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Weed management options in spring sweet corn (*Zea mays* L. saccharata)

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Abstract
A field experiment was conducted with objectives to study the bio efficacy of new generation herbicides against complex weed flora, to study the effects of different cultural and chemical control measures alone and their combinations on weeds, crop growth and yield and to find out the best method of weed management in spring sweet corn on the basis of crop yield and economic parameters. Pre-emergence application of atrazine 1000 g ha^{-1} followed by (*fb*) post-emergence application of halosulfuron-methyl 90 g ha^{-1} was the most effective in reducing the weed density and twice hand weeding at 20 and 40 DAS was found most effective in reducing weed dry matter accumulation as compared to other treatments. All the weed control treatments significantly influenced the yield and yield attributing characters. The highest green cob yield was obtained with twice hand weeding at 20 and 40 DAS (15.46 t ha^{-1}) which was at par with pre-emergence application of atrazine 1000 g ha^{-1} *fb* post-emergence application of tembotrione 120 g ha^{-1} (15.31 t ha^{-1}) among the weed control treatments. The highest net return and B:C ratio was recoded with pre-emergence application of atrazine 1000 g ha^{-1} *fb* post-emergence application of tembotrione 120 g ha^{-1} which was followed by twice hand weeding at 20 and 40 DAS. Pre-emergence application of atrazine 1000 g ha^{-1} *fb* tembotrione 120 g ha^{-1} was found best among the herbicidal treatments in all respect. Twice hand weeding at 20 and 40 DAS was found comparable with pre-emergence application of atrazine 1000 g ha^{-1} *fb* post-emergence application of tembotrione 120 g ha^{-1} and can be used as an alternative subjected to availability of labourers.

Keywords: atrazine, halosulfuron-methyl, mulching, sweet corn, tembotrione, weed control efficiency

Introduction
Sweet corn is grown for fresh green cobs for human consumption and also used as raw or processed material for the food industry throughout the world. It is an important source of dietary fiber, minerals and certain vitamins (Lertrat and Pulam, 2007) [6]. Among the several corn species, sweet corn has become more important especially as a vegetable. It is, thus, sometimes referred as vegetable maize. Its taste and nutritional value have made it a valued crop in all countries and the scope of corn production is constantly increasing (Olabode and Sangodele, 2015) [7]. In states like Punjab, Uttar Pradesh, Uttarakhand, the spring sweet corn may be a good option for replacing summer rice from the cropping system. Though the water requirement of spring sweet corn is way lower than summer rice (Feng *et al.*, 2007) [3]. Among the several factors, most critical for the low yield of maize appears to be the weeds, competing with the crop for nutrients, water, sunlight and space. Maize is highly suffered by the weeds due to wider spacing and slow initial growth of maize which favors the growth of weeds. Yield losses due to weeds in maize varies from 28 to 93%, depending on the type of weed flora and intensity and duration of crop-weed competition (Sharma and Thakur, 1998) [8]. Only the use of herbicides for controlling the weed may not be always economically and ecologically viable option as there are limitations and advantages of every weed control method, therefore integrated weed management is a good option for a sustainable production system (Ehsas *et al.*, 2016) [2]. The current experiment was conducted with objectives to study the bio efficacy of new generation herbicides and their combinations, to study the effects of different cultural and chemical control measures alone and/or in combinations, on complex weed flora, crop growth and yield of spring sweet corn and to find out the best method of weed management in spring sweet corn on the basis of crop yield and economic parameters.

Methods
Present experiment was conducted during *spring* season of 2017 in D6 block of the N.E. Borlaug Crop Research Center of Govind Ballabh Pant University of Agriculture and

Technology, Pantnagar (Uttarakhand), India. The soil of the experimental site was sandy loam, neutral in pH with high organic carbon (0.79%), medium available nitrogen (314.3 kg ha^{-1}), phosphorus (19.8 kg ha^{-1}) and potassium (220.3 kg ha^{-1}). Sweet corn variety "Sugar 75" developed by Syngenta AG was used for the experiment and for intercropping treatment, "Pant Mung 5" variety of mung bean (*Vigna radiata* (L.) wilczek) developed by Govind Ballabh Pant University of Agriculture and Technology, Pantnagar was used. The experiment was laid out in a randomized block design with twelve treatments *viz.* intercropping with mung bean, paddy straw mulching 5 t ha^{-1}, atrazine 1000 g ha^{-1}, halosulfuron-methyl 90 g ha^{-1}, tembotrione 120 g ha^{-1}, atrazine 1000 g ha^{-1} with paddy straw mulching 5 t ha^{-1}, atrazine 1000 g ha^{-1} *fb* halosulfuron-methyl 90 g ha^{-1}, atrazine 1000 g ha^{-1} *fb* tembotrione 120 g ha^{-1}, atrazine 1000 g ha^{-1} *fb* one hand weeding at 40 DAS, twice hand weeding at 20 and 40 DAS, weed free and weedy check, replicated thrice. The herbicides were applied in aqueous solution using 500 liters of water per hectare as spray volume. The amount of herbicides required was computed on the basis of gross plot size. For pre-emergence application, foot sprayer with three flat fan nozzles on a boom was used. Knapsack sprayer with flat fan nozzle was used for spraying the post-emergence herbicides. Weed density and dry matter accumulation were recorded at 45 and 60 DAS with the help of a 50×50 cm^2 quadrate placed at two places. Weed control efficiency was calculated on the basis of dry weight of weeds as per standard formula. Green cob yield, green fodder yield, yield attributing characters and harvest index were recorded at harvest stage. Net return, gross return and benefit-cost ratio were calculated with returns from green cob only. Data of weed dry matter accumulation and weed density were transformed using square root transformation ($\sqrt{(x+1)}$) before the statistical analysis. Effects of the treatments were compared statistically by Fisher's least significant difference method at 5% level of significance (Gomez and Gomez, 1984) [4]. All statistical analysis were made using IBM SPSS 24.0 software package developed by IBM Corp, 2009 [5].

Results and Discussion

Weed flora

The major weed species infesting the experimental plots were *Cynodon dactylon* (10.4%), *Echinochloa colona* (4.6%) among grasses, *Alternanthera sessilis* (11.6%), *Celosia argentea* (7.5%) among broad-leaf weeds and *Cyperus rotundus* (57.8%) among sedges at 45 DAS. Among the different weed species, *Cyperus rotundus* was found to have the highest relative weed density and *Alternanthera sessilis* was most dominating weed over all other weeds in terms of relative weed dry matter accumulation at all crop growth stages. The total contribution of grassy weeds to the total weed density was 15.0%, 9.5%, broad-leaf weeds contributed 19.1%, 14.5% and sedges contributed 57.8%, 69.5% respectively at 45 and 60 DAS of crop age.

Weed density

Total weed density reached to its maximum value at 60 DAS and slightly declined thereafter at later growth stages due to early maturity of short duration annual weeds. All the weed control treatments reduced the weed density significantly over the weedy check. The lowest weed density was recorded from the twice hand weeded plots up to 45 DAS of the crop and afterwards the lowest total weed density was recorded from with pre-emergence application of atrazine 1000 g ha^{-1} combined with post-emergence application of halosulfuron-methyl 90 g ha^{-1} due to effective control of *Cyperus rotundus* which had contributed about 70% of the total weed population at later stages of crop growth (Table 1). Similar results were also established in controlling *Cyperus rotundus* effectively in turf grass with halosulfuron-methyl by Desat *et al.* (2017) [1]. Alone post-emergence application of halosulfuron-methyl 90 g ha^{-1} was at par with twice hand weeded plots at 20 and 40 DAS at later crop growth stages. Mung bean intercropping treatment was found least effective in reducing the total weed density over all other weed control treatments may be because of the slow growth of Pant Mung 5 during the *spring* season due to initial low temperature period and an infestation of aggressive weeds which were beyond the suppressing ability of mung bean.

Weed dry matter accumulation

The highest total weed dry matter was observed in the weedy plots in all the stages followed by mung bean intercropped plots. All the weed control treatments significantly reduced total weed dry matter accumulation over the weedy check. At all the stages of crop growth, the lowest total weed dry matter accumulation was recorded from twice hand weeded plots among the weed control treatments followed by pre-emergence application of atrazine 1000 g ha^{-1} *fb* post-emergence application of tembotrione 120 g ha^{-1} (Table 1). These findings are in accordance with Swetha *et al.* (2015) [10]. Efficient control of grassy and non-grassy weeds in maize with post-emergence application of tembotrione has been also reported by Singh *et al.* (2012) [9] from Pantnagar. Dry matter accumulation in those treatments were closely followed by pre-emergence application of atrazine 1000 g ha^{-1} fb one hand weeding at 40 DAS.

Weed control efficiency

At 45 DAS, the highest weed control efficiency was recorded from the twice hand weeded plots at 20 and 40 DAS which was at par with the pre-emergence application of atrazine 1000 g ha^{-1} *fb* post-emergence application of tembotrione 120 g ha^{-1} among the weed control treatments (Table 1). Better performance of pre-emergence application of atrazine 1000 g ha^{-1} *fb* post-emergence application of tembotrione 120 g ha^{-1}, may be attributed to the fact that pre-emergence application of atrazine 1000 g ha^{-1} had good control over grassy and broad-leaf weeds at initial stages and the weeds were further taken care by the post-emergence application of tembotrione 120 g ha^{-1} at 20 DAS. These treatments were followed by alone post-emergence application of tembotrione 120 g ha^{-1} which was at par with pre-emergence application of atrazine 1000 g ha^{-1} followed by one hand weeding at 40 DAS because late appearing weeds were effectively controlled by the hand weeding at 40 DAS. The lowest weed control efficiency was recorded from the mungbean intercropped treatment due to low suppressing ability of mungbean because of the reduced growth in spring-summer months and infestation of very aggressive weeds like *Alternanthera sessilis*.

Table 1: Effect of different weed management treatments on weed density, weed dry matter accumulation and weed control efficiency.

Treatments	Dose (g ha^{-1})	Weed density (no. m^{-2})#		Weed dry matter accumulation (g m^{-2})#		Weed control efficiency at 45 DAS (%)
	-	45 DAS	60 DAS	45 DAS	60 DAS	
Intercropping with mung bean	5 t ha^{-1}	13.0 (168.0)	18.8 (353.3)	10.3 (105.4)	15.3 (233.0)	23.7
Paddy straw mulching	1000	11.0 (119.3)	16.2 (262.7)	8.5 (71.7)	13.0 (167.6)	48.0
Atrazine	90	10.2 (102.7)	15.3 (232.0)	7.6 (57.1)	11.7 (135.8)	58.7
Halosulfuron-methyl	120	8.1 (65.3)	9.5 (89.3)	8.4 (69.2)	11.6 (134.6)	49.9
Tembotrione	1000 + 5t ha^{-1}	7.8 (60.0)	12.7 (161.3)	4.8 (22.4)	8.1 (65.3)	83.8
Atrazine + Paddy Straw Mulching	1000 *fb* 90	9.9 (97.3)	15.1 (226.7)	7.2 (50.3)	11.2 (124.6)	63.6
Atrazine *fb* Halosulfuron-methyl	1000 *fb* 120	5.9 (33.3)	6.8 (45.3)	6.6 (43.0)	9.3 (86.2)	68.9
Atrazine *fb* Tembotrione	1000	7.0 (48.0)	12.0 (142.7)	3.8 (13.4)	6.8 (45.8)	90.3
Atrazine *fb* 1 Hand weeding at 40 DAS	-	7.1 (49.3)	11.2 (124.0)	4.8 (22.4)	8.2 (66.0)	83.7
Two hand weedings at 20 & 40 DAS	-	4.3 (17.3)	9.6 (92.0)	3.4 (10.4)	6.4 (40.0)	92.4
Weed Free	-	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	100.0
Weedy Check		15.2 (230.7)	20.6 (424.0)	11.8 (138.1)	17.4 (301.6)	0.0
SEm±		0.23	0.38	0.05	0.08	1.34
CD at 5%		0.68	1.13	0.14	0.23	3.96

#Original values are given in parenthesis

Yield and yield attributes

The highest cob length, numbers of filled grains/row and number of grains/cob, individual cob weight without husk were recorded from twice hand weeding at 20 and 40 DAS (20.5 cm) which was at par with pre-emergence application of atrazine 1000 g ha^{-1} *fb* post-emergence application of tembotrione 120 g ha^{-1} and followed by alone post-emergence application of tembotrione 120 g ha^{-1} among the weed control treatments (Table 2).

The highest green cob yield, green fodder yield were also recorded in twice hand weeding at 20 and 40 DAS (15.46 t ha^{-1}) which was at par with pre-emergence application of atrazine 1000 g ha^{-1} *fb* post-emergence application of tembotrione 120 g ha^{-1} (15.31 t ha^{-1}) among the weed control treatments. Pre-emergence application of atrazine 1000 g ha^{-1} *fb* post-emergence application of tembotrione 120 g ha^{-1} has resulted in highest harvest index (0.34) which was at par with alone post-emergence application of tembotrione 120 g ha^{-1} (0.32), pre-emergence application of atrazine 1000 g ha^{-1} *fb* one hand weeding at 40 DAS (0.32) and twice hand weeding at 20 and 40 DAS (0.31) (Table 2).

Table 2: Effect of different weed management treatments on yield attributing characters, grain yield and harvest index of sweet corn.

Treatments	Dose (g ha^{-1})	Cob length (cm)	No. of grains/row	No. of grains/cob	Cob weight without husk (g)	Green Cob yield (t/ha)	Harvest Index
Intercropping with mung bean	-	17.7	36.6	561.4	249.8	5.33	0.26
Paddy straw mulching	5 t ha^{-1}	18.1	37.4	622.1	258.2	6.88	0.30
Atrazine	1000	18.7	38.6	622.2	286.3	8.81	0.31
Halosulfuron-methyl	90	18.3	38.0	610.2	269.1	6.96	0.30
Tembotrione	120	19.9	41.2	633.7	310.3	13.36	0.32
Atrazine + Paddy Straw Mulching	1000 + 5t ha^{-1}	19.1	39.5	657.0	296.5	9.21	0.28
Atrazine *fb* Halosulfuron-methyl	1000 *fb* 90	19.2	39.7	635.0	282.1	10.81	0.31
Atrazine *fb* Tembotrione	1000 *fb* 120	20.1	41.6	694.9	338.4	15.31	0.34
Atrazine *fb* 1 Hand weeding at 40 DAS	1000	19.8	41.1	683.8	312.9	13.13	0.32
Two hand weedings at 20 & 40 DAS	-	20.5	42.5	736.6	341.1	15.46	0.31
Weed Free	-	20.8	43.1	717.5	345.6	15.92	0.32
Weedy Check	-	17.3	35.7	524.5	241.3	5.13	0.27
SEm±	-	0.49	0.81	28.84	2.19	0.48	0.01
CD at 5%	-	1.43	2.38	85.13	6.46	1.42	0.03

Economics of crop production

The highest cost of cultivation was incurred in twice hand weeded plots (800.73 USD ha^{-1}) among the weed control treatments which was followed by cost involved in pre-emergence application of atrazine 1000 g ha^{-1} *fb* post-emergence application of halosulfuron-methyl 90 g ha^{-1} (765.30 USD ha^{-1}), pre-emergence application of atrazine 1000 g ha^{-1} *fb* post-emergence application of tembotrione 120 g ha^{-1} (761.48 USD ha^{-1}) and pre-emergence application of atrazine 1000 g ha^{-1} *fb* one hand weeding (752.16 USD ha^{-1}) (Table 3). The highest net return and B:C ratio were observed in pre-emergence application of atrazine 1000 g ha^{-1} *fb* post-emergence application of tembotrione 120 g ha^{-1} (1426.76 USD ha^{-1}, B:C 2.87 respectively) which was followed by twice hand weeding at 20 and 40 DAS (1408.95 USD ha^{-1}, B:C 2.76 respectively) (Table 3).

Table 3: Effect of different weed management treatments on cost of cultivation, gross return, net return and B: C of sweet corn production.

Treatments	Dose (g ha^{-1})	Cost of cultivation (USD ha^{-1})	Gross return (USD ha^{-1})	Net return (USD ha^{-1})	B:C ratio
Intercropping with mung bean	-	683.96	761.81	77.85	1.11
Paddy straw mulching	5 t ha^{-1}	718.54	983.35	264.81	1.37
Atrazine	1000	698.56	1259.20	560.64	1.80
Halosulfuron-methyl	90	742.20	994.78	252.58	1.34

Tembotrione	120	738.58	1909.53	1170.95	2.59
Atrazine + Paddy Straw Mulching	1000 + 5t ha^{-1}	741.44	1316.37	574.93	1.78
Atrazine *fb* Halosulfuron-methyl	1000 *fb* 90	765.30	1545.06	779.76	2.02
Atrazine *fb* Tembotrione	1000 *fb* 120	761.48	2188.24	1426.76	2.87
Atrazine *fb* 1 Hand weeding at 40 DAS	1000	752.16	1876.65	1124.49	2.49
Two hand weedings at 20 & 40 DAS	-	800.73	2209.68	1408.95	2.76
Weed Free	-	890.06	2275.42	1385.36	2.55
Weedy Check	-	675.67	733.22	57.55	1.08

Conclusion

Pre-emergence application of atrazine 1000 g ha^{-1} *fb* post-emergence application of tembotrione 120 g ha^{-1} was the best among all the weed control treatments in terms of net return (1426.76 USD ha^{-1}), B:C ratio (2.87), weed control efficiency and yield (15.31 t ha^{-1}). No toxic symptom of any of the applied herbicides was observed on sweet corn at their recommended doses. Twice hand weeding at 20 and 40 DAS was the best among the cultural weed control treatments in terms of yield, net returns (1408.95 USD ha^{-1}), B:C ratio (2.76), weed control efficiency and comparable to that of pre-emergence application of atrazine 1000 g ha^{-1} *fb* post-emergence application of tembotrione 120 g ha^{-1}, with low impact on soil microbial environment. Twice hand weeding at 20 and 40 DAS can be used as an alternative to chemical treatment subjected to availability of labour. Other alternatives with B:C ratio >2, such as alone post-emergence application of tembotrione 120 g ha^{-1} (B:C ratio 2.5) and pre-emergence application of atrazine 1000 g ha^{-1} *fb* one hand weeding at 40 DAS (B:C ratio 2.4), can also be adopted as remunerative strategies according to availability of labours, resources and circumstances. Intercropping with mungbean was not found effective in weed suppressing weeds in spring sweet corn.

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Authors' contributions

The experiment was conducted by Prithwiraj Dey under the advisement of Tej Pratap and co-advisement of VP Singh, Rohitashav Singh and SP Singh. Article formulation, technical writing was accomplished by Prithwiraj Dey which was subjected to careful review by above mentioned advisory committee.

List of abbreviations

fb: Followed by, viz. : Namely, DAS: Days after sowing, ha: Hectare, USD: U.S. Dollars

References

1. Desai M, Patel GD, Patel NK, Patel V. Management of Cyperus rotundus L. in Turf. International Journal of Chemical Studies. 2017; 5(5):696-699.
2. Ehsas J, Desai LJ, Ahir NB, Joshi JR. Effect of integrated weed management on growth, yield, yield attributes and weed parameters on summer maize (*Zea mays* L.) under south Gujarat condition. Int J Sci Environ. 2016; 5(4):2050-2056.
3. Feng Z, Liu D, Zhang Y. Water requirements and irrigation scheduling of spring maize using GIS and Crop Wat model in Beijing-Tianjin-Hebei region. Chinese Geographical Science. 2007; 17(1):56-63.
4. Gomez KA, Gomez, AA. Statistical procedures for agricultural research. John Wiley & Sons, 1984.
5. IBM Corp. IBM SPSS statistics for windows, version 24.0. Armonk, New York. 2016.
6. Lertrat K, Pulam T. Breeding for increased sweetness in sweet corn. Int J Plant Breed. 2007; 1(1):27-30.
7. Olabode OS, Sangodele AO. Effect of weed control methods on the performance of sweet corn (*Zea mays* var. saccharata) in Ogbomoso, South West Nigeria. Journal of Global Biosciences. 2015; 4(1):1145-1150.
8. Sharma V, Thakur DR. Integrated weed management in maize (*Zea mays*) under mid-hill conditions of North-Western Himalayas. Indian Journal of Weed Science. 1998; 30(3, 4):158-162.
9. Singh VP, Guru SK, Kumar A, Banga A, Tripathi N. Bioefficacy of tembotrione against mixed weed complex in maize. Indian Journal of Weed Science. 2012; 44(1): 1-5. =
10. Swetha K, Madhavi M, Pratibha G, Ramprakash T. Weed management with new generation herbicides in maize. Indian Journal of Weed Science. 2015; 47(4):432-433.