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EFFECT OF SEQUENTIAL APPLICATION OF HERBICIDES ON WEEDS AND PRODUCTIVITY OF SPRING PLANTED SUGARCANE (*SACCHARUM OFFICINARUM* L.)

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ABSTRACT
The study was carried out during the spring seasons of 2011-12 and 2012-13 to the effect of sequential application of herbicides on weeds and productivity of spring planted sugarcane (*Saccharum officinarum* L.). Results showed that the minimum weed density at 90 DAP, weed control efficiency (94.53%) at 90 DAP and weed index were significantly highest with conventional practice (three hoeings) at 30, 60 and 90 DAP. Weight of millable cane, cane yield (135.32 t/ha), green tops yield, trash yield, biological yield and harvest index were found highest under conventional practice (three hoeings) at 30, 60 and 90 days after planting of sugarcane. Among the herbicides, the sequential application of ametryne @ 2.4 kg a.i./ha at 30 DAP *fb* 2,4-D @ 1.0 kg a.i./ha at 60 DAP of sugarcane observed as the second best treatment with lower weed density at 90 DAP, weed control efficiency (85.61%) at 90 DAP weed index (8.61%) and cane yield (123.66 t/ha).

INTRODUCTION

Sugarcane is the main source of sugar in India and holds an important agricultural commercial cash crop (Dev *et al.*, 2013) which provides gainful employment to large number of people. India is the second largest among sugarcane (*Saccharum officinarum* L.) producing countries, sharing 20 per cent of the world's sugarcane area. Sugarcane is the most important sugar crop in the world for sugar production which also plays pivotal role in Indian economy by contributing 0.67% of national GDP because of its wider adaptability over varying agro-climatic condition (Dev *et al.*, 2011). It is a chief raw material for Indian sugar industry. Sugarcane occupies an area of about 5.06 million hectares with a production of 334.54 million tonnes of canes. In India, 26.34 million tonnes of sugar produced with a recovery of 10.25%. The productivity of sugarcane in India is low (66.08 t/ha) compared with that in many other sugarcane growing countries namely Egypt (121.14 t/ha) and Colombia (100.42 t/ha). Uttar Pradesh ranks first both in area (2.21 mha) and production (130.51 mt) of sugarcane, contributing 43.68 and 39.01 per cent, respectively at the national level. This gap in the acreage and production is because of poor cane productivity in the state being 59.00 t/ha which is even less than the national average (IISR, 2013).

Productivity of sugarcane in India is low as compared to other sugar growing countries of the world. Various factors such as major acreage under small and marginal holdings, non availability of quality inputs, attack of diseases and insect-pest and occurrence of various inevitable stresses during the crop growth period restrict the crop yield particularly in the sub-tropical region of the country. Negligent attitude of farmers towards weed control is the most important among losses due to various factors in sugarcane. In sugarcane crop, weed infestation is very high due to slow initial growth of crop and wide spacing between the crop rows, frequent and heavy irrigations, application of heavy doses of manures and fertilizers and the warm and humid climate during a large part of the growing season. Weeds are fast growing and multiply at alarming rate. It is well established that plants grown first have an upper hand in utilizing various resources. Therefore, weeds, if allowed to grow unhindered, lead to severe competition for light, space, water, nutrients etc. As a result crop plants are subjected to hardship during their early growth period and heavy yield losses do occurs. Sugarcane, by virtue of its long duration, has a longer critical period of 60 to 120 days for weed competition (Chauhan and Srivastava, 2002). None of the herbicide either pre or post-emergence alone can take care of weeds for such a long period and economical. Identification of new herbicides is vital and urgently needed to reduce the possibility of evolution of resistant biotype of weeds and getting higher sugarcane yield. Hence, proper choice of the weed management system would be viable, effective and economical with the varying intensity of weed species, population and their dominant effect on sugarcane. Identification of new herbicides is vital and urgently needed to reduce the possibility of evolution of resistant biotype of weeds and getting higher sugarcane yield and recovery. The

study was carried out to find out the most suitable herbicide or a combination of herbicides to control weeds in spring planted sugarcane.

MATERIALS AND METHODS

The field experiment was conducted during two consecutive spring seasons of 2011-12 and 2012-13 at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India. The physico-chemical properties of soil of the experimental site were sandy clay loam in texture (Typical Ustochrept) with pH 7.64. It was moderately fertile being low in organic carbon (0.36%), available nitrogen (187.00 kg/ha), whereas, available phosphorus (21.03 kg/ha) and potassium (227.00 kg/ha) were medium. The experiment was laid out in randomized complete block design with three replications. Twelve treatment combinations *viz*., T_1-Weedy, T_2-Conventional practice (Three hoeings at 30, 60 & 90 DAP), T_3-Ametryne @ 1.6 kg a.i./ha at 30 DAP, T_4-Ametryne @ 2.0 kg a.i./ha at 30 DAP, T_5-Ametryne @ 2.4 kg a.i./ha at 30 DAP, T_6-Atrazine @ 1.0 kg a.i./ha at 30 DAP, T_7-Ametryne @ 1.6 kg a.i.ha at 30 DAP *fb* 2,4-D @ 1.0 kg a.i./ha at 60 DAP, T_8-Ametryne @ 2.0 kg a.i./ha at 30 DAP *fb* 2,4-D @ 1.0 kg a.i./ha at 60 DAP, T_9-Ametryne @ 2.4 kg a.i./ha at 30 DAP *fb* 2,4-D @ 1.0 kg a.i./ha at 60 DAP,T_{10}-Atrazine @ 1.0 kg a.i./ha at 30 DAP *fb* 2,4-D @ 1.0 kg a.i./ha at 60 DAP, T_{11}-Atrazine @ 1.0 kg a.i./ha at 30 DAP *fb* Carfentrazone + Glyphosate @ 1.0 kg a.i./ha at 60 DAP and T_{12}-Carfentrazone + Glyphosate @ 1.0 kg a.i./ha at 60 DAP were allotted to plots. The treatments were allocated randomly to each plot. Urea, diamonium phosphate and muriate of potash were used as a source of nitrogen, phosphorus and potassium. The crop was uniformly fertilized with 120 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha giving half of the nitrogen and full dose of phosphorus and potassium as basal in furrows. Remaining nitrogen was top dressed in two equal splits at 60 and 90 DAP. Seed canes were taken from healthy crop of CoS 98231, suitable for spring season. Canes were cut in to 3 budded pieces and healthy setts were dipped in 0.25% solution of emisan for 15 minutes to prevent any fungal infection. The treated setts were placed horizontally in 15 cm deep furrows opened at 75 cm distance. Weed control efficiency (%) was calculated at 90 DAP by using the following formula.

$$\text{Weed control efficiency (\%)} \quad \frac{WDM_C \quad WDM_t}{WDM_C} \quad 100$$

Where,

WDM_C = Weed dry matter in control plot

WDM_t = Weed dry weight in treated plot

Weed index, a measure of reduction in crop yield, was computed as using the following formula.

$$\text{Weed index (\%)} \quad \frac{X \quad Y}{X} \quad 100$$

Where,

X = Yield from weed free plots (Three hoeings)

Y = Yield from treated plot

Data for weed components were subjected to square root transformation ($\sqrt{X \quad 0.5}$) for uniformity.

RESULTS AND DISCUSSION

Weed parameters

Critical examination of data on weed density and their weed control efficiency at 90 days after planting and weed index revealed that three hoeings at 30, 60 and 90 DAP (conventional practice) was recorded minimum weed density and highest weed control efficiency (94.53%) at 90 DAP which was significantly superior over rest of the treatments during both the years of experimentation (Table 1). Among the herbicidal treatments, ametryne @ 2.4 kg a.i./ha at 30 DAP *fb* 2,4-D @ 1.0 kg a.i./ha at 60 DAP (T_9) recorded minimum weed density and maximum weed control efficiency which was closely followed by ametryne @ 2.0 kg a.i./ha at 30 DAP *fb* 2,4-D @ 1.0 kg a.i./ha at 60 DAP (T_8), ametryne @ 1.6 kg a.i./ha at 30 DAP *fb* 2,4-D @ 1.0 kg a.i./ha at 60 DAP (T_7) and atrazine @ 1.0 kg a.i./ha at 30 DAP *fb* 2,4-D @ 1.0 kg a.i./ha at 60 DAP (T_{10}). However, the application of atrazine @ 1.0 kg a.i./ha at 30 DAP *fb* carfen + glypho @ 1.0 kg a.i./ha at 60 DAP (T_{11}) was also at par with ametryne @ 2.4 kg a.i./ha at 30 DAP *fb* 2,4-D @ 1.0 kg a.i./ha at 60 DAP (T_9) on weed control efficiency at 90 DAP during experimentation. Weed index, a measure of reduction in yield was recorded the lowest (0.00 %) in three hoeings at 30, 60 and 90 DAP which was significantly lower than rest of the treatments. The second minimum weed index per cent 8.61 was recorded under ametryne @ 2.4 kg a.i./ha at 30 DAP *fb* 2,4-D @ 1.0 kg a.i./ha at 60 DAP during investigation. The highest weed index per cent was recorded in weedy plot during the experimentation. The main reason behind this was mainly due to better control of ametryne against grassy weeds plus inhibiting action of 2,4-D against sedges and broad leaf weeds. It might have happened due to effect of sequential application of herbicides which suppressed the weed density. Similar results were obtained by Singh and Lal (2008), Singh *et al*. (2008), Kumar *et al*. (2014), and Siddappa *et al*. (2015). Repeated hoeing (conventional practise) led to continuous decline in total weeds with advancement in crop age. It might have been attributed to better control of weeds after second hoeing. Srivastava *et al*. (2003) also reported that at 30 days interval hoeings were quite effective in controlling total weeds in sugarcane field.

Productivity of sugarcane

The data pertaining to weight of millable cane, cane yield, green tops yield, trash yield and biological yield are presented in Table 1 and 2. A perusal of the data revealed that the highest weight of millable cane, cane yield (135.32 t/ha), green tops yield (19.88 t/ha), trash yield (10.81 t/ha) and biological yield were recorded in crop given three hoeings at 30, 60 and 90 DAP (conventional practice) which was significantly higher than rest of the treatments. The sequential application of ametryne @ 2.4 kg a.i./ha at 30 DAP *fb* 2,4-D @ 1.0 kg a.i./ha at 60 DAP (T_9) was next treatment in maximum increasing the weight of millable cane, cane yield, green tops yield, trash yield and biological yield was found at par with ametryne @ 2.0 kg a.i./ha at 30 DAP *fb* 2,4-D @ 1.0 kg a.i./ha at 60 DAP (T_8), ametryne @ 1.6 kg a.i./ha at 30 DAP *fb* 2,4-D @ 1.0 kg a.i./ha at 60 DAP (T_7) and atrazine @ 1.0 kg a.i./ha at 30 DAP

Table 1: Weed density, weed control efficiency, weed index, weight of millable cane, cane yield and green tops yield as influenced by weed control treatments in sugarcane (pooled data of two years)

Treatment	Dose (kg/ha)	Time (DAP)	Weed density (No./m^2) 90 DAP	Weed control efficiency (%) 90 DAP	Weed index (%)	Weight of millable cane (g/cane)	Cane yield (t/ha)	Green tops yield (t/ha)
Weedy			23.94(572.41)	0.00	51.65	867.82	65.42	14.71
Conventional practice (Three hoeings)		30, 60 & 90	5.67(31.60)	94.53	0.00	1385.86	135.32	19.88
Ametryne	1.6	30	15.42(237.22)	58.59	22.22	1104.46	105.28	16.03
Ametryne	2.0	30	15.11(227.66)	60.28	20.65	1115.42	107.37	16.28
Ametryne	2.4	30	14.85(220.04)	61.61	18.15	1123.00	110.76	16.43
Atrazine	1.0	30	15.73(247.00)	56.88	22.90	1074.89	104.36	16.12
Ametryne *fb* 2,4-D	1.6 fb 1.0	30 fb 60	9.81(95.65)	83.35	12.55	1222.16	118.33	17.62
Ametryne *fb* 2,4-D	2.0 fb 1.0	30 fb 60	9.52(90.22)	84.30	10.80	1240.89	120.69	18.12
Ametryne *fb* 2,4-D	2.4 fb 1.0	30 fb 60	9.12(82.76)	85.61	8.61	1262.24	123.66	18.25
Atrazine *fb* 2,4-D	1.0 fb 1.0	30 fb 60	9.95(98.44)	82.87	13.58	1207.11	116.94	17.25
Atrazine *fb* Carfentrazone + Glyphosate *	1.0 fb 1.0	30 fb 60	10.67(113.40)	80.24	17.32	1132.76	111.87	16.56
Carfentrazone + Glyphosate *	1.0	60	14.17(200.18)	65.07	26.18	1037.12	99.89	15.73
SE m ±	-	-	0.41	2.45	0.56	36.17	3.68	0.53
CD (P = 0.05)	-	-	1.19	7.19	1.64	106.06	10.80	1.54

*Carfentrazone + Glyphosate (Ready mix formulation), Values are subjected to square root transformation ($\sqrt{X \quad 0.5}$), Original data given in parenthesis

Table 2: Trash yield, biological yield and harvest index as influenced by weed control treatments in sugarcane (pooled data of two years)

Treatment	Dose(kg/ha)	Time(DAP)	Trash yield (t/ha)	Biological yield (t/ha)	Harvest index (%)
Weedy			8.13	88.25	64.02
Conventional practice (Three hoeings)		30, 60& 90	10.81	166.00	81.54
Ametryne	1.6	30	8.88	130.18	80.89
Ametryne	2.0	30	8.93	132.58	81.01
Ametryne	2.4	30	8.99	136.18	81.35
Atrazine	1.0	30	8.83	129.31	80.72
Ametryne *fb* 2,4-D	1.6 fb 1.0	30 fb 60	9.64	145.59	81.29
Ametryne *fb* 2,4-D	2.0 fb 1.0	30 fb 60	9.79	148.59	81.24
Ametryne *fb* 2,4-D	2.4 fb 1.0	30 fb 60	9.93	151.84	81.47
Atrazine *fb* 2,4-D	1.0 fb 1.0	30 fb 60	9.48	143.67	81.41
Atrazine *fb* Carfentrazone + Glyphosate *	1.0 fb 1.0	30 fb 60	9.05	137.48	81.40
Carfentrazone + Glyphosate *	1.0	60	8.68	124.30	80.38
SE m ±	-	-	0.29	4.35	2.42
CD (P = 0.05)	-	-	0.84	12.77	7.09

*Carfentrazone + Glyphosate (Ready mix formulation)

fb 2,4-D @ 1.0 kg a.i./ha at 60 DAP (T_{10}) during both the years. An examination of data further revealed (Table 2) that maximum harvest index (81.54%) was recorded due to three hoeings at 30, 60 and 90 DAP of sugarcane which was statistically at par with rest of the treatments except weedy condition during both the years of investigation. However, minimum harvest index was observed under weedy plot (64.02%) during both the years. Such increase in yield might have been attributed to effective suppression of weeds and improved soil physical condition in these treatments. Increase in yield with conventional practice (three hoeings) at 30, 60 and 90 days after planting had also been reviewed by Agrawal *et al*. (1997), Rana and Singh (2004), Mansuri *et al*. (2014), and Kumar *et al*. (2015).

Conventional practice; three hoeings at 30, 60 and 90 DAP is the most effective weed management practice in respect of suppression density of all types of weeds. This treatment produced lowest weed index with highest weed control efficiency among all weed control measures and yield attributes as well as yield of spring planted sugarcane under the agro-climatic condition of eastern Uttar Pradesh. Nevertheless, ametryne @ 2.4 kg a.i./ha at 30 DAP *fb* 2,4-D @ 1.0 kg a.i./ha at 60 DAP may be a viable and choice for farmers in case of non-availability of labour at peak periods of crop-weed competition.

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