity of acid phosphatase, 1-phosphatase, glucose 6-phosphatase and amylase. Major losses in activities of phosphohexose isomerase and glucose oxidase took place after 2,4-D application.

J. MALEIC HYDRAZIDE (MH)

1. INTRODUCTION

Maleic hydrazide belongs to a group of miscellaneous compound known as growth inhibitors. Maleic hydrazide is a systemic growth inhibitor and its effects are mainly on apical meristem through interference with cell division at the apex, thus inducing cessation of stem elongation and loss of apical dominance.

2. RESPONSES OF SUGARCANE TO MH

a. Vegetative growth

Vallance (1956) took trials in Queenland and applied higher levels of MH (at about 4 percent concentration). This treatment caused stunted growth in sugarcane.

b. Yield, juice quality and ripening

Coleman and Herbert (1957) were unable to improve juice quality with MH applied as 2 and 6 percent solution at rates of 90 gallons per acer on sugarcane variety C.P.

34-120. Yates and Bates (1957) applied 2 percent MH at the rate of 20 gallons per acerand found no significant difference in sugar percentage. In Trinidad, Vlitos and Lawrie (1967) conducted the experiment on 7 month old sugarcane variety B-41227. Treatment of MH were given at rates of 0.5, 1 and 2 gallons per acer and harvest were made at 5,9 and 15 days after treatment. Small to moderate changes were observed in purity at 15 days. Brix value increased and also polarization and extractable juice.

Vallance (1956) concluded from the trials conducted in Queenland that MH applied to actively growing cane in March produced C.C.S. (Commercial cane sugar) increases amounting to about 4 units within a period of 7 weeks. Nickell (1983) also indicated that maleic hydrazide has great promise as ripener in sugarcane.

c. Metabolic Changes

i. Carbohydrates

Alexander (1965) found that the primary effect of MH was marked increase in reducing sugars, especially glucose between 9 to 27 days after treatment.

ii. Enzymes

Alexander (1965) noticed that the treatment of MH on sugarcane caused significant changes in several enzymes.

The activity of enzymes viz. hexokinase, aldolase, phosphohexose isomerase and condensing enzymes was increased due to MH treatment.

K. CHLORO CHOLINE CHLORIDE (CCC)

1. INTRODUCTION

2 chloroethyl trimethyl ammonium chloride is choline derivative in which hydroxy group is replaced by chlorine substituent. It is abbreviated as CCC. The other popular names for CCC are cycocel and chloremquat.

Tolebert (1960) for the first time reported that CCC caused retardation of growth of wheat plant. It is also found that CCC inhibits gibberllin biosynthesis. It has capacity to remain in soil for about 3-4 weeks.

2. RESPONSES OF SUGARCANE TO CCC

a. Germination

Yadav (1971) observed that presowing soaking of setts in 10,000 and 100 ppm of CCC did not have stimulatory effect on germination of sugarcane.

b. Vegetative growth

Nickell (1987 and 88) noticed that the pretreatment with CCC is effective in enhancing tillering in

sugarcane thus causing an increase in the number of plants per unit area.

c. Yield, Juice Quality and Ripening

Kumar and Pande (1988) reported that cycocel at 2.5 lit/ha applied in early November did not show any consistent trend in sugarcane juice. Powar (1960) on the other hand came to the conclusion that the foliar CCC treatment for 36 days at concentration of 5 kg/ha was effective in increasing brix and sucrose content in cane juice. Alexander and Montalvo (1971) have given foliar spray of cycocel (at about 0.3 percent concentration) and observed that there was progressive increase in sugar content up to the final harvest since 33 days after treatment.

Although Samuels et al. (1970) were unable to induce ripening with cycocel, in Hawaii, Nickell and Maretzki (1970) obtained positive ripening responses with cycocel. Nickell (1987) commented that chloremequat is good ripening agent commercially used in United States. Powar (1990) also showed that the artificial ripening can be done by the foliar application of CCC at 5 kg/ha to 11 month old sugarcane. Thus under Indian conditions also, CCC is effective.

d. Metabolic Changes

i. Enzymes

Alexander and Montalvo (1971) noticed that foliar spary of cycocel (at concentration of 0.3 percent) significantly lowered the acid invertase level of immature storage tissue of sugarcane cultivar C. P. 52-43.

L. GLYPHOSINE AND GLYPHOSATE

Chemical name of glyphosine is N, N-bis (phosphonomethyl) glycine and it is marketed by Monsanto company as the product Polaris. Subsequent work showed this compound to be broken down in the cane plant to another compound called glyphosate.

Untill late 1980 Polaris was the only compound registered for ripening sugarcane in U.S.A. In the Autumn of 1980 phosphonomethyl glycine was also registered as a ripener for sugarcane. This compound is known generally as glyphosate. As a ripener, glyphosate is almost an order of magnitude more active than glyphosine. Glyphosate formulation improves the sucrose content over a wide range of climatic conditions, are less cultivar specific and the ripening response they induce in sugarcane is more consistent and rapid than obtained with glyphosine (Nickell, 1987). Polaris has been evaluated over a period of several years on close to 100,000 acers in Hawaii and other sugar

producing areas (Nickell and Takahashi, 1977). It was shown to increase the sugar content between 10 to 20% when Polaris was applied at the rate of 4 pounds ai/acer and also about 10 to 15% increase in yield, which is an increase of 1 tone/acre or more when applied to certain varieties grown on rainy coasts of the Islands of Hawaii. Similarly it has been found to be effective an irrigated areas when surfactants are added. Glyphosine treatment results in a reduced rate of terminal cane growth but how this is related to its mode of action has not yet been established (Nickell, 1984).