EFFECT OF HERBICIDES AND SOIL MOISTURE ON WEED CONTROL, YIELD AND QUALITY OF SUGAR CANE (*Saccharum officinarum*L) AT KILOMBERO, TANZANIA

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ABSTRACT

Field experiments were conducted at Kilombero Sugar Company estate one under rainfed and another under rainfed plus supplemental irrigation condition to evaluate the effects of herbicides on weeds and sugarcane (*Saccharum officinarum L*) yield and quality. Experiments were laid out in a randomized complete block design with four replications. Plot sizes of 5.8 m x 4 m were used. Treatments were Volmazone (2-(2-chlorobenzyl)-4,4-dimethyl-1,2-oxazolidin-3-one) at 2.9 and 3.8 kg a.i ha^{-1}; Acetochlor 2-chloro-N-ethoxymethyl-6-ethylaceto –o-toluidide at 4.5 and 6.0 kg a.i ha^{-1} and Metribuzin 4-amino-6(1,1-dimethyl)-3-Methilthio-1,2,4 triazin-5(4H) 6.0 and 7.5 kg a.i.ha^{-1}. Which were applied as early post emergence. These were compared with weed free check which was hand weeded every two weeks and untreated check. Results revealed that there was significant difference between herbicides treated plots as compared to unweeded check plots ($p < 0.05$). There was no significant difference between herbicide treated plots and weed free check. All herbicides were effective in controlling grasses and broadleaf weeds to an acceptable level above (90%) up to 8 WAT for both irrigated and rainfed crop, a period which is quite satisfactory for sugarcane. There were variable herbicide treatment effects on individual grass weed species. Itchgrass was best controlled by Volmazone, while *Leptochloa* and *Echnochloa spp* were best controlled by acetochlor and metribuzin. Almost all herbicide treatments were ineffective incontrolling nut sedges the control was bellow an acceptable level 90%, although were significant ($p < 0.05$) as compared to unweeded check. There was a significant difference in sugarcane yield tons ha^{-1} between herbicides treated plots as compared to unweeded check plots ($p < 0.05$) for both irrigated and rainfed experiments,but no significant difference in sugarcane yield was observed between herbicide treated plots and weed free check ($p < 0.05$). For the irrigated experiment, the treatment with acetochlor 4.5 kg a.i ha^{-1}increased yield by 74.7 % which was higher than all other treatments. Other treatments, volmazone 3.8 kg a.i ha^{-1}; metribuzin 6.0 kg a.i ha^{-1};volmazone2.9 kg a.i ha^{-1}; metribuzin 7.5 kg a.i ha^{-1}; weed free check and acetochlor 6.0 kg a.i ha^{-1} increased yield between 37.8 and 57.3 % compared to unweeded check. For the rainfed experiment, treatment with acetochlor 4.5 kg a.i ha^{-1}increased yield by 50.0 % and other treatments that is acetochlor 6.0 kg a.i ha^{-1}; metribuzin 6.0 kg a.i ha^{-1}; weed free check; metribuzin 7.5 kg a.i ha^{-1}; volmazone 3.8 kg a.i ha^{-1} and volmazone 2.9 kg a.i ha^{-1} increased the yield of sugarcane between 40.3 and 48.8 % over unweeded check. Both irrigated and rainfed experiments sugarcane yields tons ha^{-1} positively correlated with number of millable stalks population ($r = 0.834$ and 0.942) respectively. Different treatments of herbicides had no effect on sugarcane quality parameters ($P < 0.05$). Economic analysis showed that the highest net benefit and marginal rate of return of 1124.2% was achieved by treatment with volmazone at 2.9 kg ai $ha^{-1}$for irrigated experiment and for the rainfed experiment the highest net benefit and marginal rate of return of 412.3 % was achieved by treatment with acetochlor at a rate of 4.5 kg a.i ha^{-1}.

DECLARATION

I, HERMAN FRANCIS KALIMBA, hereby declare to the senate of the Sokoine University of Agriculture, Morogoro that this thesis has not been submitted for a degree award in any other university

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(MSc Candidate)

The above declaration is confirmed by

Prof. K. P. Sibuga   Date

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ABREVIATION AND SYMBOLS

SBT	-	Sugar Board of Tanzania
WAT	-	Weeks after herbicide treatment
TCH	-	Tons of sugarcane per hectare
ERS%C	-	Estimated recoverable sugar percent cane
TSH	-	Tons of sugar per hectare
USA	-	United States of America
RCBD	-	Randomized complete block design
CIMMYT	-	International Maize and Wheat Improvement Centre
MRR	-	Marginal rate of return
%	-	Percent
<	-	Less than

CHAPTER ONE

1.0 INTRODUCTION

1.1 Importance of sugar industry in Tanzania

The sugar industry is one of the largest food manufacturing sector in Tanzania (Sterkenburg, 1992). It contributes substantially to the economy of the country. Sugar production not only earns the nation some revenue but also saves the national expenditure on importing it. It also provides raw materials for chemical and food processing industries. The importance of sugar in Tanzania led the government to give emphasis on high domestic sugar production (Tanzania: Ministry of Agriculture, 2006). Sugar industry contributes about 12.3 billion Tanzanian shillings to government revenue that is 1.7% of total tax revenue. It provides direct employment to about 14,000 peoples, while small scale sugarcane grower’s (Outgrower’s) total about 30,000. Secondary employments under the sector involve about 81,000 people.

The sugar sector provides sugarcane farmers with total earnings of about 4 billion Tanzanian shillings annually whose benefits are spread to a population of over 150,000 people. It plays a vital role in rural areas in the development of social amenities including schools, hospitals, water supply, township and farm roads (SBT, 2012).

1.2 General performance of sugar industry in Tanzania

1.2.1 Sugar production trend and forecasts

Sugar production trend in Tanzania has been improving after privatization initiated in 1997/98. The rise is attributed to better management of factories after the industries privatization. The industry is likely to have increased investments and its productive capacity over the period of five years and output has reached 250,000 tons in 2009/10. The aim is to increase sugar production to 420,000 tons by 2016.

1.2.2 Production constrains

Kilombero Sugar Company is one of the four sugar producing Companies in Tanzania. The Company has two factories KI and KII, which have total installation capacity of 140,000 tons of sugar per annum.In 2011/2012 the two factories produced only 103,100 tons (Mwangobola H,personal communication).The national demand is estimated to be 480,000 tons of sugar per annum.

The suboptimal use of sugar processing capacity has been attributed mainly to low cane production and subsequently low sugarcane yields attributed to several factors including insect pests, diseases and weeds (Sterkenburg, 1992). Weed infestation in the early stages of sugarcane growth is a major factor determining yield of cane. Obien and Baltazar (1979) reported 106 weed species belonging to 32 families associated with sugarcane. Of these, itchgrass (*Rottboellia cochinchinensis* (Lour) Clayton)Purple nutsedge(*Cyperus rotundus*), blue morning glory (*Ipomoea congesta*),*Panicum maximum*and *Sorghum helepense* are reported to pose serious problems atKilombero (Isa, 2000). Millhollon (1992) reported that losses of sugarcane due to itchgrass infestation were as high as 70% when the weed was not timely controlled.

At Kilombero Sugar Estate several methods are currently being used to control weeds. Hand weeding is the most common method but very expensive in terms of labour and time (Mtunda *et al*., 1999). Disking and interrow cultivation methods are also practised. However, the methods do not solve the problem fully as they do not remove weeds within the crop rows.Proper use of herbicides can ensure successful control of many weed species.However, the use of herbicides with the same mode of action (belonging to the same herbicide group) year after year has resulted into some weeds developing resistance to herbicides used (Isa, 2000). For example *Commelina diffusa* is known to be resistant to 2, 4-D, *Rottboelia cochinchinensis* and *Chenopodiun album* are reported to be resistant to atrazine (Heap, 2002).

Effective control of weeds in sugarcane fields can be achieved through application of suitable herbicides. However more information on herbicides that can be used in different production conditions is still required. Therefore theoverall objective of this study was todetermine suitable herbicidesfor weed control in sugarcane fields with the following specific objectives:

i. To evaluate the efficacy of different herbicides for controlling weeds under rainfed and rainfed plus supplemental irrigation conditions.
ii. To determine the effects of different herbicides onyield and quality of sugarcane.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 The sugarcane crop

Sugarcane is a tall growing grass crop of the family *Poaceae*, genus *saccharum* L. The *Saccharum* genus comprises six species,*S. spontaneum*, *S. officinarum*, *S. robustum*, *S. edule*, *S. barberi*, and *S. sinense (D'Hont et al., 1998)*. The most widely grown specie is *Saccharum officinarum*.

Sugarcane grows well in tropical areas with temperature between 28 and 30^{0}C. Sugarcane requires 1000 - 2000 mm of water received either as rainfall or irrigation or a combination of both depending on the climatic conditions. For the rainfed sugarcane production, a constant and reliable rainfall pattern is required (Ebrahim *et al*., 1998).

Sugarcane grows in a wide range of soils, but good yield is obtained in well drained, aerated and fertile soils,with pH ranging from 5.0 to 8.0. Sugarcane is generally propagated through cuttings of the stalks containing one or more buds. There are two basic sugarcane production cycles. The plant-cane cycle starts with planting and it ends after the first harvest. The ratoon, or ratoon-cane, cycle starts after the harvest of the plant cane and continues with successive ratoon crops until field renewal. Economic yields can be obtained up to six harvests when grown under the rainfed conditions and even more when grown under irrigation condition (Blackburn, 1984).

Depending on the crop cycle, variety, management practices and climatic conditions, sugarcane can mature in 10 to 15 months after planting (Blackburn, 1984). After harvesting of the sugarcane the underground stem emerge to give the next crop cycle referred to as ratoon crop.

2.2 Weed competition in sugarcane

A weed is any plant growing where it is not wanted. On land under cultivation, weeds compete with crops for water, light, and nutrients. Weeds, which share similar requirements for growth and development with the associatedcrop plants are characterized by properties and attribute that favor their establishment in a given cropping system. As such, they will grow in any environment conducive to crop growth.When essential resources are inadequate for the needs of any plant community, competition for resources between plants occurs to the adverse effects of each plant in the community (Peng, 1984).

Sugarcane is best grown on a well-drained fertile soil with good supply of moisture and nutrients. Such conditions also favor intense and rapid growth of a wide range of weed species (Cardoso, 1997).

Although sugarcane is a vigorous plant, the crop suffers from weed competition in its initial development stages. The most detrimental weed species are in the *Poaceae* and *Cyperaceae* families, but morning glory species may also interfere by coiling around the sugarcane plants, reducing leaf unfurling to decrease the photosynthetic area and slowing mechanical harvesting(Cardoso, 1997).

Lakshmikantham (1983) reported that weed-crop competition for the first two months after sowing the crop reduced sugarcane yield by 8% at harvest compared to weed free. The weed competition starting from 3 to 9 weeks after planting reduces yield by 77.6 and

41.7 %, respectively (Zimdhal., 1980). It was reported that weeds posed serious threat to sugarcane crop between two to four months after crop planting (Phogat *et al*., 1990).

A field experiment set to determine the effect of duration of weed competition on sugarcane indicated that maximum tillers were produced when weeds were removed up to 12 weeks after crop emergence and generally early removal of weeds from the crop resulted in increased plant height and cane yield (Khan and Hashmi, 1987).

The effect of weed competition on sugarcane has been reported by various workers. In thePhilippines, Obien and Baltazar (1979) estimated that losses due to weed infestation ranged from 25 to 75%. Fute (1990) reported that in Kilombero, Tanzania weeds reduced sugarcane yield by 83% and 84.3% compared to weeded cane for the rainfed and irrigated crops, respectively. Ibrahim (1984) reported that, in Sudan, weed reduced sugar yield by 40%. Cepero and Rodriguez (1983) reported that weeds reduced yield of sugarcane by 20 to 60% depending on the variety, crop cycle and agro ecological conditions. Millhollon (1992) reported that uncontrolled itchgrass reduced sugar yield by 70% as compared to weed free control. The reduced yield was mainly attributed to reduction in tillering and stalks population by 20% and 25% respectively.

Durigan (2005) in experiments conducted in Brazil reported that purple nutsedge population of 58 to 246 shoots per m^2 reduced sugarcane yield by 14% and a shoot population of 675 to 1198 per m^2 reduced sugarcane yield by 45%. Richard and Dalley (2007) working in Lousiana USA reported that once bermudagrass (*Cynodon dactylon*) was established, sugarcane stalk populations in plant cane, first ratoon, and second ratoon could be reduced by 23%, 15%, and 10 %, respectively. An experiment evaluating weed-crop competition in sugarcane (Millhollon, 1995), revealed that full-season Johnson grass

(*Sorghum helepense*) competition with sugarcane reduced sugarcane yields by 23% and sugar by 17% in the planted crop and 42 and 35% in the first-ratoon crop respectively. Johnsongrass population was negatively correlated with sugarcane yield, when johnsongrass and cane yield was analyzed using linear regression (Ali *et al*.,1986).

Early season weed competition (up to 6 weeks) resulted in 9 to 39 percent reduction in sugar yield (Millhollon, 1988). Nayyar *et al*., (1994) revealed that 86.7 t ha-1 cane yields 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^{-1}. Verma (2000) and Tomar *et al.*, (2003) reported that weeds if not controlled caused 12 to 72 % reduction in sugarcane yield. Another study was reported by Kuva *et al.*,(2000) in which purple nut sedge (*Cyperus rotundus*) was the predominant weed species in sugarcane crop. Weed-crop competition started at initial sugarcane sprouting. However, the purple nut sedge is very sensitive to sugarcane canopy shading and low temperature. Hence, competitions ended at 22 days after planting.

Millhollon (1992) reported that weed-crop competition between sugarcane and itchgrass for 30 to 180 days reduced sugar yield by 7 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, weed control up to shooting stage, weed control up to root transition stage, weed control up to 3-4 months, and weed control for full season in Q-88 sugarcane variety. The results revealed that cane yield increased to 98.1% with increasing weed free period and decreased to 38.1%, when weed-crop competition was 3-4 months.

2.3 Critical period of weed competition in sugarcane

Weeds compete throughout the life cycle of the crop, but the crop suffers more to the presence of weeds at a specific period during its life cycle. This is known as the critical period of weed competition during which weeds cause maximum yield loss (Zimdhal, 1980).The initial growth of sugarcane is slow and the crop is widely spaced it takes longer period to cover the soil; critical period of weeds is therefore longer (Reddy and Reddi, 2002).Zimdhal (1980) reported that the critical weed competition period varies from one location to another or within the same location depending on the growing stages and types of weeds.Srivastava *et al.*, (2003) reported that the critical period of weed competition in sugarcane ranged between one to two months.

It is generally reported that the critical period of weed competition in sugarcane fields falls within the early stages of growth that is from the emergence of primary shoots at the third week to the appearance of first tillers at the sixth week after planting(Peng, 1984).Ibrahim (1984) recorded a reduction of 30% in cane yield when cane was left under competition with weed between the fourth and eighth week after planting and thatthis period coincided with establishment of primary shoots and tillering. Peng (1984) reported that the period from the third to sixth weeks after planting was the critical period of spring planted cane. Karim (1998) reported a reduction of 37% in cane yield when weeds were not controlled within the first six weeks after planting, and reduction of 77% when the crop was not weeded for the whole season. Karim (1998) then concluded that weeds cause more economic losses in sugarcane than all other pests combined. Weeds reducesugarcane tonnage in the field sucrose recovery in the mills and can reduce number of ratoons.

In Kenya, Ochieng and Okaka (1983) reported that a weed free condition was necessary during the first 14 weeks from planting. Therefore it is evident that the early growth stages of sugarcane are vulnerable to weed infestations.

2.4 Chemical weed control

Herbicides are chemicals that inhibit or interrupt normal plant growth and development. They are widely used in agriculture, industry and urban areas for weed management. If properly used herbicides can provide cost-effective weed control while minimizing labour. Chemical weed control in sugarcane fields began in 1913, when experiments with Sodium arsenide were established in Hawaii (Peng, 1984). In 1944, Sodium Pentachlorophenol (PCP) was developed. To date more herbicides formulations have been developed and are in use in sugarcane fields.

In mauritius, diuron (3,3,4(dichlorophenyl)-1-dimethyl urea)) and atrazine (2- chloro-4-(ethylamine)-6-(isopropylamino)-5-triazine) have been recommended for higher rainfall areas while monuron [3(P-chlorophenyl)-1-1dimethyl urea] and simazine (2 chloro-4,6 bis (ethylamino)-5-triazine) have been used in dry areas (Peng, 1984). Although simazine is currently not in use because there is concern that this chemical has a carcinogenic effects.In South Africa, a mixiture of diuron (2.5 kg a.iha^{-1}) and 2,4-D (2,4-dichlorophenoxy acetic acid) (1 kg a.iha^{-1}) has often been used for early post emergence application. Diuron (2.5 kg a.iha^{-1}) mixed with paraquat(1,1 dimethyl-4,4-bipyrimidinium dichloride) at 1 kg a.iha^{-1} has been used for post emergence application (Peng, 1984).

Studies in sugarcane have shown that the use of herbicides is superior to non chemical methods. Brandauer (1977) working in Colombia recorded high cost benefit ratios in favor of chemical weed control.The return on the investment was 1:1.45 for manual weeding:and 1:3.7for chemical weed control. No one herbicide will control all species of weeds, so it is important to select herbicides based on the weeds present in a field.

Various pre and post emergence herbicides have been tested and recommended for use in sugarcane estates (Isa, 1996). However most of the tested herbicides give effective weed control only for a short period of 4 to 6 weeks (Isa, 1996; Rugaimukamu, 2000). Herbicide products, which can control weeds for a period of 8 to 10 weeks, are recommended for use in sugarcane fields.Because after8 weeks the crop develops canopy cover sufficient to suppress emerging weeds.

Although weeds can be controlled by mechanical method, mechanical weed control may damage crops. Litlle *et al.*,(2006) reported that chemical weed control is relatively efficient and economical. Turner *et al.*,(1990) reported that 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 the crop and weeds before giving recommendation for their use (Turner *et al.*,1990).

2.5. Effect of soil moisture on sugarcane, weeds and herbicide action

Moisture is essential variable resource required by both sugarcane and weeds for germination and growth especially if rainfall is the only source of water supply. If irrigation is used to supplement the available water to plant some variations in supply is reduced (Radosevich, 1984). Water requirement for the growth of weeds is primarily of interest from the stand-point of competition with the crop plant for the available moisture (Gibson, 2000).Adequate amount of available moisture is essential for weed germination and growth (Radoservich, 1984). Moisture is needed for dormancy breaking of the weed seed. The role of adequate moisture in dormancy breaking is especially important during the period just prior and during germination this is the period of high metabolic activities in the seed (Radoservich, 1984). In dry soil seeds remain dormant. Taylorson (1986) found that adequate moisture was required for foxtail seed germination and that moisture stress induced dormancy. Peng (1984) reported that weed population in cane field within the location may fluctuate mainly due to soil type and soil moisture status.

Callow (2010) reported that sugarcane can withstand certain moisture stress without any serious yield or quality loss as it has remarkable ability to recover and put up normal growth arc released from stress either through rainfall or irrigation. However under severe stress the yield loss may go up to 60-70 percent (Callow, 2010).

Moisture stress varying degree is experienced at one stage or the other of crop growing in almost all the sugarcane growing areas (Zimdhal, 1980).

Weeds possess many growth characteristics and adaptations which enable them to exploit successfully the numerous ecological niches left unoccupied by crops. Among the more important adaptations relevant to competitive advantage are properly synchronized germination, rapid establishment and growth of seedlings, tolerance to shading effects by the crop or by other weeds at the time of establishment, quick response to available soil moisture and nutrients (peng, 1984).

The competition for moisture observed in the early stages of sugarcane development had an impact to the yield (Aitken*et al*., 2011). Aitken*et al* (2011) reported that generally for producing equal amounts of dry matter, weeds transpire more water than do most of our crop plants. It becomes increasingly critical with increasing soil moisture stress, as found in arid and semi-arid areas(Aitken*et al*., 2011). Peng (1984) reported thatin weedy fields soil moisture may be exhausted by the time the sugarcane reaches the stalks formation stage which is the peak consumptive use period of the crop, causing significant loss in sugarcaneyields.

Soil moisture can influence both weed growth and herbicide action by inducing plant growth. More active plant growth results in more active metabolic processes and increased herbicide activity (Duke, 1985). How actively a weed is growing has a big effect on how much of the herbicide is absorbed into the plant after it is sprayed (Radoservich, 1984). Radoservich (1986) reported that if the plant is drought-stressed, it closes itself up to conserve moisture and survives. When this happens, spray absorption into the plant is also greatly reduced. Once the herbicide is absorbed into the plant, the killing activity occurs due to some type of effect on certain metabolic processes in the plant. Duke (1985) reported that when plant growth reduces or stops due to limited soil moisture, herbicide activity within the plant reduces or stops.Crop plants and weeds may grow and mature in the state of mutual suppression that is often found in crops where no suitable herbicide is available to control the weeds.

2.6. Phytotoxicity

Sugarcane comes into contact with herbicides by either growing in treated soil or from spray applications after the crop has emerged. In Louisiana,USA it was found that sugarcane varieties CP 44-101 and CP 52-68 were severely injured by higher rates of Dalapon when sprayed at 10 – 13.5 kg ai/ha whilethe same treatments were tolerated by variety NCo 310. When Dalapon was sprayed at post emergency at 10 kg aiha^{-1} caused significant losses ofsugarcane crop in the 1st, 2nd, and 3rd ratoon crop. There were however, no losses to the crop when ametryn at 3.0 – 5.0kg kg a.iha^{-1} was used (Diaz and Naranjo, 1980).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Location of experiments

The experiments were conducted at the estate of the Kilombero Sugar Company which is situated in Morogoro region, between latitudes $7^0$31' and $7^0$50' south and longitudes $36^0$50' and $37^0$01', east at about 300 m asl. The rainfall in the area is bimodal with pronounced wet and dry seasons. Experiments were established during the short rains in January 2012 and harvested in October 2012. During the 2011/12 seasonthere was an observed change in rainfall pattern at Kilombero. The short rains whichstarted in November 2011 extended up to Mayand the period from June to October during the season was generally dry. Mean annual rainfall at Kilombero is about 1500 mm with mean monthly temperature of 29.9 ^{0}C.The soils are predominant alluvial sands and silts. The rainfall received during experimental period is shown in appendix 1.

3.2 Field Experiments

Two field experiments were laid down at the kilombero II estate fields Januaryto October 2012; one experiment was under rainfed conditions and the other under irrigated conditions. Both experiments were located in ratoon crop fields. A ratoon crop is a new sugarcane crop that grows from the stubble of the crop already harvested.

3.3 Experimental layout

Each of the two experiments was laid out in a randomized complete block design (RCBD) with four replications. Individual experimental plots were 5.8 m x 4 m comprising 4 sugarcane rows of 4 m long spaced at 1.45 m apart. Adjacent plots and replications were separated by 2 m path. The complete set of treatment is given in table 1.

Table 1. Details of treatments

Treatments	Description	Dose	Quantity of commercial product used kg and l ha^{-1}	Application time
T1	Volmazone 480 EC	2.9 kg a.i ha^{-1}	6.0	3 weeks after ratooning
T2	Volmazone 480 EC	3.8 kg a.i ha^{-1}	8.0	3 weeks after ratooning
T3	Acetochlor 900 EC	4.5 kg a.i ha^{-1}	5.0	3 weeks after ratooning
T4	Acetochlor 900 EC	6.0 kg a.i ha^{-1}	6.7	3 weeks after ratooning
T5	Metribuzin 750 WP	6.0 kg a.i ha^{-1}	8.0	3 weeks after ratooning
T6	Metribuzin 750 WP	7.5 kg a.i ha^{-1}	10.0	3 weeks after ratooning
T7	Unweeded check	-	0.0	Unweeded from ratooning to harvesting
T8	Weed free check	-	0.0	Hand weeding after every two weeks

3.4 Fertilizer application

All experimental plots received urea as a nitrogen fertilizer at a rate of 150 kg N ha^{-1}, which was applied in single split three weeks after harvesting of sugarcane cropduringexperimentsestablishment.

3.5 Herbicide application

Herbicides were applied using a CP15 knapsack sprayer. The sprayer was calibrated prior to spraying according to procedures described by Fisher and Sabio (1984).

Herbicides were applied as post emergence three weeks after crop ratooning at a spray volume of 200 l/ha. Quantities of commercial product required were calculated using the formula:-

Q (kg or litres/ha) = Rate of herbicide

application (a.i $kgha^{-1}$) X $\frac{100}{\text{\% active ingredient}}$

A brief description of the herbicides used is shown bellow and detailed description is shown in appendix 2

Table 2: Description of herbicides used

S/N	Trade name	Chemical name	Structural formula	Time of application	Application rate
1	Volmazone	2-(2-chlorobenzyl)-4,4-dimethyl-1,2-oxazolidin-3-one		3 weeks after ratooning	2.9 kg a.i/ha
2	Metribuzin	4-amino-6-tert-4,5-dihydro-3-methylthio-1,2,4-triazin-5-one		3 weeks after rationing	6.0 kg a.i/ha
3	Acetochlor	2-chloro-N-(ethoxymethyl)-N-(2-ethyl-6-methylphenyl) acetamide		3 weeks after ratooning	4.5 kg a.i/ha

3.6 Data collection

All data were collected from two center rows in each plot.These were referred to as test rows

3.6.1 Weed assessment

3.6.2Weed species identification

Weed species in each plot in both experimental sites were identifiedtheir density, frequency and uniformity determined and recordedas described by Thomas (1985).

3.6.3 Weed count

Weeds were counted from three fixed quadrates in each plot.Quadrates were established by randomly throwing a 50 cm x 50 cm quadrate, and the area was marked by fixing pegs at the corners. At each counting all weeds from within these quadrates, were counted and recorded by species. Average from three quadrates was determined and then multiplied by 4 to get weed count per m^2. Weed counting was done at an interval of two weeks up to tenth week. The weed count data was used to determine weed density, frequency and uniformity using the procedure originally described by Thomas (1985).(Appendix 3).

3.6.4 Weed control efficiency

Weed control efficiency (WCE) was calculated by using the following formula:

$$W.C.E = \frac{X - Y}{X} \times 100$$

Where WCE = Weed control efficiency

X = weeds count in un weeded plot.

Y = Weeds count in treatment plot.

3.6.5 Sugarcane tillering

Cane tillering were assessed three months after experiments establishment by counting the number of cane shoots from two centerrows in each plot and were expressed as number of shoots per square meter.

3.6.6 Plant height

Ten stalks were selected randomly from two center rows in each plot and marked. Heights were measured from the ground level to the top visible dewlap using a graduated metal rod and were expressed in meters.

3.6.7Number of millable stalks

Millable stalks refer to the stalks that have attained their physiological maturity and are ready to harvest for processing. This was done by counting all cane stalks in the two center rows in each plot at maturity before harvesting and was expressed as number of stalks per square meter.

3.6.8 Sugarcane yield tons ha^{-1} (TCH)

All canes from two center rows in each plot were cut to the ground level, trash removed, chopped at the top visible dewlap, bundled and then weighed and recorded as kilogram of cane per plot. Tons of canes per hectare (TCH) were obtained through calculations. This was done during harvesting (10 months cane)

3.6.9 Sugarcane quality parameters

Quality parameters (Brix % cane, Pol % cane and Purity % cane) were determined just before harvesting that is ten months after establishment of the experiments

3.6.9.1 Brix % Cane

This is the percent soluble substances (sucrose and impurities) in cane. Ten canes from each treatment were crushed through a cane crusher. Juice was collected in the glass jars. Then the brix (percent) reading were determined by using a refractometer.

3.6.9.2 Pol % Cane

This is the apparent sucrose content in the cane juice. Pol reading of extracted juice for each treatment was noted with the help of saccharimeter.

3.6.9.3 Purity % Cane juice

This is the percentage apparent sucrose content in the cane juice, was calculated from the formula, %Purity = (P/B) x 100

Where P = Pol% cane and B = Brix%

3.6.9.4 Estimated recoverable sugar %Cane (ERS %C)

This was calculated using the following formula

ERS %C= a * P – b (B – P) - c * F

Where: P = Pol % cane

B = Corrected brix %

F = Fibre % cane

a, b and c are constant parameters related to factory performance

3.6.9.5 Sugar yield tons ha^{-1} (TSH)

Tons of sugar per hectare was calculated using the following formula

Tons of sugar/ha) = [Yield (tons of cane/ha) x Sugar Recovery (%)] /100

3.6.10 Economic analysis

3.6.10.1 Variable costs

All variable costs involved in experimental treatments were as described below.

3.6.10.1.1 Cost of herbicides

Herbicides price were obtained from a local dealer at Kilombero. The market prices for herbicide during the season were as follows

Volmazone = 48,000/= per litre

Acetochlor = 18,000/= per litre

Metribuzin = 26,000/= per litre

N: B 1US $ = 1635 Tsh:

3.6.10.1.2 Cost of spraying herbicides

The cost of applying herbicides was obtained as follows;-

Mandays(One manday is equivalent to 7 working hrsday^{-1})required for spraying one hectare x labor cost per manday. Time for spraying each one treatment was recorded and was used to calculate the mandays for spraying one hectare. On average two mandays were required to spray one hectare. One manday costs = 4000 Tsh according to factory rate.

3.6.10.1.3 Cost of hand weeding

The cost of hand was obtained by multiplying mandays required to weed one hectare x labor cost per manday. In each hand weeding the time for weeding plots was recorded and used to calculate mandays required to weed one hectare. Cost required to weed one hectare was equivalent to seven mandays x 4000 Tsh x five weedings.

3.6.10.2 Sugarcane price

The market price of sugarcane during the season was obtained from the Kilombero management which was 69,000 shston^{-1}. Field price of sugarcane was obtained by subtracting cutting cost, loading cost and transportation cost from market price of sugarcane. These costs were as follows:-

1. Cutting cost 2,600 Tshton^{-1}.
2. Loading cost 2,500 Tshton^{-1}.
3. Transportation cost 6,300 Tshton^{-1}

N: B: 1US $was1635 Tshs

3.7 Data analysis

3.7.1 Weed assessment

Weed control efficiencies of the treatments were subjected to transformation using arcsine (angular) transformation (Steel *et al*.,1997). Analysis of variance was done using Genstat statistical program version 14.

3.7.2 Yield data

The collected yield data wereanalyzed using a statistical method appropriate for randomized complete block design. Genstat Computer Programme was used in theanalysis of variance. Mean separation was done using the Duncan’s New Multiple Range Test.

3.7.3 Economic analysis

3.7.3.1Gross income

The sugarcane yield was calculated in ton per hectare. Gross income was obtained by multiplying sugarcane yield ton/ha and field price of sugarcane.

3.7.3.2 Net benefit

Net benefit is the difference between total cost of production and gross income. This was obtained by subtracting total variable costs from gross income of sugarcane of each treatment.

3.7.3.3 Dominance analysis

Dominance analysis was carried out by first listing the treatments in order of increasingvariable costs together with their net benefits. A treatment which had less or equal net benefit to treatment with lower variable cost was dominated (CIMMYT, 1988), and therefore was eliminated from further consideration.

3.7.3.4 Marginal rate of return

Undominated treatments were ranked from the lowest to the highest cost treatment. For each pair of ranked treatments, a % marginal rate of return (MRR) was calculated. The % MRR between any pair of undominated treatments denotes the return per unit of investment in herbicide expressed as a percentage.The marginal rate of return of treatments was calculated by dividing change in net benefit between two treatments by the change in total variable costs.

$$\text{MRR (X-Y)} = \frac{\text{Net income (X-Y)}}{\text{Total variable costs (X-Y)}}$$

Where MRR (X-Y) = Marginal rate of return when moving from one treatment to another

Net income X-Y = change in net income from one treatment to another

Total variable X-Y = change in total variable costs from one treatment to another

CHAPTER FOUR

4.0 RESULTS

4.1 Weed occurrences

4.2 Weed density

4.2.1 Irrigated field

The results are presented in table 3.Weed density showed significant differences among different weed species ($p < 0.05$). Purple nutsedge (*Cyperus rotundus*)was the dominantweed specie with an averagedensity of 24.6. Other important weeds included Itchgrass (*Rottboellia cochinchinensis* Lour.)with an average density of 3.6, blue morning glory (*Ipomoea congesta*) 2.6 and sprangle top (*Leptochloa panicea* (Retz.) Ohwi)1.9.Weeds with minor occurance included barnyard grass (*Echnochloa spp*), milkweed (*Euphorbia hilta*), broomweed (*Sida acuta*), pigweed (*Amaranthus spp*), and wandering jew (*Commelina bengalensis* L) which had density of 0.1 each.

4.2.2 Rainfed field

The results are presented in table 4. Purple nut sedge was significant from all other weed species ($p < 0.05$) with density of 34.0.Other species did not differ significantly from each other. Itchgrass had density of 4.3, purslane (*Portulaca oleracea*) 3.1 and hairy galinsoga (*Galinsoga parviflora*) 2.5. Minor weeds were Sprangle top and morning glory with density of 1.4 and 0.4 respectively (Table 4).

4.3 Weed frequency

4.3.1 Irrigated field

Results are presented in table 3.Purple nut sedge was the most commonweed specie and was significant from all other weed species ($p < 0.05$), with frequency percentage of

53.1%. Itchgrass and blue morning glory did not differ significantly and had frequency of37.7 and 28.1 each.Sprangletophad frequency of 15.7 and was not statistically different from the rest of the weeds which were minor. Weed species likepigweed, broomweed, milkweed and wanderingjewwere minor andhad frequency percentages of 3.1% each.

4.3.2 Rainfed field

Purple nut sedge showed significant different to other weed species (p< 0.05) and had a frequency of 62.5% (Table 4). The other common species were purslaneandhairy galinsoga with frequency of 28.1 and 21.9 % but they did not differ significantly (p< 0.05). Itchgrass,morning glory and sprangletop wereless frequent weeds.

Table 3: Weed density, Frequency and uniformity under irrigated conditions

Weed species	Density (No of plant/m^2)	Frequency (%)	Uniformity (%)
Rottboelia cochinchinensis	3.6 b	37.5 ab	5.3
Cyperus rotundus	24.6 a	53.1 a	9.4
Ipomoea congesta	2.6 b	28.1 ab	5.3
Leptochloa panacea	1.9 b	15.7 bc	1.9
Echinochloa crus-galli	0.2 b	3.1 c	0.6
Amaranthus sp	0.1 b	3.1 c	0.3
Sida acuta	0.1 b	3.1 c	0.3
Euphorbia hilta	0.1 b	3.1 c	0.3
Commelina bengalensis	0.1 b	3.1 c	0.3
SE ±	5.6	13.3	2.3
CV %	2.0	1.1	1.1

1. Value in the same column followed by the same letter do not differ significantly (p< 0.05) by Duncan’s New Multiple Range Test.

Table 4: Weed density, Frequency and uniformity under rainfed conditions

Weed species	Density (No of plant/m^2)	Frequency (%)	Uniformity (%)
Rottboelia cochinchinensis	4.3 b	12.5 b	1.3 b
Cyperus rotundus	34.0 a	62.5 a	6.3 a
Ipomoea congesta	0.4 b	3.1 b	3.1 ab
Leptochloa panacea	1.4 b	3.1 b	0.9 b
Galinsoga parviflora	2.5 b	21.9 b	2.2 b
Portulaca oleracea	3.1 b	28.1 ab	2.8 ab
SE ±	9.2	15.8	1.4
CV %	1.6	1.1	0.6

1. Value in the same column followed by the same letter do not differ significantly ($p < 0.05$) by Duncan's New Multiple Range Test.

4.4 Weed control efficiency

4.4.1. Grasses

4.4.1.1 Irrigated field

There were significant ($p < 0.05$) differences in grass control by herbicide treatments compared to unweeded check. All herbicide treatments controlled grassess above 90% up to 8 WAT, though metribuzin which was less effective compared to other herbicide treatments (Table 5). There were variable herbicide treatment effects on individual weed species at 4 and 8 WAT (Figures 1 and 2). Itchgrass was efficiently controlled by volmazone, while spranngle top and barnyard grass were efficiently controlled by acetochlor and metribuzin.

4.4.1.2 Rainfed field

Results obtained were similar to those of irrigated field. There was a significant ($p < 0.05$) differences in grass control by herbicides treatments compared to unweeded check , All herbicide controlled grass weed above 92% which was almost equivalent to weedfree check. Acetochlor wasmore effectivecompared toother herbicides though not statistically significant (Table 6). There were also variable herbicide treatment effects on individual weed species at 4 and 8 WAT (Figures 3 and 4).

4.4.2 Broadleaf

4.4.2.1 Irrigated field

Generally, all herbicide treatments showed significant control of broadleaf weeds compared to the unweeded check plot ($P < 0.05$). The effectiveness improved with increasing rates. Death of weeds treated with metribuzin occurred slowly within the first 4 weeks after treatment. All herbicide treatments had controlled broadleaf weeds at acceptable level up to 8 WAT, a period which is quite satisfactory for sugarcane (Table 5). At 8 weeks the crop develops canopy cover sufficient to suppress emerging weeds.

4.4.2.2 Rainfed field

All herbicide provided broadleaf control which was statistically significant ($p < 0.05$) compared to that of unweeded check efficacy of herbicide treatments were maintained up to eight weeks after herbicide application (Table 6).

4.4.3 Sedges

4.4.3.1 Irrigated field

All herbicide treatments showed poor control of sedges although controls were significant ($p < 0.05$) compared to unweeded check. Acceptable control was up to 4 weeks after herbicide application. Efficacy of herbicide treatments declined with time and by 6 WAT control score were significantly ($p < 0.05$) lower than those of the weedfree check but maintained control level greater than 70% (Table 5).

4.4.3.2 Rainfed field

Results indicated poor control of Purple nut sedge similar to those obtained in irrigated field. Herbicides efficacy declined with time just as in irrigated field (Table 6).

Table 5: Mean weed control efficiency in irrigated crop at 4 and 8 WAT

		4 WAT[2]			8 WAT		
Treatments	Rate kg a.i/ha	Broadleaf	Grasses	Sedges	Broadleaf	Grasses	Sedge
1. Volmazone	2.9	97.9[1] a	93.0 a[3]	90.7 a	89.4 b	95.3 a	93.9 ab
2. Volmazone	3.8	99.6 a	98.5 a	65.2 a	99.7 a	96.4 a	68.0 ab
3. Acetoc	4.5	83.9 a	99.3 a	100.0 a	96.8 a	96.0 a	99.4 a

	hlor							
4.	Acetoc	6.0	88.2 a	100.0 a	87.1 a	98.9 a	94.0 a	71.6 ab
	hlor							
5.	Metrib	6.0	96.0 a	99.1 a	85.5 a	96.2 a	95.9 a	85.2 ab
	uzin							
6.	Metrib	7.5	100.0 a	93.0 a	75.1 a	99.7 a	97.8 a	53.8 b
	uzin							
7.	Unweeded		0.0 b	0.0 b	0.0 b	0.0 c	0.0 b	0.0 c
8.	Weed free		100.0 a	100.0 a	100.0 a	100.0 a	100.0 a	100.0 a
	SE (±)		6.50		32.90	3.40	12.10	1.56
	CV (%)		13.80		15.10	7.20	6.19	28.50

[1] weed control assessment rating scale: 0 = no control, 100 = complete kill
[2] Weeks after treatments
[3] Value in the same column followed by the same letter do not differ significantly (p <0.05)by Duncan's New Multiple Range Test

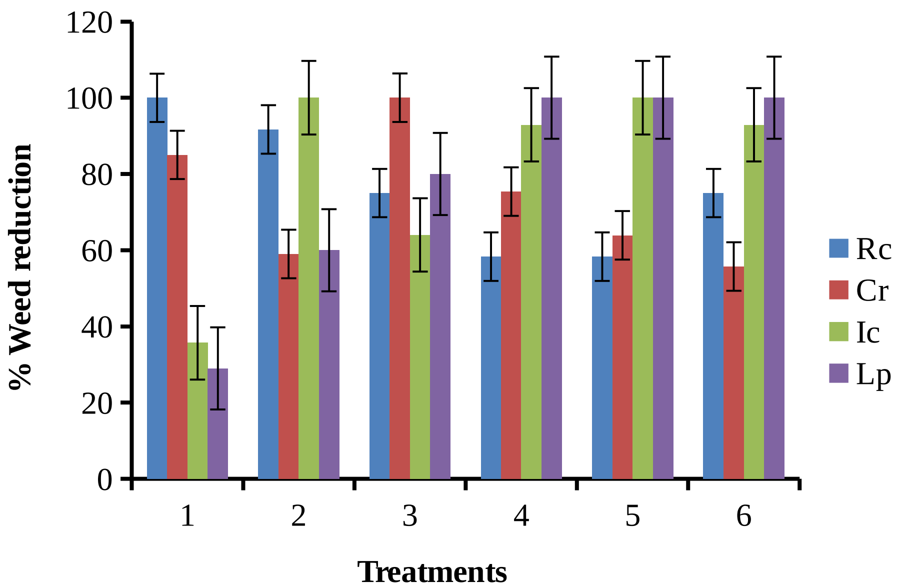

Figure 1: Percent weed reduction of major weed species compared to unweeded check at 4 WAT in irrigated crop

Key:

Treatments 1 = Volmazone 2.9 kg a.i ha^{-1}, 2 = Volmazone 3.8 kg a.i ha^{-1}

3 = Acetochlor 4.5 kg a.i ha-1, 4 = Acetochlor 6.0 kg a.i ha^{-1}
5 = Metribuzin 6.0 kg a.i ha^{-1}, 6 = Metribuzin 7.5 kg a.i ha^{-1}

Rc = *Rottboellia cochinchinensis* Ic = *Ipomoea congesta*

Cr = *Cyperus rotundus*Lp = *Leptochloa panicea*

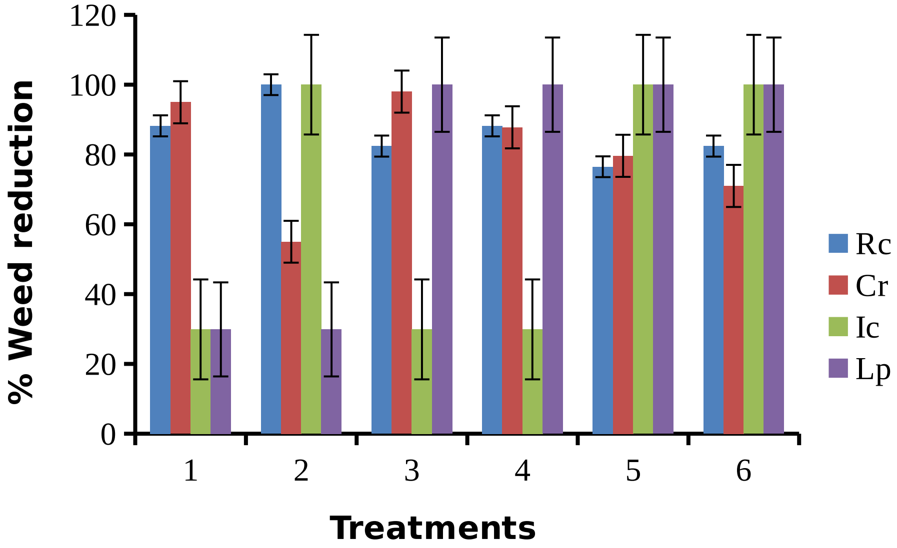

Figure 2: Percent weed reduction of major weed species compared to unweeded check at 8 WAT in irrigated crop

Key

Treatments 1 = Volmazone 2.9 kg a.i ha^{-1}, 2 = Volmazone 3.8 kg a.i ha^{-1}

3 = Acetochlor 4.5 kg a.i ha-1, 4 = Acetochlor 6.0 kg a.i ha^{-1}
5 = Metribuzin 6.0 kg a.i ha^{-1}, 6 = Metribuzin 7.5 kg a.i ha^{-1}

Rc = *Rottboellia cochinchinensis* Lp = *Leptochloa panacea*

Cr = *Cyperus rotundus*Ic = *Ipomoea congesta*

Table 6: Mean weed control efficiency in rainfed crop at 4 and 8 WAT

		4 WAT^2			8 WAT		
	Rate						
Treatment	kg	Broadlea	Grasses	Sedges	Broadlea	Grasses	Sedges

		a.i/h a	f			f		
1.	Volmazone	2.9	100.0[1] a	90.7 a[3]	84.7 a	95.2a	92.7 a	70.0 b
2.	Volmazone	3.8	100.0 a	100.0 a	94.0 a	92.5a	100.0 a	81.1 b
3.	Acetochlor	4.5	100.0 a	100.0 a	98.3 a	93.1a	99.1 a	88.0 b
4.	Acetochlor	6.0	100.0 a	98.2 a	95.2 a	97.8a	94.8 a	90.5 ab
5.	Metribuzin	6.0	100.0 a	88.3 a	87.6 a	99.1a	95.0 a	80.2 b
6.	Metribuzin	7.5	100.0 a	100.0 a	88.8 a	100.0a	100.0 a	78.4 b
7.	Weedy check	-	0.0 b	0.0 b	0.0 b	0.0b	0.0 b	0.0 c
8.	Weed free check	-	100.0 a	100.0 a	100.0a	100.0a	100.0 a	100.0 a
	SE (±)		0.66	6.19	7.00	5.03	5.26	8.14
	CV (%)		1.20	12.10	14.60	9.80	10.10	18.80

[1] weed control assessment rating scale: 0 = no control, 100 = complete kill
[2] Weeks after treatments
[3] Value in the same column followed by the same letter do not differ significantly ($p < 0.05$) by Duncan's New Multiple Range Test

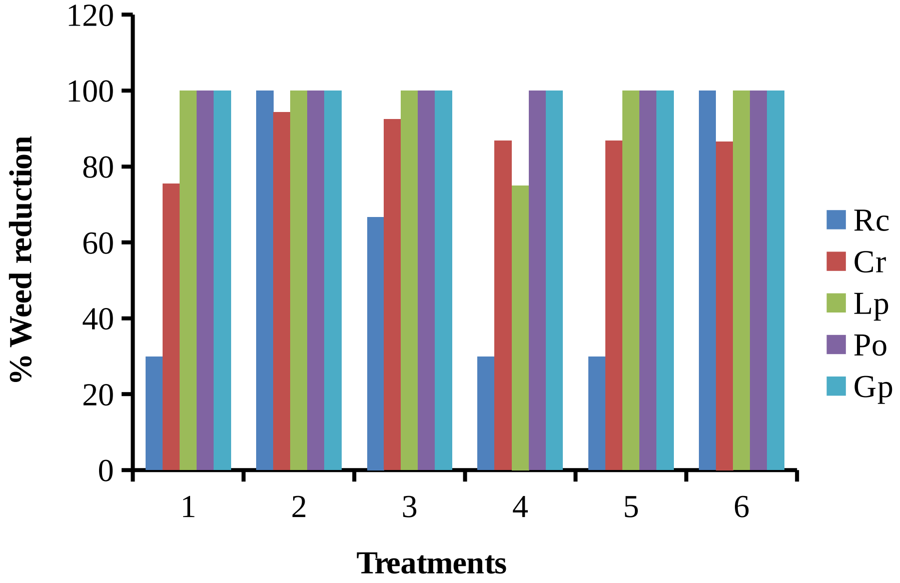

Figure 3: Percent weed reduction of major weed species compared to unweeded check at 4 WAT in rainfed crop

Key

Treatments 1 = Volmazone 2.9 kg a.i ha^{-1}, 2 = Volmazone 3.8 kg a.i ha^{-1}

3 = Acetochlor 4.5 kg a.i ha-1, 4 = Acetochlor 6.0 kg a.i ha^{-1}
5 = Metribuzin 6.0 kg a.i ha^{-1}, 6 = Metribuzin 7.5 kg a.i ha^{-1}

Rc = *Rottboellia cochinchinensis* Cr = *Cyperus rotundus*

Lp = *Leptochloa panacea*Gp = *Galinsoga parviflora*

Po = *Portulaca oleracea*

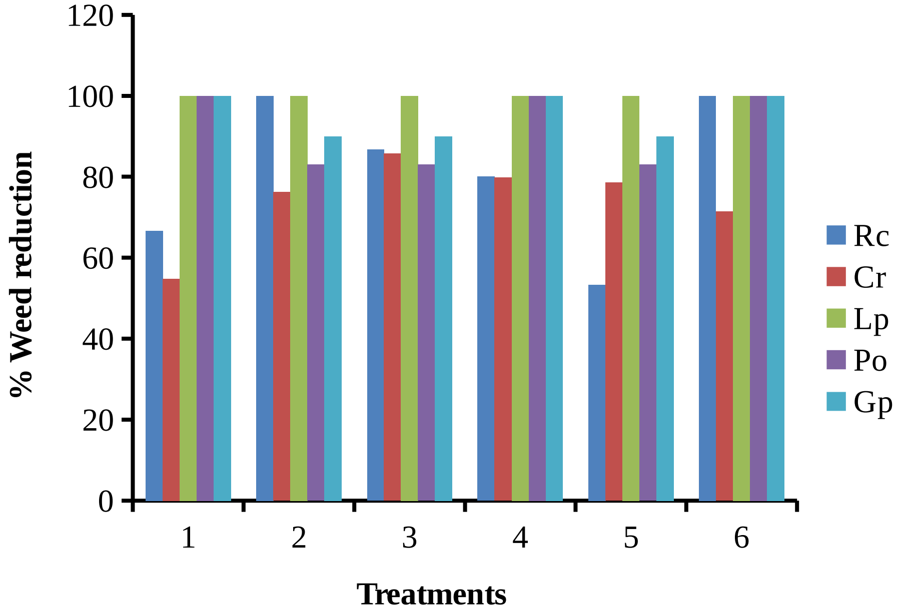

Figure 4: Percent weed reduction of major weed species compared to unweeded check at 8 WAT in rainfed crop

Key

Treatments 1 = Volmazone 2.9 kg a.i ha^{-1}, 2 = Volmazone 3.8 kg a.i ha^{-1}

3 = Acetochlor 4.5 kg a.i ha-1, 4 = Acetochlor 6.0 kg a.i ha^{-1}
5 = Metribuzin 6.0 kg a.i ha^{-1}, 6 = Metribuzin 7.5 kg a.i ha^{-1}

Rc = *Rottboellia cochinchinensis* Cr = *Cyperus rotundus*

Lp = *Leptochloa panacea* Gp = *Galinsoga parviflora*

Po = *Portulaca oleracea*

4.5 Sugarcane tillering

4.5.1 Irrigated crop

The results are presented in table 7. Tiller count three months after herbicide applicationrecorded higher number of tillers m^{-2}in herbicide treated plots compared to unweeded check. Plots treated with volmazone at 2.9 kg a.i ha^{-2} had highest number of tillers/m^{2}(26.3) next wasmetribuzin 6.0 kg a.i ha^{-2}(23.9), these two treatments did not differ significantly ($p < 0.05$) but all were statistically different from unweeded check ($p < 0.05$). Unweeded check recorded the lowest number of tiller m^{-1}(14.7). All other treatments also had higher tiller count compared to unweeded check though not significantly different ($P < 0.05$).

4.5.2 Rainfed crop

Tiller count three months after application of herbicide indicated significant difference between treated plots and unweeded control ($p < 0.05$). Plots treated with acetochlor 6.0 kg a.iha^{-1}, metribuzin 6.0 kg a.i ha^{-1},metribuzin kg a.i ha^{-1}, acetochlor kg a.i ha^{-1} were not significantly different from each other ($p < 0.05$).Volmazone 2.9 kg a.i ha^{-1}and 3.8 kg a.i ha^{-1}thoughhad higher tillers count compared to unweeded check were not significantly different ($P<0.05$).Unweeded check recorded the lowest number of tiller ha $^{-1}$ (13.8).Lower number of tillers was observed in rainfed trial compared to irrigated trial due to moisture differences at the start of experiments, and it also affected the number of millable stalks.

4.6 Number of millable stalks

4.6.1 Irrigated crop

Significant differences ($p< 0.05$) were observed between herbicide treatments in the number of millable sugarcane stalks. Volmazone 2.9 kg a.iha^{-1} which has 20.4 stalks /m^{2}had the highest stalks count next wasmetribuzin 6.0 kg a.i ha^{-1}(18.7 stalks/m^{-2}) and volmazone 3.8 kg a.i ha^{-1} (18.6 stalks/m^{-2}). The lowest number of millable stalks was observed in unweeded check treatment (Table 7).

4.6.2 Rainfed crop

Significant differences were observed between treatments ($P < 0.05$). Acetochlor (6.0 kg a.iha^{-1}) had the highest number of millable stalks compared to other treatments followed by acetochlor (4.5 kg a.iha^{-1}) and metribuzin (6.0 kg a.iha^{-1}). The lowest number of millable stalks was observed in an unweeded check treatment (Table 9).

4.7 Millable stalks height

4.7.1 Irrigated crop

There was significant difference ($p< 0.05$) in millable stalk height between treatments. volmazone 3.8 kg a.iha^{-1} had longest stalks unweeded check had the shortest millable stalks. Millable stalks height for other herbicide treatments were longer than unweeded check though not significant (Table 7)

4.7.2 Rainfed crop

All herbicidetreatments did not differ significantly with unweeded check ($P< 0.05$), although sugarcane treated with volmazone 3.8 kg a.iha^{-1} had longer millable stalks and unweeded check had shortest stalks (Table 9).

4.8 Sugarcane yield tonsha^{-1} (TCH)

4.8.1 Irrigated crop

Significant differences ($p < 0.05$) were observed between treatments for cane yield (Table7). Treatment with volmazone (2.9 kg a.iha^{-1}) had the highest yield of 166.0 tons ha^{-1} as compared to other treatments including weedfree check and was higher by 42.8% compared to unweeded check. The lowest yield was recorded in the unweeded check 95.0 tonsha^{-1}. Other treatments showed differences in yield though the differences were not significant.

4.8.2 Rainfed crop

All treatmentsdiffered significantly for sugarcane yield compared to unweeded check treatment ($P < 0.05$) (Table 10). The highest yield of 142.10 tons ha^{-1} was observed in the treatment with acetochlor 4.5 kg a.iha^{-1}other treatments were as follows acetochlor 6.0 kg a.i ha^{-1} (140.9 tonsha^{-1}), Metribuzin 6.0 kg a.iha^{-1} (140.8 tonsha^{-1}) and weedfree check 140.7 tonsha^{-1}). Unweeded check treatment had the lowest yield 94 tonsha^{-1}.

4.9 Estimated recoverable sugar %Cane (ERS %C)

4.9.1 Irrigated crop

There were no significant differences ($p < 0.05$) in the estimated recoverable sugar percent cane (ERS %C) between treatments though weed free check had the highest ERS %.C (Table 7). That is difference in herbicides treatments had no effect on (ERS %C).

4.9.2 Rainfed crop

As in the irrigated crop,herbicides treatments had no effect on ERS %C (Table 9).

4.10 Sugar yield tons ha^{-1} (TSH)

4.10.1 Irrigated crop

The results are presented in table 7. Maximum sugar yield of 17.9 tons ha^{-1} was observed in plots treated with acetochlor 4.5 kg a.iha^{-1}. All treatments except acetochlor at6.0 kg a.i ha^{-}1were significant to unweeded check($p < 0.05$).

4.10.2 Rainfed crop

There were significant differencesin sugar yieldbetween herbicides treated plots compared to unweeded check ($P < 0.05$). Acetochlor 4.5 kg a.i ha^{-1} had the highest tons of sugar ha^{-1} (15.9), followed by volmazone 2.9 kg a.i ha^{-1}, volmazone 3.8 kg a.i ha^{-1} and metribuzin 6.0 kg a.i ha^{-1}which had tons of sugar ha^{-1} of 15.1 each. Unweeded check recorded the lowest tons of sugar ha^{-1} of 10.3(Table9).

	ESR%C	TSH
	10.64 a	17.4 a
	10.05 a	15.0 a
	12.12 a	17.9 a
	10.29 a	13.5 ab
	11.12 a	16.4 a
	10.10 a	14.6 ab
	10.83 a	10.3 b
	12.16 a	17.0 a
…5	17.900	18.40

Table 7: Sugarcane growth and yield parameters: Irrigated crop during 2012 season

Treatment	g a.i./haRate	umbe of illers/m^2) Tillering	m^{2}Number of) millable	Millable stalk length	TCH
Volmazone	2.9	26.3 a[1]	20.4 a	2.24 ab	166.0 a
Volmazone	3.8	22.8 ab	18.6 ab	2.27 a	149.4 ab
Acetochlor	4.5	21.2 ab	13.4 abc	2.13 abc	148.1 ab
Acetochlor	6.0	19.0 ab	12.1 bc	2.14 abc	130.9 b
Metribuzin	6.0	23.9 a	18.7 ab	2.18 abc	148.7 ab
Metribuzin	7.5	21.2 ab	13.3 abc	1.98 bc	145.8 ab
Unweeded check	-	14.7 b	9.1 c	1.95 c	95.0 c
Weed free check	-	19.1 ab	13.1 abc	2.13 abc	139.4 ab
CV (%) SE (±)	5.20	24.80	4.50 30.50	0.17 7.804	12.30

est[1]Values in the same column followed by the same letter do not differ significantly (p <

Table 8: Sugarcane quality parameters in irrigated crop during 2012 season

Rate

Treatment	kg a.i/ha	Brix %	Pol %	Purity %
1. Volmazone	2.9	16.71 a	13.95 a	83.88 a
2. Volmazone	3.8	16.93 a	13 64 a	80.39 a
3. Acetochlor	4.5	18.93 a	15 52 a	84.32 a
4. Acetochlor	6.0	17 09 a	13.44 a	78.62 a
5. Metribuzin	6.0	18.94 a	16.03 a	84.56 a
6. Metribuzin	7.5	17.46 a	13.75 a	78.65 a
7. Weedy check	-	18.26 a	15.02 a	82.40 a
8. Weed free check	-	16 49 a	13.01 a	78.41 a
SE (±)		2.08	2.00	4.23
CV (%)		11.80	14.00	5.20

[1]Value in the same column followed by the same letter do not differ significantly ($p < 0.05$) by Duncan's New Multiple Range Test

talk Millable	TCH	ESR%C	TSH
2.58 a	132.9 a	11.39 a	15.1 a
2.59 a	133.5 a	11.33 a	15.1 a
2.58 a	142.1 a	11.13 a	15.9 a
2.47 a	140.9 a	10.17 a	14.4 a
2.52 a	140.8 a	10.71 a	15.1 a
2.58 a	134.9 a	10.92 a	14.1 a
2.46 a	94.7 b	10.90 a	10.3 b
2.54 a	140.7 a	10.70 a	15.0 a
8.90 0.23:6	12.30.79	7.2098	13.70

e 9: Sugarcane growth and yield parameters: rainfed cropduring 2012 season

Treatment	a.i./ha	Rate of Tillering (Number of	
Volmazone	2.9	17.1 ab[1]	13.3 ab
Volmazone	3.8	18.0 ab	12.9 ab
Acetochlor	4.5	18.9 a	14.1 a
Acetochlor	6.0	19.6 a	15.2 a
Metribuzin	6.0	19.0a	13.9 a
Metribuzin	7.5	19.1 a	13.6 ab
Unweeded check	-	13.8 b	10.0 b
Weed free check	-	18.4 a	13.8 ab
CV (%) SE (±)	5.40	2.80 7.60	2.40

t [1]Values in the same column followed by the same letter do not differ significantly ($p < 0.05$) by Duncan's New Multiple

Table 10: Sugarcane quality parameters in rainfed crop during 2012 season

Treatment	Rate kg a.i/ha	Brix %	Pol %	Purity%
9. Volmazone	2.9	20.23 a[1]	17.94 ab	88.71 a
10. Volmazone	3.8	19.99 a	17.77 ab	88.90 a
11. Acetochlor	4.5	20.32 a	17.94 ab	88.26 a
12. Acetochlor	6.0	20.82 a	18.62 a	89.41 a
13. Metribuzin	6.0	20.06 a	17.19 ab	86.08 a
14. Metribuzin	7.5	19.91 a	17.37 ab	87.22 a
15. Weedy check	-	19.95 a	17.37 ab	87.08 a
16. Weed free	-	19.29 a	17.02 b	88.23 a

check

SE (±)	1.22	0.89	2.02
CV (%)	6.1	5.10	2.30

[1]Value in the same column followed by the same letter do not differ significantly ($p < 0.05$) by Duncan’s New Multiple Range Test

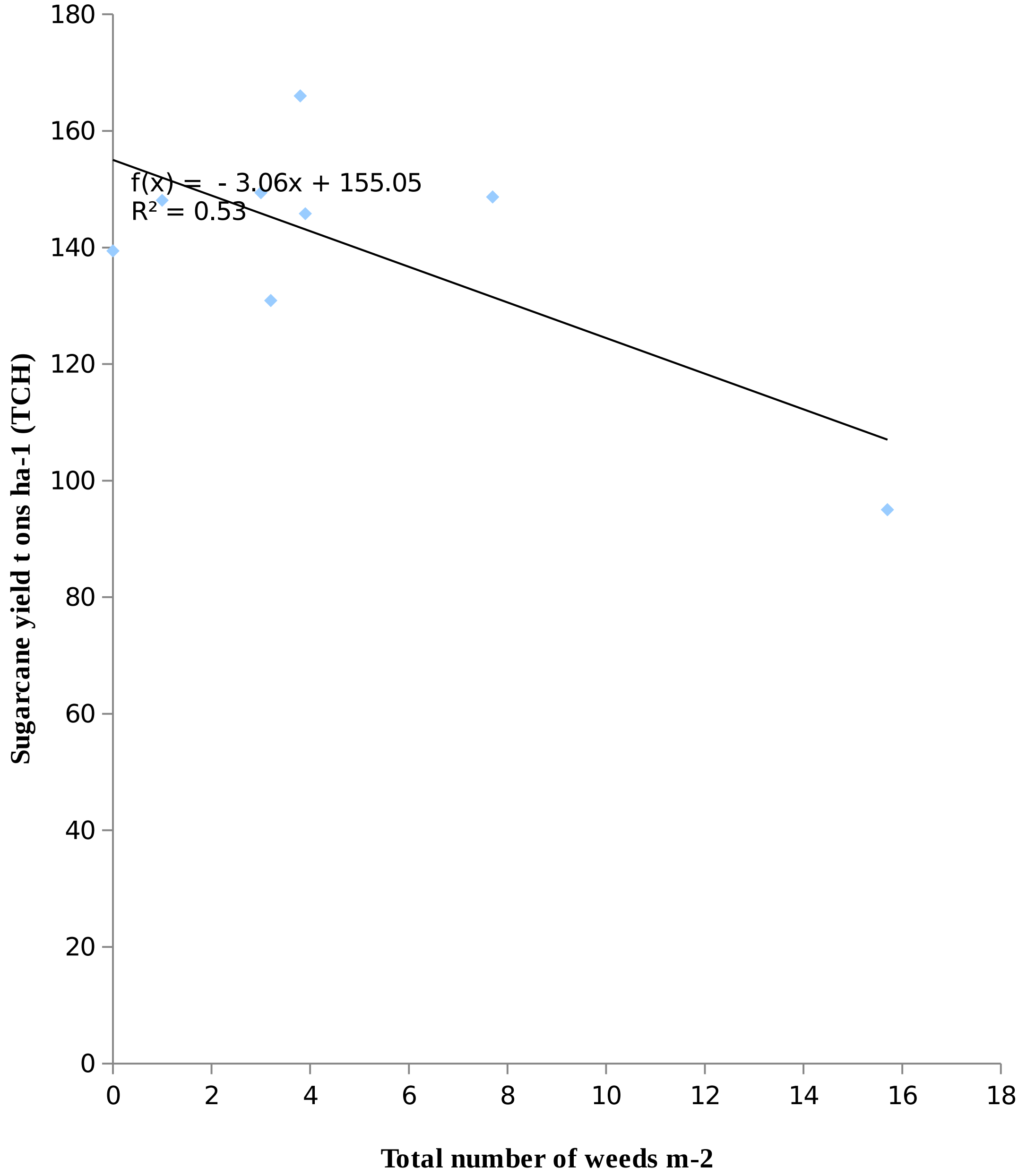

Figure 5: Relationship between total number of weeds at 8 WATand sugarcane yield in tons ha^{-1}(TCH) in irrigated crop during January to October 2012.

Treatments 1 = Volmazone 2.9 kg a.i ha^{-1}, 2 = Volmazone 3.8 kg a.i ha^{-1}

3 = Acetochlor 4.5 kg a.i ha-1, 4 = Acetochlor 6.0 kg a.i ha^{-1}
5 = Metribuzin 6.0 kg a.i ha^{-1}, 6 = Metribuzin 7.5 kg a.i ha^{-1}

7 = Unweeded check, 8 = Weed free check

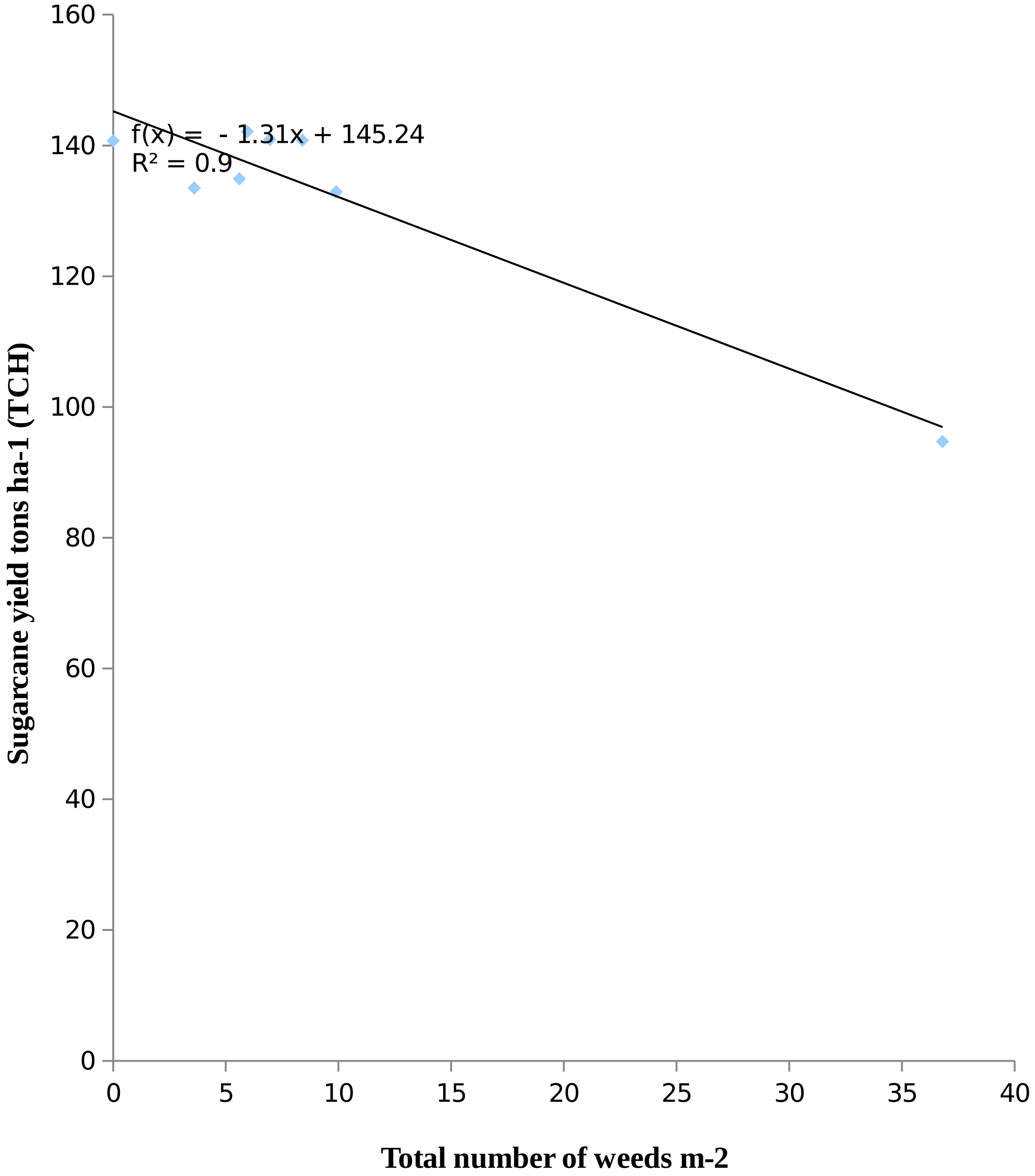

Figure 6: **Relationship between total number of weeds at 8 WAT andsugarcane yield in tons ha^{-1} (TCH) in rainfed crop during January to October 2012.**

Treatments 1 = Volmazone 2.9 kg a.i ha^{-1}, 2 = Volmazone 3.8 kg a.i ha^{-1}

3 = Acetochlor 4.5 kg a.i ha-1, 4 = Acetochlor 6.0 kg a.i ha^{-1}
5 = Metribuzin 6.0 kg a.i ha^{-1}, 6 = Metribuzin 7.5 kg a.i ha^{-1}

7 = Unweeded check, 8 = Weed free check

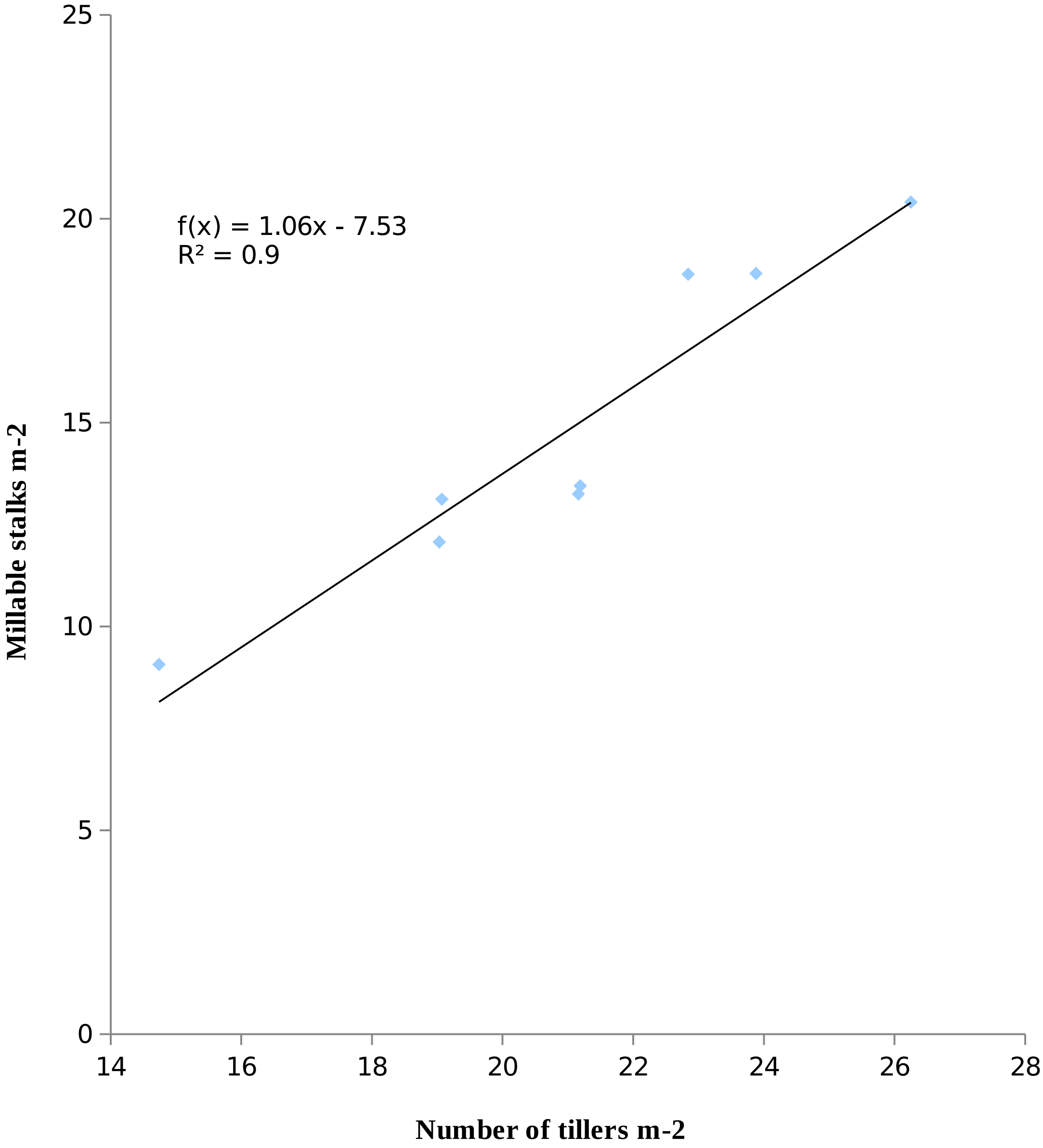

Figure 7: Relationship between number of tillersm^{-2}and number of millable stalksm^{-2} in irrigated crops during January to October 2012.

Treatments 1 = Volmazone 2.9 kg a.i ha^{-1}, 2 = Volmazone 3.8 kg a.i ha^{-1}

3 = Acetochlor 4.5 kg a.i ha-1, 4 = Acetochlor 6.0 kg a.i ha^{-1}
5 = Metribuzin 6.0 kg a.i ha^{-1}, 6 = Metribuzin 7.5 kg a.i ha^{-1}

7 = Unweeded check, 8 = Weed free check

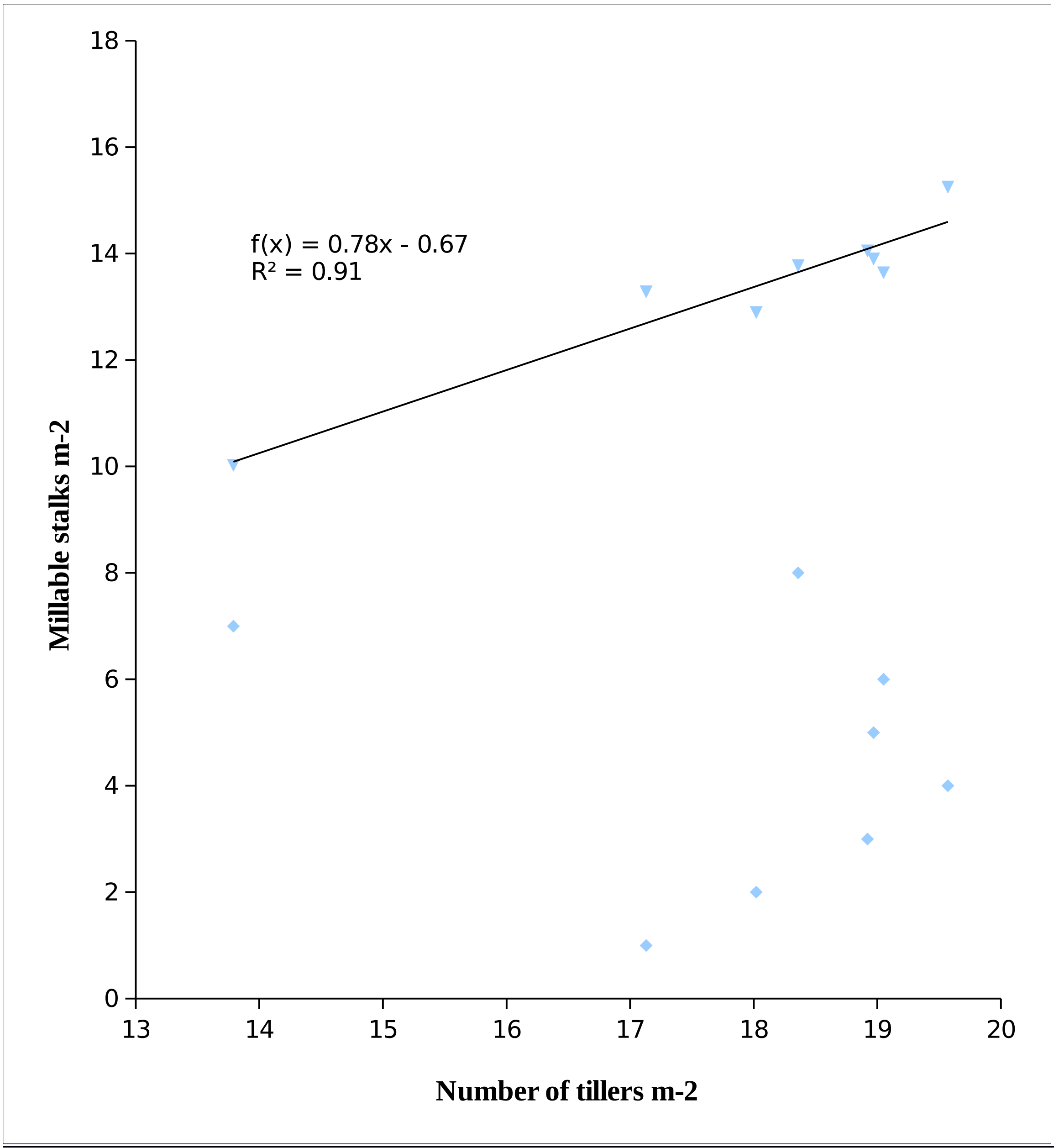

Figure 8: Relationship between number of tillers $m^{-2}$and number of millable stalksm^{-2}in rainfed crop during January to October 2012.

Treatments 1 = Volmazone 2.9 kg a.i ha^{-1}, 2 = Volmazone 3.8 kg a.i ha^{-1}

3 = Acetochlor 4.5 kg a.i ha-1, 4 = Acetochlor 6.0 kg a.i ha^{-1}
5 = Metribuzin 6.0 kg a.i ha^{-1}, 6 = Metribuzin 7.5 kg a.i ha^{-1}

7 = Unweeded check, 8 = Weed free check

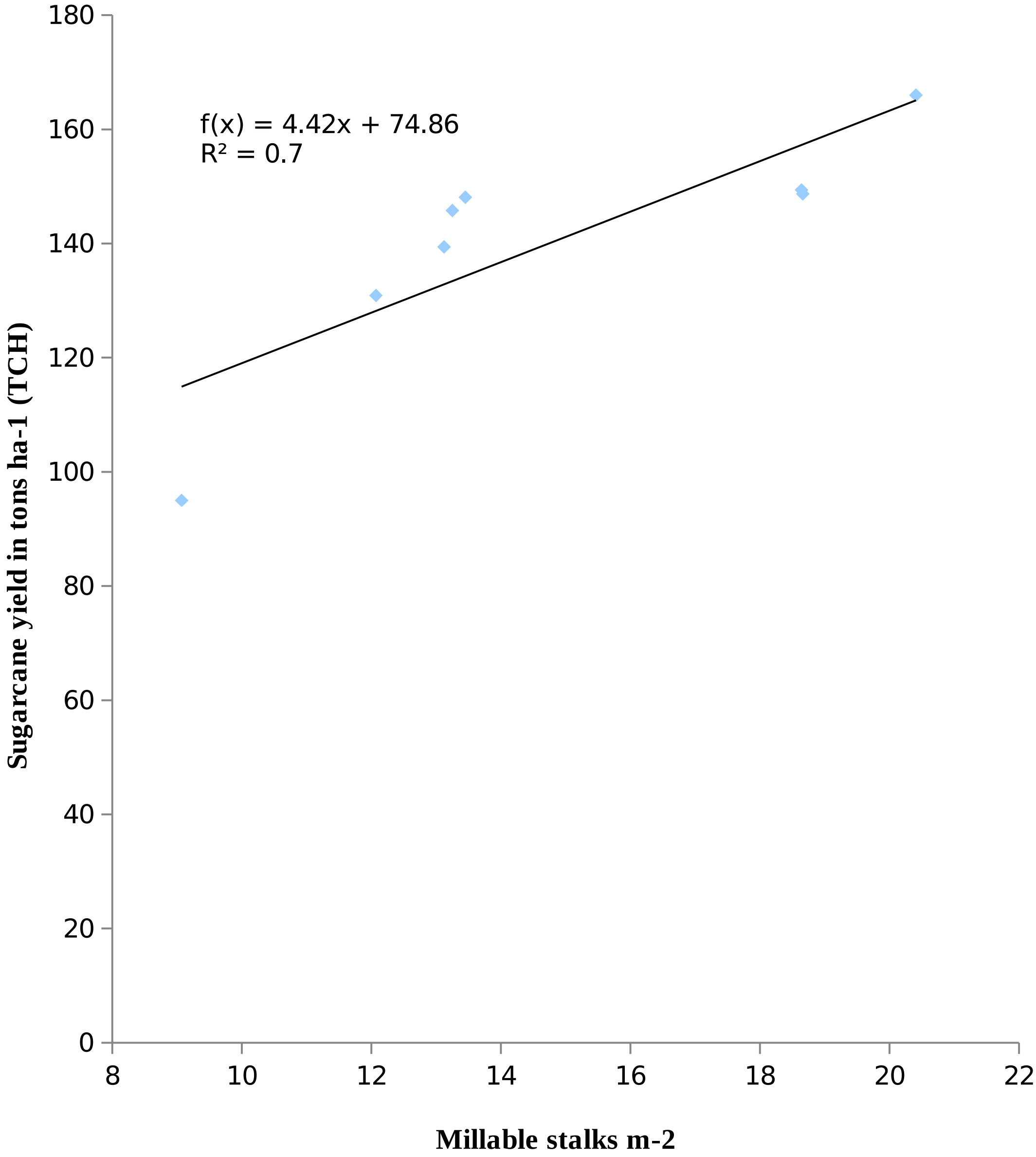

Figure 9: Relationship between sugarcane yield tons ha^{-1}and number of millable stalksm^{-2}in irrigated crop during 2012 season.

Treatments 1 = Volmazone 2.9 kg a.i ha^{-1}, 2 = Volmazone 3.8 kg a.i ha^{-1}

3 = Acetochlor 4.5 kg a.i ha-1, 4 = Acetochlor 6.0 kg a.i ha^{-1}
5 = Metribuzin 6.0 kg a.i ha^{-1}, 6 = Metribuzin 7.5 kg a.i ha^{-1}

7 = Unweeded check, 8 = Weed free check

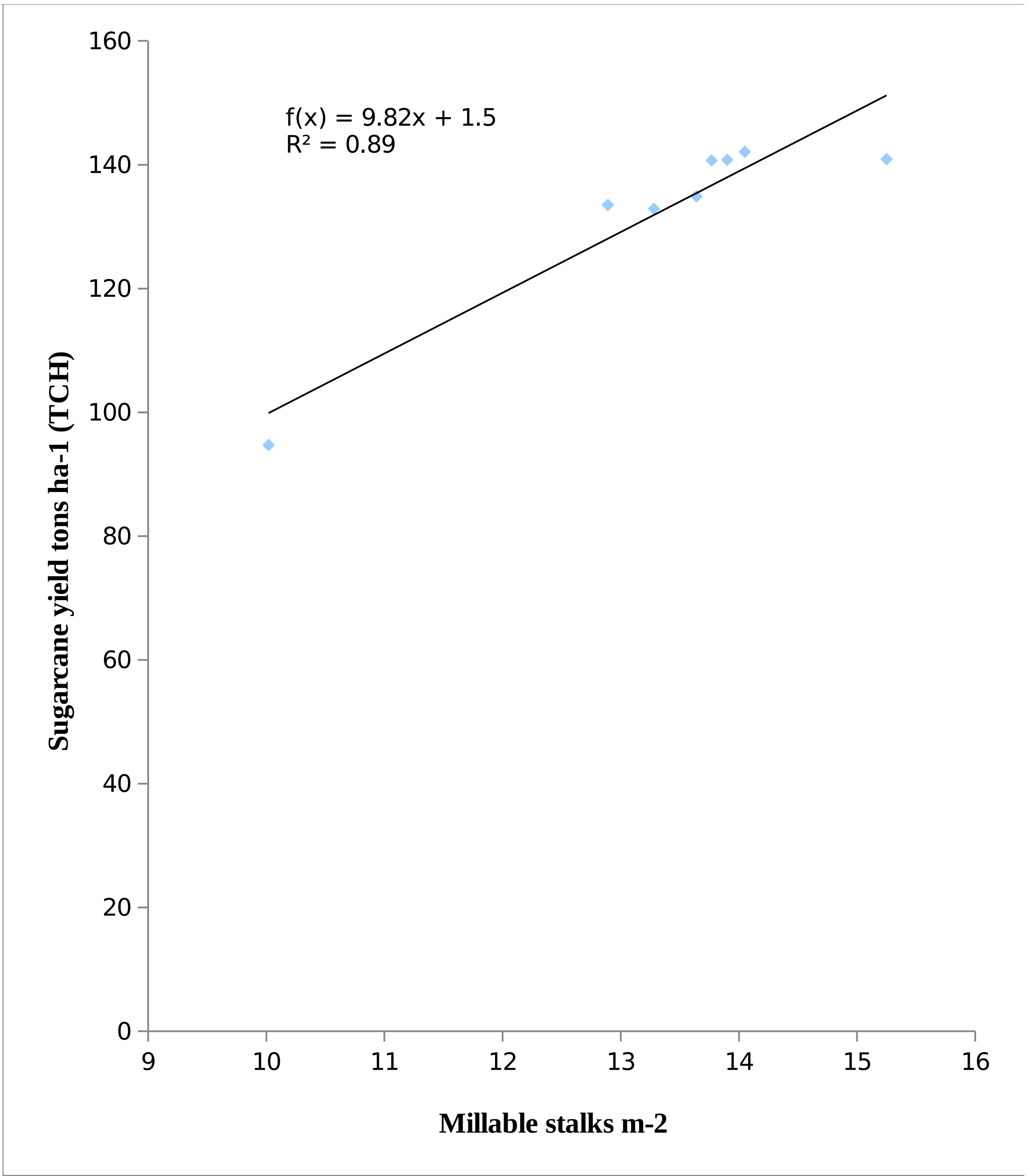

Figure 10: Relationship between sugarcane yield in tons ha^{-1}TCH and number of millablestalksm^{-2} in rainfed crop during 2012 season.

Treatments 1 = Volmazone 2.9 kg a.i ha^{-1}, 2 = Volmazone 3.8 kg a.i ha^{-1}

3 = Acetochlor 4.5 kg a.i ha-1, 4 = Acetochlor 6.0 kg a.i ha^{-1}
5 = Metribuzin 6.0 kg a.i ha^{-1}, 6 = Metribuzin 7.5 kg a.i ha^{-1}

7 = Unweeded check, 8 = Weed free check

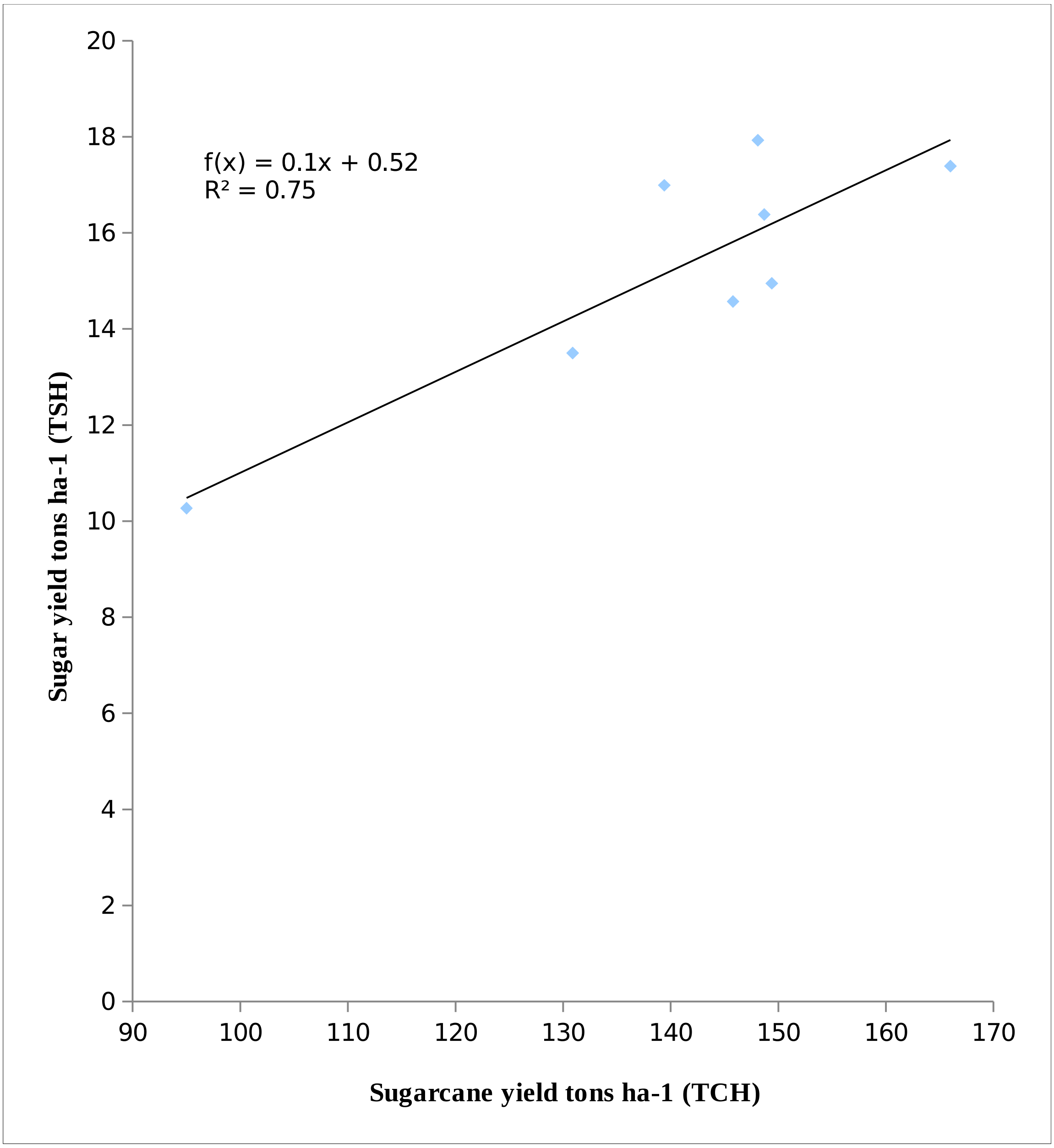

Figure 11: Relationship between sugar yield in tons ha^{-1} (TSH)and sugarcane yield in Tons ha^{-1}(TCH)in irrigated crop during 2012 season.

Treatments 1 = Volmazone 2.9 kg a.i ha^{-1}, 2 = Volmazone 3.8 kg a.i ha^{-1}

3 = Acetochlor 4.5 kg a.i ha-1, 4 = Acetochlor 6.0 kg a.i ha^{-1}
5 = Metribuzin 6.0 kg a.i ha^{-1}, 6 = Metribuzin 7.5 kg a.i ha^{-1}

7 = Unweeded check, 8 = Weed free check

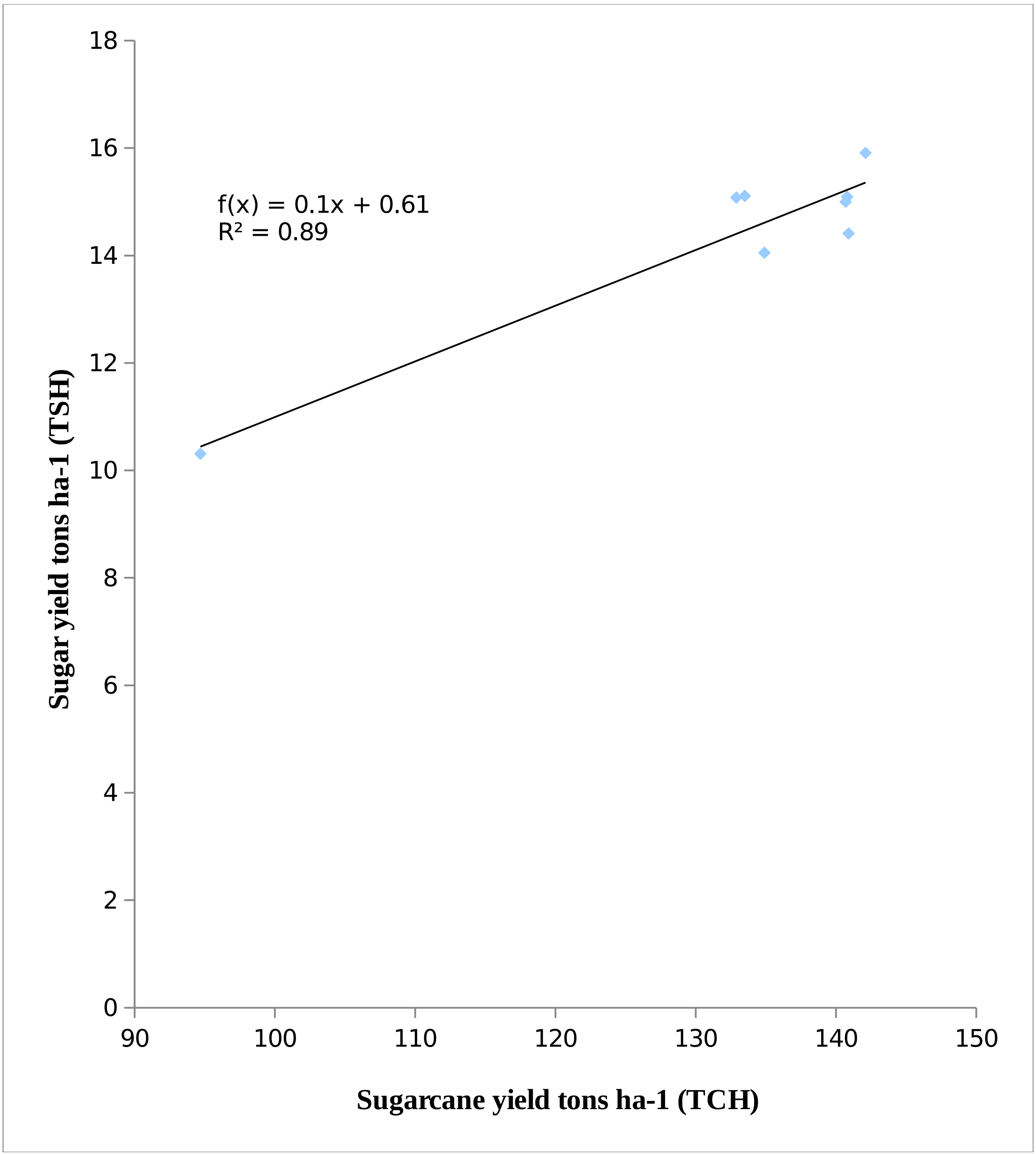

Figure 12: Relationship between sugar yield in tons ha^{-1}TSH and sugarcane yield in tons ha^{-1} TCHin rainfed crop during 2012 season.

Treatments 1 = Volmazone 2.9 kg a.i ha^{-1}, 2 = Volmazone 3.8 kg a.i ha^{-1}

3 = Acetochlor 4.5 kg a.i ha-1, 4 = Acetochlor 6.0 kg a.i ha^{-1}
5 = Metribuzin 6.0 kg a.i ha^{-1}, 6 = Metribuzin 7.5 kg a.i ha^{-1}

7 = Unweeded check, 8 = Weed free check

4.11 Economic analysis

4.11.1 Irrigated crop

Net benefit of different treatments were calculated and volmazone 2.9 kg a.iha^{-1} gave highest net benefit of 9,261,600 shsha^{-1} and unweeded check gave the lowest net benefit of 5,472,000shsha^{-1} (Table 11). However, net benefit is not sufficient parameter to explain the rate of return of each cost of investment incurred. Therefore dominance analysis was done before determination of marginal rate of return.The performed dominance analysis indicated that some of treatments were dominated by other treatments.A dominated treatment has net benefits that are less than or equal to those of a treatment with lower variable costs.In this experiment two treatments were dominated and were not subjected to marginal analysis,these treatments were metribuzin 6.0 kg ha^{-1} and metribuzin 7.5 kg ha^{-1}(Table 13).The marginal analysis of six nondominated treatment showed that the maximum return per investment can be achieved by application of volmazone at a rate of 2.9 kg a.iha^{-1} which was 1124.2 % (Table 15).

4.11.2 Rainfed crop

Just as in the irrigated crop, net benefits were calculated and acetochlor 4.5 kg a.iha^{-1} had highest net benefit of shs 8,086,960 and unweeded check had the lowest net profit of 5,454,720 shs/ha (Table 12). Dominance analysis was done prior to calculation of marginal rate of return (Table 14). The performed dominance analysis indicated that,only three treatments, unweeded check, acetochlor 4.5 kg a.i ha^{-1}, and metribuzin 6.0 kg a.i ha^{-1} were notdominated and were subjected to marginal analysis. The marginal analysis of three nondominated treatments indicated that treatment with acetochlor at a rate of 4.5 kg a.i/ha had the maximum marginal rate of return of 412.3 % and metribuzin 6.0 kg a.i ha^{-1} -186.9 % (Table 16).

Table Table 11: Partial budget of weed control in irrigated crop during January to October 2012.

Treatments	Herbicides rate kg a.i/ha	Ton/ha	Sugarcane(Shs)Gross income	Total variable costs shs/ha	shs/haNet benefit
1. Volmazone	2.9	166.0	11 450 000	2 188 400	9 261 600
2. Volmazone	3.8	149.4	10 308 600	2 095 160	8 213 440
3. Acetochlor	4.5	148.1	10 218 900	1 786 340	8 432 560
4. Acetochlor	6.0	130.9	9 032 100	1 620 860	7 411 240
5. Metribuzin	6.0	148.7	10 260 300	1 911 180	8 349 120
6. Metribuzin	7.5	145.8	10 060 200	1 930 120	8 130 080
7. Unweeded check	-	95.0	6 555 000	1 083 000	5 472 000
8. Weed free check	-	139.4	9 618 600	1 729160	7 889 440

Table 12: Partial budget of weed control in rainfed cropJanuary to October 2012.

TreatmentsWeed control	Herbicides rate kg a.i/ha	(TCH) Ton of sugarcane	shs/haGross income	Total variable costs shs/ha	shs/haNet benefit
9. Volmazone	2.9	132.9	9 170 100	1 811 060	7 359 040
10. Volmazone	3.8	133.5	9 211 500	1 913 900	7 297 600
11. Acetochlor	4.5	142.1	9 804 900	1 717 940	8 086 960
12. Acetochlor	6.0	140.9	9 722 100	1 734 860	7 987 240
13. Metribuzin	6.0	140.8	9 715 200	1 821 120	7 894 080
14. Metribuzin	7.5	134.9	9 308 100	1 805 860	7 502 240
15. Unweeded check	-	94.7	6 534 300	1 079 580	5 454 720
16. Weed free check	-	140.7	9 708 300	1 743 980	7 964 320

Table 13: Dominance analysis of weed control in irrigated crop during January to October 2012 season.

Total variable costs shs/ha	Treatment	Rate kg a.i/ha	Net benefit shs/ha
1 083 000	Unweeded check	-	5 472 000
1 620 860	Acetochlor	6.0	7 411 240
1 729 160	Weed free check	-	7 889 440
1 786 340	Acetochlor	4.5	8 432 560
1 911 180	Metribuzin	6.0	8 349 120D
1 930 120	Metribuzin	7.5	8 130 080D
2 095 160	Volmazone	3.8	8 213 440
2 188 400	Volmazone	2.9	9 261 600

D = Dominated treatments

Table 14: Dominance analysis of weed control in rainfed cropJanuary to October 2012season

	Treatments	Rate kg a.i/ha	Net benefit shs/ha
1 079 580	Unweeded check	-	5 454 720
1 717 940	Acetochlol	4.5	8 086 960
1 734 860	Acetochlor	6.0	7 987 240D
1 743 980	Weed free check	-	7 964 320D
1 805 860	Metribuzin	7.5	7 502 240D
1 811 060	Volmazone	2.9	7 359 040D
1 821 120	Metribuzin	6.0	7 894 080
1 913 900	Volmazoze	3.8	7 297 600D

D = Dominated treatments

Table 15: Marginal rate of return of undominated treatments for cash in irrigated cropJanuary to October2012 season

Treatment	Rate kg a.i/ha	Total variable costs shs/ha	Net benefit shs/ha	Marginal change in TVC	Marginal change in net benefit	MRR %
Unweeded check	-	1 083 000	5 472 000	-	-	-
Acetochlor	6.0	1 620 860	7 411 240	537 860	1 939 240	360.5
Weed free check	-	1 729 160	7 889 440	108 300	478 200	441.6
Acetochlor	4.5	1 786 340	8 432 560	57 180	543 120	949.8
Volmazone	3.8	2 095 160	8 213 440	308 820	-219 120	-71.0
Volmazone	2.9	2 188 400	9 261 600	93 240	1 048 160	1124.2

Table 16: Marginal rate of return of undominated treatments in rainfed crop Januaryto October 2012season

Treatments	Rate	Total	Net benefit	Marginal	Marginal	MRR %

	kg a.i/ha	variable costs shs/ha	shs/ha	change in TVC	change in net benefit	
Unweeded check	-	1 079 580	5 454 720	-	-	-
Acetochlor	4.5	1 717 940	8 086 960	638360	2632240	412.3
Metribuzin	6.0	1 821 120	7 894 080	103180	-192880	-186.9

CHAPTER 5

5.0 DISCUSSION

The rainfall received during the season in which the experiments were conducted,(807.9 mm) was lower than the ten year average of 1126.5 mm.The months of March, April and May were the wettest as they received 176.0 mm, 226.2mm and 155.2mm of rainfall, respectively.The weeds were grouped into grasses, sedges and broad leaved weeds.

Several weed species were observed in irrigated site compared to rainfed,due to moisture differences of two sites at the start of experiments. This implies that moisture favored the growth of weeds.Generally all herbicide treatments were effective in controlling broadleaf and grass weeds above 90 % up to eight weeks after herbicides application, for both irrigated and rainfed experiments, which is quite satisfactory for sugarcane crop. This result is in line with findings ofIsa (1996) and Rugaimukamu (2000) who reported that herbicide product which can control weeds for a period of 8 to 10 weeks are recommended for use in sugarcane fields. Generally all herbicides had poor control of nutsedge except for a few cases, example volmazone at 2.9 kg a.i ha^{-1} and acetochlor 4.5 kg a.i ha^{-1}which controlled the nutsedge by 93.9 and 99.4 percent for the irrigated cop and acetochlor at 6.0 kg a.i ha^{-1}which controlled the nutsedge by 90.5 percent for the rainfed crop.This suggests the need for an additional application or use of herbicide mixtures so as to broaden nut sedge control strategies. At 4 WAT almost all herbicides treatmentsreduced the density ofgrasses and broadleaves by an acceptable level (93 – 100 %) for irrigated crop and (90.7 – 100%) for rainfed crop respectively as compared to unweeded check. At 8 WAT no significant changes which occurred compared to assessments made at 4 WAT. After 8 WAT the crop had already developed canopy cover sufficient to suppress newly emerging weeds.(Isa, 1996: Rugaimukamu, 2000)

Results indicated that the weeds were competitive and caused substantial reduction in the vegetative growth and sugarcane yield in both irrigated and rainfed crop. The adverse effects of weeds on growth and yield of cane crop may be attributed to the fact that weeds compete with crops for important factors such as nutrients, water, light and space for their growth and reproduction (Panneerselvam and Lourduraj, 2000; Chauhan *et al*., 2002).

In both irrigated and rainfed field the highest weed density (18 m^{-2}and 36 m^{-2})resulted in low sugarcane yield. However the sugarcane quality was not affected by herbicide treatments. These results are in line with the findings of Fute (1990).A high R^2 implies that weed density was largely responsible for the yield reduction 19 % in irrigated crop and much more for rainfed crop 32 %.Because in the irrigated crop the canopy cover sufficient to suppress emerging weeds was developed earlier than in rainfed crop.

The number of tillers contribute a lot in determining the number of millable stalks, thus plays a pivotal role towards final cane yield. In this research the data regarding tillers m^{-2}suggested that weeds significantly affected the tillering ability of sugarcane crop.thus the unweeded check produced the lowest number of tillers (14.7 tillers m^{-2}) in irrigated and (13.8 tillers m^{-2}) in rainfed crops respectivelly.Similar observations were reported by Khan and Hashmi (1987) who concluded that weed infestation reduced number of tillers insugarcane crop. In the present study the highest number of tillers were produced by treatment with volmazone at 2.9 kg a.iha^{-1} (26.3), next was metribuzin at 6.0 kg a.iha^{-1} (23.9) and volmazone at 3.8 kg a.iha^{-1} (22.8) tillers m^{2} for the irrigated crop and for rainfed crop acetochlor at 6.0 kg a.i ha^{-1} (19.6) and metribuzin 7.5 kg a.iha^{-1} (19.1) tillers m^{2} respectivelly.

The number of millable stalks (number of tillers m^{-2}) is the most important yield component in sugarcane. Weeds have direct effect on the production of millable stalks. Srivastava (2001) reported that early weed free period up to 90 days after planting gave a higher number of millable sugarcane stalks than no weeding. In this experiment data revealed that for the plotswhich were affected by weeds throughout the growing period the millable stalks producing ability of the crop was significantly affected in both irrigated and rainfed conditions.Thus unweeded check produced the minimum number of millable stalks as compared to other treatments.These results are similar to those obtained by Tomer *et al*. (2003),Fute (1990) and Njalayao (1994), who reported that decrease in number of millable stalks with increase in weed competition period, could be due to competition of weeds with crop for moisture, light and nutrients.The highest number of millable stalks were produced undervolmazone at 2.9 kg a.i ha^{-1} (20.4), metribuzin at 6.0 kg a.i ha^{-1} (18.7) and volmazone at 3.8 kg a.i ha^{-1} (18.6) stalks $m^{2}$for the irrigated crop and acetochlor at 6.0 kg a.i ha^{-1} (15.2) and acetochlor 4.5 kg a.i ha^{-1} (14.1) for rainfed crop. Correlation analysis showed a strong and positive relationship between total number of tillers and millable stalks for both irrigated and rainfed experiments (r = 0.948 and 0.955). Dependence of total millable stalks on sugarcane tillering was illustrated by the high coefficient of determination R^2 = 0.899 and 0.912 for irrigated and rainfed conditions respectively.

Weeds have direct effect on sugarcane yield as they affect tillering and millable stalks producing ability of the cane.In this study the lowest cane yield were obtained where cane were infested by weeds throughout the period of the experiment. Weed reduced cane yield by 27.4-42.8 % in irrigated crop and 28.7-32.8 % in rainfed crop.Other scientists also obtained similar results. Ali *et al*., (1999) reported the lower cane yield of sugar cane due weeds infestation.Hussain and Afghan (2001) estimated cane yields reduction up to 26-27 % by weeds competition. They also proposed the chemical control of weeds as most effective and economical. Ali *et al*., (2001) recorded 20-29 % reduction in cane yield for weedy check treatment. Chattah *et al*., (2001) also reported 43.75 % increase in cane yield over weedy check with integrated weeds control. In this experiment the result showed a significant and strong positive correlations between sugarcane yield and number of millable stalks r = 0.834 and 0.942 (Fig 9 and 10) for irrigated and rainfed crop respectively.These results are similar to those reported by Fute (1990). The fact that cane yield was positively associated with this yield component indicates that cane yield can be increased by increasing tillering and subsequent millable stalks. Dependence of sugarcane yield on millable stalks was indicated by high coefficient of determination (R^2 = 0.695) for irrigated crop and (R^2= 0.887) for rainfed crop.The higher the coefficient of determination R^2implies that number of millable stalks was largely responsible for the sugarcane yield (Tons of sugarcane ha^{-1}).

Difference in Brix %, Pol % cane, cane juice purity % and ERS%C were not significant within themselves between different treatments in both the irrigated and rainfed crops. Lower brix %were observed in irrigated crop and this was caused by excess soil moisture in the field during harvesting.

Estimated Sugar Recovery% cane (ERS%C) is controlled by the genetic makeup of the varietyBahadar *et al*., (2004),therefore different weed managements did notaffect the sugar recovery significantly. These results are in line with the findings of Fute (1990) and Chattha (2007). However contrary to findings of Ibrahim, (1984) who reported that clean weeding improved ERS%C and of Njalayao (1994), who reported that weed infestation improved ERS%C compared to the weeded cane. In this researchestimatedrecoverable sugar percent ranged from 10.05 to 12.16%for irrigated crop and 10.17 to 11.39% for rainfed crops.Weed competition may have effect on this parameter, but due to that the sugarcane takes longer time to maturethis time was sufficient to improve physiological maturity of the crop after decline of weed crop competition (Zimdhal, 1980).

Sugar yield is determined bysugarcane yield tons ha^{-1} and sugar recovery % cane. In this experiment weeds did not have much effect on the sugar recovery but it affected the sugarcane yield; therefore the differences in tons of sugar ha^{-1} observed among different treatments were much contributed by yield of sugarcane (TCH) rather than the estimated recoverable % sugarand therefore weeds had an effect on sugar yield.

The highest sugar yield was obtained where acetochlor 4.5 kg a.i ha^{-1} was applied in both irrigated and rainfed crops. This treatment had good control of weeds throughout the experimentation season.There was significant and strong correlation between sugarcane yield and sugar yield $tonha^{-1}$ (r = 0.867 and 0.944) for both irrigated and rainfed crops. These results are similarto those reported by Fute (1990) and Njalayao(1994) that there was significant association between cane yield and sugar yield. Dependence of sugar yield on sugarcane yield is indicated by the high coefficient of determination (R^2 = 0.752 and 0.892) for irrigated and rainfed crops which implies that sugarcane yield was largely responsible for the sugar yield.

Economic analysis performed to determine which treatments were economically viable for adoption by farmers indicated that,in irrigated experiment treatment with volmazone at 2.9 kg a.iha^{-1} had higher marginal rate of return of 1124.2%, which implied that for every shilling invested the return would be 11.24 shillings, and for rainfed experiment the treatment with acetochlor at 4.5 kg a.i ha^{-1} had the highest marginal rate of return of 412.3% which also implies that each shilling invested would give a return of 4.12 shillings. Based on these values farmers could thus choose the herbicide rates for irrigated and rainfed conditions respectively depending on availability and also their resource.

CHAPTER 6

6.0 CONCLUSION AND RECOMMENDATIONS

The results have clearly shown that all herbicides were effective in controlling grass and broadleaf weeds butpoor control of sedges.Therefore effective control of weeds in sugarcane fields can be achieved through application of suitable herbicides.Weed infestation reduced sugarcane yield by an average of 35.3 % and 31.4 % for irrigated and rainfed crops respectively.All herbicides had no effect on the quality parameters of sugarcane in both experiments therefore sugar yield depended much on sugarcane yields. Correlation analysis showed a strong but negative relationship between weeds density and sugarcane yield the higher the weed density the lower the sugarcane yields.Economic analysis showed that the maximum marginal rate of return was obtained where volmazone at a rate of 2.9 kg a.i $ha^{-1}$for irrigated experiment and acetochlor 4.5 kg a.i $ha^{-1}$for rainfed was applied.

6.1 RECOMMENDATIONS

1. Application of herbicide is recommended so as toensure successful control of many weed species.
2. The results of this research can be used to make recommendations, which can be refined through multi-location testing over a wider area.
3. Further research on other herbicides which cane successful control purple nutsedge are required.

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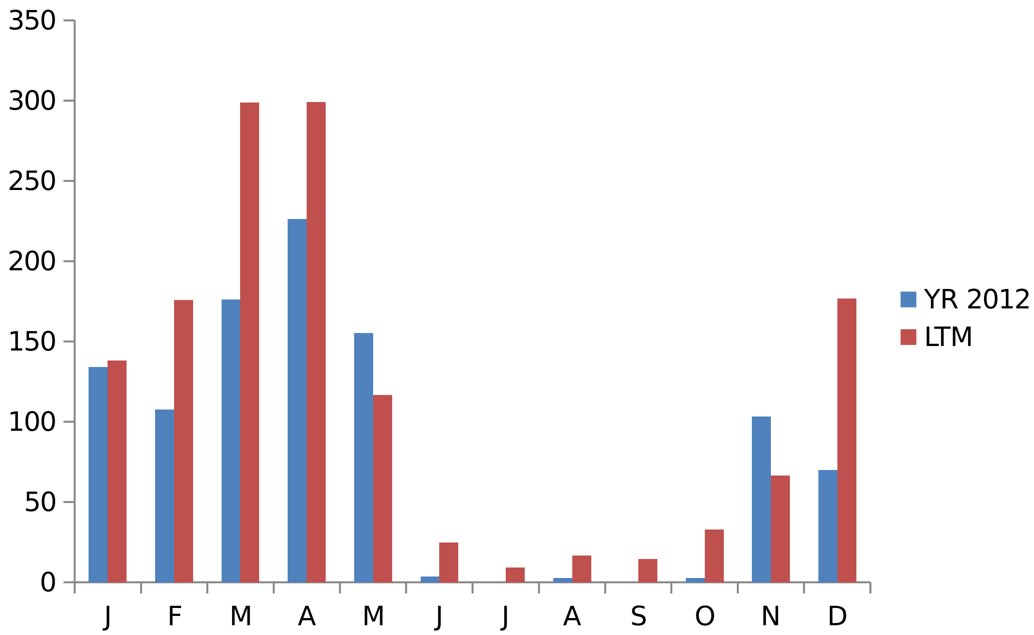
8.0 APPENDICES

Appendix 1: Rainfall distribution at Kilombero



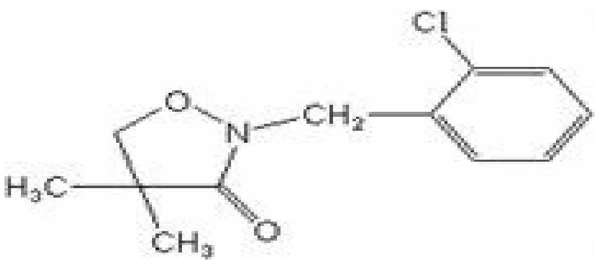
YR 2012 =Rainfall received at kilombero during the experimental season

LTM = Longterm mean rainfall at kilombero

Appendix 2: Detailed description of the herbicides evaluated, as descibed by Rao (1988)

Clomazone/Command

Chemical structure



Chemical name: 2-(2-chlorobenzyl)-4,4-dimethyl-1,2-oxazolidin-3-one

Formula:C12H14ClNO2

Molecular weight: 239.7

Appearance: a colorless to light brown

Clomazone belong to unclassified group of herbicides it is a broad-spectrum herbicide it is absorbed by roots and shoots and translocated upward. Foliar contact or vapors may cause visual symptoms of chlorosis to nearby sensitive plants. Clomazone is used for control of annual grasses and broadleaf weeds in cotton, peas, pumpkins, soybeans, sweet potatoes, tobacco, winter squash, sugarcane and fallow wheat fields. Clomazone can be applied both post and pre emergence.

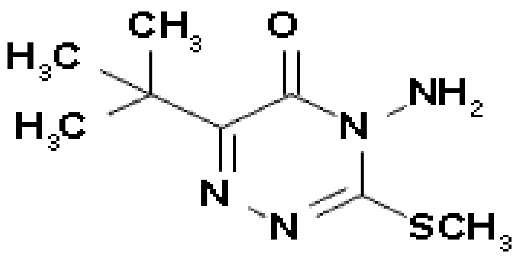
Metribuzin

Metribuzin is a selective herbicide of the chemical classes the triazinnone. Metribuzin can be applied as a foliar spray or soil treatment in order to control broadleaf weeds and annual grasses.Metribuzine can be applied both pre-emergence and post-emergance. Metribuzin is primarily absorbed by the roots, but also by the leaves to a lesser extent. It is translocated acropetally in the xylem to the leaves where it has its effect. The mode of action of metribuzin is that it acts by inhibiting photosystem II of photosynthesis by disrupting electron transfer. This results in death due to starvation in the target plant. Selectivity is due to differing metabolism of the compound within the plant. Metribuzin is approved for use on potatoes, asparagus, cereals, pulse crop, sugarcane and tomatoes.

Chemical name

4-amino-6-tert-4,5-dihydro-3-methylthio-1,2,4-triazin-5-one

Structural formula



Molecular weight

214.3

Empirical formula

$C_8H_{14}N_4OS$

Acetochlor

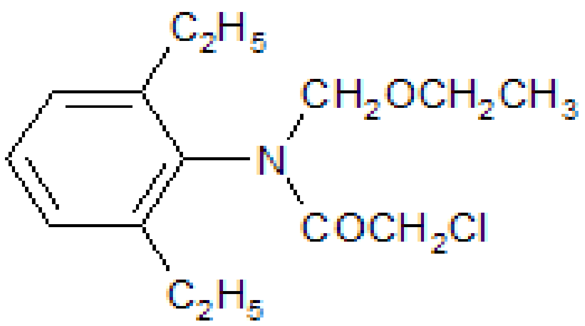
Acetochlor belong to class group of chloroacetamide is a selective herbicide, absorbed mainly by shoots of germinating plants. Acetochlor is used for control of most annual grasses and certain broadleaf weeds and yellow nutsedge. Crops include cabbage, citrus, coffee, maize , cotton, onion, sugarbeets sugarcane and vineyards

Chemical formula

2-chloro-N-(ethoxymethyl)-N-(2-ethyl-6-methylphenyl) acetamide

Empirical formula

$C_{14}H_{20}ClNO_2$
Molecular Weight: 269.8
Structural Formula



Melting point: 0 ^{0}C
Solubility

In water 233 mg/l (25 ^{0}C), also soluble in diethyl ether, acetone, benzene, chloroform, ethanol, ethyl acetate and toluene.

Appendix 3: Procedures used to determine weed density, frequency and uniformity originally described by Thomas (1985).

Weed density = $D_{ki} = \frac{\Sigma Z_j}{n}$; Where

D_{ki} = density (number of plants or spikes/panicles/m^2) of the species k in field i;

Z_j = no. of plants/spikes/panicles in each $1m^2$ sample

n = number of plots

Weed Frequency = ratio of the number of plots where the species was present, to the total number of fields:

$$F_k = \frac{\Sigma Yi}{n} * 100$$; Where

F_k = frequency of the species k

Yi = presence (1) or absence (0) of the species k in field i

N = number of plots

Weed uniformity= the average percentage of samples (from each plot) in which a given species is present

$$U_k = \frac{\Sigma\Sigma X_{ij} * 100}{10n}$$; Where

U_k = Coefficient of uniformity of the species k

X_{ij} = presence (1) or absence (0) of the species in the sub-sample j in field i

n = number of plots