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A review on halosulfuron methyl: New post emergence herbicide for effective control of sedges in sugarcane and its phytotoxicity on crops

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Abstract
Halosulfuron methyl (HM) at 67.5, 75.0, and 150.0 g/ha recorded significantly effective in lowering the population (1.2–2.2/m^2) and dry weed weight (0.45–0.49 g/m^2) of C. rotundus at 60 DAT as compared to other treatments including its lower doses. Atrazine (PE) followed by 2,4-D was not effective against C. rotundus. HM at 67.5, 75.0 and 150.0 g a.i./ha gave 96.3–97.0% control of C. rotundus as against an increase in C. rotundus population (15.1%) in atrazine (PE). 2,4-D treatment and 24.4% increase in untreated check over pre-treatment population. HM at 67.5, 75.0 and 150.0 g a.i./ha recorded higher weed control efficiency (97.8–97.9%) as compared to atrazine (PE) followed by 2,4- D (8.7%) and three hoeings (48.8%). None of the doses of HM affected the dry weight of grassy as well as broadleaf weeds recorded at 60 days after treatment. HM used at 67.5, 75.0 and 150.0 g a.i./ha also recorded significantly higher cane yield as compared to its lower doses, atrazine (PE) followed by 2,4-D and weedy check. Treatment of three hoeings gave maximum cane yield whereas; lowest cane yield was recorded in untreated plots. An increase of 60.9–64.8% in cane yield over control was recorded when HM was applied at 67.5, 75.0 and 150 g a.i./ha whereas standard check (atrazine followed by 2,4-D) recorded 33.9% increase. Critical periods of weed control (CPWC) were studied in six field trials. In ratoon cane, CPWC with natural weed infestations started between 228 and 916 growing degree days (GDD), and ended between 648 and 1311 GDD, depending on the site and cane variety. These results represented a maximum CPWC of 12 to 28 weeks after harvest (WAH). In-plant cane, the CPWC started earlier (6WAP) and was longer than those in ratoon cane.

Keywords: Sedges, sugarcane, critical periods, halosulfuron, phytotoxicity

Introduction

Sugarcane (*Saccharum* spp. L.) is a large perennial grass of the tribe Andropogoneae, family *Gramineae* (Roach & Daniels, 1987) [11]. Known to be one of the oldest cultivated plants in the world, sugar cane has been intensively hybridized and selected for its ability to accumulate sucrose (Alexander, 1973) [1]. Modern commercial varieties of sugar cane are derived from complex interspecific crosses between the wild canes (*S. spontaneum*) and the noble canes (*S. officinarum*). Sugar cane is cultivated throughout the tropical and subtropical regions of the world in a wide variety of soils and climates; it attains full development only when a long, warm growing season alternates with a short, cool and dry ripening season. Sugar cane biomass (fresh weight) production can exceed 200 t ha-1 in one year. An average of 8 to 16 t ha-1 of sugar may be produced from the juice extracted from the cane stalks which represent 70 to 85% of the total biomass. Besides sugar, production cane can also be used for manufacturing of alcoholic liquors (rum), used as fodder (cane leaves), and for cogeneration of electricity (from bagasse). This plant is currently gaining tremendous importance for the production of ethanol, a renewable source of energy and bio-fuel (Thomas & Kwong, 2001; Jolly & Woods, 2004; Autrey & Tonta, 2005) [13, 8, 2]. Due to the continuous use of atrazine, metribuzin and 2,4-D in sugarcane fields, the population of grassy and broad-leaved weeds has been decreased; whereas the population of Cyperus species has increased tremendously. Over the past few years, sugarcane growers in India have experienced an increased infestation of purple (C. rotundus L.) and yellow nutsedge (Cyperus esculentus L.). C. rotundus population has been reported to be 60–80% of total weed flora in sugarcane fields in India (Raskar 2004; Roshan *et al.* 2006) [10, 12]. Halosulfuron Methyl (3-chloro-5-(4,6-dimethoxypirimidin2 ylcarbamoylsulfamoyll-l-metbyl-pyrasole-4-carboxylate) is a selective herbicide for post-emergence control of sedges and other weeds in sugarcane crop.

Halosulfuron-methyl interferes with ALS enzyme, resulting in a rapid cessation of cell division and plant growth in both roots and shoots. The sulfonylurea herbicides are rapidly absorbed by the foliage as well as by the roots of plants (Amrein and Gerber 1985). Halosulfuron methyl is readily translocated throughout the plant and inhibits cell division. Decomposition of the sulfonylureas in the soil takes place by both hydrolytic and microbial processes. The rate of degradation is enhanced by increased temperatures, soil moisture content and low soil pH. Hence, halosulfuron methyl l75%WG (Sempra), a new sulfonylurea herbicide was evaluated for selective control of C. rotundus in sugarcane for two seasons continuously and to observe the phyto-toxicity symptoms on the sugarcane. Sugar cane was first brought to Mauritius in 1639 by the Dutch who established two sugar processing plants in 1641 (Koenig, 1988) [9]. By 1652, however, the manufacture of sugar was abandoned but the cultivation of sugar cane was continued for the production of 'arrack' (an alcoholic beverage similar to rum). The Dutch left the island in 1710 and during the French occupation (1721–1810), a great impetus was given to sugar cane production and the first sugar factories were created; some 3 000 tonnes of sugar and 300 000 gallons of arrack were produced by the beginning of the 19th century. The British captured the island in 1810 and realized that sugar production could be the greatest asset of Mauritius; as a result, the area under cane increased steadily and reached 11 000 ha in 1825. The island was already producing some 107 000 tonnes of sugar in 1854. The sugar industry has since undergone further expansion through increased acreage of sugar cane and significant technical progress due to research and development. The country recorded its maximum sugar production in 1973 when 718 464 tonnes were yielded from a cultivated area of 87 384 ha (Koenig, 1988) [9]. Since then, owing to the conversion of cane land to other uses and small-growers abandoning their production due to increasing costs, production has been falling on average; from 706 839 tonnes in 1986 to 504 900 tonnes in 2006 (MSIRI, 2006). The current area under cane is less than 67 000 ha (MSIRI, 2006). The decrease in area and production has been faster within the last five years as more lands have been converted to other new emerging sectors such as manufacturing (mainly textile), information and telecommunication technologies (ICT) and integrated resort schemes (IRS).

Halosulfuron

If you are dealing with stubborn nutsedge on your landscapes, one of the best products you can use to alleviate the problem is an active ingredient by the name of Halosulfuron. Halosulfuron is known to be effective against both yellow and purple nutsedge. Solutions Pest & Lawn has a quality selection of herbicide products in stock that contain the active ingredient Halosulfuron and we highly recommend this product to our customers who want to control aggressive sedge. On this page, you can gain some background info about Halosulfuron, its mode of action and its benefits. You can also access this page to shop our entire line of products that contain Halosulfuron. Halosulfuron mode of action involves interfering with the acetolactate synthase enzyme in targeted plants, which quickly slows cell division and growth at all phases of development.

Benefits of Halosulfuron

Halosulfuron has shown to be very effective in controlling nutsedge and other types of sedges on turf. It works selectively on many common types of turf, targeting the sedges without injuring your desired grass. It also works systemically, being absorbed into the plant in 24 to 48 hours then begins moving through the plant to the roots and nutlets underground, resulting in a quick death after a few weeks. Halosulfuron is labeled for nutsedges and horsetail only and is unable to control other grassy or broadleaf weeds.

Effect on Weeds

In the experimental field, C. rotundus was the dominant weed during the growing season. This weed consisted of approximately 79.1 and 82.8% of total weed flora followed by broad-leaved (12.1 and 8.6%) and grassy weeds (8.8 and 8.6%) during the growing season. Due to the continuous use of atrazine and 2,4-D in sugarcane fields, the population of grassy and broad leaf weeds has decreased and C. rotundus has increased in the experimental field since these herbicides are ineffective against C. rotundus. Roshan *et al*. (2006) [12] also reported higher C. rotundus intensity as compared to grasses and broad leaved weeds in weed surveys conducted in different sugar mill zones of Haryana state in India. The data on pre-treatment observations on weeds, i.e. before spray of halosufuron treatment reveal that preemergence application of atrazine reduced the population of grasses and broad leaf weeds but not C. rotundus during the growing season. C. rotundus population was 49–51/m^2 in all the treatments except in three hoeing treatment, where it ranged from 25 to 28/m^2. Population of grassy weeds ranged from 5 to 7/m^2 in all the treatments except three hoeing treatment and atrazine (PE) where the population of 1–2/m^2 was recorded. Over the past few years, sugarcane growers in India have experienced an increase in purple (C. rotundus L.) and yellow nutsedge (C. esculentus L.). The proliferation of nutsedge is likely due to the poor control obtained with atrazine, metribuzin, trifluralin and pendimethalin, which reduce grass competition but provide little control of nutsedge (Dotray *et al*. 2001; Grichar and Nester 1997; Raskar 2004, Roshan *et al*. 2006) [3, 6, 10, 12].

Weed population

Halosulfuron methyl applied at 67.5, 75.0, and 150.0 g a.i./ha being at par recorded a significantly lesser population of C. rotundus (3.1–3.4/m^2) as compared to other treatments. Atrazine (PE) followed by 2,4-D was not effective against C. rotundus Halosulfuron at 67.5, 75.0 and 150.0 g/ha gave 93.3–94.1% control of C. rotundus, however, the population of C. rotundus increased by 11.5% in atrazine (PE) followed by 2,4-D treatment and 18% increase in untreated check plot over pretreatment population. C. rotundus is considered the world's worst weed and yield decreases in sugarcane of 75% in Argentina and 38% in Australia have been reported (Holm *et al*. 1997) [7]. Turner (1984) [14] stated that plant cane may suffer severely from the effects of competition and suggested some control methods. Van Biuon *et al*. (1996) [15] reported that post-emergence applications of 36 g a.i./ha made from the four leaves stage to just prior to flowering afforded 85–95% control of both Cyperus esculentus et rotundus depending on climatic conditions.

Weed dry weight

Dry weed biomass of C. rotundus was significantly lower with an application of halosulfuron at 67.5, 75.0 and 150.0 g/ha (0.45–0.49 g/m^2) compared to its lower doses. Halosulfuron at 67.5, 75.0 and 150.0 g/ha recorded higher weed control efficiency (97.8–97.9%) as compared to atrazine (PE) followed by 2,4-D (8.7%) and three hoeings (48.8%).

None of the doses of halosulfuron methyl affected the dry weight of grassy as well as broad leaved weeds recorded. Among the various four doses of Halosulfuron methyl the highest dose @ 135 g ha-1 recorded 87.66 and 84.38 per cent better sedge weed control in regards to density, respectively than PE application of Atrazine 50 WP @ 2.0 kg ha-1. The corresponding figures for Halosulfuron methyl applied @ 135 g ha-1 over the POE application of 2,4-D amine salt 58 SL @ 3.5 kg ha-1 were 88.01and 84.71per cent. The findings were in accordance with the findings of Webster and Coble (1997) [17] while worked on Halosulfuron at 72.0 g ha-1 in cane. Being a Halosulfuron it is rapidly absorbed by the foliage as well as by the roots of plants and translocated throughout the plant. Halosulfuronmethyl at 67.5, 75.0 and 150.0 g a.i./ha recorded similar control of C. rotundus and weed control efficacy and thus 67.5 g a.i./ha was realized to be the optimum dose of halosulfuron for control of C. rotundus in sugarcane. Atrazine (PE) followed by 2,4-D gave effective control of grasses and broad leaves weeds is but not of C. rotundus). Halosulfuron, an ALS-inhibiting herbicide, effectively reduced purple nutsedge regrowth to less than 5% of the nontreated following soil and/or foliar applications (Vencill *et al*. 1995) [16]. In corn, a foliar application of halosulfuron at 72 g a.i./ha controlled purple nutsedge more than 90% 58 days after planting (Webster and Coble 1997) [17], but new shoots had emerged by 120 days after planting. Halosulfuron usually stops the reserve food supply and blocks the normal function of enzyme ALS or AHAS which is essential for amino acid (protein) synthesis (Vencill *et al.*, 1995) [16].

Effect on crop

Germination percentage in different treatments did not differ significantly indicating that halosulfuron methyl did not have any adverse effect on the germination of sugarcane. Halosulfuron methyl applied at 67.5, 75.0 and 150.0 g/ha being at par recorded a significantly higher number of tillers and millable canes as compared to its lower doses (52.5 and 60.0 g a.i./ha), atrazine (PE) followed by 2,4-D and an untreated check. The highest number of tillers and millable canes were recorded in three hoeings treatment; whereas, the lowest numbers were recorded in untreated plots. All the herbicidal treatments recorded a significantly higher number of tillers and millable canes over untreated plots. A reduction in the ability of nutsedge to reestablish a significant underground tuber population will allow sugarcane to establish a stable root system (Etheredge *et al*. 2006; Etheredge and Griffin 2008) [4]. Halosulfuron at 67.5, 75.0 and 150.0 g a.i./ha being at par recorded significantly higher cane yield as compared to halosulfuron at 52.5 and 60.0 g/ha, atrazine (PE) followed by 2,4-D and unweeded control. Maximum cane yield was observed in three hoeings treatment, whereas, lowest cane yield was recorded in untreated plots. An increase of 60.9–64.8% in cane yield was recorded when halosulfuron was applied at 67.5, 75 and 150 g a.i./ha over control, while standard check (atrazine followed by 2,4-D) recorded 33.9% increase in cane yield over control. All the herbicidal treatments recorded significantly higher cane yield over untreated plots. However, single cane weight was not affected significantly by different treatments of halosulfuron methyl. All the herbicidal treatments recorded significantly higher cane weight over untreated plots. A higher number of tillers, millable canes, single cane weight and cane yield in halosulfuron methyl treatments was obtained because of weed free environment due to better control of C. rotundus over the standard check.

Efficiency parameters

The weed control efficiency (WCE) of different treatments was higher during the initial stages of growth (30DAA) and it was declined with days of crop growth Among the herbicidal treatments highest WCE was achieved with PE application of Atrazine 50 WP @2.0 kg ha-1 (30, 45 and 60 DAA- 64.3, 62.6 and 61.0%, respectively) followed by Halosulfuron Methyl 75 WG@ 135 g ha-1 (30, 45 and 60 DAA- 44.2, 40.1 and 37.4%, respectively) and its lower doses at different days of observation. Similar trends have been observed in the weed control index (WCI). But for inhibition of sedge weeds, the highest WCE and WCI was observed against the application of Halosulfuron Methyl 75 WG @ 135 g ha- 1 followed by its lower doses. At 30 DAA Halosulfuron Methyl 75 WG @ 135 g ha-1 recorded 77.88 and 84.41per cent greater WCE on sedges than PE application of Atrazine 50 WP @ 2 kg ha-1 and 2,4-D amine salt 58 SL @ 3.5 kg ha-1, respectively. This conforms with the earlier findings of Rathika *et al.* (2013). The WCI was higher at initial observation and then gradually decreased as the crop growth advances towards maturity. The probable reason is WCI is determined on a weed dry weight basis which normally increases over time as the herbicide efficacy is decreased gradually after its half-life period. Highest herbicide efficiency index (HEI) was recorded with the application of Atrazine 50 WP @ 2.0 kg ha-1 (0.96%) followed by 2,4-D amine salt 58 SL @ 3.5 kg ha-1 (0.33%), Halosulfuron Methyl 75 WG applied @ 135 g ha-1 (0.23%) and its lower three doses. This is because of the reason that Halosulfuron Methyl 75 WG mainly controls the grassy weeds while 2,4-D amine salt 58 SL is capable to control only the broadleaf weeds but Atrazine 50 WP can able to manage all categories of annual weeds in sugarcane. A similar trend has been reflected in the case of agronomic management index (AMI), weed management index (WMI) and integrated weed management index (IWMI).

Phyto-toxicity on Crop

There was no phytotoxicity in respect of crop discoloration, chlorosis, stunting, wilting, deformation and vein clearing in sugarcane plant by application of halosulfuron methyl even up to 150.0 g a.i./ha indicating that it was safe to the sugarcane crop (data not given). Etheredge *et al*. (2010) also did not observe a reduction in sugarcane growth later in the growing season and any injury to the crop due to halosulfuron.

Conclusion

Halosulfuron methyl at 67.5, 75.0 and 150.0 g a.i./ha applied 3–4 leaf stage of weed (45 DAP) gave effective control (97.8–97.9%) of C. rotundus. It was found safe to sugarcane and follow up crops (black gram, maize, and cucumber) even up to the dose of 150.0 g/ha. Halosulfuron methyl at 67.5 g a.i./ha being at par with its higher doses (75.0 and 150.0 g a.i./ha) provided significantly higher percent control of C. rotundus, weed control efficiency and cane yield as compared to its lower doses. Thus, halosulfuron methyl (Sempra) 67.5 g a.i./ha at 40 days after planting was realized to be the best treatment for effective control of C. rotundus in sugarcane.

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