Evaluation of Sulfentrazone 48% F for weed control in Sugarcane (*Saccharum officinarum* L.)

Dissertation
of
Post-Doctoral Research

Submitted to the Division of Crop Production
Indian Institute of Sugarcane Research, Lucknow (India)

By
Dr. Nadir Flayh Ali Almubarak
Assistant Professor (Field Crops)
College of Agriculture
University of Diyala
Iraq

February, 2013

TABLE OF CONTENTS

Figures

Appendix

ACKNOWLEDGEMENTS

Foremost, I would like to thank God for giving me the ability to pursue Post –doctoral Research Program. I am also very grateful God has blessed me with the best family I could ever hope for.

I thanks my Wife for soft heart and open ear has helped to calm the storm of many a stressful day. Your influence in my life is what has contributed to my success and all that I have accomplished.

Secondly, I thank my sons Zainab, Abdulla and Abdulrahman for their love and support during my Post-Doctoral Research Program at Indian Institute of Sugarcane Research(IISR), UP, India .Without my wife's patience and son's persistence and encouragement.

To Ministry of Higher Education and Scientific Research, University of Diyala, College of Agriculture thank you for grant me Sabbatical Leave for doing Post-doctorate Research Program in India.

To Director of IISR, I would like to thank you for accepting me into your Post-Doctoral Research Program .

Thanks to Dr.T.K. Srivastava for his time and guidance on this project, The experience of working with you had an enormous influence on both my professional and personal life.

I would also like to thank the staff at Crop Production Division for their cooperation and help, especially Dr. A.K. Sing, Dr.S.N.Singh , Dr.Ishwar Singh , Dr.Sah, Dr.K.P..sing and Dr.R.K.sing, you have been invaluable part of conducting research and you have made my job a lot easier. I would also like to thank the technical S.N.Srivastava and Assistant technical Radish for their time and effort on both coordinating and conducting my researches.

I thanks Dr.S.Hasan, whose efforts are commonly overlooked.

Finally, to IISR Scientist, Thank you, your door has always been open for Questions.

I wish all of you the best in the future.

N.F. Almubarak

ABSTRACT

The study was conducted during 2012-13 at the Indian Institute of Sugarcane Research (IISR), Lucknow (UP), India to assess the effect of weed control methods *viz*., sulfentrazone both as pre-planting incorporation (PPI) and pre-emergence (pre-em) spray, 2,4-D applied 60 days after planting (DAP), atrazine (pre-em), trash mulching (pre-em) and three-hoeing (30,60 and 90 DAP) on growth of prevalent weeds in sugarcane, phyto-toxicity to sugarcane, growth attributes of sugarcane, cane yield and quality traits of the crop. All the weed control methods were applied at tillering stage of sugarcane (cv. CoSe 92423). The field experiment was laid in Randomized Complete Block Design (RCBD) with three replications for first experiment and four replications for the second.

Findings of the experiments revealed that the weed density and dry matter accumulation were significantly reduced due to different treatments at all the growth stages of the crop in comparison to that of control. Weed growth in terms of weed density was recorded to be the lowest with sulfentrazone (pre-em; 900 g ai/ha) at 60, 90 and 120 DAP. However, the dry matter accumulation by weeds was the lowest with three-hoeing as observed at the same growth stages. Three-hoeing as well as sulfentrazone (PPI 600 g ai/ha + hoeing) led to a decrease in cane height as compared to control at 150 and 330 DAP. Sulfentrazone (PPI 720 g ai/ha) caused the significantly highest increase in cane girth. Pre-plant incorporation of sulfentrazone (600 g ai/ha) + one hoeing and its pre-emergence spray (600 g ai/ha) + one hoeing led to the highest significant increase in number of millable canes recorded to be 103300 and 114700 canes/ha, respectively against that of control (50600 canes/ha). These treatments were also effective in reducing the number of non-millable canes to 28300 and 21900/ha, respectively compared to that recorded in control (74200 canes/ha). Number of sugarcane green leaves at 60 DAP increased significantly with sulfentrazone (PPI 900 g ai/ha) and sulfentrazone (PPI 600 g ai/ha). The highest leaf area and leaf area index were recorded in sulfentrazone (pre-em; 720 g ai/ha) at 210 and 300 DAP. Leaf

area ratio was not significantly affected by use of various weed control methods. However, pre-emergence spray of sulfentrazone registered the highest leaf area duration (48.3 cm^2/day) compared to the control (34.5 cm^2/day).

All the weed control methods were found significantly effective in increasing the cane yield. Three-hoeing treatment achieved highest increase in cane yield (78.0 t/ha) followed by sulfentrazone (PPI 600 g ai/ha + one hoeing) and sulfentrazone (pre-em 600 g ai/ha) which recorded 71.5 and 70.6 t/ha cane yields, respectively against 48.1 t/ha recorded in control. Cane yields with these treatments were 62, 49 and 47% higher, respectively over control. Three-hoeing also produced the highest increase in sugar yield (12.9 t/ha) followed by sulfentrazone (pre-em; 600 g ai/ha) + one hoeing (11.7 t/ha) against 7.8 t/ha recorded in control.

The experiment on phyto-toxicity revealed that pre-plant incorporation of sulfentrazone even at higher rates up to (1440 g ai/ha) significantly reduced the weed dry matter accumulation and weed density at the 60, 90 and 120 DAP without any phyto-toxicity to sugarcane. There was increase in number of millable canes both with pre-plant incorporation and pre-emergence of sulfentrazone recording 169200 millable canes/ha at 210 DAP. The numbers of millable canes stood at 131900 and 132800/ha under the respective treatments at 300 DAP. This led to respective cane yields of 84.1 and 80.8 t/ha being 115 and 106% higher over control. Also, Sulfentrazone PPI (1440 g ai/ha) and sulfentrazone pre-em (1440 g ai/ha) caused significant increase in sugar yield (13.85 and 13.50 t/ha, respectively) that were 120 and 114% higher over control.

CHAPTER 1
LITERATURE REVIEW

Sugarcane is a tropical, perennial grass that forms lateral shoots at the base to produce multiple stems, typically three to four meters high and about 2-5 cm in diameter. The stems grow into cane stalk, which when mature constitutes approximately 75% of the entire plant. A mature stalk is typically composed of 11–16% fiber, 12–16% soluble sugars, 2–3% non-sugars, and 63–73% water. A sugarcane crop is sensitive to the climate, soil type, irrigation, fertilizers, insects, disease control, varieties, and the harvest period. The average yield of cane stalk is 60-70 tonnes/ha per year. However, this figure can vary between 30 and 180 tonnes/ha depending on knowledge and crop management approach used in sugarcane cultivation. Sugarcane is a cash crop, but it is also used as livestock fodder (Rena Perez, 1997).

Sugarcane is any of 6 to 37 species (depending on which taxonomic system is used) of tall perennial true grasses of the genus *Saccharum*, tribe Andropogoneae, native to the warm temperate to tropical regions of South Asia. They have stout jointed fibrous stalks that are rich in sugar, and measure 2-6 meters (6 to 19 feet) tall. All sugar cane species interbreed, and the major commercial cultivars are complex hybrids. It belongs to the grass family (Poaceae), an economically important seed plant family that includes maize, wheat, rice, and sorghum and many forage crops. The main product of sugarcane is sucrose, which accumulates in the stalk internodes. Sucrose, extracted and purified in specialized mill factories, is used as raw material in human food industries or is fermented to produce ethanol. Ethanol is produced on a large scale by the Brazilian sugarcane industry (Curtis, 2006 and Jonathan Siebert, 2003). Sugarcane is the world's largest crop (FAO, 2010). In 2010, FAO-estimates it was cultivated on about 23.8 million hectares, in more than 90 countries, with a worldwide harvest of 1.69 billion tonnes. Brazil was the largest producer of sugar cane in the world. The next five major producers, in decreasing amounts of production, were India, China, Thailand, Pakistan and Mexico.

The world demand for sugar is the primary driver of sugarcane agriculture. Cane accounts for 80% of sugar produced; most of the rest is made from sugar beets. Sugarcane predominantly grows in the tropical and subtropical regions, and sugar beet predominantly grows in colder temperate regions of the world. Other than sugar, products derived from sugarcane include falernum, molasses, rum, cachaça (a traditional spirit from Brazil), bagasse and ethanol. In some regions, people use sugarcane reeds to make pens, mats, screens, and thatch. The young unexpanded inflorescence of tebu telor is eaten raw, steamed or toasted, and prepared in various ways in certain island communities of Indonesia (Dahlia *et al.*, 2009). Sugarcane plantations, like cotton farms, were a major driver of large human migrations in the 19th and early 20th century, influencing the ethnic mix, political conflicts and cultural evolution of various Caribbean, South American, and Indian Ocean and Pacific island nations (Sidney Mintz, 1986 and Naguk , 2010).

Sugarcane cultivation requires a tropical or temperate climate, with a minimum of 60 centimeters (24 in) of annual moisture. It is one of the most efficient photo- synthesizers in the plant kingdom. It is a C_4 plant, able to convert up to one percent of incident solar energy into biomass (www.life.illinois.edu/govindjee, 2012). In prime growing regions, such as Mauritius, Dominican Republic, Puerto Rico, India, Indonesia, Pakistan, Peru, Brazil, Bolivia, Colombia, Australia, Ecuador, Cuba, the Philippines, El Salvador and Hawaii, sugarcane crop can produce over 15 kilograms of cane per square meter of sunshine.

Sugarcane is cultivated in the tropics and subtropics in areas with plentiful supply of water, for a continuous period of more than six to seven months each year, either from natural rainfall or through irrigation. The crop does not tolerate severe frosts. Therefore, most of the world's sugarcane is grown between 22°N and 22°S, and some up to 33°N and 33°S (George Rolph, 1873). When sugarcane crop is found outside this range, such as the Natal region of South Africa, it is normally due to anomalous climatic conditions in the region such as warm ocean currents that sweep down the coast. In terms of altitude, sugarcane crop is found up to 1600 m close to the equator in countries such as Colombia, Ecuador and Peru (Peter Griffee, 2000). Sugarcane can be grown on many soils ranging from highly fertile well drained mollisols, through heavy cracking vertisols, infertile acid oxisols, peaty histosols to rocky andisols. Both plentiful sunshine and water supplies increase cane production. This has made desert countries with good irrigation facilities such as Egypt as some of the highest yielding sugarcane cultivating regions (Anonymous, 2001b).

Some sugarcane varieties are known to be capable of fixing atmospheric nitrogen in association with the bacterium *Glucoacetobacter diazotrophicus* (Yamada *et al*., 1998). Unlike legumes and other nitrogen fixing plants which form root nodules in the soil in association with bacteria, *G. diazotrophicus* lives within the intercellular spaces of the sugarcane's stem (Dong *et al*., 1994 and Boddey *et al*., 1991).

Brazil led the world in sugarcane production in 2010 with a 719,157,000 tons harvest (FAO, 2010). India was the second largest producer with 277,750,000 tons, and China the third largest producer with 111,454,000 tons harvest. The average worldwide yield of sugarcane crops in 2010 was 70.7 t/ha (FAO, 2010). The most productive farms in the world were in Peru with a nationwide average sugarcane crop yield of 125.5 t/ha. The theoretical possible yield for sugarcane, according to study of Duke, 1983, is about 280 metric tons per hectare per year, and small experimental plots in Brazil have demonstrated yields of 236-280 metric tons of fresh cane per hectare (Bogden, 1977 and James Duke, 1983). The most promising region for high yield sugarcane production were in sun drenched, irrigated farms of northern Africa, and other deserts with plentiful water from river or irrigation canals.

Brazil uses sugarcane to produce sugar and ethanol for gasoline-ethanol blends (gasohol), a locally popular transportation fuel. In India, sugarcane is used to produce sugar, jaggery and alcoholic beverages.

Weeds are a major factor limiting production of sugarcane in India. In a typical production system herbicides are sprayed pre-emergence to weeds in March and April around the same time that sugarcane starts to emerge from the winter dormant period. Successful weed control is essential for economical sugarcane production. Weeds can reduce sugarcane yields by competing for moisture, nutrients, and light during the growing season. Several weed species also serve as alternate hosts for disease and insect-pests. Weed control is most critical early in the season prior to sugarcane canopy closure over the inter-row spaces. Heavy weed infestations can also interfere with sugarcane harvest by adding unnecessary harvesting expenses. A weed that is allowed to mature and produce seed will multiply weed control problems by being a source of seed bank replenishment and re-infestation in subsequent years (Odero and Dusky, 2009). Weeds compete with cultivated crops for growth factors (water, light, nutrients, and space) and harbour pests and plant pathogens (Qasem and Foy, 2001). The competition depends upon the crop stand and weed population as well as competition period. The critical period of weed competition is the shortest time span during the crop growth when weeding results in highest economic returns. The initial period of crop-weed competition starts with beginning of interference from weeds and ends when crop covers 80% of soil. The length of critical period of crop-weed competition depends on the nature of crops, its competitive ability, variety, growth habit, field conditions and sowing technique. As plant grow, leaf area index and root density increase leading to mutual interference in the absorption of one or more growth factors (Reddy and Reddi, 2002).

A field experiment was conducted in India to find out the critical period of crop-weed competition in sugarcane (cv Co Lk 8001. Treatments included control, weed free up to 30, 60, 90, 120, 150 days, conventional practices (3 hand weeding at 30, 60، and 90 DAP + two inter-culturing at 45 and 90 DAP) and weed free after 30, 60, 90, and 120 DAP. Results (Patel *et al.*, 2007) revealed that sugarcane field kept weed free up to 150 DAP gave highest cane plant height (275 cm), number of millable canes (126072/ha), cane yield (90.24 t/ha), CCS (11.70

t/ha) as well as highest gross realization (Rs. 72192/ha) and additional income over control (Rs. 30000/ha). As in sugarcane initial growth is slow and crop is widely spaced so it takes longer period to cover the soil, critical period of weeds is therefore longer (Reddy and Reddi, 2002).

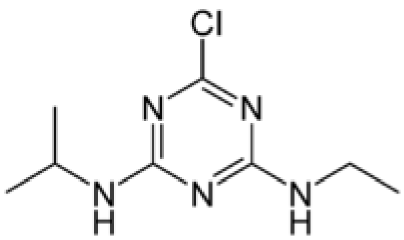
Durigan (2005) carried out field experiment in Brazil to evaluate the weed crop competition. Results showed that purple nut sedge population of 58 to 246 shoots per m^2 reduced sugarcane yield by 14% and a shoot populations of 675 to 1198 per m^2 reduced sugarcane yield by 45%. In another trial, purple nut sedge shoot populations as well as shoot dry weight were reduced by 47 and 67%, respectively, when subjected to 40% shade of the crop for 50 days (Santos *et al*., 1997). An experiment to evaluate weed-crop competition was carried out by Millhollon (1995), results revealed that full-season Johnson grass competition with sugarcane reduced sugarcane and sugar yields by 23 and 17% in the planted crop and 42 and 35% in the first-ratoon crop, respectively.

The weed seeds germinate rapidly than sugar cane and establish better position in weed-crop competition. Early season weed competition (up to 6 weeks) resulted in 9-39 % reduction in sugar yield (Millhollon, 1988). Nayyar *et al*., (1994) revealed that 86.7 t/ha cane yield was obtained from weed free duration up to 90 days, closely followed by weed free duration up to 56 days with an average yield of 80 t/ha. Verma, (2000) and Tomar *et al*. (2003a) reported that weeds, if not controlled, caused 12-72 % reduction in cane yield. However, the damage depends on the crop stand and weed flora. Another study was reported by Kuva *et al*. (2000) in which purple nut sedge (*Cyperus rotundus*) was the predominant weed species in sugarcane crop. However, the purple nut sedge is very sensitive to sugarcane canopy shading and low temperature. Hence, competitions ended at 22 DAP. Further, it was concluded that sugarcane exhibited weed tolerance of only 41days after planting. Millhollon (1992) reported that weed-crop competition between sugarcane and itch grass for 30, 60, and 180 days reduced sugar yield by 7, 17, and 19% respectively. It proved that itch grass must be removed from sugarcane prior to 30 days weed competition. Jarwar *et al*. (2004) compared eight weed-crop competition periods *viz.*, competition up to shooting stage, competition up to root transition stage, weed-crop competition up to 3-4 months, and weed-crop competition for full season in cv. Q-88 of sugarcane. The results revealed that cane yield increased to 98.1% with increasing weed free period and decreased to 38.1when weed-crop competition was for 3-4 months. Furthermore, it was also concluded that the critical period was shooting stage and root transition stage of the cane crop.

Singh and Tomar (2003) conducted a study to assess the critical period for weed removal in sugarcane. The results revealed that when weeds were removed after competition of 30, 45, 60, and 75 days, a reduction of 17.5, 23.8, 59.7, and 74.7%، was recorded in cane yield, respectively. The respective losses were 20.5, 21.9, 49.7, and 74.5% in each year.

Herbicides can be useful and economical tool in sugarcane production. They must be incorporated into an overall management plan to obtain their maximum benefit. It is important that sugarcane plants have the initial competitive advantage against weeds. Pre-emergence herbicide application in conjunction with mechanical cultivation helps to ensure the early season advantage. Directed or semi-directed post-emergence herbicide application can generally only be effective if the sugarcane is taller than the competing weeds. Accurate herbicide placement is crucial for banded or directed applications. Proper timing of herbicide application with respect to the growth stage of the weeds is extremely critical. Normally, weeds should be treated when they are 4 to 8" in height. Herbicides applied in the “Spring” help to prevent weeds from competing with the developing crop. In May following fertilizer application the sugarcane row middles are cultivated and a pre-emergence herbicide is applied broadcast. The goal of this layby herbicide application is to keep the crop free from weed competition until harvest.

Atrazine is widely used to control weeds in sugarcane in India at lay by but control failures are common. This is primarily due to the long period of time between atrazine application and sugarcane harvest (at least three months). In addition to losses from competition, some weeds also climb and wrap sugarcane stalks, which can cause lodging and reduce both the number of harvestable stalks removed from the field and the efficiency of mechanical harvesters (Viator *et al*., 2002a).



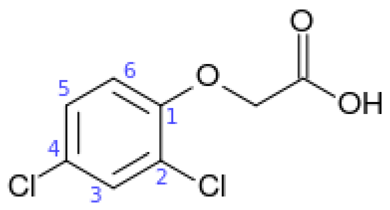
1-Chloro-3-ethylamino-5-isopropylamino-2, 4, 6-triazine

Registry name: Atrazine
Chemical name: 2-Chloro-4-ethylamino-6-isopropylamino-1,3,5-triazine
Synonyms, Trade names: 6-Chloro-N-ethyl-N'-(1-methylethyl)-1,3,5-triazin-2,4-diamine, 2-chloro-4-ethylamino-6-isopropylamino-s-triazin, Gesaprim
Chemical name (German): Atrazin, 2-Chlor-4-ethylamino-6-isopropylamino-1,3,5-triazin

A field experiment was conducted during spring seasons of 2000–01 and 2001–2002 to evaluate the usefulness of herbicides for weed control in sugarcane. Significant reduction in weed density and weed dry matter at 120 days after planting was obtained with pre-emergence application of metribuzin 1.5 kg/ha supplemented with post emergence application of 2,4-D Na salt 1 kg/ha. Highest cane and CCS yields were also obtained with aforesaid treatment and they were 36.32 and 50.10% higher than weedy check, respectively (Raskar, 2004).

Many producers are forced to apply 2, 4-D in late season to facilitate harvest. Griffin *et al*. (2000) reported that 2,4-D was highly effective on weeds if the rate was matched to weed size. Currently recommended 2,4-D rates for weed control are 0.53 kg ai/ha for small plants in the 2 to 3 leaf stage and up to 1.59 kg/ha when plants have climbed the sugarcane stalks (Anonymous 2001a). Even so, residential areas and municipalities are in many cases adjacent to sugarcane fields and the off-target movement issue with 2,4-D is still of great concern. 2,4-D, a phenoxy herbicide applied as a foliar treatment, has a half-life of 10 to 12 days under warm and moist soil conditions (Ahrens 1994). High soil organic matter, soil pH (neutral to slightly alkaline), high soil temperature, and soil moisture all tend to reduce persistence of 2, 4-D (Erickson and Gault, 1950). Once absorbed by foliage 2, 4-D is translocated primarily symplastically to the growing points of the root and shoots. Robertson and Kirkwood (1969) reported that absorption of 2, 4-D was strongly influenced by cuticle structure of the plant, humidity, light, temperature, herbicide formulation, spray pH, and surfactants. Wall *et al*. (1991) found that 65% of the

2, 4-D applied to bean [*Silene vulgaris* (Moench) Garcke] was absorbed within 72 hours of treatment. Approximately 35% of the 2, 4-D absorbed was translocated out of the leaf after 72 hours. Ashton (1958) reported that sugarcane plants absorbed 94.8% of the applied 2,4-D, compared to 83% absorption by bean (*Phaseolus vulgarius* L.) plants in the same experiment, and also documented slower translocation of 2,4-D in sugarcane plants when compared to bean. At the time of harvest, sugarcane leaves still contained 93.5% of the total 2,4-D in the plant, and virtually no 2,4-D was present in the meristematic tissues. It was proposed that tolerance of monocots to 2, 4-D could be explained by the slower rate of translocation and the lower concentration in plant tissue.



Chemical Name: 2, 4-Dichlorophenoxyacetic acid (2, 4-D)

Chemical Formula: $C_8H_6Cl_2O_3$

Sulfantrazone

Trade names: Spartan, Portfolio, Dismiss

Chemical name: N-[2,4-dichloro-5-[4-(difluoromethyl)-4,5-dihydro-3-methyl-5-oxo-1H-1,2,4-triazol-1-yl]phenyl]methanesulfonamide,

Chemical type: aryl triazolinone

Pesticide classification: herbicide

Registered use status: General Use Pesticide

Manufacturer: FMC Corp.

Formulation(s): 75% dispersible granule, 4 lb/gal flowable liquid

Remarks Soil-applied: pre-emergent triazolinone herbicide that can be applied either pre-plant incorporated or pre-emergence treatment. Note recropping intervals.

Water solubility: 10 ppm at pH 5 and 300 ppm at pH 7

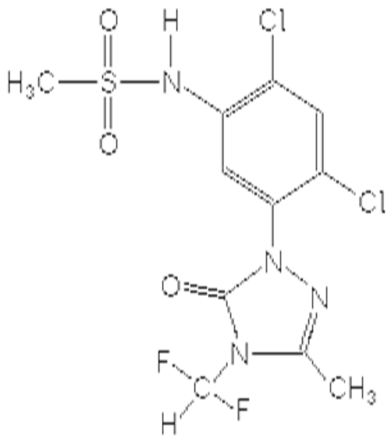
Storage conditions: Stable in dry, cool conditions.

Acute toxicity: LD50 - 2,416 mg/kg

Action in plant disrupts cell membranes by inhibiting protoporphyrinogen oxidase (PPO) in the chlorophyll biosynthetic pathway, leading to a buildup of toxic intermediates.

Site of action Group 14: protoporphyrinogen oxidase inhibitor

Chemical family: Triazinone



Sulfentrazone is registered for use in crop and non-crop sites for selective pre- and early post-emergent weed control. For terrestrial use only. Selective, pre- and early post-emergent herbicide for control of broadleaf weeds‹ grasses and sedges.

Sulfentrazone controls weeds by process of protoporphyrinogen oxidase inhibition (membrane disruption), a mode-of-action commonly referred to as PPO inhibition. Sulfentrazone is primarily taken up by the roots of treated plants. Plants emerging from treated soil turn necrotic and die after exposure to light. Foliar contact causes rapid desiccation and necrosis of exposed plant tissue. Shoot-root soil placement studies indicate that sulfentrazone is primarily absorbed by the roots of the plant following soil applications. Ground broadcast spray, spot and localized spray applications. Rates are adjustable from 5.33 to 8 ounces per acre. Timing is dependent on the target plant and desired results. Total vegetation management is best obtained with early spring applications coupled with later summer treatment for residual control. Sulfentrazone is persistent in the plant, soil and water. The primary routes of dissipation are aqueous photolysis and leaching. This product does not degrade through biodegradation. There is a very high potential for sulfentrazone to leach into groundwater when applied as directed. Sulfentrazone could potentially reach surface waters via spray drift and/or runoff when certain conditions exist. Sulfentrazone is an aryl triazolinone herbicide used for pre-emergent control of certain broadleaf weeds, grasses and sedges. Sulfentrazone inhibits photosynthesis in plants. Sulfentrazone also has agricultural uses (Eric Johnson, 2006 and Anonymous, 2008).

There is a need to introduce herbicides with different modes of action to prevent the development of and to manage herbicide resistant weeds. Many broadleaf crops such as flax have limited broadleaf weed control options. Sulfentrazone is a Group 14 herbicide with a unique mode of action. It has been screened in a number of broadleaf crops, including flax. Sulfentrazone is a soil applied herbicide that requires rainfall for activation (Viator *et al*., 2002b).

Sulfentrazone is commonly used for weed control in soybeans and tobacco, and vegetable crops and cotton are often rotated with soybeans and tobacco. Studies were conducted to evaluate the potential for sulfentrazone to carryover and injure several vegetable crops and cotton. Sulfentrazone was applied PRE to soybean at 0, 210, 420, and 840 g ai/ha before planting bell pepper, cabbage, cotton, cucumber, onion, snap bean, squash, sweet potato, tomato, and watermelon. Cotton, known to be susceptible to sulfentrazone carryover, was included as an indicator species. Cotton injury ranged from 14 to 18% with a 32% loss of yield in 1 of 2 year when the labeled use rate of sulfentrazone (210 g/ha) was applied to the preceding crop. High use rates of sulfentrazone caused at least 50% injury with yield loss ranging from 36 to 100%. Bell pepper, snap bean, onion, tomato, and watermelon were injured < 18% by sulfentrazone at 840 g/ha. Squash was injured < 3% and < 36% by sulfentrazone at 210 and 840 g/ha, respectively. Yield of these crops was not affected regardless of sulfentrazone rate. Cabbage and cucumber were injured < 13% by sulfentrazone at 210 and 420 g/ha, and yields were not affected. Sulfentrazone at 840 g/ha injured cabbage up to 46% and reduced yield in 1 of 2 years. Sulfentrazone injured cucumber up to 63% and reduced yield of No. 2 grade fruits. Sulfentrazone at 210 and 420 g/ha injured sweet potato < 6% and did not affect yield. Sulfentrazone at 840 g/ha injured sweet potato 14% and reduced total yield 26% (Dayan and Duke, 1997, Dayan *et al*.,1996) .

Field experiments were conducted in Louisiana during 1992-1993 and 1993-1994 growing seasons to evaluate the use of at-planting pre-emergence applications of mixtures of clomazone with atrazine or sulfometuron or imazapyr with atrazine. Treatments were followed by metribuzin post-emergence in the spring at the start of the sugarcane crop's initial (plant-cane) growing season. Bermuda grass was the only weed present in the control and covered 82% of the plant-cane crop's row top in late May each year. Standard at-planting treatments of metribuzin at 2.6 kg ai/ha and terbacil at 1.6 kg ai/ha or treatment with sulfentrazone at 0.6 kg ai/ha had little impact on Bermuda grass cover when followed by a metribuzin application in the spring. Bermudagrass cover following at-planting applications of mixtures containing clomazone at 2.2 kg ai/ha with atrazine or sulfentrazone or imazapyr at 0.6 kg ai/ha with atrazine was reduced in May to at least 18% (1992/1993) and 58% (1993/1994). At-planting applications of imazapyr at 0.3 kg/ha controlled Bermuda grass equivalent to clomazone at 1.1 kg/ha, while imazapyr at 0.6 kg/ha controlled Bermuda grass at levels equivalent to the 2.2 kg/ha rate of clomazone each year. Crop injury from the various systems was minimal (<5%) both years. Gross cane and sugar yields were equal to the control where metribuzin, terbacil, or sulfentrazone were applied alone at-planting. At planting applications of clomazone at 2.2 kg/ha in mixture with either atrazine or sulfentrazone or imazapyr at 0.6 kg/ha with atrazine were the only treatments evaluated that increased cane (7%) and sugar (9%) yields over the control (Edward, 1995) .

Field studies were conducted in 2000 and 2001 in Plains, GA, to determine peanut and weed response to the residual herbicides sulfentrazone, imazapyr, diclosulam, and flumioxazin. Herbicide treatments included sulfentrazone applied pre-emergence or pre-plant incorporated at 112, 168, 224, and 280 g ai/ha, imazapyr post-emergence at 71 g ai/ha, diclosulam PPI at 26 g ai/ha, and flumioxazin PRE at 88 g ai/ha. Peanut exhibited early-season injury from all herbicide treatments, ranging from 0 to 10% for sulfentrazone PPI or PRE, 10% for imazapyr, 3 to 23% for flumioxazin, and 1 to 7% for diclosulam. Yields were similar for sulfentrazone PPI- or PRE-treated and flumioxazin-, imazapyr, and diclosulam-treated peanut. Yellow nut sedge control was 83% or greater with all rates of sulfentrazone PRE or PPI, 83 and 90% with diclosulam, and 96 and 99% with imazapyr, respectively. Flumioxazin did not control yellow nut sedge or wild poinsettia. Tall morning glory control was 82% or greater with imazapyr, diclosulam, flumioxazin, and sulfentrazone PPI or PRE at 168 g/ha or higher. Florida beggar weed control was 88% or greater with diclosulam, flumioxazin, and sulfentrazone PRE at 224 and 280 g/ha. Overall, peanut tolerance to sulfentrazone at 112 to 280 g/ha PPI and PRE was high and yield was equivalent to the currently registered peanut residual herbicides (Timothy *et al.*, 2004).

Literature Cited

Afzal, M., S.H. Shah, A. Jabbar, and M.S. Nazir. 2005. Cane quality parameters as influenced by single and blended herbicidal weed management. *Pak. Sugar Journal*, Vol. XX (02): 13-20.

Ahrens, W.H. 1994. Herbicide Handbook. 7th edition. Champaign, II: Weed Science Society of America. p. 79-81.

Anonymous. 2001a. Controlling Weeds in Sugarcane. Baton Rouge, LA. Louisiana State University Ag Center and Louisiana Cooperative Extension Service. Pub.2314 .pp. 2-4.

Anonymous. 2001b. Sugarcane Production Handbook. Baton Rouge, LA. Louisiana State University AgCenter and Louisiana Cooperative Extension Service. Pub.2859 .pp. 1-10.

Ashton, F. M. 1958. Absorption and translocation of radioactive 2,4-D in sugarcane and bean plants. Weeds 6:257-262.

Anonymous, 2008. Spartan 48% F Herbicide. Crop Data Management Systems. http://www.cdms.net/LDat/ld3LT010.pdf. Accessed: September 9, 2008.

Bahadar, K., M. Jama, and H. Azim. 2004. Effect of weeds on cane yield and content of sugarcane. *Pak. J. Weed Sci. Res.* 10(1-2): 47-50.

Boddey, R. M., S. Urquiaga, V. Reis and j. Döbereiner. 1991. Biological nitrogen fixation associated with sugar cane, *Plant and Soil*, Volume 137, Number 1.

Bogden.1977. Tropical Pasture and Fodder Plants (Tropical Agriculture). ISBN 978-0-582-46676-0.

Boger, P and Wakabayashi, K. 1999 . “Sulfentrazone” in “Peroxidizing Herbicides”, p. 365.

Chattha, A.A., M.A. Grawal, F.G. Ali, and A. Zulfiqar. 2001. Exploitation of cane yield potential of sugarcane varieties. *Pak. Sugar Journal*, 16: 51-55.

Chauhan, R.S. and T.K. Srivastava. 2002. Influence of weed management practices on weed growth and yield of sugarcane. *Indian Journal of Weed Science,* 34 (3-4): 318-319.

Curtis A. Jones.2006. Red morningglory (*Ipomoea coccinea* L.) biology and management in sugarcane. A dissertation, Faculty of the Louisiana State University and Agricultural and Mechanical College.

Dayan, F. E., B. M. Armstrong, and J. D. Weete. 1998. Inhibitory activity of sulfentrazone and its metabolic derivatives on soybean (*Glycine max*) protoporphyrinogen oxidase. *J. Agric. Food Chem.* 46:2024–2029.

Dayan, F. E. and S. O. Duke. 1997. Phytotoxicity of protoporphyrinogen oxidase inhibitors: phenomenology, mode of action, and mechanisms of resistance 11–35. *In*. Roe, R. M., J. D. Burton, and R. J. Kuhr. Herbicide Activity: Toxicology, Biochemistry and Molecular Biology. Washington, DC IOS

Dayan, F. E., H. M. Green, J. D. Weete, and H. G. Hancock. 1996a. Postemergence activity of sulfentrazone: effects of surfactants and leaf surfaces. *Weed Science* 44:797–803.

Dayan, F. E., J. D. Weete, S. O. Duke, and H. G. Hancock. 1997. Soybean (*Glycine max*) cultivar differences in response to sulfentrazone. *Weed Sci* 45:634–641.

Dayan, F. E., J. D. Weete, and H. G. Hancock. 1996. Physiological basis for differential sensitivity to sulfentrazone by sicklepod (*Senna obtusifolia*) and coffee senna (*Cassia occidentalis*). *Weed Sci* 44:12–17

Durigan, J.C. 2005. Effects of plant densities and management of purple nutsedge on sugarcane yield and effect of growth stages and main way of herbicides contact and absorption on the control of tubers. *J. Environ. Sci. and Health*. B40:111-117.

Eric Johnson. 2006. Evaluation of Sulfentrazone for Weed Control in Flax. Weed Biologist with Agriculture and Agri-Food Canada.

Erickson, L. C. and H. S. Gault. 1950. The duration and effect of 2, 4-D toxicity to crops grown on calcareous soil under controlled irrigation conditions. Agron. J. 42:226- 229.

Ferrell, J. A., W. W. Witt, and W. K. Vencill. 2003. Sulfentrazone absorption by plant roots increases as soil or solution pH decreases. Weed Sci 51:826–830.

Food and Agriculture Organization of the United Nations.2010. "Crop production". http://faostat.fao.org.

Food and Agriculture Organization, United Nations. 2009. Agribusiness Handbook: Sugar beet white sugarhttp://www.eastagri.org.

Gascho, G. J., O. C. Ruelke and S. H. West. 1973. Residual effects of germination temperature in sugarcane. Crop Sci. 13:274-276.

George Rolph.1873. Something about sugar: its history, growth, manufacture and distribution. http://www.archive.org.

Grey, T. L., R. H. Walker, G. R. Wehtje, J., Adams Jr, F. E. Dayan, J. D. Weete, H. G. Hancock, and O. Kwon. 2000. Behavior of sulfentrazone in ionic exchange resins, electrophoresis gels, and cation-saturated soils. *Weed Sci* 48:239–247.

Griffin, J. L., B. J. Viator and J. M. Ellis. 2000. Tie-vine (morning glory) control at layby. Sugar Bull. 78:23-35.

Houston, W.A. 1970. The ten worst weeds of field crops. Crops Soils. 10- 2309.

Jarwar, A.D., S. Tunio, M.A. Ansari, I. Majeedano, M.A. Kaisrani. 2004. Weed competition studies in sugarcane. *Indus Journal of Plant Sciences*, 3(4): 442-445.

James Duke. 1983. "*Saccharum officinarum* L.". Purdue University. http://www.hort.purdue.edu/newcrop/duke_energy/Saccharum_officinarum.html.

Jonathan Siebert. 2003. Sugarcane seed response to 2,4-D and alternative herbicides for red morning glory (*Ipomoea coccinea* L.) control. Thesis, Faculty of the Louisiana State University and Agricultural and Mechanical College

Kuva, M.A., P.J. Pitelli, R.A. Christoffoloeti, and PLCA. Alves. 2000. Interference periods of weeds in sugarcane culture. I – Purple nut sedge. *Planta-Daninha* 18 (2): 241-251.

Lang, G. 1990. Dormancy: a new universal terminology. *Hort. Sci*. 22:817-820.

Litlle, K. P. Adams, H. Frochet, J. Java, S. Gous, R. A. Lautenschlaget, G. Orlander, K. V. Sankaran, R. G. Wagnet, Run-Peng Wel, and I. Wiloughby. 2006. Reducing herbicide use through integrated forest vegetation management practices. Institute for Commercial Forestry Research, Scotsville, South Africa.

Main, C. L., T. C. Mueller, R. M. Hayes, J. W. Wilcut, T. F. Peeper, R. E. Talbert, and W. W. Witt. 2004. Sulfentrazone persistence in southern soils: bioavailable concentration and effect on a rotational cotton crop. *Weed Technol* 18:346–352.

Mathew, T., D. Alexander, and G. Jayakumar. 2002. Screening of herbicides for effective weed control in spring planted sugarcane. *Cooperative-Sugar*, 33 (9): 741-742.

Mathur, P.S. and Kirtikar. 1965. Ind. Sugarcane Jr. IX (2): 101-104.

Mishra, P.J., P.K. Mishra, S. Biswal, S.K. Panda, and M.K. Mishra. 2003. Studies on integrated weed management practices in spring planted sugarcane of coastal Orissa. *Indian Sugar*, 52 (11): 925-929.

Millhollon, R.W. 1992. Effect of itch grass interference on growth and yield of sugarcane. *Weed Sci*. 40 (I): 48-53.

Millhollon, R.W. 1995. Growth and yield of sugarcane as affected by Johnson grass (*Sorghum halepense*) interferences. *J. Am. Soc. Sugar Cane Technol*. 15: 32-40.

Millhollon, R.W.1988. Differential response of sugarcane cultivars to competition from Johnson grass (*Sorghum halepense* L.) *In*. Proc. Inter. Soc. Sugarcane Technol. 20: 577-584.

Millhollon, R. W. 1988. Control of morning glory (*Ipomoea coccinea*) in sugarcane with layby herbicide treatments. *J. Am. Soc. Sugarcane Technol*.

Miller, T. W. 2003. Effect of several herbicides on green pea (*Pisum sativum*) and subsequent crops. *Weed Technol* 17:731–737.

Nayyar, M.M., M. Shafi, M.L. Shah, and T. Mahmood. 1994. Critical period for weed control in sugarcane: In Absts. 4th all Pak. Weed Sci. Conf. Univ. Agri. Faisalabad, Pakistan, March 26-27.

Ohmes, G. A., R. M. Hayes, and T. C. Mueller. 2000. Sulfentrazone dissipation in a Tennessee soil. *Weed Sci* 14:100–105.

Patel, C.L., D.D. Patel, and M.N., Patel. 2007. Critical period of crop weed competition in sugarcane (Var. Co Lk 8001). *Indian Sugar*, LVI (12): 27-32.

Peter Griffee. 2000. "*Saccharum Officinarum*". Food and Agriculture Organization of the United Nations. http://www.fao.org.

Qasem, J.R., and C.L. Foy. 2001. Weed allelopathy, its ecological impacts and future prospect: a review. *J. Crop Prod*, 4: 43-120.

Reddy, T.Y. and G.H.S. Reddi. 2002. Principles of Agronomy. 3rd ed., Kalyani publisher,New Delhi-11002: 427-428.

Robertson, M. M. and R. C. Kirkwood. 1969. The mode of action of foliar – applied translocated herbicides with particular reference to the phenoxy – acid compounds.The mechanism and factors influencing herbicide absorption. *Weed Res*. 9:224-240.

Roshan, L., S.N.L. Srivastava, and M. Chand. 2006. Integrated weed management for sugarcane (*Saccharum officinarum*) plant-ratoon cropping system. *Indian journal of Agronomy*, 51 (4): 251-255.

Saini, J.P. and I.S. Chakor. 1992. Correlation and regression studies of yield and yield attributing characters of sugarcane. *Indian Sugar*, 42 (5): 311-313.

Shafi, M., S. Afghan, M.L. Shah, and T. Mehmood. 1994. Screening of herbicides for weeds in sugarcane at post-emergence stage. *Pak. Sugar Journal*, 8 (1): 9-12

Singh, A., A.S. Svirk, J. Singh, J. Singh, A. Singh, J. Singh. 2001. Efficacy of new herbicide for the control of weeds in sugarcane. *Cooperative Sugar*, 33: 315-316.

Singh, H., N. Kumar, and D.K. Dwivedi. 2008. Efficacy of some new herbicides on weed dynamics and yield of sugarcane. *Indian Sugar*, LVIII (9): 71-74.

Singh, R. G., Singh, S., S. Tripathi, and V.K. Singh. 2003. Management of *Ipomoea* spp. and other weeds in spring planted sugarcane under Uttaranchal Tarai. *Indian Journal of Weed Science*, 35 (1/2): 74-76.

Singh, R., D. Sen, V.K. Singh, N.S. Rana, S. Kumar. 2005. Effect of weed-management practices on spring-planted sugarcane. *Indian journal of Agronomy*, 50 (3): 236- 238 (CAB Abstracts, 2005).

Srivastava, T.K. 2001. Efficacy of certain new herbicides in spring planted sugarcane. *Indian J. of Weed Sci*., 33(1): 256-58.

Santos, B.M., J.P. Morales-Payan, W.M., Stall, T.A. Bewick, and D.G. Shilling. 1997. Effects of shading on the growth of nutsedge (*Cyperus* spp.). Weed Sci. 45: 670-673.

Singh, D. and P.K. Tomar. 2003. Studies on critical period of crop-weed competition in late-planted sugarcane (*Saccharum officinarum* L.). *Indian Sugar* 53 (8): 579-583.

Sathyavelu, A., E. Somasundaram, R. Poonzuhalan, and T. Rangaraj. 2002. Integrated weed management in sugarcane. *Indian Sugar*, LI (12): 871-873.

Sidney Mintz .1986. Sweetness and Power: The Place of Sugar in Modern History. Penguin. ISBN 978-0-14-009233-2.

Stafstrom, J. 1995. Developmental potential of shoot buds. In B. Gartner ed. Plant stems: Physiology and Functional Morphology. San Diego, CA: Academic Press. pp. 257-279.

Steeves, T. and I. Sussex. 1989. Patterns in Plant Development. New York: Cambridge University Press. pp. 388.

Sulfentrazone Herbicide Fact Sheet, US Department of Energy Bonneville Power Administration. 2004

Tamas, I. A., J. L. Schlossberg-Jacobs, R. Lim, L. B. Friedman, and C. C. Barone. 1989. Effect of plant growth substances on the growth of auxillary buds in cultured stem segments of *Phaseolus vulgaris* L. Plant Growth Reg.

The Pesticide Manual: A World Compendium, 7th ed. 1983. C.R. Worthing, ed. The British Crop Protection Council, Croydon, England. 695 pp.

Timothy. grey , David c. Bridges , h. Gary hancock , and Jerry w. davis. (2004) Influence of Sulfentrazone Rate and Application Method on Peanut Weed Control. *Weed Technology*. Vol. 18, No. 3, pp. 619-625.

Tomar, P.K., Om. Prakash, and D. Singh. 2003a. Economical methods of weed management to improve the productivity and sugar recovery in late planted sugarcane. *Indian Sugar*, LIII (5): 339-342.

Tomer, P.K., Om. Prakash, and D. Singh. 2003b. Population growth of weeds and productivity of sugarcane as influenced by weed management practices. *Cooperative Sugar*, 35: 205-210.

The Photosynthetic Process. 2012. Concepts in Photobiology: Photosynthesis and Photomorphogenesis. University of Illinois. http://www.life.illinois.edu.

Thomson, W.T. 1981. Agricultural chemicals - book 2: herbicides. Revised ed. Thomson Publications, Fresno, CA. 274 pp.

Turner, P.E.T., N.B. Libleibbrandt and L.H. Wiehe. 1990. The phytotoxic effects of herbicides on sugarcane in South Africa. Proceedings of South African Sugar Technologist Association. Mount Edgecumbe, 4300.

Vencill, W. K. 2002. Herbicide Handbook. 8th ed. Lawrence, KS Weed Science Society of America. 405–406.

Viator, B. J., J. L. Griffin and E. P. Richard. 2002a. Evaluation of red morning glory (*Ipomoea coccinea*) for potential atrazine resistance. *Weed Technol*. 16:96-101.

Viator, B. J., J. L. Griffin, and J. M. Ellis. 2002b. Red morning glory (*Ipomoea coccinea*) control with sulfentrazone and azafeniden applied at layby in sugarcane (*Saccharum* spp.). *Weed Technol*. 16:142-148.

Wall, D. A., J. C. Hall and I. N. Morrison. 1991. Uptake, translocation, and fate of 2,4-D and chlorsulfuron in *Silene vulgaris* (Moench) Garcke. *Weed Res*. 31:81-88.

Weed Science Society of America, Herbicide Handbook Committee. 1983. Herbicide handbook of the weed science society of America, 5th ed. Weed Science Society of America, Champaign, IL. 515 pp.

CHAPTER 2

EVALUATION OF BIOEFFICACY OF SULFENTRAZONE 48 % F AGAINST WEED SPECTRUM IN SUGARCANE

Sugarcane crop suffers heavy infestation with weeds that can be controlled manually, mechanically, biologically and chemically. Manual weed control is laborious, time consuming and expensive than chemical weed control. Mechanical weed control may damage crop plants. Chemical weed control by herbicides is relatively efficient and economical. The effectiveness and relatively low cost of herbicides has resulted in management systems which are reliant upon their continued availability, and has led to almost a total exclusion of non-herbicidal methods of weed control (Litlle *et al*., 2006). Herbicides have little effect on crop growth in comparison with the effects of competition from weeds. They may cause some damage to sugarcane so they must be evaluated for their effects on crop and weeds before giving recommendation for their use (Turner *et al*., 1990). Sugarcane yield can be increased by good crop husbandry. Removal of weeds, is important component of crop husbandry as higher cane yield (65.43 t/ha) and profit with conventional practice (3 hoeing and weeding at 15, 30 and 45 days after planting) were achieved (Singh *et al*., 2001). According to Srivastava (2001) manual hoeing performed at 30, 60 and 90 days after planting (DAP) suppressed the weed population and dry matter accumulation most effectively and resulted in the highest number of millable canes and cane yield. In a field study, Tomar *et al*. (2003a) recorded lowest weed density and dry matter accumulation, and the highest number of millable canes, cane yield, commercial cane sugar, net returns, and cost benefit ratio in weed-free control and hoeing at 30, 60، and 90 DAP.

In sugarcane weeds have been estimated to cause 12 to 72 % reduction in cane yield depending upon the severity of infestation. The nature of weed problem in sugarcane cultivation is quite different from other field crops because sugarcane is planted with relatively wider row spacing and crop growth is very slow in the initial stages. It takes about 30 - 45 days to complete germination and another 60-75 days for developing full canopy cover. Further, availability of abundant water and nutrients in sugarcane production system provides ample scope for weeds to flourish long before crop establishment. In ratoon crop very little preparatory tillage is taken up hence weeds that have established in the plant crop tend to flourish well (Anonymous, 2001). Weed flora in sugarcane field besides competing for moisture and light also remove about 4 times N and P and 2.5 times of K as compared to crop during the first 50-days period. Weeds also harbor certain diseases and pests that attack sugarcane and thus lead to indirect losses. Weeds that are present in the furrows i.e., along the cane rows cause more harm than those present in the inter-row spaces during early crop growth sub-periods. Thus the initial 90-120 days period of crop growth is considered as most critical period of weed competition. Therefore the weed management practice adopted should ensure a weed-free field condition for the first 3-4 months period (Kanchan Nainwal, 2009).

There are many compounds used for weed control in sugarcane crop. An experiment was conducted to evaluate different weed control methods in sugarcane crop. Ten treatments *viz*. T1 -Atrazine @ 2 kg ai/ha pre-emergence + 2,4-D @1 kg ae/ha at 60 DAP, T2 -Metribuzin @ 1 kg ai/ha as pre-emergence + hoeing at 60 DAP, T3 -Ametryn @ 2 kg ai/ha pre-emergence + one hand weeding at 60 DAP, T4- Metribuzin @ 1 kg ai/ha pre-emergence + 2,4-D @ 1 kg ae/ha at 60 DAP, T5 -T4+ hoeing at 90 DAP, T6 -Glyphosate @ 1 liter ai /ha at 20 DAP uniform spray + hoeing at 90 DAP, T7 -Hexazinone (46.8 %) + Diuron (13.2 %) mixture 60% WP @ 1.20 kg ai /ha as pre-emergence and T8 -T7 + hoeing at 90 DAP, were compared with hoeing at 30, 60 and 90 DAP (T9) and weedy check (control) (T10). Results revealed that all the weed control methods significantly reduced weed flora and weed biomass as compared to weedy check. However, integrated method with pre-emergence application of Metribuzin +2,4-D at 60 DAP + hoeing at 90 DAP produced maximum number of millable canes (Singh *et al*., 2008).

Mathur and Kirtikar (1965) reported that Nata @ 11.2 kg and 16.8 kg/ha did not effectively control the weeds and it led to deleterious effects on the cane crop and reduced the yield whereas post-emergence application of dalapon sodium salt @ 5.6 kg/ha did not have any appreciable effect on weeds. Chattha *et al*. (2001) proposed that cane yield could be increased to 68% with proper weed control over weedy check. He also found that 43.75% improvement in cane yield was recorded with integrated weed control over weedy check. A field experiment was conducted Tomar *et al*. (2003b) which consisted of 15 treatments (Herbicide alone, herbicide in combination with intercultural operation, intercrops, and trash mulch) along with weedy check and weed free. Among all the fifteen treatments, highest cane yield (84.6 t/ha and 80.6 t/ha) and CCS (10.1 and 9.3 t/ha) in first and second year, respectively were recorded from completely weed free treatment during both the years which were at par with three hoeing (30, 60, and 90 DAP) which produced cane yield (77.0 and 75.3 t/ha) during 2001-2002 and 2002-2003, respectively. Losses in cane yield due to weeds were recorded 43.4% during 2001-2002 and 43.9% during 2002-2003. Total weed population and dry matter were higher in weedy check and lowest in weed free and 3 hoeing treatments. Among herbicide treatments use of metribuzin along with either one hoeing (60 DAP) or use of 2,4-D@ 1.0 kg ha-1 (post-emergence 30 DAP) gave significantly lower total weed population and weed dry weight than the rest of treatments.

Herbicides to control weeds are essential to prevent weed competition and losses in sugarcane production. Sugarcane is most susceptible to weed competition during the first eight to 10 weeks after cane emergence. Unless herbicides are applied immediately after planting, weed seed present in the soil following a fallow program will germinate, producing viable seeds and/or rhizomes. Selection of pre-emergence herbicides should be based on soil texture and organic matter content, weed problem and the variety of sugarcane. For best results, apply pre-emergence herbicides immediately after planting.

Atrazine is the common name for an herbicide that is widely used to kill weeds. It is used mostly on farms. Pure atrazine is an odorless, white powder. It is not very volatile, reactive, or flammable. It will dissolve in water. Atrazine is made in the laboratory and does not occur naturally. Atrazine is used on crops such as sugarcane, corn, pineapples, sorghum, and macadamia nuts, and on evergreen tree farms and for evergreen forest regrowth. It has also been used to keep weeds from growing on both highway and railroad rights-of-way. Atrazine can be sprayed on croplands before crops start growing and after they have emerged from the soil. Some of the trade names of atrazine are Aatrex, Aatram, Atratol, and Gesaprim.

2,4-D is a broadleaf herbicide in the phenoxy group used in turf and no-till field crop production. Now, it is mainly used in a blend with other herbicides to allow lower rates of herbicides to be used; it is the most widely used herbicide in the world, and third most commonly used in the United States. It is an example of synthetic auxin (Kogevinas *et al*., 1997). The use of 2,4-D to control broadleaf weeds in grass crops is common. Even though grass crops are considered tolerant to 2,4-D, application particularly during the reproductive growth stages can result in excessive injury (Ahrens 1994). The specific mode of action for 2,4-D is not completely understood, but like other auxin-type herbicides ethylene evolution is stimulated and uncontrolled growth ensues (Jonathan Siebert, 2003).

Sulfentrazone applied pre-emergence to weeds controls several broadleaf weeds and sedges that are not easily controlled by clomazone (Krausz *et al*. 1998; Stringer *et al*. 1998; Vidrine *et al*. 1996). At higher rates, sulfentrazone provides some PRE control of grass weeds (Stringer *et al*., l998). Currently، atrazine is partnered with labeled herbicides such as the dinitroanilines to provide broad spectrum weed control at planting and in the spring (Anonymous 1994). Sulfentrazone's ability to control particularly troublesome weeds like morning glory (*Ipomoea* spp.) and nut sedge (*Cyperus* spp.), as well as providing some control of grass weeds, would make it a logical partner with herbicides having predominately grass activity to insure broad spectrum control of grass and broadleaf weeds. Research has shown that imazapyr provides some control of Bermuda grass when applied PRE at planting. A second POST application in the spring can provide additional Bermuda grass control but is phytotoxic to sugarcane and reduces yield (Richard 1998).

Along term project in which new herbicides (sulfentrazone and other herbicides) were tasted regularly on two years cycle recorded *Cyperus rotundus, Sorghum halepense, Cynodon dactylon, Convolvulus arvensis, Digera arvensis and Echinochloa* spp., as predominant weeds. Uncontrolled weed growth caused 27.5% loss in cane yield. Various herbicide treatments screened for their weed control efficiency brought down the weed infestation. Significant reduction in density and dry weight of weeds was recorded with pre-emergence application of sulfentrazone 1.0 kg/ha, sulfentrazone 0.5 kg + atrazine 2.0 kg/ha, ametryn 3.0 kg/ha and sequential spray of atrazine 2.0 kg/ha (pre-emergence) followed by basta 4.0 kg/ha (45 DAP) or 2,4-D 1 kg/ha (60 DAP). Sulfentrazone alone as well as in combination with atrazine proved very effective against *cyperus rotundus*. During initial stages, sugarcane plants in the plots sprayed with sulfentrazone showed reddening of midribs which automatically subsided within 15 days without having any adverse effect on growth and vigour of the crop. The highest yield (86.8 t/ha) was recorded with 3 manual hoeings. Among herbicide treatments sulfentrazone 0.5 + atrazine 2.0

kg/ha gave the best yield (86.4 t/ha). Juice quality remained unaffected due to various treatments (IISR Annual report, 2000).

Field study carried out during 2010-2011 at Indian Institute of Sugarcane Research Farm, under subtropical Indian conditions in a loamy soil having pH value of 7.1 comprised of 10 treatments including untreated control. Seven dozes of sulfentrazone (720, 480, 960, 1080, 1200, 1320 and 2400g ai/ha) along with atrazine 50WP@1250 g ai/ha pre-emergence at 3 days after planting and 2,4-D Na salt 80 WP 1200 g ai/ha as post emergence at 45 DAP were applied. Total weed density (233-262 plants/m^2) was recorded highest with weedy check (control) which was brought down to 7.3-172 plants/m^2 with the application of sulfentrazone doses. Dry matter accumulation in weeds was recorded highest with weedy ckeck (193-333 g/m^2) followed by 2,4-D (93-142 g/m^2) and atrazine (84-142 g/m^2). Doses of sulfentrazone showed the lowest accumulation of dry matter (67-147 g/ m^2) at all the stages. Highest weed control efficiency (62.0-75.0%) was registered with sulfentrazone application followed by atrazine (53.0%) and 2,4-D (33.0%) at 60 days of planting (Singh *et al*., 2012).

Chauhan and Srivastava (2002) conducted a field experiment on weed management in sugarcane. They reported that the best treatment for controlling weeds in sugarcane was atrazine @ 870 g ai/ha applied immediately after planting + manual hoeing at 45 days after planting. Mishra *et al*., (2003) concluded that pre-emergence application of ametryn with one hoeing at 60 days after planting (DAP) recorded lower weed flora and dry weight and higher average cane yield of 149.8 t/ha. Similarly, yield of sugarcane increased with atrazine application @ 1500, 2000, or 2500 g/ha as pre or post-emergence and hand hoeing compared to the untreated control.

Field trials were conducted in Nigeria to compare the efficiency of the pre-emergence CGA 362 + ametryn at 3.0 kg/ha on weed control in sugarcane with the conventional recommended pre-emergence herbicides: diuron at 4.0 kg/ha, atrazine at 3.0 kg/ha, hoeing at 3, 6, and 9 weeks after planting and weedy control. The weeds included *Paspalum orbiculare* [*P. scrobiculatum*], *Rottboellia cochinchinesis, Cynodon dactylon*, *Cyperus rotundus*, *Commelina benghalensis* and *Cleome viscosa*. The weed control treatments have no significant effect on percentage germination count at 21days after planting and crop growth, but effect was significant on weed parameters as well as of sugarcane growth and yield. Among the treatments, the weedy control gave the poorest weed control and sugarcane growth. The best weed control was achieved by CGA 362 + Ametryn at 3.0 kg/ha which recorded significantly higher yield (82.5 t/ha) as compared to the earlier recommended herbicides (Gana *et al*., 2006).

An experiment to evaluate the efficacy of integrated weed management practices in spring planted sugarcane was conducted. Pre-emergence application of ametryn with one hoeing at 60 DAP recorded lower weed flora and dry weight and produced highest average cane yield of 149.8 t/ha followed by three-manual hoeing (146.2 t/ha) as compared to weedy check (103.4 t/ha). Benefit Cost ratio (1.51) and highest net return was obtained with pre-emergence treatments of ametryn with one hoeing at 60 DAP (Mishra *et al*., 2003). In another experiment, efficacy of various herbicides was investigated against the recommended herbicides in India by Singh *et al*. (2003). The treatments consisted of hand weeding (3 hoeings), Sencor 70 WP (metribuzin) and Atrataf 50 WP (atrazine) as pre-emergence each at 2.0 kg/ha, Round up (paraquat) at 2.5 and 3.0 liters/ha, Gramoxone (paraquat) at 1.0 and 1.5 liters/ha, Glycel (glyphosate) at 1.5 liters/ha as post-emergence, and Sencor as pre-emergence followed by 2,4-D (80% sodium salt) as post-emergence each at 2.0 kg/ha and control. The pre-emergence herbicides were applied within 3 days and the post-emergence at 40-45 days after sowing. The prominent weeds of the field were *Eleusine indica, E. aegyptiaca [Dactyloctenium aegyptim], Amaranthus spinosus, Euphorbia hirta, Tribulus terrestris, Trianthema monogyna [Trianthema portulacastrum], Vicoa indica, Eragrostis tenella and Digitaria sanguinalis ،Sorghum halepense, Cynodon dactylon* and *Cyperus rotundus*. All the treatments increased the cane yield from 87.8 to 138.7% over the control. Hand weeding and the chemical weed control (application of Sencor as pre-emergence followed by 2,4-D as post-emergence, each at 2.0 kg/ha and Round up at 3.0 liters/ha, as post emergence (produced the same cane yield but significantly higher than the other treatments, except for Round up at 2.5 liters/ha. The increase in cane yield by these herbicides was due to reduction in dry weight of weeds significantly over the control, with a weed control efficiency of 78.3, 71.7, and 78.3%, respectively.

A field experiment was carried out in India by Srivstava (2003) to evaluate the bio-efficacy of sulfentrazone for weed control specially *C. rotundus* in sugarcane (cv. CoLk 8102). The experiment I comprised pre-emergence application of sulfentrazone @0.5 kg + atrazine @ 2.0 kg/ha, ametryn @ 1.5 and 3.0 kg/ha, ametryn @ 1.5 kg+ atrazine @ 1.0 kg/ha, Basta (glufosinate) @ 0.4 and 0.8 kg/ha, atrazine @ 2.0 kg/ha followed by Basta @ 0.4 kg/ha, atrazine @ 2.0 kg/ha followed by 2,4-D @ 1.0 kg/ha, 3 hoeings at 30, 60 and 90 days after planting and weedy control. The lowest weed density was recorded with pre-emergence application of sulfentrazone @ 0.5 kg+ atrazine @ 2.0 kg/ha. However, the lowest weed dry matter accumulation was achieved with 3 manual hoeings, closely followed by application of sulfentrazone + atrazine. The highest number of millable canes was recorded with 3 manual hoeings and tank-mix spray of sulfentrazone @ 0.5 kg + atrazine @ 2.0 kg/ha. The highest cane yield (82.4 t/ha) was obtained with 3-

manual hoeing, closely followed by the application of sulfentrazone + atrazine (80.1 t/ha).

Saini and Chakor (1992) evaluated the comparative performance of different weed control methods in sugarcane crop. The treatments were control, six manual weeding, and pre-emergence application of atrazine @ 1.52, and 2.50 g ha-1. He concluded that maximum weed control as well as higher cane yield was obtained by manual hoeing. Shafi *et al*. (1994) conducted an experiment for evaluating the comparative performance of different weed control strategies i.e., weedicides like Gesapax Combi-80 wp Besta-20 SL U-46-D fluid and hand weeding. He concluded that maximum weed control was achieved in Gesapax combi followed by hand weeding. However, higher cane yield 68.17 t/ha was obtained with manual hoeing followed by Gesapax combi where cane yield was 64.66 t/ha.

In view of high temperature and extensive weed growth during summer, mulching for moisture conservation and suppression of weeds, is highly useful in sugarcane. Besides, it adds to the organic matter content of the soil. Mulching the inter row spaces with 7.5 to 10 cm thick layer of dry leaves of sugarcane (trash) or any other organic source is quite effective . About 10 tonnes of sugarcane trash per hectare is required . Mulching in ratoon is more convenient than in the plant crop . The trash on decomposition release nutrients which improves the fertility of soil. Mulching with sugarcane trash is, therefore, advantageous over burning which is usually practiced to reduce the incidence of diseases and insect-pests, as in the case of scale insect (Kanchan Nainwal, 2009).

In view of information recorded in foregoing paragraphs the present study was carried out **to evaluate the efficacy of sulfentrazone alone or in combination with other weed control methods for the control of weeds in sugarcane.**

Materials and Methods

Field experiments were conducted during 2012-13 to assess the effect of weed control methods on growth and development of weeds in sugarcane and the effect of various treatments on sugarcane growth, yield attributes, yield and juice quality at the Indian Institute of Sugarcane Research, Lucknow (UP), India. Application of weed control methods was made at tiller stage of sugarcane crop (Variety CoSe 92423). In all 14 treatments comprising various doses and time of application of sufentrazone alone or in combination with other weed control methods including other herbicides were evaluated in Randomized Complete Block Design (RCBD) with three replications. The treatment details are presented in table 1.

Table 1: Treatment details

No.	Treatment	Time of application	Dose (g ai/ha)	Dose (ml/ha)
T_1	Sulfentrazone 48% F	PPI	480	1000
T_2	Sulfentrazone 48% F	PPI	600	1250
T_3	Sulfentrazone 48% F	PPI	720	1500
T_4	Sulfentrazone 48% F	PPI	900	1875
T_5	Sulfentrazone 48% F	Pre-em:3DAP	480	1000
T_6	Sulfentrazone 48% F	Pre-em:3DAP	600	1250
T_7	Sulfentrazone 48% F	Pre-em:3DAP	720	1500
T_8	Sulfentrazone 48% F	Pre-em:3DAP	900	1875
T_9	Atrazine 50 WP+2,4 D 80% WP	Pre-em:3DAP + 60 DAP	2000+1000	
T_{10}	Three-hoeing	60, 90, 120 DAP		
T_{11}	Trash mulching	3 DAP		
T_{12}	T_2 + one hoeing at 60 DAP			
T_{13}	T_6 + one hoeing at 60 DAP			
T_{14}	Untreated control (weedy)			

Pre-em: Pre-emergence DAP: Days after planting

The soil of the experimental site was Sandy loam with pH 7.83 and organic carbon 0.40%, however available N, P_2O_5 and K_2O were determined to be 222.6, 16.8 and 186.1 kg/ha, respectively. The gross plot size was kept 36m² comprising six rows of sugarcane placed at 75 cm distance from each other.

Each experimental unit was separated from other by 0.5 m while distance between two replications was 1.5 m. Each experimental unit contained six rows of sugarcane having length of 8 m. Recommended doses of fertilizers including 150 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha was added to experimental land. Nitrogen was added by application of urea (46% N), in three parts. First part before planting, second part 60 days after planting and the third part 90 DAP. Full dose of P and K was applied at the time of planting. Bavistin (systemic fungicide) was used for seed treatment @ 0.2%, whereas chlorpyriphos (insecticide) was applied at the rate of 5 L/ha for drenching of sugarcane setts to ward of termites and other insects.

The methods applied in recording of observations on different parameters are as follows:

Germination percentage

Calculated number of plants that appeared above soil surface 45 DAP.

Weed Species

All the weeds present in the control experimental plot were uprooted and identified.

Weed density (number/m^2)

A quadrant sized 1.0 m X 1.0 m was thrown randomly in each experimental unit three times and green weed plants those were not affected by herbicides were counted and averaged.

Percentage of weed control (%)

Was calculated from the following equation:

$$\text{Percentage of weed control} = \frac{\text{No.of weeds in control} - \text{No.of weeds in treated plot}}{\text{No.of weeds in control}} \times 100$$

Dry weight of weeds (g)

Green weed plants were cut at the soil surface from the same site in the experimental unit three times the quadrant (1.0 m^2) was used for counting of weeds for calculating weed density. The weeds samples were air dried under laboratory conditions.

Inhibition proportion of dry matter (%): Was calculated from the following equation:

$$\text{Inhibition proportion of dry matter} = \frac{\text{Weed dry weight in control} - \text{Weed dry weight in treated plot}}{\text{Weed dry weight in control}} \times 100$$

Analysis of data was done using statistical tools of Randomized Complete Block Design. LSD was used to compare treatments at significant level of 0.05 (Steel and Torrie, 1960)

Results and Discussion

Germination percentage

The research findings indicate that weed control methods significantly affected germination of sugarcane (Fig. 1). All the treatments were found effective in increasing the germination in sugarcane compared to the control treatment. Application of atrazine + 2, 4-D led to increase in germination to the highest level to 48.6 % compared to the control (27.6 %). Enhanced germination of sugarcane due to different weed control treatments may be attributed to better availability of moisture and other growth conditions under such treatments.

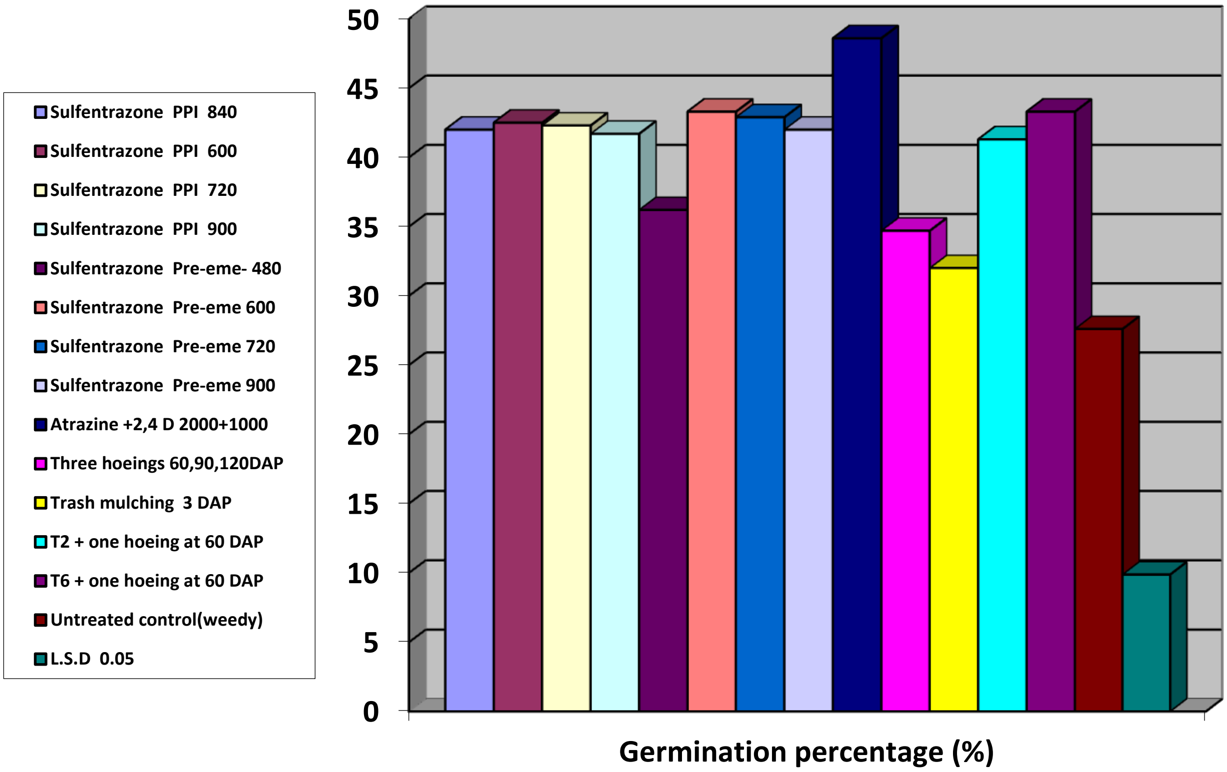


Figure 1. Effect of weed control methods on germination (%) of sugarcane

Weed Density and percentage of weed control

The weed species present in the sugarcane field were: *Amaranthus sp., Chenopodium album, Chorcorus sp., Portulaca oleracea, Parthenium sp., Solanum nigrum, Digera arvensis, Trianthema monogyna, Cyperus rotundus, Sorghum halepense, Cynodon dactylon, Convolvulus arvensis, Digera arvensis, Echinochloa spp., Panicum sp.* (Table 2). At 60 DAP the prominent weed species were the sedges, *Cyperus rotundus* occupied 56.8 per cent share in total weed population. Whereas, the broad leaved annual weed, *Amaranthus hybridus* and broad leaved perennial weed i.e. *Solamum nigrum* were in a very few numbers and constituted 13.4 per cent of the total weed population. The grasses, including *Cynodon dactylon* and *Echinochloa crus-galli,* constituted 29.8 % to total weed density (Table 3).

At 90 DAP the prominent weed species were the sedges and *Cyperus rotundus* occupied 35.6 per cent share in total weed population (Table 2). Whereas, the broad leaved annual weed, *Amaranthus hybridus* and broad leaved perennial weeds i.e *Solamum nigrum* were in a very few numbers that constituted 17.3 per cent of the total weed population. Grasses including perennial (*Cynodon dactylon)* and annual (*Echinochloa crus-galli)* constituted 47.1 % of total weed density (Table 4). At 120 DAP, sedges (*Cyperus rotundus)* and broad leaved weeds occupied 25.1 and 18.5 per cent share in total weed population, respectively. Whereas, the grasses contributed 55.3% to total weed density (Table 5). Change in weed flora with the advancement in crop growth may be attributed to changing micro-climate and weather conditions. It has been reported that grasses and sedges thrive well in sugarcane fields particularly during rainy months that coincides with post 90-days growth stage of sugarcane crop in sub-tropical north Indian conditions (Srivastava *et al*., 2006).

Different weed control treatments affected the weed type and density however the different types of weeds had varied response to different control methods at various growth stages (Table 6). Weed growth in the plots treated with sulfentrazone (pre-em; 900 g ai/ha) recorded significant decrease in weed density (15.7, 18.0 and 28.3/m^2) and achieved highest increase (Fig. 2) in extent of weed control (82.1, 83.0 and 75.6%) compared to the control treatment (87.3, 105.7 and 116.0 plant/m^2) at the 60, 90 and 120 DAP, respectively.

Table 2 Name and type of weeds found present in sugarcane

Scientific name	Common name	Family	Life cycle	Weed type
Amaranthus hybridus	Pigweed, smooth	Amaranthaceae	Summer annual	Broadleaf
Chenopodium album	Lambsquarters	Chenopodiaceae	Summer annual	Broadleaf
Portulaca oleracea	-	Portulacaceae	Annual	Broadleaf
Parthenium sp.	Congress weed	Compositeae	Annual	Broadleaf
Solamum nigrum	Black nightshade	Solanaceae	perennial	Broadleaf
Digera arvensis	False Amaranth	Amaranthaceae	Annual	Broadleaf
Trianthema monogyna	Carpet weed		Annual	Broadleaf
Cyperus rotundus	Purple nut-sedge	Cyperaceae	Summer perennial	Sedges
Sorghum halepense	Johnson grass	Poaceae (Graminae)	Perennial	Grass
Cynodon dactylon	Bermuda grass	Poaceae	Summer perennial	Grass
Convolvulus arvensis	Field bindweed	Convolvulaceae	Perennial	Broadleaf
Echinochloa crus-galli	Barnyard grass	Poaceae (Graminae)	Annual	Grass
Panicum sp.		Gramineae	Annual	Grass

Table 3 Effect of weed control methods on density of weeds (number/m²) in sugarcane at 60 DAP

Treatment	Grasses	Broadleaf	Sedges	Total
Sulfentrazone PPI 480 g ai/ha	44	8	48	100
Sulfentrazone PPI 600 g ai/ha	32	4	30	66
Sulfentrazone PPI 720 g ai/ha	30	0	30	60
Sulfentrazone PPI 900 g ai/ha	34	0	17	51
Sulfentrazone Pre-em 480 g ai/ha	36	8	86	130
Sulfentrazone Pre-em 600 g ai/ha	20	8	52	80
Sulfentrazone Pre-em 720 g ai/ha	21	5	54	80
Sulfentrazone Pre-em 900 g ai/ha	15	10	22	47
Atrazine 50 WP+2,4 D 80% (60 DAP)	28	8	90	126
Three hoeing	13	12	48	73
Trash mulching	16	4	74	94
T2 + one hoeing at 60 DAP	26	4	46	76
T6 + one hoeing at 60 DAP	24	0	64	88
Untreated control(weedy)	58	108	96	262
Total	397	179	757	1333

Table 4 Effect of weed control methods on density of weeds ($NO./m^2$) in sugarcane at 90 DAP

Treatment	Grasses	Broadleaf	Sedges	Total
Sulfentrazone PPI 480 g ai/ha	65	22	37	124
Sulfentrazone PPI 600 g ai/ha	55	18	23	96
Sulfentrazone PPI 720 g ai/ha	53	0	13	66
Sulfentrazone PPI 900 g ai/ha	50	0	8	58
Sulfentrazone Pre-em 480 g ai/ha	82	20	55	157
Sulfentrazone Pre-em 600 g ai/ha	65	22	30	117
Sulfentrazone Pre-em 720 g ai/ha	46	13	29	88
Sulfentrazone Pre-em 900 g ai/ha	36	8	10	54
Atrazine 50 WP+2,4 D 80% DAP	40	7	56	103
Three hoeings	9	2	39	50
Trash mulching	34	15	58	107
T2 + one hoeing at 60 DAP	18	3	33	54
T6 + one hoeing at 60 DAP	24	5	49	78
Untreated control(weedy)	115	119	83	317
Total	692	254	523	1469

Table 5 Effect of weed control methods on density of weeds (No./m^2) in sugarcane at 120 DAP

Treatment	Grasses	Broadleaf	Sedge	Total
Sulfentrazone PPI 480 g ai/ha	100	26	16	142
Sulfentrazone PPI 600 g ai/ha	91	27	11	129
Sulfentrazone PPI 720 g ai/ha	94	18	6	118
Sulfentrazone PPI 900 g ai/ha	74	3	8	85
Sulfentrazone Pre-em 480 g ai/ha	104	36	26	166
Sulfentrazone Pre-em 600 g ai/ha	80	32	23	135
Sulfentrazone Pre-em 720 g ai/ha	44	9	36	89
Sulfentrazone Pre-em 900 g ai/ha	40	20	25	85
Atrazine 50 WP+2,4 D 80% DAP	22	3	66	91
Three hoeings	18	24	44	86
Trash mulching	92	18	43	153
T2 + one hoeing at 60 DAP	30	24	38	92
T6 + one hoeing at 60 DAP	40	14	42	96
Untreated control(weedy)	175	101	72	348
Total	1004	355	456	1815

Table 6 Effect of weed control methods on weed density ($No./m^2$) at different growth stages of sugarcane

Treatment	Time of application	Dose (g a.i./ha)	60DAP	90DAP	120DAP
Sulfentrazone	PPI	840	33.3	41.3	47.3
Sulfentrazone	PPI	600	22.0	32.0	43.0
Sulfentrazone	PPI	720	20.0	22.0	39.3
Sulfentrazone	PPI	900	17.0	19.3	28.3
Sulfentrazone	Pre-em: 3 DAP	480	43.3	52.3	55
Sulfentrazone	Pre-em: 3 DAP	600	26.7	39.0	45.0
Sulfentrazone	Pre-em: 3 DAP	720	26.7	28.7	29.7
Sulfentrazone	Pre-em: 3 DAP	900	15.7	18.0	28.3
Atrazine 50 WP+2,4 D 80% WP	Pre-em: 3DAP+60 DAP	2000+1000	42.0	34.3	30.3
Three hoeing	60,90,120 DAP		24.3	16.7	28.7
Trash mulching	3 DAP		31.3	35.7	51.0
T2 + one hoeing at 60 DAP	-	-	25.3	18.0	30.7
T6 + one hoeing at 60 DAP	-	-	29.3	26.0	32
Untreated control(weedy)	-	-	87.3	105.7	116.0
L.S.D. 0.05			12.34	12.86	19.27

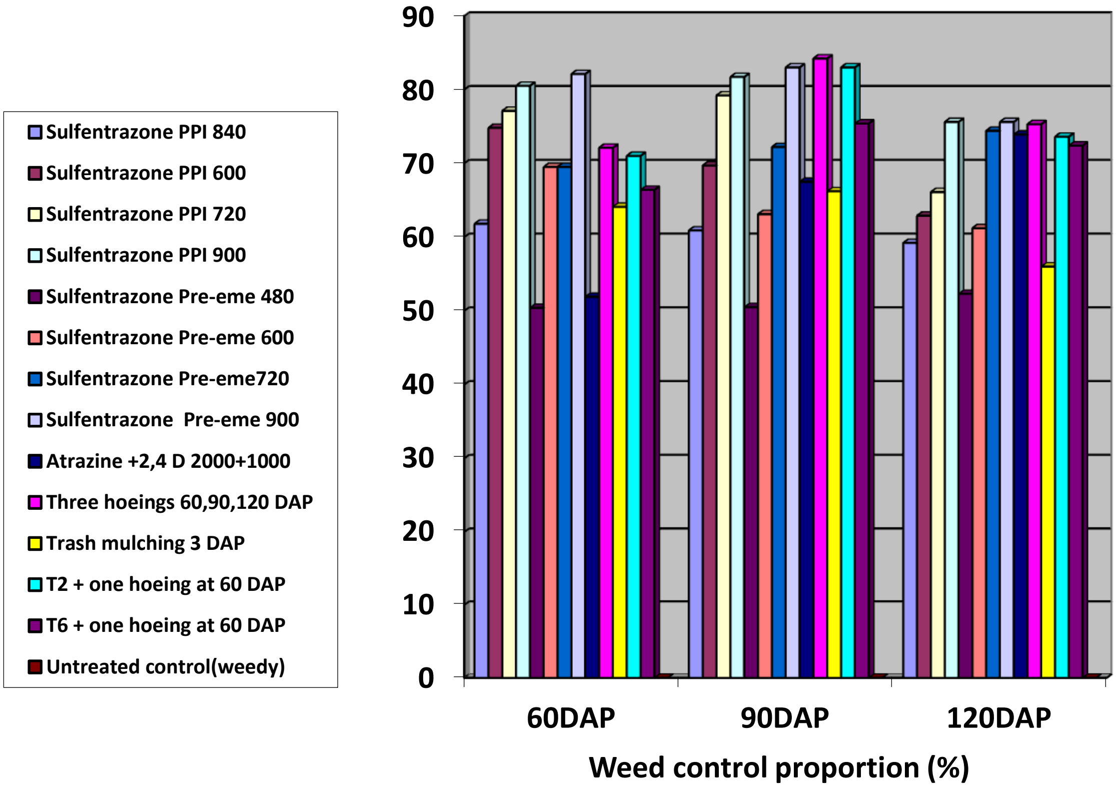


Figure 2. Effect of weed control methods on weed control extent (%) at different growth stages of sugarcane

Dry weight of weeds (g)

The research findings presented in table 8 indicates that all the weed control treatments were effective in significantly reducing the dry weight of weeds as compared to that in. The dry matter accumulation in weeds was the lowest (13.8, 14.9 and 53.7 g/m²) in three-hoeing treatment which brought about significant reduction in dry matter production by weeds (93.2, 94.2 and 75.5 %) as compared with the control treatment (Fig. 2) (203.9, 259.3 and 218.8 g/m²) at the 60, 90 and 120 DAP respectively.

Table 7 Effect of weed control methods on dry matter production of weeds (g/m²) at different growth stages of sugarcane

Treatment	Time of application	Dose (g ai/ha)	60DAP	90DAP	120DAP
Sulfentrazone	PPI	840	33.1	66.7	136.7
Sulfentrazone	PPI	600	24.6	61.1	132.5
Sulfentrazone	PPI	720	21.7	42.9	117.7
Sulfentrazone	PPI	900	15.7	34.7	116.4
Sulfentrazone	Pre-eme: 3 DAP	480	33.7	57.4	136.1
Sulfentrazone	Pre-eme: 3 DAP	600	31.4	50.2	121.9
Sulfentrazone	Pre-eme: 3 DAP	720	26.5	46.9	114.7
Sulfentrazone	Pre-eme: 3 DAP	900	24.7	35.3	114.2
Atrazine 50 WP+2,4 D 80%	Pre-em: 3DAP+60 DAP	2000+1000	37.8	37.5	67.2
Three-hoeing	60,90,120 DAP		13.8	14.9	53.7
Trash mulching	3 DAP		25.6	22.3	88.4
T2 + one hoeing at 60 DAP	-	-	30.9	27.7	68.7
T6 + one hoeing at 60 DAP	-	-	36.0	20.9	59.1
Untreated control(weedy)	-	-	203.9	259.3	218.8
L.S.D 0.05			46.18	20.92	20.89

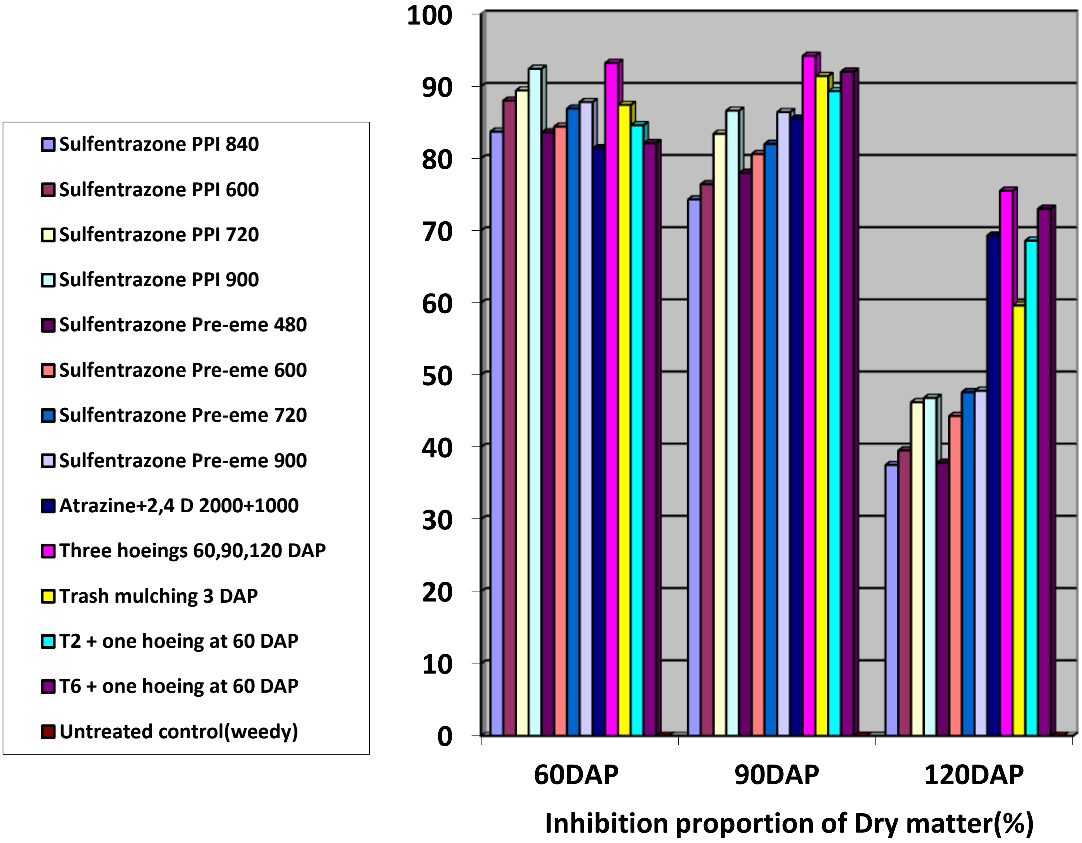


Figure 3 Effect of weed control methods on reduction of weed dry matter production (%) at different growth stages of sugarcane

Literature Cited

Annual Report. 2000. Indian Institute of Sugarcane Research. pp: 54-55.

Anonymous. 2001. Controlling Weeds in Sugarcane. Baton Rouge, LA. Louisiana State University AgCenter and Louisiana Cooperative Extension Service. Pub.2314 .pp. 2-4.

Anonymous. 1994. Louisiana's Suggested Chemical Weed Control Guide for 1994. Baton Rouge, LA. Louisiana State University Agricultural Center, Louisiana Cooperative Extension Service Pub. 1565. 154p.

Ahrens, W.H. 1994. Herbicide Handbook. 7th Edition. Champaign, II: Weed Science Society of America. p. 79-81.

Jonathan Siebert. 2003.Sugarcane seed response to 2,4-d and alternative herbicides for red morningglory (ipomoea coccinea l.) control .Thesis, Louisiana State University. p: 67.

Kanchan Nainwal. 2009. Weed Infestation in sugarcane. (C.F. ONLINE)

WWW.atsdr.cdc.gov

Kogevinas, M., Becher, H., Benn, T., Bertazzi, P. A., Boffetta, P., Bueno-De-Mesquita, HB., Coggon, D and Colin, D . 1997. "Cancer mortality in workers exposed to phenoxy herbicides, chlorophenols, and dioxins. An expanded and updated international cohort study". *American Journal of Epidemiology* 145 (12): 1061–75.

Kettles, MK; Browning, SR; Prince, TS; Horstman, SW .1997. "Triazine herbicide exposure and breast cancer incidence: An ecologic study of Kentucky counties". Environmental Health Perspectives 105 (11): 1222–7

Krausz, R. F., G. Kapusta, J. L. Matthews. 1998. Sulfentrazone for weed control in soybean (*Glycine max*). *Weed Technol*. 12:684-689.

Richard, Jr. 2000. At-planting herbicides for Bermuda grass (*Cynodon dactylon*) control in sugarcane (*Saccharum* spp. hybrids). Journal of American Society of Sugarcane Technologists. Volume 20:?

Richard, E. P., Jr. 1998. Control of perenniated Bermuda grass (*Cynodon dactylon*) and johnsongrass (*Sorghum halepense*) in sugarcane (*Saccharum* spp. hybrids). *Weed Technol*. 12:128-133.

Stringer, S. J., E. V. Gage, H. G. Hancock, and L. D. Hatfield. 1998. Weed control in sugarcane with clomazone. Proc. South. Weed Sci. Soc. 51:219.

Vidrine, P. R., J. L. Griffin, D. L. Jordan and D. B. Reynolds. 1996. Broad leaf weed control in soybean (*Glycine max*) with sulfentrazone. *Weed Technol*. 10: 762 - 765.

CHAPTER 3

EVALUATION OF PHYTOTOXICITY OF SULFANTRAZONE 48% F TO SUGARCANE

Introduction

Early experiments with sugarcane confirmed the need to control weeds and the efficiency of herbicide treatments for their control (Gosnell, 1965). Some herbicides have little effect on crop growth in comparison with the effects of competition from weeds (Gosnell and Thompson, 1964). However, herbicides may cause some damage to sugarcane. Herbicides that are effective in control of weeds were tested for possible phyto-toxic effects on sugarcane at the South African Sugar Association Experiment Station. Results have shown small effects on cane yield without necessarily reaching levels of statistical significance in individual experiments. The results of experiments conducted with standard treatments and other commonly used combinations of herbicides on variety NC0376 are summarized. Other factors such as the amount of chemical used per hectare and the method of spraying, and whether it was a plant or ratoon crop, were investigated at different sites for their effects on the development of the crop and reductions in yield. Relatively small differences were apparent in the average effects of these factors. However, the average reduction in yield from all post-emergence applications was 3% while no reduction in yield was apparent with pre-emergence applications (Turner *et al*., 1990).

The average reduction in yield, based on results of 123 post-emergence applications to cane, was 3%. Results of 24 pre-emergence applications gave an average yield which was 101 % of unsprayed plots. These results provide a useful guide to the effects of herbicide treatments on sugarcane crops, although they include some treatments applied over the cane rows at double rates and on cane at a late stage of growth. The summary of comparisons between methods of spraying, the amount of chemical used per hectare, plant and ratoon crops, and different experiment sites showed that these factors caused relatively small reductions in yield in comparison with the standard treatments. However, it appears that single rates applied away from the cane foliage are likely to cause less damage. The stage of growth of cane at the time of spraying is also likely to be an important factor in determining the extent of reductions in cane yield, but this factor needs to be studied further to eliminate the possible effects of the age of the crop at the time of harvest and the weather conditions at the time of spraying. From the available data there does not seem to be a relationship between the stage of cane growth when it is sprayed and the effect on yield (Turner *et al*., 1990). Sugarcane varieties can present different responses to the herbicides and have as results phytotoxicity problems that could cause reduction in the sugarcane yield. With the objective of studying the selectivity of herbicides on the sugarcane varieties RB 925345, RB 925211, RB 935744 and RB 855036, four experiments were carried out in the random block design, one for each variety. The treatments consisted of herbicides trifloxysulfuron-sodium + ametryn (351 + 99 g a.i/ha) + diuron + hexazinone (1097 + 27.77 g a.i/ha), trifloxysulfuron-sodium + ametryn (1463 + 37 g a.i/ha), diuron + hexazinone (1170 + 330 g a.i/ha), metribuzin (4000 g a.i/ha), imazapyr (122.5 g a.i/ha) and imazapyr (0.5 L a.i/ha). Visual evaluations of selectivity were taken at 15, 30, 45, 60, 90 days after application (DAA), heights of the plants at 30, 90, 180 DAA, tiller height and technological analysis of soluble solids (ºBrix), Pol (%) broth, Pol (%) cane, Fiber (%) and Purity (%) were made at 380 DAA. Initially all varieties presented intoxication symptoms due to herbicides. The inhibitors of ALS (imazapyr and imazapic) induced inhibition of growth, twisted leaves and purple coloration at 30 DAA. At 90 DAA the varieties did not present symptoms of phytotoxicity, being considered tolerant to the applied herbicides. Significant differences in tiller height, height of the plants, and technological quality were not observed due to treatments (Patricia Andrea , 2011).

Sulfentrazone is a phenyl triazolinone herbicide used for control of certain broad-leaf and grassy weeds. Sulfentrazone persists in soil and has residual activity beyond the season of application. A laboratory bioassay was developed for the detection of sulfentrazone in soil using root and shoot response of several crops. Shoot length inhibition of sugar beet was found to be the most sensitive and reproducible parameter for measurement of soil-incorporated sulfentrazone. The sugar beet bioassay was then used to examine the effect of soil properties on sulfentrazone phytotoxicity using 10 different Canadian prairie soils. Concentrations corresponding to 50% inhibition (I50 values) were obtained from the dose–response curves constructed for the soils. Sulfentrazone phytotoxicity was strongly correlated to the percentage organic carbon (P=0.01) and also to percentage clay content (P = 0.05), whereas correlation with soil pH was non-significant (P = 0.21). Because sulfentrazone phytotoxicity was found to be soil dependent, the efficacy of sulfentrazone for weed control and sulfentrazone potential carryover injury will vary with soil type in the Canadian prairies (Anna *et al.*, 2009).

Sulfentrazone adsorption and mobility in six soils with varying soil properties were evaluated under laboratory conditions. Adsorption was evaluated using a modified slurry technique. Mobility was evaluated using packed-soil columns under saturated flow conditions. The order of adsorption to soil was Sequatchie loam > Dothan loamy sand=Bosket fine sandy loam > Malden loamy sand > Commerce silty clay loam > Harkey clay loam. Greater sulfentrazone adsorption occurred in soils with lower pH. Sulfentrazone movement under saturated flow conditions in 27-cm soil-packed columns was greater in soils with low adsorption, high pH, and coarse texture. Sulfentrazone movement was limited in the Sequatchie loam but was greater in the other soils examined. No clear relationship was evident between sulfentrazone mobility and adsorption in these soils (Ohmes and Mueller, 2007).

In view of soil dependant behavior of sulfentrazone its effect including phyto-toxicity on sugarcane crop was studied at higher concentration with objectives of assessing phyto-toxicity symptoms, trend of mortality and loss in yield, if any.

Materials and Methods

Study was conducted during 2012-13 to evaluate phytotoxicity of sulfentrazone to sugarcane plants at normal or higher than recommended rate of applications. Package of practices for raising sugarcane crop was similar as in first experiment. In this field experiment two levels of sulfentrazone with varying time of application was evaluated against control for phyto-toxic effects on sugarcane (cv CoSe 92423). The experiment was laid in Randomized Complete Block Design (RCBD) with four replications. The following table indicates about the treatments used (Table 9). The soil of the experimental site was sandy loam with pH 7.83, organic carbon 0.40%, and available N, P_2O_5, K_2O were 222.65, 16.86 and 186.12 kg/ha, respectively. The gross plot size was 51 m^2 and the distance between the experimental unit and others was 0.5 m while distance between replicate was 1.5 m. Each experimental unit contains six row-length of 8 m and the distance between lines was 0.75 m. 150 kg N / ha was added to experimental land by application of urea (46% N), in three parts. First part before planting , second part at 60 days after planting and third part at 90 DAP . Dap fertilizer (18-46-0) at the rate of 60 kg/ha was applied once after planting. So, KCL at the rate of 60 Kg/ha was applied once after planting. Bavistin (systemic fungicide) at the rate of 200 Kg/ha and Hilban (chloribyriphos) (Insecticide) at the rate of 5 L/ha were used and 37000 – 40000 sets/ha .

Table 8 Different treatments used in the experiment

Treatment	Time of application	Dose (g a.i/ha)	Dose g/ml/ha	Dose g/ml/acre
Sulfentrazone	PPI	720	1500	600
Sulfentrazone	PPI	1440	3000	1200
Sulfentrazone	Pre-em: 3 DAP	720	1500	600
Sulfentrazone	Pre-em: 3 DAP	1440	3000	1200
Untreated control(weedy)	-	-	-	-

Germination percentage:

Calculated number of plants that appeared above soil surface 45 DAP.

Weed Species:

Been diagnosed type of weeds in land of the experiment.

Weed density (number/m²):

A quadrant sized 1.0 m X 1.0 m was thrown randomly in each experimental unit three times at 60, 90 and 120 days after planting and green weed plants those were not affected by herbicides were counted and averaged .

Percentage of weed control(%) :

Was calculated from the following equation:

$$\text{Percentage of weed control} = \frac{\text{Control treatment- Weed control treatment}}{\text{Control treatment}} \times 100$$

Dry weight of weeds (g)

Green weed plants were cut at the soil surface from the same site in the experimental unit three times the quadrant (1.0 m²) was used for counting of weeds for calculating weed density. The weeds samples were air dried under laboratory conditions.

Inhibition proportion of dry matter (%)

Was calculated from the following equation:

$$\text{Inhibition proportion of dry matter} = \frac{\text{Control treatment – Dry matter treatment}}{\text{Control treatment}} \times 100$$

Phytotoxicity:

Calculated of numbers of plants affected by herbicide at 70 DAP.

Number of Tillers:

Millable cane, Non-millable cane and Total counted at 60,90,120,150,180, 210 and 300 DAP .

Number of Internode:

Number of internode calculated at 180 and 300 DAP.

Number of green Leaves:

Number of green leaves calculated at 90 DAP.

Cane yield (t/ha)

The canes were collected from middle lines of each experimental unit and after topping cane were weighed to obtain cane yield.

Five samples were selected from each experimental unit to measure juice quality parameters. Following tests were conducted on selected samples:

Percentage of total soluble solids:

It was recorded with the help of Hand-refractometer by putting a drop of fresh sugarcane juice on the reading glass. This indicates presence of total soluble solids in the juice assumed to indicate sucrose concentration.

Percentage of sucrose in juice:

It was indirectly measured with the help of polarimeter/ suchrometer based on dextro rotatory properties of sugar. The sucrose concentration is expressed as sucrose (%) in juice.

Purity:

Relative concentration of sucrose, compared with other solids, dissolved in juice was calculated using following equation

$$\text{Purity (\%)} = \frac{\text{Sucrose (\%)}}{\text{Brix (\%)}} \times 100$$

Sugar yield:

Was calculated using following equation:

Sugar Yield (tonnes/ha) = Cane Yield (tonnes/ha) x Percentage of Sucrose

Analysis of data was made using statistical tools of Randomized Complete Block Design. LSD was used to compare treatments at significant level of 0.05 (Steel and Torrie, 1960).

Results and Discussion

Germination percentage

Data depicted below (Fig. 5) indicate significant effect of sulfentrazone on average germination in sugarcane. Sulfentrazone PPI 1440 g ai/ha registered the highest increase of germination (56.9 %) that didn't differ significantly from other treatments . However, all the sulfentrazone treatments helped to produce significantly higher germination percentage of sugarcane compared to the control (38.6 %).

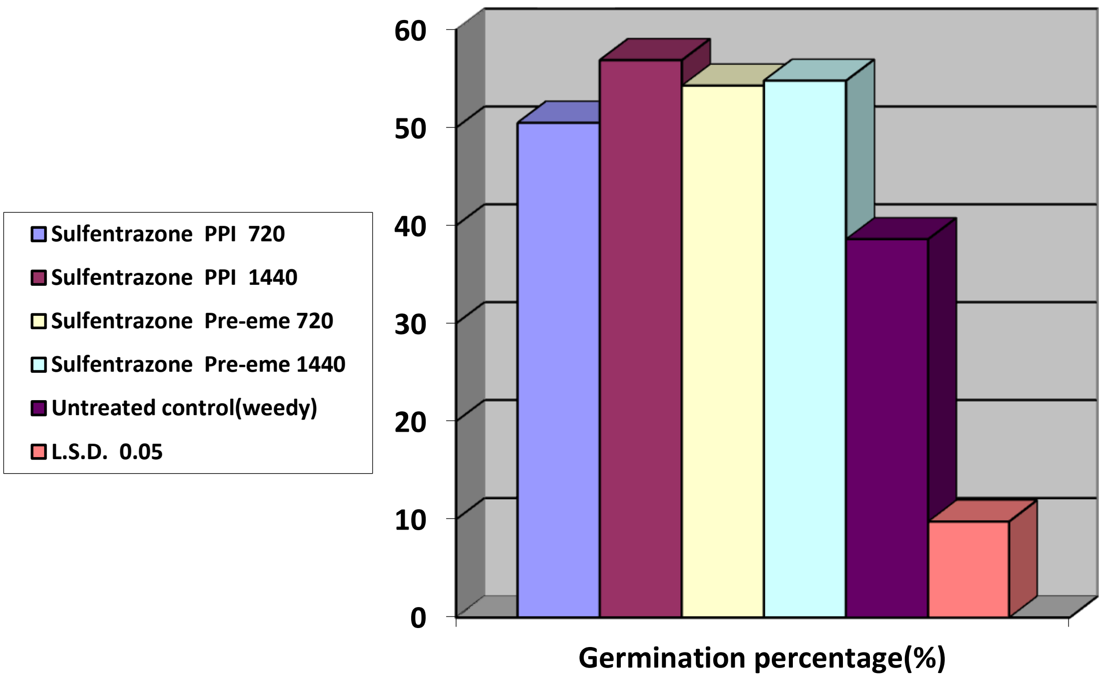


Figure 4 Effect of sulfentrazone on germination (%) of sugarcane

Weed density (g/m²) and weed control proportion (%)

The weed species present in the second field of sugarcane were: *Amaranthus sp., Chenopodium album, Portulaca oleracea, Digera arvensis, Trianthema monogyna, Cyperus rotundus, Sorghum halepense, Cynodon dactylon, Convolvulus arvensis* (Table 10). At 60 DAP among these the prominent weed species were the sedges occupying 72.1 per cent share in total weed population . Whereas, the broad leaved weeds viz *Amaranthus hybridus* and grasses like *Cynodon dactylon* were in a very few numbers that constitutes 12.1 and 15.8 per cent of the total weed population respectively (Table 11). At 90 DAP, prominent weed species were the sedges that occupied 55.8 per cent share in total weed population .Whereas, the broad leaved weeds viz *Amaranthus hybridus* and grasses like *Cynodon dactylon* were in a very few numbers that constituted 19.8 and 24.4 per cent of the total weed population respectively (Table 12).

At 120 DAP sedges, broad leaved weeds and grasses occupied 44.4, 22.4 and 33.2 per cent share in total weed population respectively (Table 13). Use of weed control methods controlled the weeds. The weed density was the least under its treatments at all the growth stages of the crop till harvest compared with the control treatment.

Weed growth in the plots treated with sulfentrazone (PPI; 1440 g ai/ha) led to a high decrease in weed density (12.8, 19.8 and 30.5 plant/m²), achieved highest increase in proportion of weed control (76.3, 69.0 and 74.2 %) (Figure 6) as compared to the control treatment (53.8, 63.8 and 118.0/m²) at the 60, 90 and 120 DAP respectively).

Table 9 Weed species spreading in second experimental field

Scientific name	Common name	Family	Life cycle	Weed type
Amaranthus hybridus	Pigweed, smooth	Amaranthaceae	Annual	Broadleaf
Chenopodium album	Lambsquarters	Chenopodiaceae	Annual	Broadleaf
Portulaca oleracea		Portulacaceae	Annual	Broadleaf
Digera arvensis	False Amaranth	Amaranthaceae	Annual	Broadleaf
Trianthema monogyna	Carpetweed	Gland pigweed	Annual	Broadleaf
Cyperus rotundus	Nutsedge, purple	Cyperaceae	Perennial	Sedge
Sorghum halepense	Johnsongrass	Poaceae(Graminae)	Perennial	Grass
Cynodon dactylon	Bermudagrass	Poaceae	Perennial	Grass
Convolvulus arvensis	Bindweed	Convolvulaceae	Perennial	Broadleaf

Table 10 Effect of sulfentrazone herbicide on density of Weed (No./m²) of sugarcane (60 DAP)

Treatments	Grasses	Broadleaf	Sedge	Total
Sulfentrazone	10	1	72	83
Sulfentrazone	2	0	49	51
Sulfentrazone	6	1	85	92
Sulfentrazone	1	1	63	65
Untreated control (weedy)	61	58	96	215
Total	80	61	365	506

Table 11 Effect of sulfentrazone herbicide on density of Weed (No./m²) of sugarcane (90 DAP)

Treatments	Grasses	Broadleaf	Sedges	Total
Sulfentrazone	27	14	88	129
Sulfentrazone	13	9	57	79
Sulfentrazone	26	19	93	138
Sulfentrazone	12	10	58	80
Untreated control (weedy)	88	83	84	255
Total	166	135	380	681

Table 12 Effect of sulfentrazone herbicide on density of Weed (No./m²) of sugarcane (120 DAP)

Treatment	Grasses	Broadleaf	Sedges	Total
Sulfentrazone	59	29	115	203
Sulfentrazone	29	21	72	122
Sulfentrazone	62	34	100	196
Sulfentrazone	34	25	84	143
Untreated control (weedy)	194	145	133	472
Total	378	254	504	1136

Table 13 Effect of sulfentrazone herbicide on weed density (No./m²) at different growth stages of sugarcane

Treatment	Time of applicat ion	Dose (g a.i/ha)	60D AP	90D AP	120D AP
Sulfentrazone	PPI	720	20.8	32.3	50.8
Sulfentrazone	PPI	1440	12.8	19.8	30.5
Sulfentrazone	Pre-eme	720	23.0	34.5	49.0
Sulfentrazone	Pre-eme	1440	16.3	20	35.8
Untreated control(weedy)	-	-	53.8	63.8	118.0
L.S.D. 0.05					

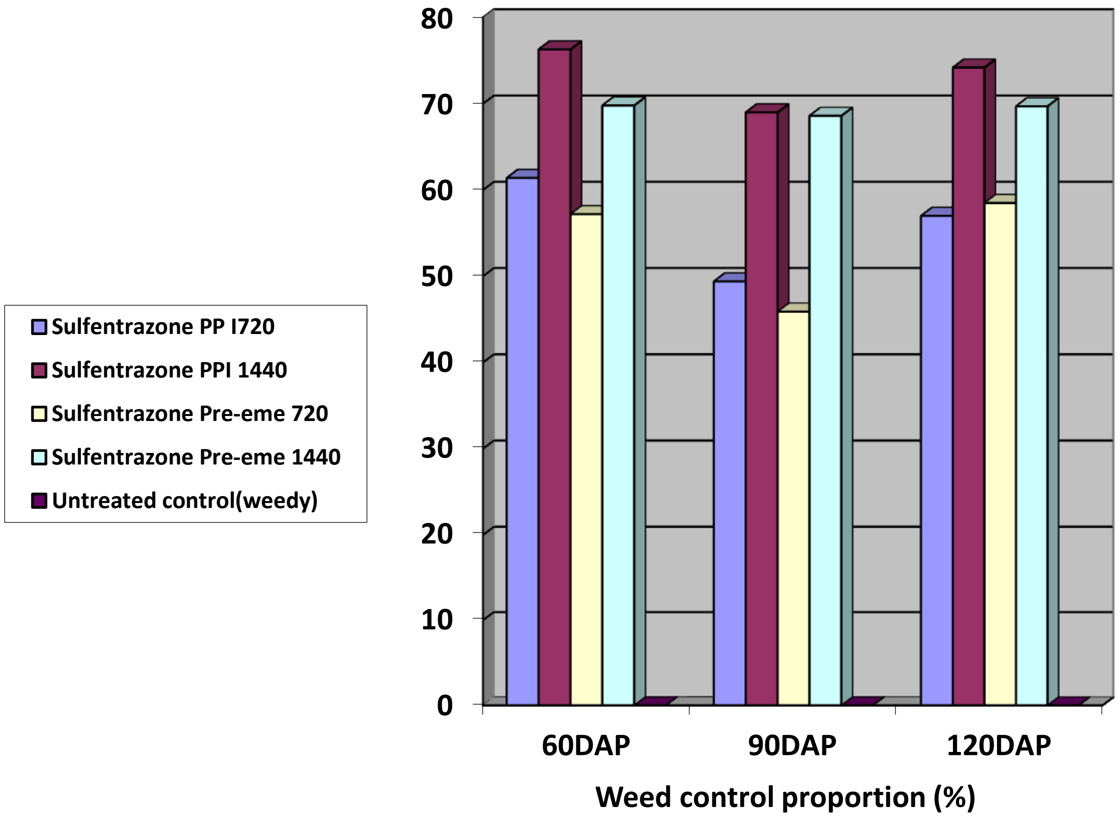


Figure 5 Effect of sulfentrazone herbicide on Proportion of weed control (%) density during the different growth stages of sugarcane

Dry matter of weeds (g/m²) and inhibition proportion of dry weight (%)

The research finding presented in table 15 indicates that weed control methods significantly affected dry weight of weeds. All the treatments were found effective in significantly reducing the dry weight of weeds compared to the control treatment. The dry matter accumulation in weeds was the lowest (7.2, 10.6 and 22.8 g/m²) in sulfentrazone PPI 1440 a.i./ha treatment achieved highest inhibition proportion of dry matter (90.2, 88.9 and 83.5 %) (Figure 7) compared with the control treatment (72.6, 95.9 and 138.0 g/m²) at the 60, 90 and 120 DAP respectively.

Table 14 Effect of sulfentrazone on dry matter weight (g/m²) of weeds at different growth stages of sugarcane

Treatments	Time of application	Dose (g a.i/ha)	60DAP	90DAP	120DAP
Sulfentrazone	PPI	720	9.9	15.2	29.9
Sulfentrazone	PPI	1440	7.2	10.6	22.8
Sulfentrazone	Pre-eme	720	12.4	18.9	36.3
Sulfentrazone	Pre-eme	1440	8.8	14.1	25.1
Untreated control(weedy)	-	-	72.6	95.5	138.0
L.S.D. 0.05			7.59	6.70	21.68

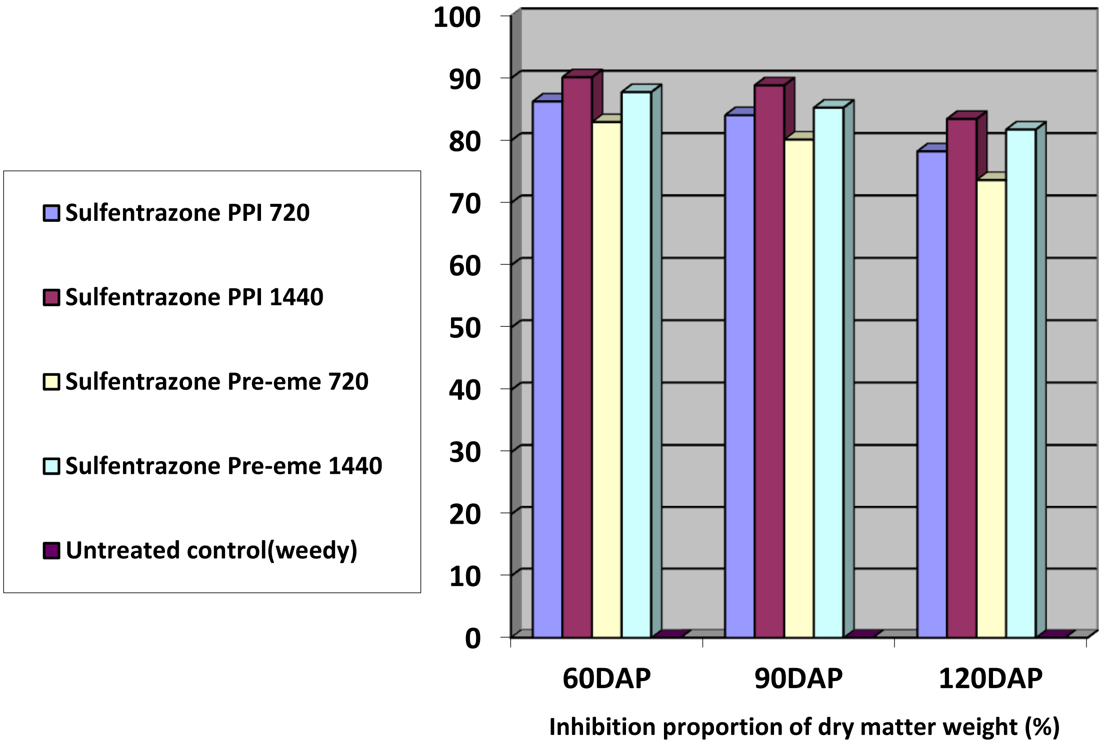


Figure 6 Effect of sulfentrazone on inhibition of dry matter (%) of weeds during the different growth stages of sugarcane

Phytotoxicity

Phytotoxicity Table (16) was not significantly affected by use of sulfentrazone herbicide.

Table 15 Phytotoxicity of sulfentrazone herbicide in sugarcane (shoots/ha) 70 DAP

Treatments	Time of application	Dose (g a.i/ha)	Phytotoxicity (shoots/ha)
Sulfentrazone	PPI	720	4062.435
Sulfentrazone	PPI	1440	7291.550
Sulfentrazone	Pre-eme	720	2187.465
Sulfentrazone	Pre-eme	1440	3749.940
Untreated control (weedy)	-	-	0000.000
L.S.D. 0.05			NS

Number of tillers

The table 16 indicates a significant increase in average number of canes by using sulfentrazone PPI 1440 g a.i./ha led to even the highest increase in this attribute amounted to 262000, 181700, 186500, 188500 and 169900 cane/ha .sulfentrazone Pre-eme 1440 g a.i./ha application also significantly enhanced average number of canes (258300 ,199800 , 199200 ,188900 and 171100 cane/ha) over control (73400, 153100, 94300, 1148000 and 138300 cane /ha at the 90,120,150,210 and 300 DAP respectively

Also, The figure 7 indicates a significant increase in average number of millable canes and decrease in average number of non-millable cane by using sulfentrazone PPI 1440 g a.i./ha and sulfentrazone Pre-eme 1440 g a.i./ha led to even the highest increase in millable canes amounted to 169.2 and 169.2 cane/ha and the highest decrease in non-millable canes amounted to 19.2 and 19.6 cane/ha at the 210 DAP (figure 8) . in the same direction, the highest increase in millable canes amounted to 131.9 and 132.8 cane/ha and the highest decrease in non-millable canes amounted to 38.0 and 38.3 cane/ha at the 300DAP (figure 9).

Table 16 Effect of sulfentrazone herbicide on number of tillers (000/ha) during the different growth stages of sugarcane .

Treat. No.	Time of application	Dose (g a.i/ha)	90 DAP	120 DAP	150 DAP	210 DAP	300 DAP
Sulfentrazone	PPI	720	202.7	176.0	148.9	150.7	153.0
Sulfentrazone	PPI	1440	262.0	181.7	186.5	188.5	169.9
Sulfentrazone	Pre-eme	720	232.6	158.1	160.4	174.8	164.6
Sulfentrazone	Pre-eme	1440	258.3	199.8	199.2	188.9	171.1
Untreated control(weedy)	-	-	073.4	153.1	094.3	114.8	138.3
L.S.D 0.05			60.94	NS		32.83	20.35

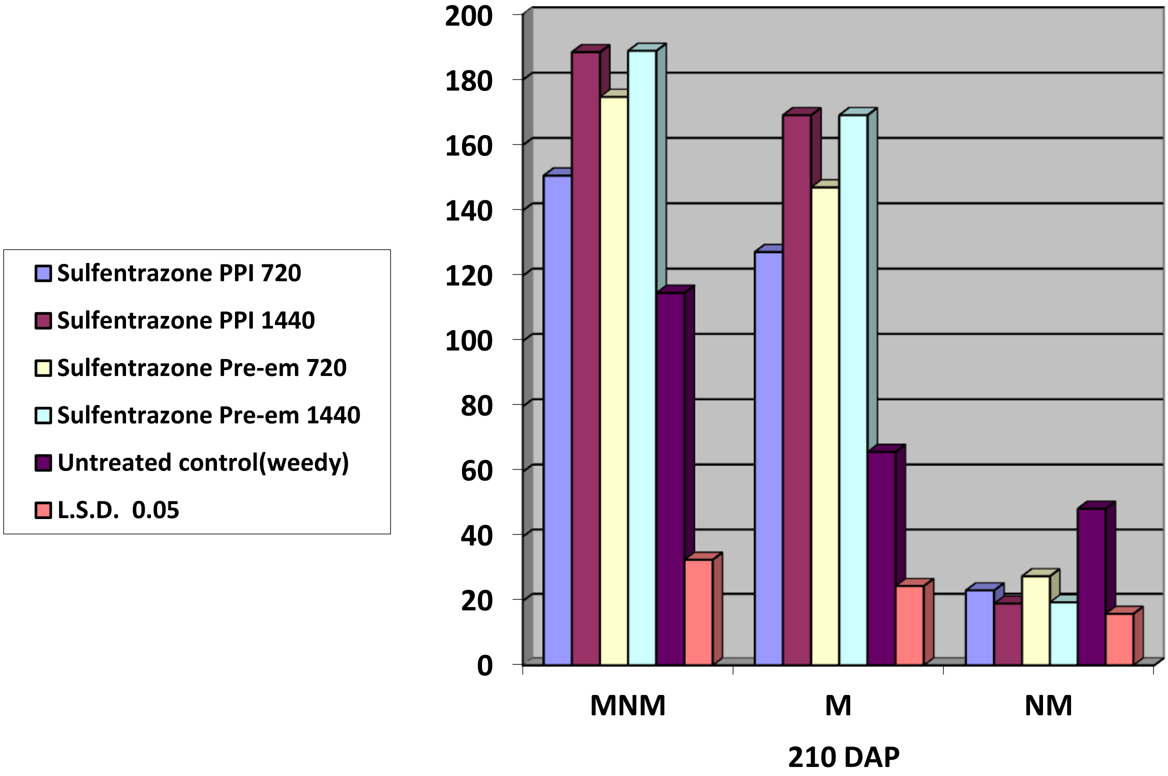


Figure 7 Effect of sulfentrazone herbicide on number of Millable canes (M), Non –millable canes (NM) and total (MNM) (000/ha) of sugarcane at 210 DAP.

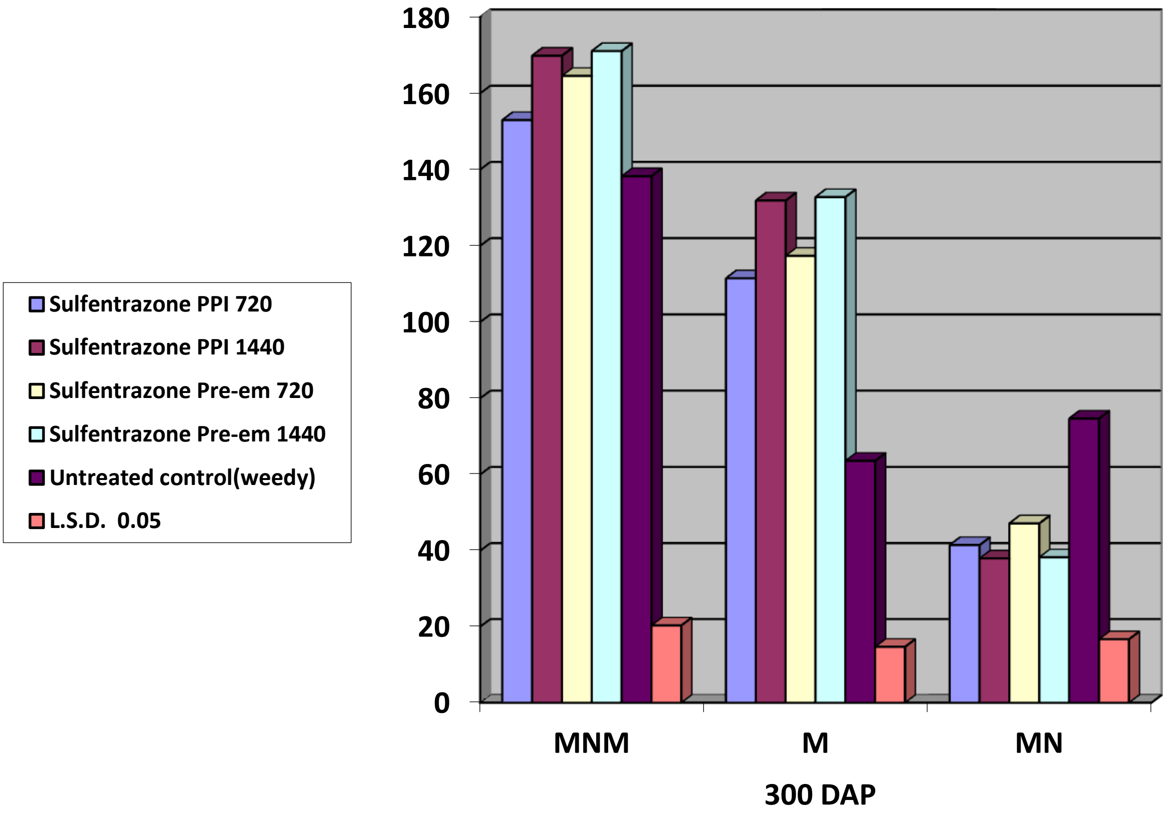


Figure 8 Effect of sulfentrazone herbicide on number of millable canes (M), Non-millable cans (NM) and total (MNM) (000/ha) of sugarcane at 300 DAP.

Cane length (cm)

Sulfentrazone treatments in sugarcane to control weeds registered significant effect on cane length (figure 10). Application of sulfentrazone PPI 1440 g a.i./ha led to increase in cane length to the highest level to 270 cm.

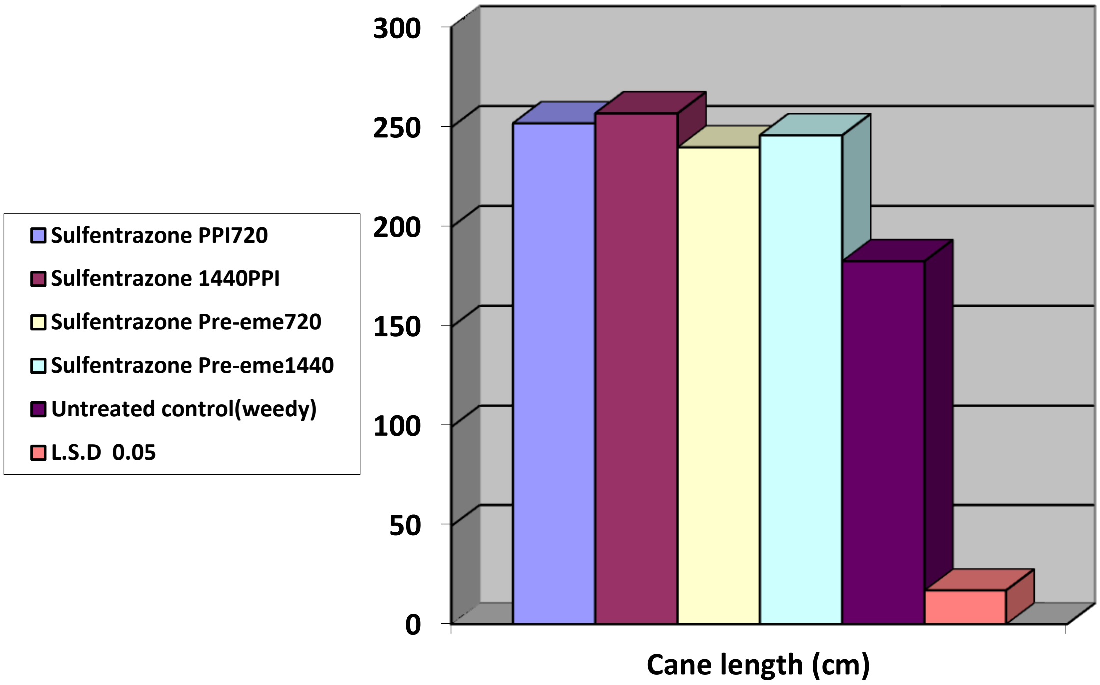


Figure 9 Effect of sulfentrazone herbicide on cane length (cm) Of sugarcane at 330 DAP.

Cane girth (cm)

Also, Sulfentrazone treatments in sugarcane to control weeds registered significant effect on cane girth (Table 11). Application of sulfentrazone PPI 1440 g a.i./ha led to increase in cane girth to the highest level to 2.85 cm.

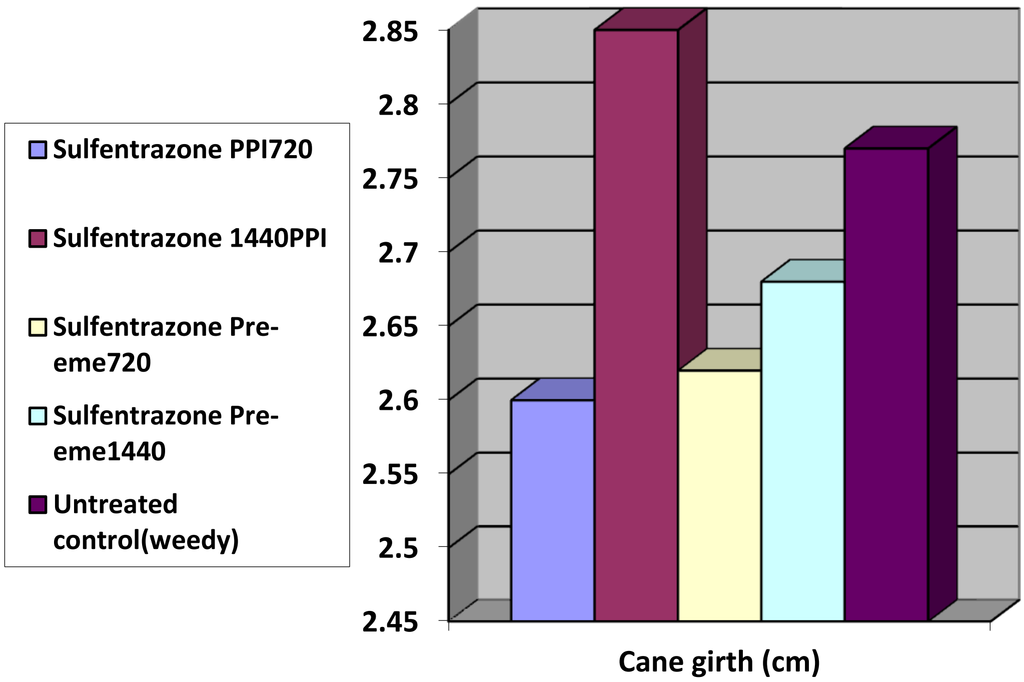


Figure 10 Effect of sulfentrazone herbicide on cane girth (cm) Of Sugarcane at 330 DAP

The increase in cane length , cane girth , number of tillers and number of millable canes and decrease in non-millable canes as a result of use of sulfentrazone PPI 1440 g a.i. /ha may be due to the role of this treatment in decrease weed density (Table 14) and dry matter for green weeds (Table 15) and increase weed control proportion (Figure 6) and inhibition proportion of dry matter weight (Figure 7).Causing weakness or absence of competition between the crop and the weeds on the necessary growth requirements such as water, food, light and space. Low of competition on the place may cause an increase in the number of tillers during the different growth stages of sugarcane (Table 17) and that the low of competition on the water and food may cause an increase in plant height and number of millable cane (Figures 8 and 9) while low of competition on the light may cause increased cane girth (Figure 11) .
This means that low or absence of competition between the crop and the weeds because of use of sulfentrazone PPI 1440 g a.i. /ha has led to the events of these morphological changes of the crop.

Cane yield (t/ha)

The data presented in table 17 reveals that use of sulfentrazone treatments to control weeds in sugarcane significantly enhanced the cane yield. The use of sulfentrazone PPI 1440 g a.i./ha registered the highest cane yield (84.1 t/ha) that was significantly higher to the tune of 44.94 % over control.

That the reason increase cane yield by using sulfentrazone PPI 1440 g a.i. /ha and sulfentrazone Pre-eme 1440 g a.i./ha may be due to role of the herbicide in increasing the number of millable cane since the early stages of crop growth until harvest.

Brix (%)

Use of various weed control methods in sugarcane to control weeds registered no significant effect on Percentage of total soluble solids (Table 17).

Sucrose (%)

Sucrose Table 17 was not significantly affected by use of various weed control methods .

Purity (%)

Also, the table 17 indicates no significant effect of weed control methods on average of purity of sugarcane .

Sugar yield (t/ha)

Addition of sulfentrazone treatments significantly affected sugar yield (table 17). Sulfentrazone PPI 1440 g a.i./ha and sulfentrazone Pre-eme 1440 g a.i./ha caused highest increase in this character to 13.850 and 13.500 t/ha respectively .

That reason increase sugar cane by using sulfentrazone PPI 1440 g a.i. /ha may be due to its role in increasing proportion of attendant weed control of sugarcane crop and increase percentage of inhibition of dry matter weight of as well as the role of this herbicide in increasing number of millable canes with no significant differences in percentage of sucrose. All these factors were reflected positively in increasing sugar yield.

Table 17 Effect of sulfentrazone herbicide on cane yield and quality characters of sugarcane at 330 days after planting.

Treatments	Time of application	Dose (g a.i/ha)	Cane yield (t/ha)	Sucrose (%)	Purity (%)	Sugar yield (t/ha)
Sulfentrazone	PPI	720	74.3	16.56	87.96	12.325
Sulfentrazone	PPI	1440	84.1	16.48	88.39	13.850
Sulfentrazone	Pre-eme	720	69.1	16.26	88.08	11.225
Sulfentrazone	Pre-eme	1440	80.8	16.73	88.59	13.500
Untreated control(weedy)	-	-	39.2	16.10	88.74	6.300
L.S.D 0.05			5.00	NS	NS	1.03

Literature cited

Anna M.Szmigieiski,Jeff J. Schoenau, Eric N.Johnson, Frederick A. Holm,Ken L.Sapsford,and Juxin Liu. 2009. Developement of a laboratory bioassay and effect of soil properties on sulfentrazone phytotoxicity in soil.Weed Technology.23,486-491.

Gosnell, JM (1965). Herbicide trials in Natal sugarcane, 1964 -65. Proc S AfrSug Techno! Ass39: 171-18I.

Gosnell, JM and Thompson,GO (1964). The results of herbicide Trials 1963-64. Proc S AfrSug Techno! Ass 38: 166-174.

Ohmes, G. A. and T. C. Mueller. 2007. Sulfentrazone adsorption and mobility in surface soil of the southern United States. Weed Technol 21:796–800.

Turner, P. E. T., N. B. Leibbrandt and L. H. G. Wiehe. 1990 .The phytotoxic effects of herbicides on sugarcane in south Africa. Proceedings of The South African Sugar Technologists' Association .

Patricia Andrea. 2011. Selectivity of herbicides in varieties of sugarcane. Bragantia., 70(2): 286-293[C.F. ONLINE]

CHAPTER 4

EFFECT OF SULFENTRAZONE ON GROWTH CHARACTERS, SUGAR YIELD AND QUALITY OF SUGARCANE

Introduction

Unlike other grass crops the reproductive structures in sugarcane are of no economic importance when the crop is grown for sugar production and injury from 2,4-D would not be expected. Van Overbeek (1947) stated that it would require special conditions, which rarely exist in practical agriculture, to kill or even seriously damage a sugarcane plant with 2,4-D. Sugarcane is least sensitive to 2,4-D and that even young plants appear to be insensitive to 2,4-D at concentrations necessary to kill weeds. Nolla (1950) supported this contention by stating that sugarcane plants under two months of age could be sprayed “indiscriminately” with 2,4-D without injury. This protection from 2,4-D action in young sugarcane was attributed to the closely united leaf sheaths that act as a barrier against entrance of the herbicide solution into the regions of meristematic tissue. Although not yield limiting, bronzing and reddening of midribs, and bleaching or yellowing of the leaf blades were observed.

Brown and Holdeman (1947) also observed similar sugarcane injury response to 2,4-D. Havis (1953) reported that the 2,4-D amine formulation sprayed at rates of up to 1.1kg ai/ha did not affect the growth of one-month-old sugarcane plants and rates of up to 4.5 kg/ha were safe for plants two months old. Richardson (1969) also documented early injury with 2,4-D applied post-emergence on several varieties of sugarcane but growth measurements indicated that at normal rates of application yield was unlikely to be affected. Later research showed a relationship between growth stage and 2,4-D injury (Richardson, 1973). The more advanced the growth stage of the crop at the time of application the greater the height reduction and foliar damage observed. When 2,4-D was applied at the same growth stage, crop injury was slightly greater in the plant cane crop than in ratoon crop, no residual effects from previous 2,4-D applications were apparent in the subsequent ratoon crops. Rochecouste (1967) reported that plant cane can be very sensitive to 2,4-D injury during root initiation, which was attributed to enhanced 2,4-D uptake associated with the thinness of the cutin layer of the young leaves. The 2,4-D rates in research contributed by Richardson (1973) and Rochecouste (1967) were in excess of 3.4 kg/ha, much higher than present use rates in Louisiana sugarcane of 0.35 to 1.59 kg/ha.

Field experiments carried out to study the bio-efficacy of sulfentrazone for weed control in sugarcane in general and control of *Cyperus rotundus* in particular revealed that pre-emergence tank-mix application of sulfentrazone 0.5 kg + atrazine 2.0 kg/ha or sulfentrazone 1.0 kg+atrazine 2.0 kg/ha brought about highest magnitude of weed control upto 120 days after planting (DAP), and was statistically at par with manual hoeings. These treatments resulted into the significantly highest number of millable canes (105.5 and 117.7 '000/ha) and cane yield (80.7 and 86.2 t/ha). It was significant to note that performance of these treatments was superior to that of three hoeings. Application of sulfentrazone and atrazine as a tank mix provided excellent control of *C. rotundus* and the plot remained free of *C. rotundus* up to 120 DAP. There was no conspicuous effect of various treatments on juice quality in both the experiments (Srivastava, 2003).

A field study was carried out during 2010-2011 at Indian Institute of Sugarcane Research Farm, under subtropical Indian conditions in a loamy soil having pH value of 7.1 .The experiment comprised of 10 treatments including untreated control. Seven dozes of sulfentrazone (720,480,960,1080,1200,1320,and 2400g a.i/ha)along with atrazine 50WP @ 1250 g a.i./ha pre-emergence at 3 days after planting and 2,4-D Na salt 80 WP 1200 g a.i./ha as post emergence at 45 DAP were applied. Millable cane population significantly increased with sulfentrazone (109600-119600) and atrazine (108000/ha) over 2,4-D (903000/ha) and untreated control (75000/ha) .In general ,uncontrolled growth of weeds adversely affected the sugarcane growth and thus a reduction of 33% in cane yield was recorded (60.0 t/ha) over the yields obtained with varying doses of sulfentrazone (77.7-82.0 t/ha).Among the different doses of sulfentrazone, no significant differences in yield were noticed . Therefore, it is indicated that for effective and economic control of weeds in sugarcane, lower doses of sulfentrazone (720/840 g a.i./ha) may be preferred over higher doses. Quality of cane juice (pol %) could not be influenced by any of the treatments (Singh *et al*., 2012).

Materials and Methods

Study was conducted in March, 17, 2012 to know the effect of weed control methods on growth characters, Cane yield and Quality at fields of Indian Institute of Sugarcane Research (IISR) in India. Application of weed control methods was made at tiller stage of sugarcane crop (Variety CoSe 92423). Randomized Complete Block Design (RCBD) was applied with three replications. The treatments used in the experiment are shown in Table 1. The soil of the experimental site was clay loam with PH 7.83 , organic carbon 0.40%, and available N, P2O5, K2O were 222.65 , 16.86 and 186.12 kg/ha respectively. The experimental unit area $36m^2$ and the distance between the experimental unit and others was 0.5 m while distance between replicate was 1.5 m. Each experimental unit contains six lines length of 8 m and the distance between lines was 0.75 m. 150 kg N / ha was added to experimental land by application of urea (46% N), in Three parts . First part before planting , second part at 60 days after planting and third part at 90 DAP. Dap fertilizer (18-46-0) at the rate of 60 kg/ha was applied once after planting. So, KCL at the rate of 60 Kg/ha was applied once after planting. Bavistin (systemic fungicide) at the rate of 200 Kg/ha and Hilban (chloribyriphos) (Insecticide) at the rate of 5 L/ha were used and 37000 – 40000 sets/ha .

Plant traits were measured following :

Cane height (cm)

0.75 square meter in the middle line of each experimental unit were used to record the cane height at 60, 150,180 day after planting and at date of harvesting .

Number of tillers and canes

Number of tillers(60, 90,120,150,180 DAP), millable canes and non- millable canes (210, 240 DAP) were sorted and counted from four line in midlle of the each plot at .

Cane diameter (mm)

Cane diameter was measured at five centimeters above the soil surface by using Vernier caliper (diameter device) at the harvesting from the same plants that have been selected to measure the cane height.

Number of green leaves

Number of green leaves was calculated for the same canes that have been selected to measure cane height and cane diameter at 60,150,180 DAP .

Cane yield (ton ha-1)

The canes were collected from middle lines of each experimental unit and after topping cane were weighed to obtain cane yield.

Five samples were selected from each experimental unit to measure juice quality parameters. Following tests were conducted on selected samples:

Percentage of total soluble solids:

They total dissolved solids in the 100 liter from the juice. Is extracted by a refractometer.

Percentage of sucrose in juice:

Is the weight of sucrose in the 100 liter from the juice measured by secchurameter device

Purity:

Relative concentration of sucrose, compared with other solids, dissolved in juice was calculated using following equation

$$\text{Purity (\%)} = \frac{\text{Sucrose (\%)}}{\text{Brix (\%)}} \times 100$$

Sugar yield:

Was calculated using following equation:

Sugar Yield (tonnes/ha) = Cane Yield (tonnes/ha) x Percentage of Sucrose

Analyzed of data was made using statistical tools of Randomized Complete Block Design.. LSD was used to compare treatments at significant level of 0.05 (Steel and Torrie, 1960)

Results and Discussion

Cane height (cm)

Methods of weed control application in sugarcane to control weeds registered significant effect on cane height during the different growth stages (Table 18).

There were significant differences in cane height of sugarcane at 150 and 330 DAP due to weed control methods. Use of hoeing method led to a decrease in cane height (218.0 and 250.0 cm) as compared to control treatment (85.7 and 196.0 cm) as well, (sulfentrazone PPI; 600 g a.i./ha + hoeing treatment (209.2 and 247.0 cm) respectively.

Cane girth (cm)

Use of weed control methods, sulfentrazone PPI 720 g a.i./ha caused a highest significant increase to 2.93 cm (figure 13) , while use of (sulfentrazone PPI; 600 g a.i./ha + one hoeing) caused a highest significant decrease to 2.40 cm compared to the control treatment (2.83cm).

Table 18 Effect of weed control methods on cane height (cm) during the different growth stages of sugarcane

Treatments	Time of application	Dose (g a.i./ha)	60DAP	150DAP	180DAP	330 DAP cane length
Sulfentrazone	PPI	840	11.98	138.9	122.7	218
Sulfentrazone	PPI	600	11.65	129.5	164.3	232
Sulfentrazone	PPI	720	13.18	131.2	154.5	236
Sulfentrazone	PPI	900	11.31	137.5	183.7	240
Sulfentrazone	Pre-eme: 3 DAP	480	08.68	150.7	147.6	216
Sulfentrazone	Pre-eme: 3 DAP	600	12.07	142.2	156.2	227
Sulfentrazone	Pre-eme: 3 DAP	720	12.08	124.6	141.8	230
Sulfentrazone	Pre-eme: 3 DAP	900	14.30	152.2	178.9	236
Atrazine 50 WP+2,4 D 80% WP	Pre-em: 3DAP+60 DAP	2000+1000	11.89	143.6	170.1	237
Three hoeings	60,90,120 DAP		10.37	139.2	218.0	250
Trash mulching	3 DAP		14.47	129.3	146.2	226
T2 + one hoeing at 60 DAP	-	-	12.06	139.3	209.2	247
T6 + one hoeing at 60 DAP	-	-	12.05	157.1	197.0	244
Untreated control(weedy)	-	-	14.31	96.9	085.7	196
L.S.D 0.05			NS	NS	59.58	20.75

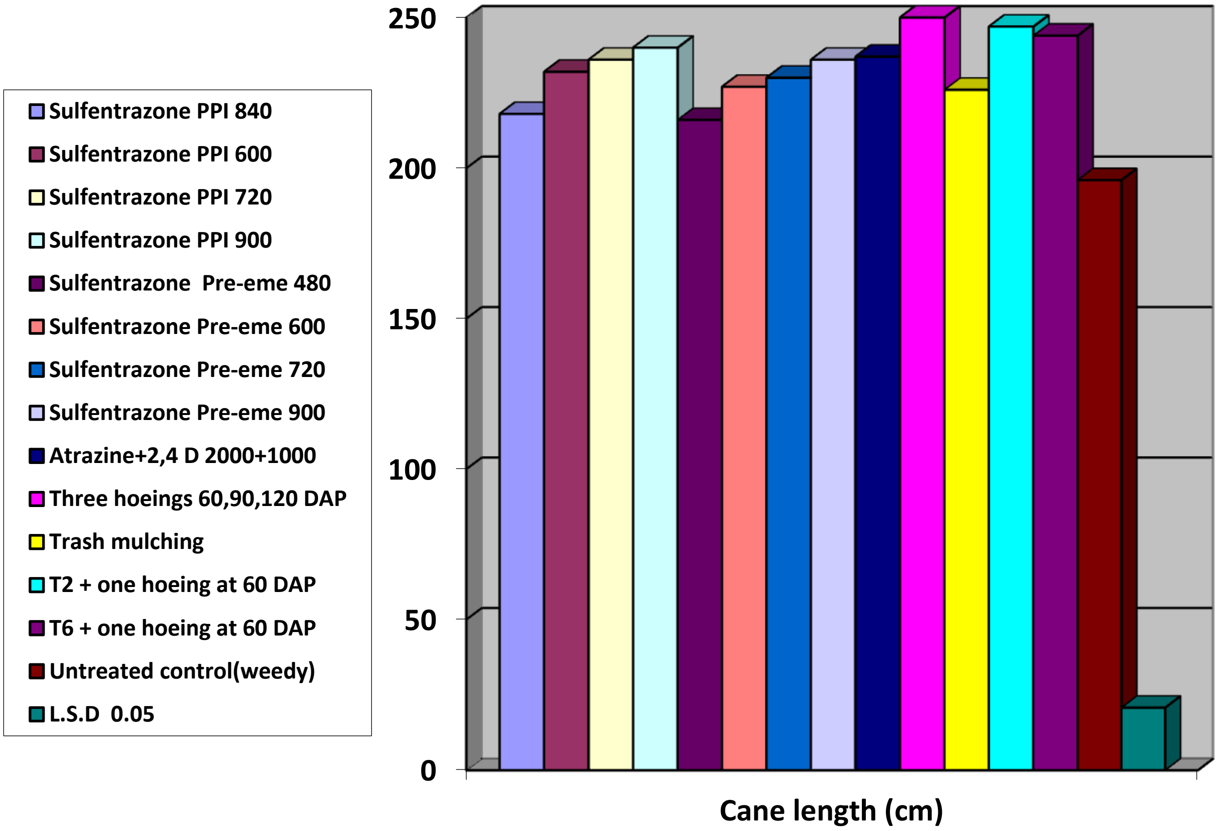


Figure 11 Effect of weed control methods on cane length (cm) at Harvesting of sugarcane (330 DAP)

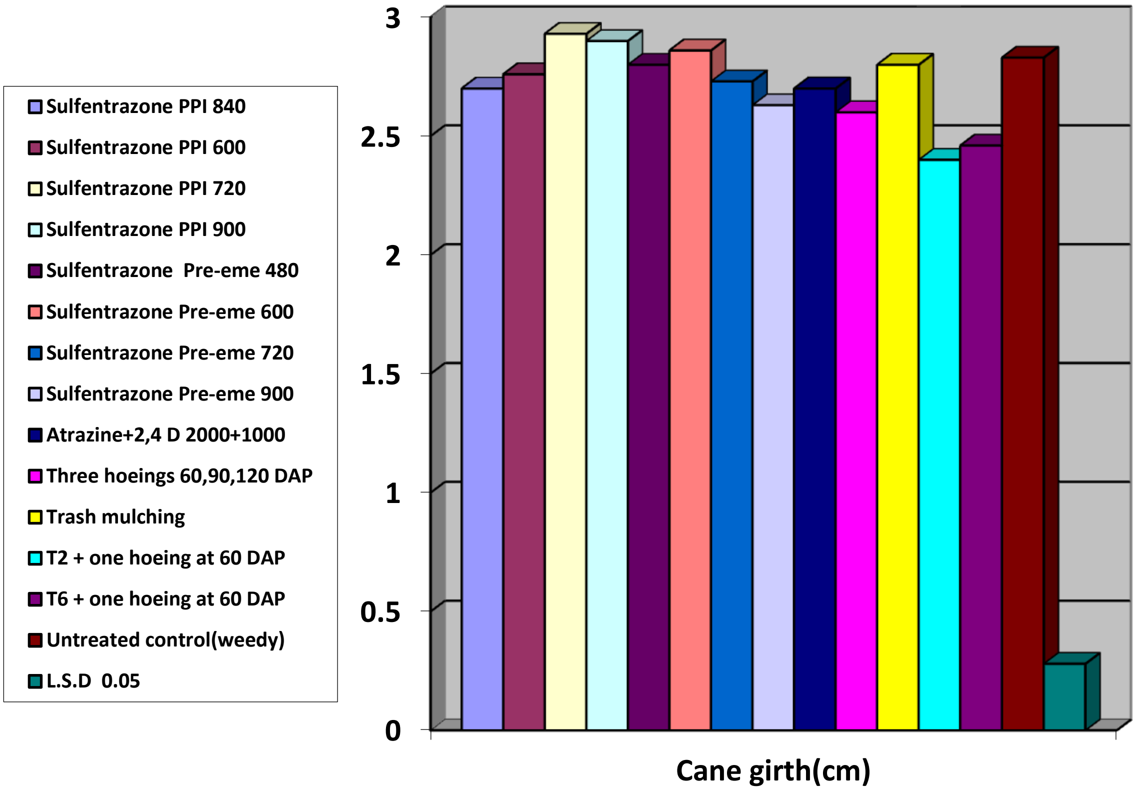


Figure 12 Effect of weed control methods on cane girth (cm) at harvesting of sugarcane (330 DAP)

Number of canes

The table 19 indicates significant effect of weed control methods application on average number of canes in sugarcane during the different growth stages. At 210 DAP, number of canes was significantly affected by use of weed control methods (Figure 14). Addition of sulfentrazone pre-em. 900 g a.i./ha gave higher number of tillers (millable and non-millable canes) but addition of (sulfentrazone PPI 600 g a.i./ha + one hoeing) ,and (sulfentrazone Pre-eme 600 g a.i./ha + one hoeing) led to a maximum significant increase in number of millable canes to 122600 and 123400 canes/ha respectively compared to the control treatment (44500 canes/ha). The effect of these treatments were also reflected in reducing the number of non-millable canes to 18.6 and 11.3 t/ha, respectively compared with the control treatment (74400 canes/ha) .

At 300 DAP, Number of tillers (number of millable and non-millable cane) and number of non-millable cane (Figure 15) were not significantly affected by use of weed control methods, but addition of (sulfentrazone PPI 600 g a.i./ha + one hoeing), and (sulfentrazone Pre-eme 600 g a.i./ha + one hoeing) led to a maximum significant increase in number of millable canes to 103300 and 114700 canes/ha, respectively compared to the control treatment (50600 canes/ha). The effect of these treatments were also reflected in reducing the number of non-millable canes to 28300 and 21900 t/ha respectively compared with the control treatment (74200 canes/ha)

Table 19 Effect of weed control methods on number of canes (000/ha) during the different growth stages of sugarcane

Treatment	Time of Application	Dose (g a.i./ha)	60 DAP	120 DAP	150 DAP	210 DAP	300 DAP
Sulfentrazone	PPI	840	106.1	141.5	088.6	139.8	143.8
Sulfentrazone	PPI	600	82.5	148.3	112.0	137.3	139.5
Sulfentrazone	PPI	720	110.6	169.5	102.2	140.4	155.8
Sulfentrazone	PPI	900	136.1	169.9	110.0	135.9	139.9
Sulfentrazone	Pre-eme: 3 DAP	480	084.8	126.9	081.8	118.6	127.1
Sulfentrazone	Pre-eme: 3 DAP	600	148.4	162.0	098.0	131.9	140.9
Sulfentrazone	Pre-eme: 3 DAP	720	135.4	170.9	110.8	136.9	137.2
Sulfentrazone	Pre-eme: 3 DAP	900	144.0	174.7	113.6	146.5	151.4
Atrazine 50 WP+2,4 D 80% WP	Pre-em: 3DAP+60 DAP	2000+1000	107.6	167.2	122.9	131.5	142.1
Three hoeings	60,90,120 DAP		099.1	155.2	123.8	112.2	115.5
Trash mulching	3 DAP		108.7	103.5	083.7	107.0	108.9
T2 + one hoeing at 60 DAP	-	-	146.6	206.4	161.6	141.2	131.6
T6 + one hoeing at 60 DAP	-	-	128.4	182.0	155.1	135.2	136.6
Untreated control(weedy)	-	-	118.1	88.3	058.1	119.0	124.8
L.S.D 0.05			NS		45.10	17.61	NS

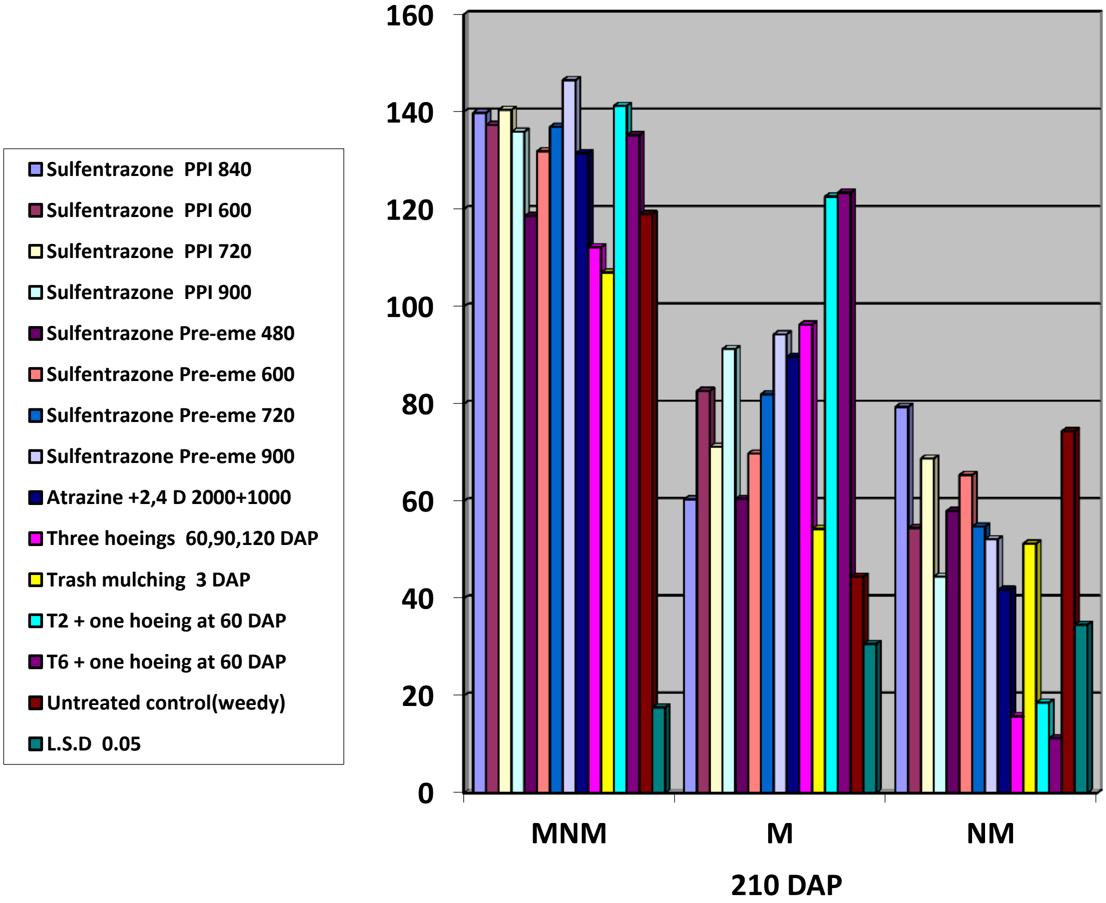


Figure 13 Effect of weed control methods on number of millable canes (M), non-millable canes (NM) and total (MNM) (000/ha) during the different growth stages of sugarcane (210DAP).

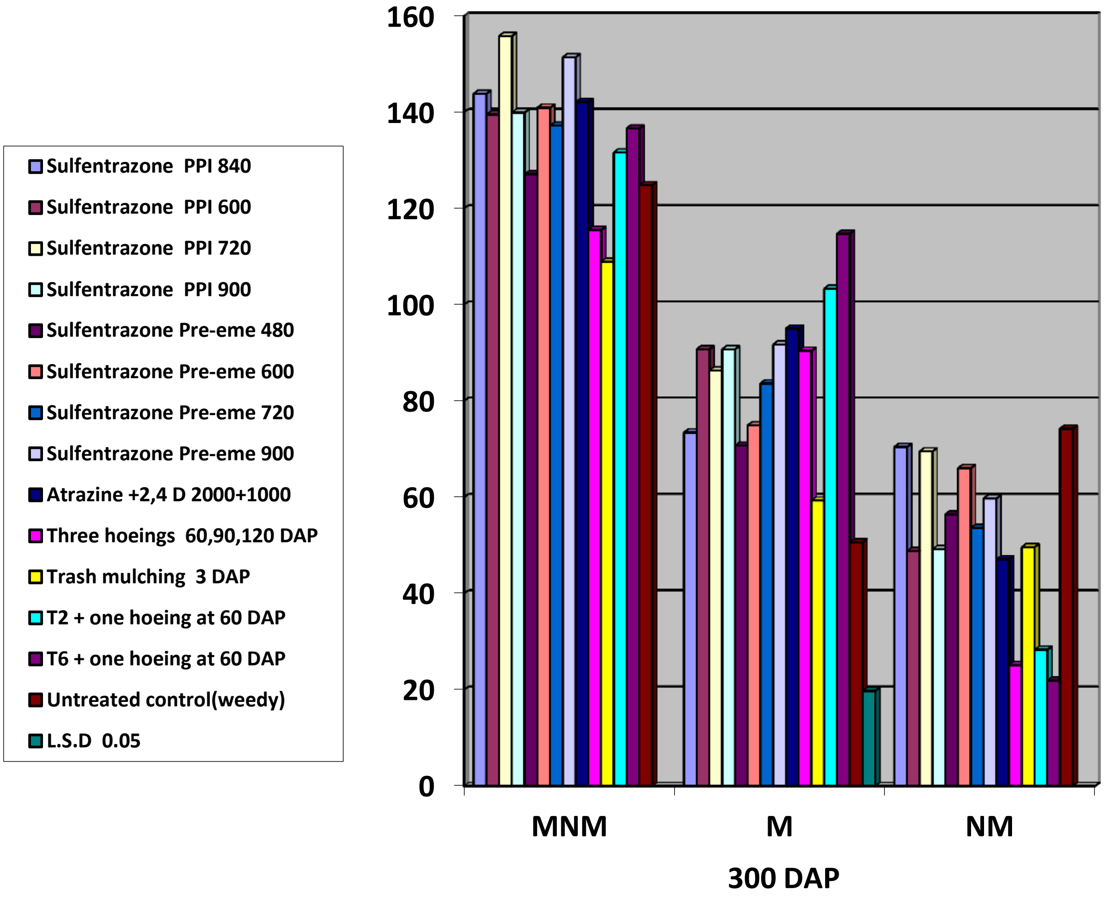


Figure 14 Effect of weed control methods on number of millable canes (M), Non-millable canes (NM) and total (MNM) (000/ha) during the different growth stages of sugarcane (300 DAP) .

Seen from this results the clear excellence to use sulfentrazone PPI 600 g a.i./ha + one hoeing 60 DAP in causing changes in the shoot morphology for sugarcane crop. It caused an increase in cane height (Table 18 and Figure 12) without affecting cane girth (Figure 13) . Also this treatment caused an increase in total number of tillers and number of millable canes with low number of non-millable canes at 210 DAP(Table 19 and Figure 14) . Also caused increase in number of millable canes with reduction in number of non-millable canes without significant influence to total number of the tillers at 300 DAP (Table 19 and Figure 15)

This may be due to role of this treatment in weed control since the early stages of crop growth through low weed density (Table 6) and increase percentage of control (Figure 2) with low dry weight of green weeds and increase the percentage of inhibition of dry weight.

This certainly has reflected positively in increasing the food supply of crop to the lack of competition for food between the crop and weeds .
The main crop stalk takes his need of food and the remainder goes to the buds, causing an increase in the number of other tillers . What also helps is the opportunity for the tillers growth and development as a result of the lack of competition for the place between the crop and weeds .

Number of green leaves

The table 20 indicates significant effect of weed control methods application on average number of green leaves in sugarcane.

There were significant differences in number of green leaves of sugarcane at 60 and 150 DAP due to weed control methods. Use of sulfentrazone PPI 900 g a.i./ha and sulfentrazone PPI 600 g a.i./h led to a maximum decrease in number of green leaves (112.67 and 109.0 leaves /0.75 m^2) respectively as compared to control treatment (36.0 leaf /0.75 m^2) at 60 DAP. While at 150 DAP, use of sulfentrazone Pre-eme

900 g a.i./ha and hoeing treatment caused high increase in this attribute (155.3 and 155.0 leaf /0.75 m^2) respectively compared to the control treatment (51.7 leaf /0.75m^2) . Number of green leaves was not significantly affected by use of weed control methods at 180 DAP

The lack of weeds since the early stages of crop growth ( ) may cause increased exposure foliage of the crop to light as a result of the lack of competition on this important environment factor between the crop and weeds , which had an evident positive impact in increasing number of green leaves and continued sustainability until harvest

Table 20 Effect of weed control methods on Number of green leaves /0.75m² during the different growth stages of sugarcane

Treatments	Time of Application	Dose (g a.i. / ha)	60 DAP	150 DAP	180 DAP
Sulfentrazone	PPI	840	75.33	110	144
Sulfentrazone	PPI	600	109.00	121	117.3
Sulfentrazone	PPI	720	84.67	107	155
Sulfentrazone	PPI	900	112.67	140.3	147
Sulfentrazone	Pre-eme: 3 DAP	480	79.00	97	136
Sulfentrazone	Pre-eme: 3 DAP	600	100.00	137	125.7
Sulfentrazone	Pre-eme: 3 DAP	720	66.67	111.7	139
Sulfentrazone	Pre-eme: 3 DAP	900	97.67	155.3	131
Atrazine 50 WP+2,4 D 80% DAP	Pre-em: 3DAP+60 DAP	2000 + 1000	70.33	132.7	112.3
Three hoeings	60,90,120 DAP		56.67	150	101
Trash mulching	3 DAP		34.33	78.3	91
T2 + one hoeing at 60 DAP	-	-	77.00	143.7	133.7
T6 + one hoeing at 60 DAP	-	-	83.33	143.6	120.7
Untreated control(weedy)	-	-	36.00	51.7	119
L.S.D 0.05			46.85	52.68	NS

Cane yield (ton ha^{-1})

The data presented in table 21 reveals that use of weed control methods to control weeds in sugarcane significantly enhanced the cane yield. All the weed control methods were found effective in significantly increase the cane yield compared to the control treatment. The hoeing treatment achieved higher increase in cane yield (78.0 t/ha) followed (sulfentrazone PPI 600 g a.i./ha + one hoeing) and (sulfentrazone Pre-eme 600 g a.i./ha) achieved 71.5 and 70.6 t/ha respectively compared to the control (48.1 t/ha) .

The lack of competition between the crop and weeds by using these treatments had a significant impact in increasing cane length (Figure 12), increase the number of millable canes (Figure 14 & 15), decrease in number of non- millable canes (Figure 14 & 15) and increase the number of green leaves until the harvest (Table 20) with no significant influence in cane girth (Figure 13), All of these factors have had a positive impact in increasing cane yield .

Table 21 Effect of weed control methods on cane yield (t/ha) and quality characters of sugarcane (330 DAP)

Treatment	Time of application	Dose (g a.i./ha)	Cane yield (t/ha)	Sucrose (%)	Purity (%)	Sugar yield (ton/ha)
Sulfentrazone PPI -480	PPI	840	61.5	16.11	87.15	9.9
Sulfentrazone PPI -600	PPI	600	62.4	15.92	86.01	9.9
Sulfentrazone PPI -720	PPI	720	63.7	16.28	87.39	10.4
Sulfentrazone PPI -900	PPI	900	71.6	16.66	87.16	12.0
Sulfentrazone Pre-em 480	Pre-eme: 3 DAP	480	60.0	16.41	88.10	9.8
Sulfentrazone Pre-em 600	Pre-eme: 3 DAP	600	61.5	15.99	87.25	9.8
Sulfentrazone Pre-em 720	Pre-eme: 3 DAP	720	62.3	16.64	86.82	10.4
Sulfentrazone Pre-em 900	Pre-eme: 3 DAP	900	68.7	16.25	87.02	11.2
Atrazine 50 WP+2,4 D 80% WP	Pre-em: 3DAP+60 DAP	2000+1000	68.0	16.83	87.45	11.4
Three hoeings	60,90,120 DAP		78.0	16.57	87.71	12.9
Trash mulching	3 DAP		60.7	16.11	87.30	9.8
T2 + one hoeing at 60 DAP	-	-	71.5	16.27	86.71	10.4
T6 + one hoeing at 60 DAP	-	-	70.6	16.59	86.36	11.7
Untreated control(weedy)	-	-	48.1	16.28	87.01	7.8
L.S.D 0.05			11.45	NS	NS	1.77

Percentage of Sucrose

There is no significant effect of weed control methods in percentage of sucrose as shown in table 21.

Brix

Addition of weed control methods no affected Brix significantly as it is clear from table 21.

Purity

Addition of weed control methods has no significant affect on purity of juice of sugarcane as depicted in table 21 .

Sugar yield

The research findings presented in table 21 indicates that weed control methods significantly affected sugar yield. All the weed control methods were found effective in significantly increase the sugar yield compared to the control. The hoeing treatment achieved higher increase in sugar yield (12.9 t/ha) followed (sulfentrazone pre-em; 600 g a.i./ha + one hoeing) treatment (11.7 t/ha) compared to the control (7.8 t/ha) .

The main reason for increase of sugar yield by using these treatments due to the positive impact in increasing cane yield only with The absence of a significant effect in the percentage of sucrose

Literature cited

Singh,A.K., R.S. Chauhan and T,K. Srivastava .2012. Effect of pre-emergence application of sulfentrazone in spring planted sugarcane under sub-tropical India . International conference on APCHNE.

Brown, C. A. and Q. L. Holdeman. 1947. Controlling alligator weed in sugarcane with 2,4-D. Louisiana State University Agricultural Experiment Station and A & M College. Bull. 410. pp 16.

Havis, J. R. 1953. Effect of 2,4-D sprays on the growth of young sugar cane. Weeds 2:148-154.

Nolla, J. A. B. 1950. Injury to sugarcane from 2,4-D. Proc. Int. Soc. Sugarcane Technol. 10:178-189.

Richardson, F. E. 1969. Injury to sugarcane by 2,4-D formulations. Proc. South African Sugar Technol. Assoc. 122-129.

Richardson, F. E. 1973. Critical growth stages for 2,4-D phytotoxicity to sugarcane in South Africa. South African Sugar Jour. 3:143-151.

Rochecouste, E. 1967. Weed control in sugarcane. Mauritius Sugar Industry Research Institute. Reduit, Mauritius. p. 12 -13.

Srivastava T. K.2003. Bio-efficacy of Sulfentrazone against Nut-sedge (Cyperus rotundus) and Other Weeds in Sugarcane. Indian Journal of Weed Science Vo(35): 1&2.pp : 82- 86.

Van Overbeek, J. 1947. Use of synthetic hormones as weed killers in tropical agriculture. Econ. Bot. 1:446-458.

CHAPTER 5

EFFECT OF SULFENTRAZOLE ON PHYSIOLOGICAL CHARACTERS OF SUGARCANE

Introduction

Sugarcane (*Saccharum* spp. hybrids), is one of the most productive plant species known, since it can potentially produce from 41.1 (Cheeroo-Nayamuth *et al*., 2000) to about 65 tonnes of dry weight/ha/year (Bakker, 1999). Crop growth duration can vary from 9 months to 36 months (Evensen *et al*., 1997). Sugarcane is a C_4 plant that produces multiple tillers, each having numerous nodes separated by internodes. The internodes consist of sucrose storing parenchyma cells and vascular tissue, with the stem being the major sink for photosynthates (sucrose) (Moore, 1987; Australian Government, 2004).

Sugarcane stem tissues have been studied over many years since its maturation is characterized by the accumulation of sucrose in developing internodes (Glasziou and Gaylor, 1972, Moore, 1995). In addition, some recent studies have been motivated by the discovery of the endophyte *Gluconacetobacter diazotrophicus* living in the stem apoplast (Dong *et al*., 1994, Tejera *et al*., 2006). The percentage of sucrose in sugarcane juice (with a pH of 4.9–5.5), usually referred to, in the sugar industry, as the polarization value (Pol), varies from 8 to 15% (Tewari *et al*., 2003).

Studies of carbon partitioning in sugarcane have focused primarily on the sugar pool, and have revealed that a cycle of a rapid sucrose synthesis and degradation exists in sugarcane(Komor *et al*., 1996; Vorster and Botha, 1999). Other non-sucrose metabolic pathways have also proved to be significant sinks. These include the water insoluble compounds (assumed to be primarily fibre) and the respiratory pathway (Whittaker and Botha, 1997). It has been suggested that total allocation to these pathways decreases with the tissue maturation and at the same time a concomitant rise in partitioning of sucrose to the stem parenchyma occurs (Whittaker and Botha, 1997).

In not mature tissue, proteins and fibre are the competing sinks with sucrose for incoming carbon (Bindon and Botha, 2002). Studies in order to determine the factors responsible for yield variation in sugarcane have been carried out in some countries, where this plant is extensively cultivated (Inman-Bamber and Thompson, 1989; Muchow *et al*., 1994, Robertson *et al*., 1996). Most of them have used growth analysis information and other plant characteristics (architecture, age, variety), integrated with climatic variables such as radiation, water availability, temperature, with the aim of predict the yield by using different mathematics models (Cheeroo-Nayamuth *et al*., 2000; Inman-Bamber *et al*., 2002). However, the physiology of yield accumulation has rarely been examined on a dry matter basis with all components, including tops, stalks, trash and roots (Evensen *et al*., 1997).

The improvement of commercial varieties by conventional breeding is in good progress in Florida (Edme et al., 2005) nevertheless molecular tools for modifying sugarcane metabolism has been also developed in Cuba and other countries (Arencibia and Cornide, 1999; Grof and Campbell, 2001). Even though the morphology and anatomy of sugarcane has been extensively studied (Moore, 1987), the physiological aspects necessary to understand the growth and sucrose storage mechanisms of the plant, are still poorly understood compared to other crops.

At cellular level the relationship between photosynthesis and respiration are basic processes for carbon income. At organism level the plant growth could be related to net assimilation rate and the partitioning and allocation of the carbon gained. To know physiological and morphological traits related with plant productivity could be very valuable not only to plant physiologists but to plant breeders and biotechnologists also.

The aim of this study was to investigate some physiological indicators of sugarcane yield. For this purpose, several parameters related to growth, leaf area(LA), leaf area index(LAI),leaf weight(LW), leaf area ratio(LAR), leaf area duration(LA) were evaluated.

Materials and Methods

Study was conducted during 12 months to know the effect of weed control methods on physiological characters of sugarcane at fields of Indian Institute of Sugarcane Research (IISR) in India. Application of weed control methods was made at tiller stage of sugarcane crop (Variety CoSe 92423). Randomized Complete Block Design (RCBD) was applied with three replications. The treatments used in the experiment are shown in Table 22. The soil of the experimental site was clay loam with PH 7.83 , organic carbon 0.40%, and available N, P2O5, K2O were 222.65 , 16.86 and 186.12 kg/ha respectively. The experimental unit area 36m² and the distance between the experimental unit and others was 0.5 m while distance between replicate was 1.5 m. Each experimental unit contains six lines length of 8 m and the distance between lines was 0.75 m. 150 kg N / ha was added to experimental land by application of urea (46% N), in Three parts . First part before planting, second part at 60 days after planting and third part at 90 DAP. Dap fertilizer (18-46-0) at the rate of 60 kg/ha was applied once after planting. So, KCL at the rate of 60 Kg/ha was applied once after planting. Bavistin (systemic fungicide) at the rate of 200 Kg/ha and Hilban (chloribyriphos) (Insecticide) at the rate of 5 L/ha were used and 37000 – 40000 sets/ha .

Plant traits were measured following:

Table 22: the treatments used in land of the experiment .

Treatment	Time of Application	Dose (g a.i./ha)	Dose (ml/ha)
Sulfentrazone 48% F	PPI	720	1500
Sulfentrazone 48% F	Pre-em: 3DAP	720	1500
Trash mulching	3 DAP	-	-
Three hoeings	60,90,120 DAP	-	-
Untreated control(weedy)	-	-	-

Leaf area (LA) (cm^2) :

The area per Leaf was calculated multiplying the result of length by width by the factor 0.7. This factor results from the relationship between the real leaf area and product of blade width by blade length (Lerch et al., 1977). It was calculated from the same canes that have been selected to measure cane height and cane girth. Calculated from the following equation:

Leaf area (cm^2) =(L x W) x 0.70
L= Length
W= Width

Leaf are index (LAI):

Leaf area index was calculated by multiplying the mean value of leaf area per stalk by the number of stalks present in a known area. The growth parameters were individually calculated using the formulae of Kvet *et al*. (1971).

Leaf area ratio (LAR) (cm^2/g):

Leaf area ratio = L/W, relates leaf area with the total stalk dry matter

Leaf area duration (LAD) (cm^2 day):

Leaf area duration = L2 + L1 (t2 t1)/2.

Results and Discussion

Dry and green leaf number

The table 22a indicates significant effect of weed control methods on average number of dry leaves in sugarcane. Hoeing treatment registered the highest increase of dry leaves per cane (9.5 leaves/ cane) that didn't differ significantly from sulfentrazone PPI 720 g a.i./ha and sulfentrazone Pre-eme 720 g a.i./ha (8.2 and 8.1 leaves/cane respectively) compared with the control treatment (5.2 leaves/cane), while there is no significant effect between the treatments on number of green leaves.

Number of internode

The research findings presented in table 22a indicates that weed control methods significantly affected number of internode .All the treatments were found effective in significantly increasing number of internode except trash mulching treatment did not significantly affect (16.4 node/cane) compared to the control treatment (14.5 node/cane).

Length of stalk (cm)

The use of weed control methods helped sugarcane crop to produce significantly higher length of stalk over control (Table 22a). The highest length of stalk (191.9 cm) was recorded in hoeing treatment followed sulfentrazone Pre-eme 720 g a.i./ha treatment(172.5 cm) , While, other weed control methods could not have a significantly influence on this character over control treatment (138.6 cm).

Table 23a. Effect of weed control methods on some of the vegetative characteristics of sugarcane

Treatment	Time of application	Dose (g a.i./ha)	Length of stalk (cm)	No. of Internode	Leaf No.	
					Dry leaf No.	Green leaf No.
Sulfentrazone 48% F	PPI	720	154.3	17.0	8.2	9.6
Sulfentrazone 48% F	Pre-em: 3DAP	720	172.5	18.6	8.1	10.5
Trash mulching	3 DAP	-	162.3	16.4	5.7	11.0
Three hoeings	60,90,120 DAP	-	191.9	17.5	9.5	9.3
Untreated control (weedy)	-	-	138.6	14.5	5.2	10.5
L.S.D. 0.05			29.28	2.34	1.94	NS

Dry and green leaf weight (g)

The table 23b indicates significant effect of weed control methods on average dry and green leaves in sugarcane. Sulfentrazone PPI 720 g a.i./ha registered the highest increase of dry leaf weight (50.8 g) that didn't differ significantly from the other treatments compared with the control treatment (15.6 g), while there is no significant effect between the treatments on green leaf weight.

Fresh weight of stalk and sheath (g)

The research findings presented in table 23b indicates that weed control methods significantly affected fresh weight of stalk .All the treatments were found effective in significantly increasing the fresh weight of stalk compared to the control . hoeing treatment gave higher increase (703.2 g) followed trash mulching (698.1 g), thus sulfentrazone Pre-eme (665.6 g) and sulfentrazone PPI (589.3 g) compared to the control treatment (362.5 g), while did not differ significantly weed control methods on fresh weight of sheath .

Table 23b Effect of weed control methods on some of the vegetative characteristics of sugarcane

Treatment	Time of application	Dose (g ai/ha)	Fresh weight of stalk (g)	Green leaf weight (g)	Dry leaf weight (g)	Fresh weight of sheath
Sulfentrazone 48% F	PPI	720	589.3	126.0	50.8	72.2
Sulfentrazone 48% F	Pre-em:3DAP	720	665.6	131.2	50.6	82.0
Trash mulching	3 DAP	-	698.1	142.2	35.3	86.6
Three hoeing	60,90,120 DAP	-	703.2	118.9	45.6	79.3
Untreated control(weedy)	-	-	362.5	128.6	15.6	69.7
L.S.D. 0.05			127.15	NS	9.41	NS

Leaf area (cm^2) and Leaf area index

The use of weed control methods helped sugarcane crop to produce significantly higher leaf area over control (Table 24a). The highest leaf area (473.3 and 332.2 cm^2/stalk) was recorded in sulfentrazone Pre-eme 720 g a.i./ha at 210 and 300 DAP compared with the control treatment (306.4 and 268.4 cm^2/stalk) respectively. Also, these treatments achieved maximum leaf area index (7.9 and 4.8) compared to the control (5.1 and 3.4), respectively.

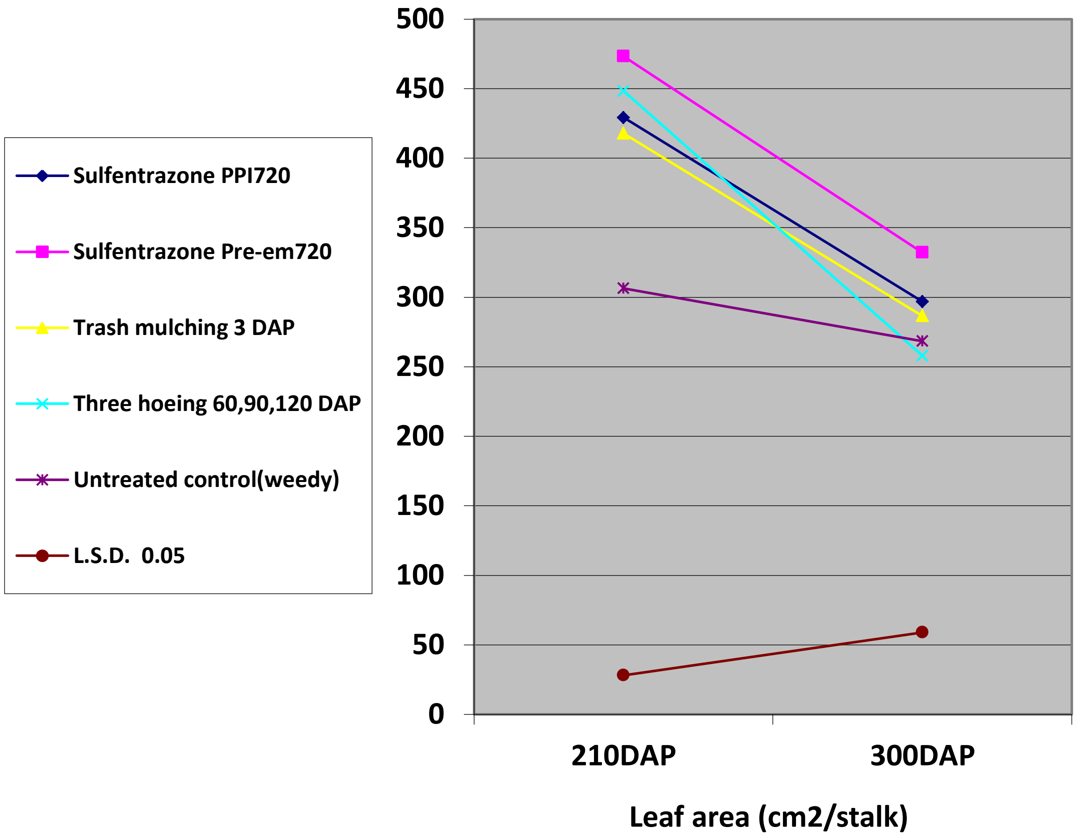


Figure 15 Effect of weed control methods on leaf area (cm^2/ stalk) of sugarcane.

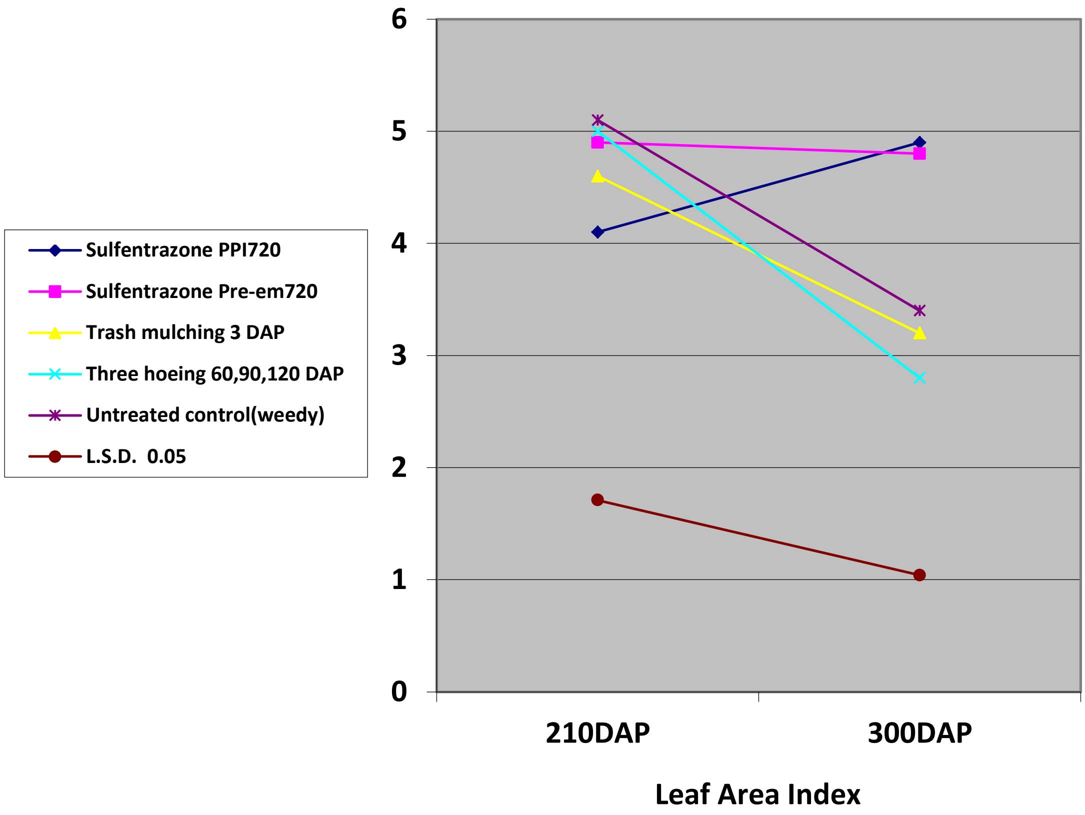


Figure 16 Effect of weed control methods on Leaf Area Index of sugarcane

Stalk dry matter (g)

The research findings presented in table 24b indicates that weed control methods significantly affected stalk dry matter .All the weed control methods were found effective in significantly increasing the stalk dry matter compared to the control (168.6 g). The dry matter accumulation in stalk was the highest (252.9 g) in trash mulching treatment.

Total leaf weight (g)

Also, the research findings presented in table 24b indicates that weed control methods significantly affected total leaf weight. Also, all the weed control methods were found effective in significantly increasing the total leaf weight. Use of trash mulching registered the highest total leaf weight (142.2 g) compared to the control treatment (93.1 g)

Leaf area ratio (cm^2/g)

Leaf area ratio Table 24b was not significantly affected by use of various weed control methods.

Leaf area duration (cm^2/day)

The data presented in table 24b reveals that use of weed control methods to control weeds in sugarcane significantly enhanced the leaf area duration .The use of sulfentrazone Pre-eme registered the highest leaf area duration (48.3 cm^2/day) compared to the control (34.5 cm^2/day) .

Table 24 Effect of weed control methods on some Physiological characteristics of sugarcane

Treatment	Time of Application	Dose (g a.i./ha)	Stalk Dry matter (g)	Total Leaf weight(g) 210 DAP	Leaf area ratio(cm^2/g) 210DAP	Leaf area duration (cm^2/ day) X 10^3
Sulfentrazone 48% F	PPI	720	203.1	126.0	3.409	43.7
Sulfentrazone 48% F	Pre-em:3DAP	720	209.2	131.5	3.603	48.3
Trash mulching	3 DAP	-	252.9	142.2	3.015	42.3
Three hoeing	60,90,120 DAP	-	218.3	118.9	3.783	42.4
Untreated control(weedy)	-	-	168.6	93.1	3.327	34.5
L.S.D. 0.05			75.12	34.66	NS	7.49

Increase of length of stalk, number of dry leaf with no a significant effected in number of green leaf (Table 23a) and increase of dry and green leaf weight (Table 23b), increase of leaf area and leaf area index (Figures 16 and 17) has contributed to increase leaf area duration (Table 24) , This is certainly a positive role in increasing cane yield and sugar yield for crop.

Literature Cited

Arencibia, A.D., Cornide, M.T., 1999. Biodiversidad y biotecnologý´a de la can˜a de azu´car. Elfos Scientiae, La Habana, p. 168.

Australian Government, 2004. The Biology and Ecology of Sugarcane (Saccharum spp. hybrids) in Australia. Department of Health and Ageing.
Australia, Office of the Gene Technology Regulator, pp. 1–31. http//:www.ogtr.gov.au/rtf/ir/biologysugarcane.rtf.

Bakker, H., 1999. Sugar Cane Cultivation and Management. Kluwer Academic/Plenum Publisher, p. 679.

Bindon, K.A., Botha, F.C., 2002. Carbon allocation to the insoluble fraction, respiration and triose-phosphate cycling in the sugarcane culm. Physiol. Plant. 116, 12–19.

Cheeroo-Nayamuth, F.C., Robertson, M.J.,Wegener, M.K., Nayamuth, A.R.H. 2000 .Using a simulation model to assess potential and attainable sugar cane yield in Mauritius. Field Crops Res. 66, 225–243.

Dong, Z., Canny, M.J., McCully, M., Reboredo, M.R., Ferna´ndez, C., Ortega, E., Rode´s, R., 1994. A nitrogen-fixing endophyte of sugarcane stems: a new role for the apoplast. Plant Physiol. 105, 1139–1147.

Edme, S.J., Miller, J.D., Glaz, B., Tai, P.Y.P., Comstock, J.C., 2005. Genetic contribution to yield gains in the Florida sugarcane industry across 33 years. Crop Sci. 45, 92–97.

Evensen, C.I., Muchow, R.C., El-Swaify, S.A., Osgood, R.V., 1997. Yield accumulation in irrigated sugarcane. I. effect of crop age and cultivar. Agron. J. 89, 638–646.

Glasziou, K.T., Gaylor, K.R., 1972. Storage of sugars in stalks of sugar cane. Bot. Rev. 38, 471–490.

Grof, C.P.L., Campbell, J.A., 2001. Sugarcane sucrose metabolism: scope for molecular manipulation. Aust. J. Plant Physiol. 28, 1–12.

Inman-Bamber, N.G., Thompson, G.D., 1989. Models of dry mater accumulation by sugarcane. In: Proc. Annu. Congr. S. Afr. Sugar Technol. Assoc., vol. 63. pp. 212–316.

Komor, E., Zingsheim, O., Sprugel, H., 1996. Cycles of sugar transport and sucrose metabolism in sugarcane tissue. Quantitative determination. In: Wilson, J.R., Hogarth, D.M., Campbell, J.A., Garside, A.L. (Eds.), Sugarcane:Research Toward Efficient and Sustainable Production. CSIRO.Division of Tropical Crops and Pastures, Brisbane, pp. 92–94.

Kvet, J., Ondok, J.P., Necas, J., Jarvis, P.G., 1971. Methods of growth analysis. In: Sestak, Z., Catski, J., Jarvis, P.G. (Eds.), Plant Photosynthetic Production. The Hague: The Hague Publisher, pp. 343–391.

Lerch, G.R., Reyes, R., Garcý a, R., Leal, P., 1977. Crecimiento, desarrollo y variacio´n del ý´ndice refractome´trico (Brix) en seis variedades de can˜a de azu´car. Cien. Agric. 1, 79–105.

Moore, P.H., 1987. Anatomy and physiology. In: Heinz, D.J. (Ed.), Sugarcane Improvement Through Breeding. Elsevier, Amsterdam, pp. 273–311.

Moore, P.H., 1995. Temporal and special regulation of sucrose metabolism in the sugarcane stem. Aust. J. Plant. Physiol. 22, 661–679.

Muchow, R.C., Spillman, M.F., Wood, A.W., Thomas, M.R., 1994. Radiation interception and biomass accumulation in a sugarcane crop grown under irrigated tropical conditions. Aust. J. Agric. Res. 45, 1–13.

Rai,R K., Sing,P., Chandra A. and Yadav R.L.2011. Variation in size of apparent free space and assimilatory apparatus in sugarcane varieties with differential sucrose accumulation in to the stalks affecting source-sink relationship. *Indian Journal of Sugarcane Technology*. 26(1):41-50.

Robertson, M.J.,Wood, A.W., Muchow, R.C., 1996. Growth of sugarcane under high input conditions in tropical Australia. I. Radiation use, biomass accumulation and partitioning. *Field Crops Res*. 48, 11–25.

Tejera, N. A.,Rosa R., Eduardo O., Rosario C., Carmen L.2007. Comparative analysis of physiological characteristics and yield components in sugarcane cultivars . *Field Crops Research* (102) : 64–72

Tejera, N., Ortega, E., Rode´s, R., Lluch, C., 2006. Nitrogen compounds in the apoplastic sap of sugarcane stem: some implications in the association with endophytes. *J. Plant Physiol*. 163, 80–85.

Tewari, J., Mehrotra, R., Irudayaraj, J., 2003. Direct near infrared analysis of sugar cane clear juice using a fibre-optic transmittance probe. J. Near Infrared Spectrosc. 11, 351–356.

Vorster, D.J., Botha, F.C., 1999. Sugarcane internodal invertases and maturity. *J. Plant Physiol*. 155, 470–476.

Whittaker, A., Botha, F.C., 1997. Carbon partitioning during sucrose accumulation in sugarcane internodal tissue. *Plant Physiol*. 115, 1561–1651.

Evidenced by the current study, possibility using sulfentrazone herbicide on sugarcane crop by ability of this compound in effect of vegetative growth , yield and qualitative characteristics of crop by increasing cane yield and raise proportion of sucrose and then a positive impact in increasing sugar yield as spraying of herbicide has shown a significant impact in number of tillers and cause a real increase in number of millable cane at harvest also cause an increase in proportion of sucrose . It was found from the results of the current study that the process of configuring the tillers during the vegetative growth period of plant evolution formed by the herbicide is one of the characteristics of the sugar cane crop because of its direct in yield . In a time when leading environmental conditions play a significant role in influencing such Van herbicide role no less important than the impact of these conditions Through the role of herbicide in weed control , which helps in providing different growth requirements for those tillers , Through improved light interception by the crop plants in the absence of weeds And the possibility of improved water absorption and transmission of nutrients and direct part of it to meet the requirements of the new tellers growth And thus increase the number of millable cane later . also The herbicide influential role in the increase of weed control growing with sugar cane plants Especially perennial weeds deployed heavily in the fields of study, which reaches 74 % and then the biggest impact the final output , It is the process of combat that weeds is a difficult process Because the proliferation of these weeds as well as seeds can be done through the vegetative parts found beneath surface of the soil , any harm is not limited to the existence of the vegetation above the soil surface But lies viability of these plants to restore growth of the ground parts after killing the vegetative parts located above the soil surface Since the tillers stage for sugar cane crop is one of the important and sensitive stages It must be accompanied by the absence of the weeds and hence the lack of the crop competition. Therefore, use of the herbicide has had a positive impact in control a large proportion of the weeds and that the increase in weed control by this compound has helped in the early stimulation of the tillers and then increase of number of millable cane by giving the opportunity to the emerging tillers growth and development and therefore, to be effective . At the same time, the compound has helped to increase the proportion of sucrose in juice through his role in the weed control and thus provide products of photosynthesis are the best of the crop plants. Generally The adoption of use of weed control is through its ability to raise the proportion to weed control with sugar cane plants and in raising the sugar yield .

APPENDIX: RAW DATA

First Experiment

Appendix 1 Effect of weed control methods on germination percentage (%) of sugarcane .

Treatments	Time of Application	Dose (g a.i./ha)	Mean
Sulfentrazone	PPI	840	42.0
Sulfentrazone	PPI	600	42.5
Sulfentrazone	PPI	720	42.3
Sulfentrazone	PPI	900	41.7
Sulfentrazone	Pre-eme: 3 DAP	480	36.2
Sulfentrazone	Pre-eme: 3 DAP	600	43.3
Sulfentrazone	Pre-eme: 3 DAP	720	42.9
Sulfentrazone	Pre-eme: 3 DAP	900	42.0
Atrazine 50 WP+2,4 D 80% WP	Pre-em: 3DAP+60 DAP	2000+1000	48.6
Three hoeings	60,90,120 DAP		34.7
Trash mulching	3 DAP		32.0
T2 + one hoeing at 60 DAP	-	-	41.3
T6 + one hoeing at 60 DAP	-	-	43.3
Untreated control(weedy)	-	-	27.6
L.S.D 0.05			9.87

Appendix 2 Effect of weed control methods on inhibition proportion of dry matter (%) for weed during the different growth stages of sugarcane

Treatment	Time of application	Dose (g a.i./ha)	60DAP	90DAP	120DAP
Sulfentrazone	PPI	840	83.7	74.3	37.5
Sulfentrazone	PPI	600	88.0	76.4	39.5
Sulfentrazone	PPI	720	89.4	83.4	46.2
Sulfentrazone	PPI	900	92.4	86.6	46.8
Sulfentrazone	Pre-eme: 3 DAP	480	83.6	78.0	37.8
Sulfentrazone	Pre-eme: 3 DAP	600	84.4	80.6	44.3
Sulfentrazone	Pre-eme: 3 DAP	720	86.9	82.0	47.6
Sulfentrazone	Pre-eme: 3 DAP	900	87.8	86.4	47.8
Atrazine 50 WP+2,4 D 80% DAP	Pre-em: 3DAP+60 DAP	2000+1000	81.4	85.5	69.3
Three hoeings	60,90,120 DAP		93.2	94.2	75.5
Trash mulching	3 DAP		87.4	91.4	59.6
T2 + one hoeing at 60 DAP	-	-	84.6	89.3	68.6
T6 + one hoeing at 60 DAP	-	-	82.1	92.0	73.0
Untreated control(weedy)	-	-	00.0	00.0	00.0

Appendix 3 Effect of weed control methods on weed control proportion (%) during the different growth stages of sugarcane

Treatments	Time of Application	Dose (g a.i./ha)	60DAP	90DAP	120DAP
Sulfentrazone	PPI	840	61.8	60.9	59.2
Sulfentrazone	PPI	600	74.8	69.7	62.9
Sulfentrazone	PPI	720	77.1	79.2	66.1
Sulfentrazone	PPI	900	80.5	81.7	75.6
Sulfentrazone	Pre-eme: 3 DAP	480	50.4	50.5	52.3
Sulfentrazone	Pre-eme: 3 DAP	600	69.5	63.1	61.2
Sulfentrazone	Pre-eme: 3 DAP	720	69.5	72.2	74.4
Sulfentrazone	Pre-eme: 3 DAP	900	82.1	83.0	75.6
Atrazine 50 WP+2,4 D 80% WP	Pre-em: 3DAP+60 DAP	2000+1000	51.9	67.5	73.9
Three hoeings	60,90,120 DAP		72.1	84.2	75.3
Trash mulching	3 DAP		64.1	66.2	56.0
T2 + one hoeing at 60 DAP	-	-	71.0	83.0	73.6
T6 + one hoeing at 60 DAP	-	-	66.4	75.4	72.4
Untreated control(weedy)	-	-	00.0	00.0	00.0

Appendix 4 Effect of weed control methods on cane length (cm) and Cane girth (cm) at harvesting of sugarcane (330 DAP)

Treatment	Time of application	Dose (g a.i./ha)	Cane length(cm)	Cane girth(cm)
Sulfentrazone	PPI	840	218	2.70
Sulfentrazone	PPI	600	232	2.76
Sulfentrazone	PPI	720	236	2.93
Sulfentrazone	PPI	900	240	2.90
Sulfentrazone	Pre-eme: 3 DAP	480	216	2.80
Sulfentrazone	Pre-eme: 3 DAP	600	227	2.86
Sulfentrazone	Pre-eme: 3 DAP	720	230	2.73
Sulfentrazone	Pre-eme: 3 DAP	900	236	2.63
Atrazine 50 WP+2,4 D 80% WP	Pre-em: 3DAP+60 DAP	2000+1000	237	2.70
Three hoeings	60,90,120 DAP		250	2.60
Trash mulching	3 DAP		226	2.80
T2 + one hoeing at 60 DAP	-	-	247	2.40
T6 + one hoeing at 60 DAP	-	-	244	2.46
Untreated control(weedy)	-	-	196	2.83
L.S.D 0.05			20.75	0.28

Appendix 5 Effect of weed control methods on number of millable and Non -millable cane (000/ha) during the different growth stages of sugarcane (210DAP)

Treatment	Time of application	Dose (g a.i./ha)	Millable and non-millable cane	Millable cane	Non-millable cane
Sulfentrazone	PPI	840	139.8	60.4	79.4
Sulfentrazone	PPI	600	137.3	82.7	54.5
Sulfentrazone	PPI	720	140.4	71.2	68.8
Sulfentrazone	PPI	900	135.9	91.3	44.5
Sulfentrazone	Pre-eme: 3 DAP	480	118.6	60.5	58.0
Sulfentrazone	Pre-eme: 3 DAP	600	131.9	69.8	65.4
Sulfentrazone	Pre-eme: 3 DAP	720	136.9	82.0	54.8
Sulfentrazone	Pre-eme: 3 DAP	900	146.5	94.3	52.2
Atrazine 50 WP+2,4 D 80% WP	Pre-em: 3DAP+60 DAP	2000+1000	131.5	89.7	41.8
Three hoeings	60,90,120 DAP		112.2	96.3	15.8
Trash mulching	3 DAP		107.0	54.3	51.3
T2 + one hoeing at 60 DAP	-	-	141.2	122.6	18.6
T6 + one hoeing at 60 DAP	-	-	135.2	123.4	11.3
Untreated control(weedy)	-	-	119.0	44.5	74.4
L.S.D 0.05			17.61	30.66	34.61

Appendix 6 Effect of weed control methods on number of millable and Non -millable cane (000/ha) during the different growth stages of sugarcane (300DAP).

Treatreatments	Time of Application	Dose (g a.i./ha)	Millable and non-millable cane	Millable cane	Non-millable cane
Sulfentrazone	PPI	840	143.8	73.4	70.4
Sulfentrazone	PPI	600	139.5	90.7	48.8
Sulfentrazone	PPI	720	155.8	86.3	69.5
Sulfentrazone	PPI	900	139.9	90.7	49.2
Sulfentrazone	Pre-eme: 3 DAP	480	127.1	70.7	56.4
Sulfentrazone	Pre-eme: 3 DAP	600	140.9	74.9	66.0
Sulfentrazone	Pre-eme: 3 DAP	720	137.2	83.6	53.6
Sulfentrazone	Pre-eme: 3 DAP	900	151.4	91.7	59.7
Atrazine 50 WP+2,4 D 80% DAP	Pre-em: 3DAP+60 DAP	2000+1000	142.1	95.0	47.1
Three hoeings	60,90,120 DAP		115.5	90.4	25.1
Trash mulching	3 DAP		108.9	59.3	49.6
T2 + one hoeing at 60 DAP	-	-	131.6	103.3	28.3
T6 + one hoeing at 60 DAP	-	-	136.6	114.7	21.9
Untreated control(weedy)	-	-	124.8	50.6	74.2
L.S.D 0.05			NS	19.74	NS

Appendix 7 Results of analysis of variance (ANOVA) for sugarcane germination percentage.

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	2	29.47762	14.73881	0.4258	0.6577
Treatments	13	1165.677381	89.667491	2.5905	0.0188
Error	26	899.969048	34.614194		
Mean	39.9881				
C.V.	14.7128				
S.E.	3.3968				
L.S.D 5%	9.8742				
L.S.D1%	13.3484				

Appendix 8 Results of analysis of variance (ANOVA) for attendant weed density of sugarcane (60 DAP).

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	2	103.857100	51.928570	0.9602	0.3960
Treatments	13	13171.071429	1013.159341	18.7336	0.0000
Error	26	1406.142857	54.082418		

Appendix 9 Results of analysis of variance (ANOVA) for attendant weed density of sugarcane (90 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	2	3639.243000	1819.622000	11.7419	0.0002
Treatments	13	64732.077381	4979.390568	32.1318	0.0000
Error	26	4029.163333	154.967821		

Appendix 10 Results of analysis of variance (ANOVA) for attendant weed density of sugarcane (120 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	2	985.761900	492.881000	3.7402	0.0374
Treatments	13	21027.833333	1617.525641	12.2746	0.0000
Error	26	3426.238095	131.778388		

Appendix 11 Results of analysis of variance (ANOVA) for Dry Matter (gr) of sugarcane (60 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	2	1593.691000	796.845700	1.0521	0.3636
Treatments	13	1465586.579048	112737.429158	148.8448	0.0000
Error	26	19692.815238	757.415971		
Mean	154.3714				
C.V.	17.8279				
S.E.	15.8894				
L.S.D 5%	46.1896				
L.S.D1%	62.4408				

Appendix 12 Results of analysis of variance (ANOVA) for dry Matter (g) of sugarcane (90 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	2	237.180500	118.590200	0.7630	0.4764
Treatments	13	144202.673333	11092.513333	71.3677	0.0000
Error	26	4041.119524	155.427674		

Appendix 13 Results of analysis of variance (ANOVA) for dry matter (g) of sugarcane (120 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	2	29.47762	14.73881	0.4258	0.6577
Treatments	13	1165.677381	89.667491	2.5905	0.0188
Error	26	899.969048	34.614194		
Mean	39.9881				
C.V.	14.7128				
S.E.	3.3968				
L.S.D 5%	9.8742				
L.S.D1%	13.3484				

Appendix 14 Results of analysis of variance (ANOVA) for Can height (cm) / 0.75 m² of sugarcane (60DAP) .

source of variation.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replications	2	26.567580	13.283790	2.6624	0.0887
Treatments	13	95.912648	7.377896	1.4787	0.1915
Error	26	129.726024	4.989462		
Mean	12.17				
C.V.	18.35				
S.E.	1.29				
L.S.D 5%	-				
L.S.D1%	-				

Appendix 15 Results of analysis of variance (ANOVA) for Cane height(cm) /0.75 m² of sugarcane(150DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	2	432.490000	216.245000	0.4923	0.6168
Treatments	13	8441.937381	649.379799	1.4783	0.1916
Error	26	11421.383333	439.283974		
Mean	136.5786				
C.V.	15.3458				
S.E.	12.1007				
L.S.D 5%	-				
L.S.D1%	-				

Appendix 16 Results of analysis of variance (ANOVA) for Cane height(cm)/0.75 m² of sugarcane (180 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	2	615.198500	307.599300	0.2441	0.7852
Treatments	13	47212.332381	3631.717875	2.8817	0.0104
Error	26	32767.025933	1260.270228		
Mean	162.5752				
C.V.	21.8362				
S.E.	20.4961				
L.S.D 5%	59.5811				
L.S.D1%	80.5440				

Appendix 17 Results of analysis of variance (ANOVA) for cane length (cm) of sugarcane (330 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	2				
Treatments	13				
Error	26				

Appendix 18 Results of analysis of variance (ANOVA) for cane girth (cm) of sugarcane (330 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	2	0.091905	0.045952	1.6716	0.2075
Treatments	13	0.949524	0.073040	2.6569	0.0164
Error	26	0.714762	0.027491		

Appendix 19 Results of analysis of variance (ANOVA) for No. of tillers / 0.75 m² of sugarcane (60 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	2	93.476190	46.738090	1.9541	0.1619
Treatments	13	657.642857	50.587912	2.1151	0.0504
Error	26	621.857143	23.917582		
Mean	13.98				
C.V.	34.99				
S.E.	2.82				
L.S.D 5%	8.21				
L.S.D1%	11.10				

Appendix 20 Results of analysis of variance (ANOVA) for No. of tillers /0.75 m² of sugarcane (150 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	2	36.904760	18.452380	2.6108	0.0926
Treatments	13	272.309524	20.946886	2.9637	0.0089
Error	26	183.761905	7.067766		
Mean	10.6905				
C.V.	24.8682				
S.E.	1.5349				
L.S.D 5%	4.4619				
L.S.D1%	6.0317				

Appendix 21 Results of analysis of variance (ANOVA) for No.of Tillers / 0.75 m² of sugarcane (180 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	2	12.761900	6.380952	1.6718	0.2075
Treatments	13	96.119048	7.393773	1.9371	0.0734
Error	26	99.238095	3.816850		
Mean	11.4048				
C.V.	17.1304				
S.E.	1.1280				
L.S.D 5%	-				
L.S.D1%	-				

Appendix 22 Results of analysis of variance (ANOVA) for No. of tillers (000/h) of sugarcane (60DAP) .

source of var.	df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	2	482.527000	241.263500	0.0915	0.9129
Treatments	13	18803.527284	1446.425176	0.5485	0.8714
Error	26	68558.008854	2636.846494		
Mean	118.36				
C.V.	43.38				
S.E.	29.65				
L.S.D 5%	-				
L.S.D1%	-				

Appendix 23 Results of analysis of variance (ANOVA) for No. of tillers (000/h) of sugarcane (90DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	2	156.690000	78.345000	0.2161	0.8071
Treatments	13	38841.703095	2987.823315	8.2406	0.0000
Error	26	9426.883333	362.572436		
Mean	155.3357				
C.V.	12.2582				
S.E.	10.9935				
L.S.D 5%	31.9576				
L.S.D1%	43.2015				

Appendix 24 Results of analysis of variance (ANOVA) for No. of tillers (000/h) of sugarcane (150 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	2	65.080090	32.540040	0.0451	0.9560
Treatments	13	29676.674250	2282.821096	3.1613	0.0060
Error	26	18774.966214	722.114085		
Mean	108.7703				
C.V.	24.7055				
S.E.	15.5147				
L.S.D 5%	45.1003				
L.S.D1%	60.9683				

Appendix 25 Results of analysis of variance (ANOVA) for No. of Millable and Non-millable cane (000/h) of sugarcane (210 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	2	371.298700	185.649300	1.6854	0.2050
Treatments	13	5564.508058	428.039081	3.8858	0.0016
Error	26	2864.016231	110.154470		
Mean	131.0025				
C.V.	8.0116				
S.E.	6.0596				
L.S.D 5%	17.6148				
L.S.D1%	23.8124				

Appendix 26 Results of analysis of variance (ANOVA) for No. of Millable cane (000/h) of sugarcane (210 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	2	140.698300	70.349140	0.2108	0.8113
Treatments	13	21698.363006	1669.104847	5.0006	0.0002
Error	26	8678.329044	333.781886		
Mean	81.6966				
C.V.	22.3629				
S.E.	10.5480				
L.S.D 5%	30.6625				
L.S.D1%	41.4508				

Appendix 27 Results of analysis of variance (ANOVA) for No. of Non -millable cane (000/h) of sugarcane (210 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	2	756.547900	378.274000	0.8894	0.4230
Treatments	13	17730.731900	1363.902454	3.2070	0.0055
Error	26	11057.634989	425.293653		
Mean	49.3948				
C.V.	41.7506				
S.E.	11.9065				
L.S.D 5%	34.6116				
L.S.D1%	46.7892				

Appendix 28 Results of analysis of variance (ANOVA) for No. of millable and non-millable cane (000/ha) of sugarcane (300 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	2	424.619000	212.309500	0.5458	0.5859
Treatments	13	6357.644048	489.049542	1.2573	0.2982
Error	26	10113.060952	388.963883		

Appendix 29 Results of analysis of variance (ANOVA) for No. of millable cane (000/ha) of sugarcane (300 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	2	45.510480	22.755240	0.1645	0.8492
Treatments	13	11202.171429	861.705495	6.2303	0.0000
Error	26	3596.002857	138.307802		

Appendix 30 Results of analysis of variance (ANOVA) for No. of Non -millable cane (000/ha) of sugarcane (300 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	2	596.939000	298.469500	0.6143	0.5487
Treatments	13	10926.698333	840.515256	1.7299	0.1136
Error	26	12632.940952	485.882344		

Appendix 31 Results of analysis of variance (ANOVA) for leaf number / 0.75 m² of sugarcane (60 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	2	956.333300	478.166700	0.6136	0.5491
Treatments	13	22267.333333	1712.871795	2.1980	0.0424
Error	26	20261.666667	779.294872		
Mean	77.33				
C.V.	36.10				
S.E.	16.12				
L.S.D 5%	46.85				
L.S.D1%	63.34				

Appendix 32 Results of analysis of variance (ANOVA) for Leaf number /0.75 m² of sugarcane(150 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	2	2637.762000	1318.881000	1.3386	0.2797
Treatments	13	34216.571429	2632.043956	2.6713	0.0159
Error	26	25617.571429	985.291209		
Mean	119.9524				
C.V.	26.1682				
S.E.	18.1227				
L.S.D 5%	52.6816				
L.S.D1%	71.2170				

Appendix 33 Results of analysis of variance (ANOVA) for Leaf number /0.75 m² of sugarcane (180 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	2	5009.333000	2504.667000	4.2877	0.0246
Treatments	13	12428.571429	956.043956	1.6366	0.1381
Error	26	15188.000000	584.153846		
Mean	126.6190				
C.V.	19.0882				
S.E.	13.9541				
L.S.D 5%	-				
L.S.D1%	-				

Appendix 34 Results of analysis of variance (ANOVA) for cane yield (t/ha) of sugarcane (330 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	2				
Treatments	13				
Error	26				

Appendix 35 Results of analysis of variance (ANOVA) for sucrose (%) of sugarcane (330 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	2	0.624091	0.312045	1.3124	0.2864
Treatments	13	2.919317	0.224563	0.9444	0.5252
Error	26	6.182176	0.237776		

Appendix 36 Results of analysis of variance (ANOVA) for Purity (%) of sugarcane (330 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	2	0.126686	0.063343	0.0365	0.9643
Treatments	13	10.920098	0.840008	0.4834	0.9146
Error	26	45.182181	1.737776		

Appendix 37 Results of analysis of variance (ANOVA) for sugar yield (t/ha) of sugarcane (330 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	2	29.47762	14.73881	0.4258	0.6577
Treatments	13	1165.677381	89.667491	2.5905	0.0188
Error	26	899.969048	34.614194		
Mean	39.9881				
C.V.	14.7128				
S.E.	3.3968				
L.S.D 5%	9.8742				
L.S.D1%	13.3484				

Second Experiment

Appendix 38 Effect of sulfentrazone herbicide on germination Percentage (%) of sugarcane (45 DAP) .

Treatments	Time of application	Dose (g a.i/ha)	Mean
Sulfentrazone	PPI	720	50.5
Sulfentrazone	PPI	1440	56.9
Sulfentrazone	Pre-eme	720	54.3
Sulfentrazone	Pre-eme	1440	54.8
Untreated control(weedy)	-	-	38.6
L.S.D. 0.05			9.77

Appendix 39 Effect of sulfentrazone herbicide on proportion of weed control (%) during the different growth stages of sugarcane

Treatments	Time of application	Dose (g a.i/ha)	60DAP	90DAP	120DAP
Sulfentrazone	PPI	720	61.4	49.4	57.0
Sulfentrazone	PPI	1440	76.3	69	74.2
Sulfentrazone	Pre-eme	720	57.2	45.9	58.5
Sulfentrazone	Pre-eme	1440	69.8	68.6	69.7
Untreated control(weedy)	-	-	00.0	00.0	00.0

Appendix 40 Effect of sulfentrazone herbicide on Proportion of inhibition of dry matter (%) during the different growth stages of sugarcane

Treatments	Time of application	Dose (g a.i/ha)	60DAP	90DAP	120DAP
Sulfentrazone	PPI	720	86.3	84.1	78.3
Sulfentrazone	PPI	1440	90.2	88.9	83.5
Sulfentrazone	Pre-eme	720	83.0	80.2	73.7
Sulfentrazone	Pre-eme	1440	87.8	85.3	81.8
Untreated control(weedy)	-	-	00.0	00.0	00.0

Appendix 41 Effect of sulfentrazone herbicide on number of millable and non-millable cans (000/ha) of sugarcane at 210 DAP.

Treatments	Time of application	Dose (g a.i./ha)	Millable and non-millable cane	millable cane	Non-millable cane
Sulfentrazone	PPI	720	150.7	127.3	23.3
Sulfentrazone	PPI	1440	188.5	169.2	19.2
Sulfentrazone	Pre-eme	720	174.8	147.1	27.7
Sulfentrazone	Pre-eme	1440	188.9	169.2	19.6
Untreated control(weedy)	-	-	114.8	66.1	48.7
L.S.D. 0.05			32.83	24.66	16.01

Appendix 42 Effect of sulfentrazone herbicide on number of millable And non-millable cans (000/ha) of sugarcane at 300 DAP.

Treatments	Time of application	Dose (g a.i/ha)	Millable and non-millable cane	millable cane	Non-millable cane
Sulfentrazone	PPI	720	153.0	111.5	41.5
Sulfentrazone	PPI	1440	169.9	131.9	38.0
Sulfentrazone	Pre-eme	720	164.6	117.4	47.2
Sulfentrazone	Pre-eme	1440	171.1	132.8	38.3
Untreated control(weedy)	-	-	138.3	63.6	74.7
L.S.D 0.05			20.35	14.72	16.71

Appendix 43 Effect of sulfentrazone herbicide on cane length and girth (cm) of sugarcane at 330 DAP.

Treatments	Time of application	Dose (g a.i/ha)	Cane length (cm)	Cane girth (cm)
Sulfentrazone	PPI	720	252	2.60
Sulfentrazone	PPI	1440	257	2.85
Sulfentrazone	Pre-eme	720	240	2.62
Sulfentrazone	Pre-eme	1440	246	2.68
Untreated control(weedy)	-	-	183	2.77
L.S.D 0.05			17.25	NS

Appendix 44 Results of analysis of variance (ANOVA) for Germination percentage (%) of sugarcane .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	3	87.037500	29.012500	0.7213	0.5583
Treatments	4	856.592000	214.148000	5.3240	0.0106
Error	12	482.680000	40.223333		
Mean	50.9950				
C.V.	12.4369				
S.E.	3.1711				
L.S.D 5%	9.7710				
L.S.D1%	13.6984				

Appendix 45 Results of analysis of variance (ANOVA) for weed density /m² of sugarcane (60 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	3	25.000000	8.333333	0.2488	0.8607
Treatments	4	4299.200000	1074.800000	32.0836	0.0000
Error	12	402.000000	33.500000		

Appendix 46 Results of analysis of variance (ANOVA) for weed density /m² of sugarcane (90 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	3	130.950000	43.650000	1.0512	0.4056
Treatments	4	5149.700000	1287.425000	31.0036	0.0000
Error	12	498.300000	41.525000		

Appendix 47 Results of analysis of variance (ANOVA) for weed density /m² of sugarcane (120 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	3	25.000000	8.333333	0.2488	0.8607
Treatments	4	4299.200000	1074.800000	32.0836	0.0000
Error	12	402.000000	33.500000		

Appendix 48 Results of analysis of variance (ANOVA) for dry matter (g/m²) of sugarcane (60 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	3	248.756000	82.918660	3.4155	0.0529
Treatments	4	12780.627000	3195.156750	131.6102	0.0000
Error	12	291.329000	24.277417		

Appendix 49 Results of analysis of variance (ANOVA) for dry matter (g/m²) of sugarcane (90 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	3	169.121500	56.373840	2.9833	0.0737
Treatments	4	21056.147000	5264.036750	278.5684	0.0000
Error	12	226.761000	18.896750		

Appendix 50 Results of analysis of variance (ANOVA) for dry matter (g/m²) of sugarcane (120 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	3	1076.698000	358.899200	1.8127	0.1985
Treatments	4	38782.007000	9695.501750	48.9700	0.0000
Error	12	2375.865000	197.988750		

Appendix 51 Results of analysis of variance (ANOVA) for cane length (cm) of sugarcane (330 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	3	2136.550000	712.183300	5.6816	0.0117
Treatments	4	13413.800000	3353.450000	26.7527	0.0000
Error	12	1504.200000	125.350000		

Appendix 52 Results of analysis of variance (ANOVA) for cane Girth (cm) of sugarcane (330 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	3	0.001500	0.000500	0.0113	0.9983
Treatments	4	0.177000	0.044250	1.0000	0.4449
Error	12	0.531000	0.044250		

Appendix 53 Results of analysis of variance (ANOVA) for No. of tillers (000/h) of sugarcane (90DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	3	4817.103000	1605.701000	1.0264	0.4155
Treatments	4	96703.361952	24175.840488	15.4539	0.0001
Error	12	18772.607391	1564.383949		
Mean	205.8345				
C.V.	19.2156				
S.E.	19.7762				
L.S.D 5%	60.9358				
L.S.D1%	85.4283				

Appendix 54 Results of analysis of variance (ANOVA) for No. of tillers (000/h) of sugarcane (120 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	3	6289.010000	2096.337000	1.0908	0.3904
Treatments	4	5690.949848	1422.737462	0.7403	0.5825
Error	12	23062.970378	1921.914198		
Mean	173.7926				
C.V.	25.2253				
S.E.	21.9198				
L.S.D 5%	-				
L.S.D1%	-				

Appendix 55 Results of analysis of variance (ANOVA) for No of Tillers (000/h) of sugarcane (180 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	3	2855.709000	951.903000	3.2528	0.0598
Treatments	4	26619.640974	6654.910244	22.7409	0.0000
Error	12	3511.687475	292.640623		
Mean	157.9174				
C.V.	10.8327				
S.E.	8.5534				
L.S.D 5%	26.3553				
L.S.D1%	36.9486				

Appendix 56 Results of analysis of variance (ANOVA) for No. of tillers (000/h) of sugarcane (210 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	3	2368.457000	789.485600	1.7390	0.2122
Treatments	4	15722.166918	3930.541729	8.6580	0.0016
Error	12	5447.718030	453.976502		
Mean	163.6049				
C.V.	13.0233				
S.E.	10.6534				
L.S.D 5%	32.8260				
L.S.D1%	46.0200				

Appendix 57 Results of analysis of variance (ANOVA) for No. of Millable can (000/ h) of sugarcane (210 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	3	1282.778000	427.592800	1.6687	0.2263
Treatments	4	29170.856780	7292.714195	28.4607	0.0000
Error	12	3074.856668	256.238056		
Mean	135.8547				
C.V.	11.7828				
S.E.	8.0037				
L.S.D 5%	24.6617				
L.S.D1%	34.5742				

Appendix 58 Results of analysis of variance (ANOVA) for No. of Non -millable cane (000/h) of sugarcane (210 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	3	205.351300	68.450420	0.6337	0.6074
Treatments	4	2389.703001	597.425750	5.5309	0.0092
Error	12	1296.183446	108.015287		
Mean	27.7497				
C.V.	37.4528				
S.E.	5.1965				
L.S.D 5%	16.0119				
L.S.D1%	22.4478				

Appendix 59 Results of analysis of variance (ANOVA) for No. of tillers (000/h) of sugarcane (300 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	3	1000.468000	333.489300	1.9110	0.1817
Treatments	4	3057.428000	764.357000	4.3801	0.0206
Error	12	2094.092000	174.507667		
Mean	159.3600				
C.V.	8.2895				
S.E.	6.6051				
L.S.D 5%	20.3521				
L.S.D1%	28.5324				

Appendix 60 Results of analysis of variance (ANOVA) for No. of Millable cane (000/h) of sugarcane (300 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	3	592.492000	197.497300	2.1625	0.1455
Treatments	4	12820.823000	3205.205750	35.0956	0.0000
Error	12	1095.933000	91.327750		
Mean	111.4400				
C.V.	8.5755				
S.E.	4.7783				
L.S.D 5%	14.7232				
L.S.D1%	20.6410				

Appendix 61 Results of analysis of variance (ANOVA) for No. of non -millable cane (000/h) of sugarcane (300 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	3	375.452000	125.150700	1.0643	0.4005
Treatments	4	3798.517000	949.629250	8.0756	0.0021
Error	12	1411.103000	117.591917		
Mean	47.9200				
C.V.	22.6293				
S.E.	5.4220				
L.S.D 5%	16.7067				
L.S.D1%	23.4217				

Appendix 62 Results of analysis of variance (ANOVA) for Phytotoxicity of sugarcane (90DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	3	209.800000	69.933330	0.9215	0.4599
Treatments	4	661.700000	165.425000	2.1798	0.1331
Error	12	910.700000	75.891667		
Mean	8.3000				
C.V.	104.9588				
S.E.	4.3558				
L.S.D 5%	-				
L.S.D1%	-				

Appendix 63 Results of analysis of variance (ANOVA) for cane Yield (t/ha) of sugarcane (330 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	3	95.802000	31.934000	3.0731	0.0687
Treatments	4	5136.418000	1284.104500	123.5726	0.0000
Error	12	124.698000	10.391500		

Appendix 64 Results of analysis of variance (ANOVA) for sucrose (%) of sugarcane (330 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	3	0.046480	0.015493	0.1251	0.9434
Treatments	4	0.978100	0.244525	1.9746	0.1627
Error	12	1.486020	0.123835		

Appendix 65 Results of analysis of variance (ANOVA) for purity (%) of sugarcane (330 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	3	4.365175	1.455058	1.9148	0.1811
Treatments	4	1.753670	0.438417	0.5769	0.6849
Error	12	9.118850	0.759904		

Appendix 66 Results of analysis of variance (ANOVA) for sugar yield (t/ha) of sugarcane (330 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	3	2.921500	0.973833	2.1921	0.1418
Treatments	4	148.177000	37.044250	83.3861	0.0000
Error	12	5.331000	0.444250		

Third Experiment
Effect of some of weed control methods on some of physiological characters of sugarcane

Appendix 67 Effect of weed control methods on some physiological characteristics of sugarcane.

Treatment	Time of Application	Dose (g a.i./ha)	Leaf area (cm^2/stalk)		Leaf area index	
			210DAP	300DAP	210DAP	300DAP
Sulfentrazone 48% F	PPI	720	429.2	296.9	4.1	4.9
Sulfentrazone 48% F	Pre-em:3DAP	720	473.3	332.2	4.9	4.8
Trash mulching	3 DAP	-	417.8	286.6	4.6	3.2
Three hoeing	60,90,120 DAP	-	448.3	258.0	5.0	2.8
Untreated control(weedy)	-	-	306.4	268.4	5.1	3.4
L.S.D. 0.05			28.18	59.05	1.71	1.04

Appendix 68 Results of analysis of variance (ANOVA) for Length of stalks of sugarcane (210 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	2	1697.809000	848.904700	3.5105	0.0805
Treatments	4	4775.497333	1193.874333	4.9371	0.0266
Error	8	1934.530667	241.816333		
Mean	163.9133				
C.V.	9.4870				
S.E.	8.9781				
L.S.D 5%	29.2790				
L.S.D1%	42.6029				

Appendix 69 Results of analysis of variance (ANOVA) for No. of internodes of sugarcane (210 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	2	4.144000	2.072000	1.3444	0.3138
Treatments	4	28.266667	7.066667	4.5853	0.0322
Error	8	12.329333	1.541167		
Mean	16.8000				
C.V.	7.3895				
S.E.	0.7167				
L.S.D 5%	2.3374				
L.S.D1%	3.4011				

Appendix 70 Results of analysis of variance (ANOVA) for No. of dry leaf of sugarcane (210AP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	2	6.569334	3.284667	3.0948	0.1010
Treatments	4	40.953333	10.238333	9.6467	0.0038
Error	8	8.490667	1.061333		
Mean	7.3333				
C.V.	14.0483				
S.E.	0.5948				
L.S.D 5%	1.9397				
L.S.D1%	2.8224				

Appendix 71 Results of analysis of variance (ANOVA) for No. of Green leaf of sugarcane (210 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	2	3.605333	1.802667	3.0588	0.1031
Treatments	4	5.629333	1.407333	2.3880	0.1371
Error	8	4.714667	0.589333		
Mean	10.1733				
C.V.	7.5460				
S.E.	0.4432				
L.S.D 5%	-				
L.S.D1%	-				

Appendix 72 Results of analysis of variance (ANOVA) for Fresh weight of stalks of sugarcane (210 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	2	66148.430000	33074.210000	7.2525	0.0160
Treatments	4	242946.696000	60736.674000	13.3183	0.0013
Error	8	36483.108000	4560.388500		
Mean	603.6600				
C.V.	11.1869				
S.E.	38.9888				
L.S.D 5%	127.1493				
L.S.D1%	185.0110				

Appendix 73 Results of analysis of variance (ANOVA) for Green Leaf weight of sugarcane (210 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	2	125.356000	62.678000	0.0664	0.9363
Treatments	4	869.630667	217.407667	0.2303	0.9137
Error	8	7552.057333	944.007167		
Mean	129.3800				
C.V.	23.7476				
S.E.	17.7389				
L.S.D 5%	-				
L.S.D1%	-				

Appendix 74 Results of analysis of variance (ANOVA) for Dry leaf weight of sugarcane (210 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	2	103.996000	51.998000	2.0804	0.1873
Treatments	4	2635.202667	658.800667	26.3577	0.0001
Error	8	199.957333	24.994667		
Mean	39.5600				
C.V.	12.6377				
S.E.	2.8864				
L.S.D 5%	9.4132				
L.S.D1%	13.6968				

Appendix 75 Results of analysis of variance (ANOVA) for Fresh weight of sheath of sugarcane (210 DAP) .

source of var.	Df	Sum of Squares	Mean Squares	f value	Prob.
Replicate	2	742.385300	371.192700	3.4448	0.0833
Treatments	4	579.716000	144.929000	1.3450	0.3334
Error	8	862.028000	107.753500		
Mean	77.9733				
C.V.	13.3128				
S.E.	5.9931				
L.S.D 5%	-				
L.S.D1%	-				

photos about the experiments and different treatments

2,4-D spray 60 DAP

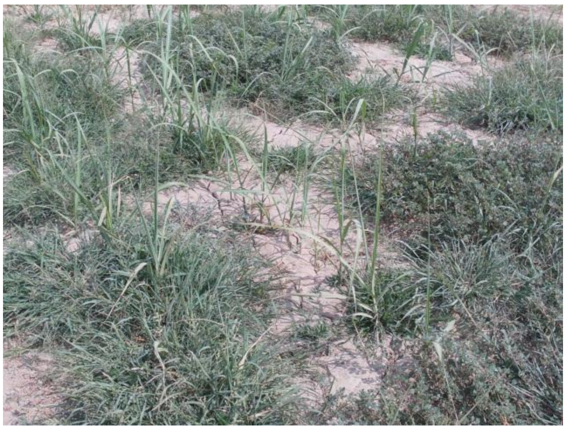
Sulfentrazone spray PPI

Preparation of experiments land

The different treatments at 90 days after planting. (First Experiment)

Left : Sulfentrazone -PPI- 480 g a.i/ha
Right: Sulfentrazone -PPI- 600 g a.i/ha

Left : Sulfentrazone -PPI- 720 g a.i/ha
Right: Sulfentrazone -PPI- 900 g a.i/ha




Left : Sulfentrazone -Pre-eme 480 g a.i/ha
Right: Sulfentrazone -Pre-eme 600 g a.i/ha


Left : Sulfentrazone -Pre-eme 720 g a.i/ha
Right: Sulfentrazone -Pre-eme 900 g a.i/ha


Left: Atrazine 50 WP + 2,4-D 80% WP
2000 + 1000 g a.i/ha
Right: Three hoeings 60,90 and 120 DAP


Left: Trash Mulching
Right: T2 + one hoeing at 60 DAP

Left: T6 + one hoeing at 60 DAP
Right: Untreated control(Weedy)

The different treatments at 90 days after planting (Second Experiment)

Sulfentrazone 4 F -PPI- 720 a.i/ha

Sulfentrazone 4 F -PPI- 1440 a.i/ha

Sulfentrazone 4 F -Pre-eme- 720 a.i/ha

Sulfentrazone 4 F -Pre-eme- 1440 a.i/ha

Control untreated (Weedy)

DEDICATE

To the Pure spirit of my father and mother
To the pure spirit of my brother
AMER and my sister LEMYA

TO MY DEAR WIFE

NIDHAL

and my dear sons
ZAINAB, ABDULLA
and
ABDULRAHMAN

Dedicate the fruit of my best

Dr. N.F. ALMUBARAK