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Management of weeds for sustainable sugarcane production in sub tropical India

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ABSTRACT

Field investigations were carried out during 2009-12 at Ladhowal centre of Punjab Agricultural University, Ludhiana to develop effective methods of weed control for sustainable sugarcane production in sub-tropical India. The soil of the experimental site was sandy loam in texture, low in organic carbon, medium in available phosphorus and high in exchangeable potassium. The results showed that mean weed density and weed biomass substantially reduced with three hand hoeings at 30, 60 and 90 days after planting-DAP (34.6 weeds/m^2 and 56.8g/m^2) as well as with pre–emergence application of metribuzin @ 1.25 kg a.i./ha followed by 2,4-D @ 1.0 kg a.i./ha 75 DAP (38.8 weeds/m^2 and 69.6 g/m^2). Unweeded control registered highest weed count (72.2 weeds/ m^2) and weed biomass (197.5 g/m^2). The highest number of millable canes (99,600/ha) and cane yield (77.0 t/ha) was recorded with pre-emergence application of metribuzin @ 1.25 kg a.i./ha fb 2, 4-D @ 1.0 kg a.i./ha 75 DAP and it was closely followed by hand hoeing thrice at 30, 60 and 90 DAP (94,500/ha and 75.6 t/ha) and was further followed by pre–emergence application of metribuzin @ 1.25 kg a.i./ha integrated with post emergence spray of almix @ 20 g/ha (93,200/ha and 73.4 t/ha). Integrating pre-emergence application of metribuzin @ 1.25 kg a.i./ha with post emergence application of 2,4-D @ 1.0 kg a.i./ha 75 DAP exhibited 65.3% weed control efficiency (WCE) which was comparable to 69.7% WCE registered with three hand hoeing at 30, 60 and 90 DAP.

Keywords: Sugarcane, weed management, metribuzin, hand hoeing, weed control efficiency

The day to day agriculture is rife with weeds. They are insidious tyrants on earth. Their occurrence in the cultivated field is not by chance, but due to the influence of certain soil characteristics, tillage practices, prevailing climate and other crop management practices. Competition by weeds during the growing season of the crop for soil moisture, mineral constituents, sunlight, and space along with unhealthy nutrient management practices is the major constraint in enhancing the crop productivity. Besides, reducing the crop yield directly, heavy infestation of weeds interfere with crop harvest and elevate farm production costs through energy spent in controlling them. A weed which escapes the control measures and produces seed at maturity, further multiplies weed control problems by acting as a source of seed bank replenishment and re-infestation in the subsequent years. In sugarcane, the reduction in cane yield due to weeds ranged from 40 – 67 %, the highest being in those areas where farmers are not familiar to improved weed management technologies (Chauhan and Srivastava 2002, Singh *et al.* 2010). Weed control is most critical early in the season prior to the sugarcane canopy closure over the row middles. Wide spacing in between sugarcane rows allows wide range of weed flora to grow profusely. The kind of weed specie and the duration of its infestation have a major impact on stalk size, number of millable canes and finally the cane and sugar yields. In sugarcane, weeds are generally controlled with manual and cultural manipulations. Timely availability of labour is a problem. Now–a–days, herbicide use for weed control in sugarcane is considered to be economical and thus becoming increasingly popular. Hence, providing a weed free environment is absolutely essential to realize the full potential of new varieties and to make the best use of key production factors like nutrients, moisture and other natural resources.

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MATERIALS AND METHODS

The field experiment was conducted at Sugarcane Research Station of P.A.U. located at Ladhowal for three consecutive years i.e. 2009-10 (Yr 1), 2010-11 (Yr 2) and 2011-12 (Yr 3). The objective of the study was to search effective methods of weed control for sustainable sugarcane production in sub-tropical India. The soil of the experimental site was sandy loam in texture, analyed low in organic carbon (0.36 %), medium in available phosphorus (18.5 kg/ha) and high in exchangeable potassium (315 kg/ha). The experiment comprised of ten weed control treatments with combination of pre and post emergent herbicides [T_1- Control (weedy check),T_2 - hoeing at 30,60 and 90 days after planting (DAP), T_3 – Atrazine @ 2.0 kg a.i./ha as pre-emergence (PE) followed by 2,4 – D @ 1.0 kg a.i./ha at 60 DAP, T_4 – Atrazine @ 2.0 kg a.i./ha after 1st irrigation and hoeing followed by 2,4 – D @ 1.0 kg a.i./ha at 75 DAP, T_5 – Metribuzine @ 1.25 kg a.i./ha

(PE) followed by 2,4 – D @ 1.0 kg a.i./ha at 75 DAP, T_6 - Atrazine @ 2.0 kg a.i./ha (PE) followed by Almix @ 20g /ha at 75 DAP, T_7 - Metribuzine @ 1.25 kg a.i./ha (PE) followed by Almix @ 20g /ha.i./ha at 75 DAP, T_8 - Atrazine @ 2.0 kg a.i./ha (PE) followed by Ethoxysulfuron @ 50g /ha at 75 DAP, T_9 - Atrazine @ 2.0 kg a.i./ha (PE) followed by Dicamba @ 350g a.i./ha at 75 DAP, T_{10} - Metribuzine @ 1.25 kg a.i./ha (PE) followed by Dicamba @ 350g a.i./ha at 75 DAP]. These treatments were evaluated under randomized block design with three replications. Sugarcane variety 'CoJ 88' was planted in spring in rows 75 cm apart using 50,000 three budded setts per ha (approximately 75 qtls seed) on 12.03.2009, 11.3.2010 and 11.3.2011 over the three consecutive years during spring season.

Uniform dose of 150 kg nitrogen per ha was applied in two equal splits at first irrigation after germination and the second in May end alongside cane rows. All other cultural operations were followed as per recommended package of practices to raise a healthy cane crop. Herbicides were applied using knapsack sprayer fitted with flat fan nozzle using a spray volume of 562.5 lts per ha. A quadrat of 0.25 m^2 was used to record the weed count at 120 DAP and the fresh samples of weeds so obtained from that quadrat were kept in hot air oven at 70^0C (till constant wt. is recorded) for determining dry matter accumulation and weed control efficiency.

RESULTS AND DISCUSSION

Weed Management

Weed Flora

The dominant weeds which emerge after the sugarcane planting during the three seasons were *Digitaria ciliaris, Eleusine aegyptiacum, Sorghum halepense, Cynodon dactylon, Cyperus rotundus, Euphorbia hirta, Digera arvensis, Bracharia reptans, Ipomoea pestigradis and Convolvulus arvensis.*

Weed density

The weed population observed 120 days after the herbicidal spray in sugarcane crop differed significantly during all the three consecutive years of experimentation (2009-10, 2010-11, 2011-12). The results in table 1 revealed that different weed control treatments recorded significantly lower weed density than the unweeded control (T_1). The lowest weed density in all the experimental years was registered in plots where weeds were manually controlled by hoeing at 30, 60 and 90 DAP. The pooled data indicated that pre–emergence application of metribuzin @ 1.25 kg a.i./ha followed by 2,4-D @ 1.0 kg a.i./ha 75 DAP (T_5) (38.8/m^2) being at par to three hand weedings (T_2) (34.6/m^2) recorded significantly lower weed density than the pre-emergence application of atrazine @ 2.0 kg a.i/ha followed by almix @ 20 g/ha 75 DAP (T_6) (51.2/m^2). The weed density values in pre-emergence application of metribuzin @ 1.25 kg a.i./ha or atrazine @ 2.0 kg a.i. / ha integrated with post emergence application of 2,4-D or dicamba or ethoxysulfuron (T_3, T_4, T_5, T_8, T_9, T_{10}) were comparable to each other. Similarly the values of weed density with three hand weedings (T_2) were at par to the pre–emergence application of atrazine 2.0 kg a.i./ha fb 2,4-D @ 1.0 kg 75 DAP (T_4) and pre-emergence application of metribuzin 1.25 kg a.i./ha fb either 2,4-D (T_5) or dicamba (T_{10}) 75 DAP. The results are in line with Singh *et al* (2012) who reported the lowest weed density with three handweedings followed by pre-emergence application of metribuzin + hoeing+ 2,4-D which was further followed by pre-emergence application of atrazine + 2,4-D.

Weed biomass (Dry wt. of weeds)

The pooled data (table 1) revealed that the handweeding thrice at 30, 60 and 90 DAP (T_2) effectively reduced the weed biomass being at par to pre-emergence application of metribuzin @ 1.25 kg a.i./ha (PE) fb 2,4-D @ 1.0 kg a.i./ha 75 DAP (T_5) but significantly better in reducing the weed biomass registered in all the other weed control treatments. Similar trend was noticed in data of individual years. Integration of metribuzin with 2, 4-D 75 DAP (T_5) too reduced the dry weight of weeds significantly when compared to the integration of metribuzin or atrazine with almix, ethoxysulfuron or dicamba at variable doses (T_6, T_7, T_8, T_9, T_{10}). Pre-emergence application of metribuzin or atrazine fb 2, 4-D (T_5, T_4 and T_3) registered statistically similar weed biomass. Efficacy of metribuzin in controlling weed biomass has also been reported by Mishra *et al* (2012), Sundara (2000) and Singh *et al* (2001).

Weed control efficiency (WCE)

The weed control efficiency among the weed management practices ranged from 58.9 to 65.3% in 2009-10, 40.5 – 69.9% in 2010-11 and 42.3 – 74.1% in 2011-12. The highest weed control efficiency of 69.7% (mean of three years) was found in treatment given three hoeings at 30, 60 and 90 DAP (T_2). The next best treatments were pre-emergence application of metribuzin @ 1.25kg a.i./ha fb 2,4–D @ 1.0 kg a.i./ha 75 DAP (T_5 = 65.3%) and pre-emergence application of atrazine @ 2.0 kg a.i./ha fb 2,4–D @ 1.0 kg a.i./ha 75 DAP (T_4 = 61.5%). Integration of pre-emergence application of metribuzin or atrazine and post emergence spray of 2,4-D during grand growth period of sugarcane (75 DAP) might have effectively controlled the weeds. Similar observations were made by Chitkala Devi *et al* (2011).

Growth

Germination, Tiller number, Cane height and Internodes per cane

The pooled data on germination count of sugarcane (table 1) varied from 34.1 to 36.4% indicating non–significant differences among weed control treatments. A perusal of pooled data in table 2 followed similar trend showing non–

Table 1 Percent germination, weed density/m^2, dry weight of weeds (g/m^2) and weed control efficiency as influenced by different weed control treatments

Treatment	Percent germination (%)				Weed density/m^2				Dry weight of weeds (g/m^2)				Weed control efficiency (%			
	Yr 1	Yr 2	Yr 3	Mean	Yr 1	Yr 2	Yr 3	Mean	Yr 1	Yr 2	Yr 3	Mean	Yr 1	Yr 2	Yr 3	Mean
T_1 Control (weedy check)	31.0	37.6	36.6	35.1	48.7	65.3	102.7	72.2	108.7	169.7	314.2	197.5	-	-	-	-
T_2 Hoeing at 30,60 and 90 DAP	33.3	37.8	37.2	36.1	24.0	31.7	48.0	34.6	38.0	51.0	81.3	56.8	65.0	69.9	74.1	69.7
T_3 Atrazine @ 2.0 kg a.i./ha (PE) fb 2,4–D @ 1.0 kg a.i./ha at 60 DAP	32.0	37.6	39.2	36.3	32.3	40.0	66.7	46.3	43.3	62.0	158.7	88.0	60.1	63.5	49.5	57.7
T_4 Atrazine @ 2.0 kg a.i./ha after 1st irrign and hoeing f b 2,4–D @ 1.0 kg a.i./ha at 75 DAP	32.7	36.1	36.7	35.2	27.3	44.7	61.3	44.4	37.7	56.3	149.3	81.1	65.3	66.8	52.5	61.5
T_5 Metribuzin @ 1.25 kg a.i./ha (PE) fb 2,4–D @ 1.0 kg a.i./ha at 75 DAP	31.3	33.5	38.7	34.5	25.7	32.0	58.7	38.8	39.3	52.0	117.3	69.6	63.8	69.4	62.7	65.3
T_6 Atrazine @ 2.0 kg a.i./ha (PE) fb Almix @ 20g /ha at 75 DAP	32.0	34.7	39.7	35.5	31.7	52.7	69.3	51.2	43.0	101.0	173.3	105.8	60.4	40.5	44.8	48.6
T_7 Metribuzin @ 1.25 kg a.i./ha (PE) fb Almix @ 20g /ha at 75 DAP	34.0	35.3	39.8	36.4	28.0	36.7	74.7	46.4	39.0	54.0	181.3	91.4	64.1	68.2	42.3	58.2
T_8 Atrazine @ 2.0 kg a.i./ha (PE) fb Ethoxysulfuron @ 50g /ha at 75 DAP	30.3	33.3	38.6	34.1	29.7	39.3	70.7	46.6	44.7	93.7	153.3	97.2	58.9	44.8	51.2	51.6
T_9 Atrazine @ 2.0 kg a.i./ha (PE) fb Dicamba @ 350g a.i./ha at 75 DAP	31.3	35.5	37.6	34.8	32.0	42.7	65.3	46.7	44.0	85.0	166.7	98.6	59.5	49.9	47.0	52.1
T_{10} Metribuzin @ 1.25 kg a.i./ha (PE) fb Dicamba @ 350g /ha at 75 DAP	32.3	33.2	39.8	35.1	26.3	41.0	62.7	43.3	38.7	81.0	154.7	91.4	64.4	52.3	50.8	55.8
C.D (p=0.05)	NS	NS	NS	NS	8.3	14.3	22.8	11.3	7.9	22.7	51.9	21.0	-	-	-	-

Yr 1, Yr 2, and Yr 3 represents 2009-10, 2010-11 and 2011-12 respectively. DAP – Days after planting, fb – followed by

significant differences for number of tillers, cane height and internodes per cane. No set pattern was observed for cane height and internodes per cane on analysing the pooled and the individual year data. But for tiller number, unweeded control registered lowest mean number of tillers but the differences were not significant although the various weed management modules registered numerically higher tiller count than the weedy check. The data on tiller number during 2009-10 (in the first year of experimentation) recorded significant differences which exhibited significantly lowest number of tillers under unweeded control plot (T_1). Hand weeding thrice and pre-emergence application of metribuzin integrated with 2,4-D or dicamba 75 DAP (T_5 and T_{10}) significantly recorded higher tiller count than the pre-emergence application of atrazine integrated with 2,4-D or almix or ethoxysulfuron or dicamba (T_4, T_6, T_8, T_9).

Yield attributes and Yield

Single cane weight, Number of millable cane (NMC)s and Cane Yield (CY)

Reductions in yield due to weeds were brought about mainly by the effect of weeds on the number or millable canes and

their height. The data regarding various weed management modules in table 3 depicted non–significant differences for single cane weight. However, the number of millable canes (NMC) and cane yield (CY) showed substantial reduction due to the presence of weeds particularly during the grand growth period of cane growth. Among the weed control treatments, pre-emergence application of metribuzine @ 1.25 kg a.i./ha fb 2,4-D @ 1.0 kg a.i./ha 75 DAP (T_5) registered the highest number of pooled millable canes (99,600/ha) and pooled cane yield (77.0 t/ha) which was at par with hand hoeings thrice at 30, 60 and 90 DAP (T_2) [NMC-94,500/ha and CY- 75.6 t/ha] and also with pre–emergence application of metribuzin @ 1.25 kg a.i./ha was integrated with almix @ 20 g/ha (T_7) [NMC-93,200/ha and CY-73.4 t/ha] but were significantly greater to the treatments where pre-emergence application of atrazine @ 2.0 kg a.i./ha was integrated with the post emergence application of 2,4-D @ 1.0 kg a.i./ha (T_3 & T_4), almix @ 20 g/ha (T_6), ethoxysulfuron @ 50 g/ha (T_8) or dicamba @ 350 g/ha (T_9). The widespread infestation of weeds throughout the crop season cause severe decline in the cane yield to the tune of 32.9% when compared with the pre and post emergence spray of metribuzin and 2,4-D respectively (T_5) and to the tune of 31.6% when compared to the three hand weedings at 30, 60 and 90 DAP (T_2). Sugarcane raised with three hand hoeings (T_2) and pre-emergence application of metribuzin fb 2,4-D (T_5) produced higher yield components by virtue of reduced competition of weeds for nutrients, moisture and sunlight which ultimately have converted more number of tillers to millable canes. These results are in agreement with the findings of Srivastava and Chauhan (2006). Unweeded control plot registered lowest number of millable canes and cane yield on account of higher competition by the weeds for the resources to be utilized by the sugarcane crop in the weed free environment. Similar findings has also been reported earlier by Singh and Tomar (2005) and Chitkala Devi *et. al* (2011).

Table 2 Sugarcane growth in terms of tiller number, cane length and internodes per cane as influenced by different weed control treatments.

Treatments	Number of tillers (000/ha)				Cane length (cms)				Internodes per cane			
	2009-10	2010-11	2011-12	Mean	2009-10	2010-11	2011-12	Mean	2009-10	2010-11	2011-12	Mean
T_1 Control (weedy check)	80.2	170.7	154.3	135.1	158.3	194.3	206.0	186.2	15.7	17.5	19.9	17.7
T_2 Hoeing at 30,60 and 90 DAP	130.7	168.4	205.0	168.0	163.7	200.0	209.7	191.1	17.5	17.9	18.7	18.0
T_3 Atrazine @ 2.0 kg a.i./ha (PE) fb 2,4–D @ 1.0 kg a.i./ha at 60 DAP	113.6	182.7	192.7	163.0	177.7	175.3	212.7	188.6	19.7	16.5	19.2	18.5
T_4 Atrazine @ 2.0 kg a.i./ha after 1st irrign and hoeing f b 2,4–D @ 1.0 kg a.i./ha at 75 DAP	111.8	153.1	191.3	152.1	171.0	197.0	221.0	196.3	16.1	17.4	20.6	18.0
T_5 Metribuzin @ 1.25 kg a.i./ha (PE) fb 2,4–D @ 1.0 kg a.i./ha at 75 DAP	132.7	160.5	206.0	166.5	174.0	197.7	213.3	195.0	17.8	17.9	20.7	18.8
T_6 Atrazine @ 2.0 kg a.i./ha (PE) fb Almix @ 20g /ha at 75 DAP	111.8	191.8	177.0	160.3	165.3	187.7	218.7	190.6	18.4	16.8	20.9	18.7
T_7 Metribuzin @ 1.25 kg a.i./ha (PE) fb Almix @ 20g /ha at 75 DAP	122.7	176.5	196.3	165.2	165.7	194.6	217.7	192.7	16.7	16.9	19.3	17.6
T_8 Atrazine @ 2.0 kg a.i./ha (PE) fb Ethoxysulfuron @ 50g /ha at 75 DAP	111.8	170.7	203.3	161.9	143.7	209.6	205.0	186.1	14.5	19.5	19.0	17.6
T_9 Atrazine @ 2.0 kg a.i./ha (PE) fb Dicamba @ 350g a.i./ha at 75 DAP	113.8	178.0	163.0	151.6	157.0	203.3	215.0	191.8	18.0	17.7	19.7	18.5
T_{10} Metribuzin @ 1.25 kg a.i./ha (PE) fb Dicamba @ 350g /ha at 75 DAP	131.3	158.7	194.7	161.6	164.0	186.0	199.7	183.2	17.9	17.7	19.4	18.4
C.D (p=0.05)	17.2	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 3 Yield and Yield attributes of sugarcane in terms of single cane weight, number of millable canes and cane yield as influenced by different weed management modules.

Treatments	Single Cane weight (g)				No. of Millable canes (000/ha)				Cane Yield (t/ha)			
	2009-10	2010-11	2011-12	Mean	2009-10	2010-11	2011-12	Mean	2009-10	2010-11	2011-12	Mean
T_1 Control (weedy check)	960.8	703.4	694.1	786.1	62.9	72.0	72.2	69.0	54.3	50.7	50.0	51.7
T_2 Hoeing at 30,60 and 90 DAP	798.7	822.6	788.1	803.1	93.6	90.4	99.5	94.5	74.7	74.1	78.0	75.6
T_3 Atrazine @ 2.0 kg a.i./ha (PE) fb 2,4–D @ 1.0 kg a.i./ha at 60 DAP	842.8	760.2	781.3	794.8	84.4	81.5	84.9	83.7	70.7	61.9	65.8	66.1
T_4 Atrazine @ 2.0 kg a.i./ha after 1st irrign and hoeing f b 2,4–D @ 1.0 kg a.i./ha at 75 DAP	777.4	722.9	789.2	763.2	90.7	93.1	86.7	90.1	70.0	67.3	68.5	68.6
T_5 Metribuzin @ 1.25 kg a.i./ha (PE) fb 2,4–D @ 1.0 kg a.i./ha at 75 DAP	756.8	770.1	798.9	775.2	101.3	100.2	97.3	99.6	76.7	77.3	77.1	77.0
T_6 Atrazine @ 2.0 kg a.i./ha (PE) fb Almix @ 20g /ha at 75 DAP	828.2	765.9	756.3	783.5	84.3	84.7	83.8	84.3	69.3	64.6	62.9	65.6
T_7 Metribuzin @ 1.25 kg a.i./ha (PE) fb Almix @ 20g /ha at 75 DAP	751.2	840.3	782.2	791.3	96.7	88.2	94.7	93.2	72.9	73.5	74.0	73.4
T_8 Atrazine @ 2.0 kg a.i./ha (PE) fb Ethoxysulfuron @ 50g /ha at 75 DAP	723.2	818.1	771.5	770.9	94.3	85.6	88.0	89.3	68.4	69.9	67.1	68.5
T_9 Atrazine @ 2.0 kg a.i./ha (PE) fb Dicamba @ 350g a.i./ha at 75 DAP	787.3	788.9	787.9	788.0	88.4	86.2	80.9	85.3	69.6	67.6	63.6	66.9
T_{10} Metribuzin @ 1.25 kg a.i./ha (PE) fb Dicamba @ 350g /ha at 75 DAP	775.2	772.9	816.5	788.2	97.8	89.8	81.8	89.8	75.8	68.8	66.7	70.4
C.D (p=0.05)	NS	NS	NS	NS	20.2	14.0	14.4	8.8	10.4	12.5	10.4	5.6

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