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Weed seed bank in soil as affected by different weed management practices in spring sweet corn

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ABSTRACT

A field study was conducted in spring season of 2016 and 2017 on sweet corn to evaluate the effect of different weed management practices upon the weed seed bank dynamics in the soil. In the sample from seed bank studied, the per cent contribution of *Cleome viscosa* was highest among all the weed species before sowing and harvest stage of the crop and was followed by *Dactyloctenium aegypticum*, in both the stages and years. Depth wise weed seed distribution indicated highest weed seed in 10-15 cm depth before sowing and in 0-5 cm depth at harvest stage of the crop. Effect of all the weed control treatments upon previous season's dormant seeds was non-significant. Twice hand weeding was effective to reduce seed bank in deeper layer. Atrazine 1000 g/ha followed by tembotrione 120 g/ha and tembotrione alone 120 g/ha had caused a significant reduction in weed seed number in 0-5 and 0-10 cm layer but weed seed number at 10-15 cm layer remained unchanged.

INTRODUCTION

Weeds generally depends on its seed bank in the soil for the persistence in agricultural systems (Buhler *et al.* 1997). It is very likely that if all the weeds in a particular land germinate at once, there is very possibility that we will get rid of weeds permanently. But unfortunately, weeds persists and the major cause behind the weed persistence is the maintenance of the weed seed bank in the soil (Borgy *et al.* 2015). So, it is necessary to understand the weed seed bank dynamics as affected by the different weed management strategies because only controlling the weeds in short term is not desirable. Weed management options that manage the seed bank of weeds also controls the weeds for the future instances. Weed seed bank dynamics is a potent inference of the reproductive biology of the weed species and must be considered while devising a functional weed management strategy (Bhowmik 1997, Hossain and Begum 2015). In the present experiment, the nature of weed seed bank present in the studied cropping system and the effect of different weed management strategies upon weed seed bank in terms of species wise and layer wise net seed addition or reduction of viable seed reserve, were studied. The study aims to find out the best management practice to manage the weeds and their seed bank for formulating a sustainable weed management system.

MATERIALS AND METHODS

The current experiment was conducted during spring seasons of 2016 and 2017 in N. E Borlaug Crop Research Centre of G.B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India (29ÚN, 79.3ÚE). The soil on the experimental site was sandy loam, neutral in pH (7.3) with high organic carbon (0.79%), medium available nitrogen (314.3 kg/ha), phosphorus (19.8 kg/ha) and potassium (220.3 kg/ha). Sweet corn variety *'Sugar 75'* was used for the experiment. The experiment was laid out in a randomized block design with three replications and seven treatments *viz.* pre-emergence application (PE) of atrazine at 1000 g/ha, post-emergence application (POST) of tembotrione at 120 g/ha, atrazine at 1000 g/ha PE *fb* tembotrione PoE at 120 g/ha, atrazine at 1000 g/ha PRE *fb* one hand weeding at 40 DAS, hand weeding twice at 20 and 40 DAS, weed free and weedy check.

Soil samples were taken before sowing of the crop after final land preparation and at harvest stage of the crop in a zigzag manner from three places at

soil depths of 0-5, 5-10 and 10-15 cm in three replications (Smutný and Køen 2002). The samples were drawn with the help of 'khurpi' and 'spade' using a 0.0625 m^2 (0.25 × 0.25) quadrate for sampling. Each of the collected soil was washed using 0.2 mm brass sieve and seeds were collected. All the other propagules and crop seeds were discarded and only weed seeds were considered for this study. The seeds were then graded visually and identified. Unidentified seeds were germinated in a seed germinator at 25°C, 90% RH in paper-tower method using an artificial fluorescent illumination for 8 hrs. per day (Chalam *et al.* 1967). Seedlings were identified after 14 days (Konstantinovich 2012).

Data from both the years were pooled for analysis as no significant time to treatment interaction was found (Elsami and Afgani 2009). General species wise contributions in terms of seeds/square meter were expressed as pooled mean value ± standard deviation. The weed seeds count from the samples were transformed using square root transformation ($\sqrt{x+1}$) for the purpose of treatment comparison using ANOVA. Effect of the treatments was compared statistically by Fisher's least significant difference method at 5% level of significance (Gomez and Gomez, 1984). All statistical analysis were made using IBM SPSS 24.0 software package developed by IBM Corp. (2016).

RESULTS AND DISCUSSION

The weed seeds identified in both the years were *Ageratum conyzoides* (3.27%), *Amaranthus retroflexus* (5.72%), *Brachiaraia mutica* (7.16%), *Celosia argentea* (6.56%), *Chenopudium album* (5.86%), *Cleome viscosa* (16.07%), *Dactyloctenium aegypticum* (10.60%), *Digera arvensis* (10.33%), *Digitaria sanguinallis* (10.10%), *Echinochloa colona* (3.98%), *Parthenium hysterophorus* (6.08%), *Physalis minima* (1.69%), *Polygonum aviculare* (4.29%) and *Trianthema portulacastrum* (7.17%). Some weed seeds were left unidentified as they failed to germinate in controlled condition in spite of being alive in tetrazolium test. They are classified and analyzed as 'other seeds'. Other seeds contributed 0.90%, on an average, in total seeds found initially in weedy check.

The per cent contribution was highest for *Cleome viscosa* among all the weed species, which was followed by *Dactyloctenium aegypticum* in both the sampling stages. Depth wise contribution was found highest in 10-15 cm depth before sowing and in 0-5 cm depth at harvest stage of the crop in both the years (**Table 1**). This may be due to the inversion in soil due to tillage at the final land preparation, which may have caused deep burial of the weed seeds that were present on upper surface at the end of previous crop. As there was no soil disturbance at the time of sampling on the completion of sweet corn season, more number of seeds were found on the shallow depth up to 5 cm (Clements *et al.* 1996).

Weeds of preceding crop were mostly present on the deeper soil layer (10-15 cm depth) and the current season weed seeds were mostly found on surface and only up to medium depth due to lack of soil disturbance. The weed seeds of previous season were mainly of *Amaranthus retroflexus*, *Brachiaria*

Table 1. Soil depth wise and species wise weed seed number and their contribution to weed seed bank in weedy check (pooled data of 2016 and 2017)

Weed species	Depth (0-5 cm) (no. of seeds/m^2 soil)		Depth (5-10 cm) (no. of seeds/m^2 soil)		Depth (10-15 cm) (no. of seeds/m^2 soil)		Contribution (%)	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Ageratum conyzoides	53.5±7.9	98.8±14.6	17.8±2.6	26.7±4.0	0.0±0.0	1.8±0.3	3.27±0.5	4.43±0.7
Amaranthus retroflexus	15.6±2.0	22.0±2.8	43.4±5.4	62.5±7.8	65.6±8.2	66.2±8.3	5.72±0.7	5.24±0.7
Brachiaraia mutica	23.4±2.2	29.6±2.8	36.3±3.4	52.3±4.9	96.1±8.9	100.9±9.4	7.16±0.7	6.35±0.6
Celosia argentea	77.4±10.2	138.0±18.3	31.2±4.1	46.9±6.2	34.3±4.5	34.1±4.5	6.56±0.9	7.61±1.0
Chenopudium album	49.7±8.2	94.2±15.5	33.9±5.6	51.0±8.4	44.0±7.2	45.4±7.5	5.86±1.0	6.63±1.1
Cleome viscosa	70.0±9.9	92.6±13.1	82.6±11.7	112.9±16.0	197.2±28.0	202.6±28.7	16.07±2.3	14.19±2.0
Dactyloctenium aegypticum	49.4±6.4	58.8±7.6	74.7±9.7	107.2±13.9	106.6±13.9	111.9±14.5	10.60±1.4	9.66±1.3
Digera arvensis	34.8±4.6	37.9±5.0	50.8±6.7	74.5±9.9	139.3±18.4	136.5±18.1	10.33±1.4	8.65±1.1
Digitaria sanguinallis	36.8±4.5	46.5±5.7	76.2±9.3	110.8±13.5	111.8±13.6	108.1±13.2	10.10±1.2	9.23±1.1
Echinochloa colona	68.6±7.2	142.1±14.8	18.0±1.9	27.1±2.8	0.0±0.0	0.0±0.0	3.98±0.4	5.88±0.6
Parthenium hysterophorus	53.8±7.1	99.5±13.2	34.9±4.6	48.4±6.4	43.6±5.8	39.8±5.3	6.08±0.8	6.52±0.9
Physalis minima	27.3±4.5	70.7±11.6	9.6±1.6	3.8±0.6	0.0±0.0	0.0±0.0	1.69±0.3	2.59±0.4
Polygonum aviculare	93.3±13.9	147.7±22.1	0.0±0.0	0.0±0.0	0.0±0.0	6.5±1.0	4.29±0.6	5.36±0.8
Trianthema portulacastrum	14.5±1.8	26.8±3.3	33.7±4.1	50.5±6.2	107.9±13.3	110.1±13.5	7.17±0.9	6.51±0.8
Other	7.3±1.1	16.5±2.4	7.6±1.1	11.2±1.7	4.6±0.7	5.3±0.8	0.90±0.1	1.15±0.2
% Contribution:	31.02±4.0	38.99±4.4	25.30±3.1	27.32±3.0	43.68±5.8	33.69±4.2	-	-

*Pooled mean values ± Standard deviation

Table 2. Effect of different treatments on the initial and final weed seed number of different weed species number (pooled data of 2016 and 2017)

Treatment	Previous season weed seeds (no. of seeds/m^2 soil)							Current season weed seeds (no. of seeds/m^2 soil)						
	Amaranthus sp.	*Brachiaria* sp.	*Cleome* sp.	*Dactyloctenium* sp.	*Digera* sp.	*Digitaria* sp.	*Trianthema* sp.	*Celosia* sp.	*Echinochloa* sp.	*Parthenium* sp.	*Physalis* sp.	*Polygonum* sp.	*Ageratum* sp.	*Chenopodium* sp.
Atrazine 1000 g/ha	11.2 (124.7)	12.7 (159.4)	18.5 (341.1)	15.4 (237.2)	14.7 (215.0)	14.8 (218.7)	12.6 (158.1)	12.0 (143.0)	9.3 (86.4)	11.3 (127.7)	5.4 (28.4)	9.7 (92.2)	8.5 (72.1)	11.5 (131.4)
Tembotrione 120 g/ha	11.2 (123.5)	12.0 (141.9)	17.4 (302.1)	14.7 (214.2)	13.9 (192.0)	13.9 (193.1)	11.9 (140.6)	8.6 (73.0)	5.8 (32.1)	9.3 (85.0)	3.6 (11.7)	4.6 (20.6)	5.9 (34.4)	9.0 (80.9)
Atrazine 1000 g *fb* tembotrione 120 g/ha	11.1 (123.3)	12.5 (156.5)	18.3 (332.2)	15.4 (235.6)	14.6 (212.2)	14.6 (213.5)	12.6 (156.7)	11.8 (137.1)	9.1 (81.5)	11.1 (123.3)	5.3 (26.6)	9.3 (85.9)	8.3 (68.2)	11.3 (127.2)
Atrazine 1000 g *fb* 1 HW at 40 DAS	10.7 (113.7)	12.9 (165.3)	18.9 (358.0)	15.2 (231.3)	15.2 (229.4)	14.8 (219.3)	13.5 (180.2)	9.1 (81.6)	5.5 (29.3)	8.8 (76.9)	4.3 (17.5)	4.9 (23.1)	6.1 (36.7)	9.2 (83.2)
2 Hand weeding at 20 and 40 DAS	10.6 (111.8)	11.8 (138.9)	17.4 (303.4)	14.0 (196.0)	14.0 (194.4)	13.7 (185.8)	12.3 (150.2)	8.6 (72.9)	5.2 (26.2)	8.3 (68.6)	4.1 (15.6)	4.6 (20.6)	5.8 (32.8)	8.7 (74.3)
Weed free	10.3 (106.1)	11.6 (134.3)	17.1 (293.1)	13.8 (190.6)	13.8 (189.4)	13.5 (181.8)	12.1 (146.0)	8.4 (70.1)	5.1 (25.3)	8.2 (66.0)	4.0 (15.1)	4.5 (19.7)	5.7 (32.0)	8.5 (71.8)
Weedy check	11.3 (126.6)	12.5 (154.6)	18.4 (338.4)	15.2 (229.3)	14.6 (210.8)	14.9 (220.8)	12.6 (157.0)	12.7 (159.7)	10.8 (114.9)	11.9 (141.1)	7.1 (49.1)	10.1 (101.8)	8.8 (76.6)	12.1 (145.0)
LSD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	1.04	0.91	0.99	0.56	0.91	0.72	0.32

mutica, *Cleome viscosa*, *Dactyloctenium aegypticum*, *Digera arvensis*, *Digitaria sanguinallis* and *Trianthema portulacastrum*. The weeds that appeared in the current season were *Celosia argentea*, *Echinochloa colona*, *Parthenium hysterophorus*, *Physalis minima*, *Polygonum aviculare*, *Ageratum conyzoides* and *Chenopudium album* (**Table 2**).

Different weed control treatments effect upon the number of previous season's dormant seeds was non-significant as herbicides have no control over the dormant seeds (Dyer 1995). Manual weeding may expose dormant seeds to desiccating sun but it had negligible effects on the previous season's seeds which were at 10-15 cm depth. On the contrary, all the weed control treatments had significant effect on the number of seeds of all weeds present at harvest stage of sweet corn. In all the weed species that have germinated in studied season (spring), weed free plots were recorded to have lowest seed count per square meter of soil which was at par with the twice hand weeding at 20 and 40 DAS, atrazine 1000 g/ha *fb* tembotrione 120 g/ha and alone application of tembotrione 120 g/ha in both the experimentation years. This result was in accordance with findings of Buhler (1999). The significant reduction in seed addition in the seed bank indicates the effective control of weeds by the weed control treatments. Before sowing of the crop, all the treatments were having similar seed counts on particular depth (**Figure 1**). Highest seed number before sowing of the crop was recorded at 10-15 cm depth. But at harvest stage, the difference in seed number at harvest stage from the initial values is a clear indication of net weed seed addition or reduction in the seed bank. The highest reduction in weed seed number in all the depths was recorded in hand weeded twice plots. The maximum effects of the treatments on the weed seed count at harvest was observed in the 0-5 cm soil depth with little change in 10-15 cm layer. Treatments having hand weeding as a component had reduced weed seed number in 10-15 cm soil depth due to certain soil disturbance due to hand weeding, which might have promoted weed seed germination from deeper soil layer and their subsequent removal or mortality.

Conclusion

It was concluded that weed seed placement depth has a role in weed seed bank strength and its persistence over time. Previous season's weeds, if not germinated in current season, are likely to be unaffected by the recommended chemical treatments. However, manual weeding may cause slight weed seed reduction in deeper layers too, due to soil disturbance. Hand weeding twice was effective to reduce deeper layer seed bank. Atrazine 1000 g/ha followed by tembotrione 120 g/ha and tembotrione alone 120 g/ha have caused significant reduction in weed seed bank of 0-5 and 5-10 cm layer, but weed seed number at 10-15 cm layer remained unchanged.

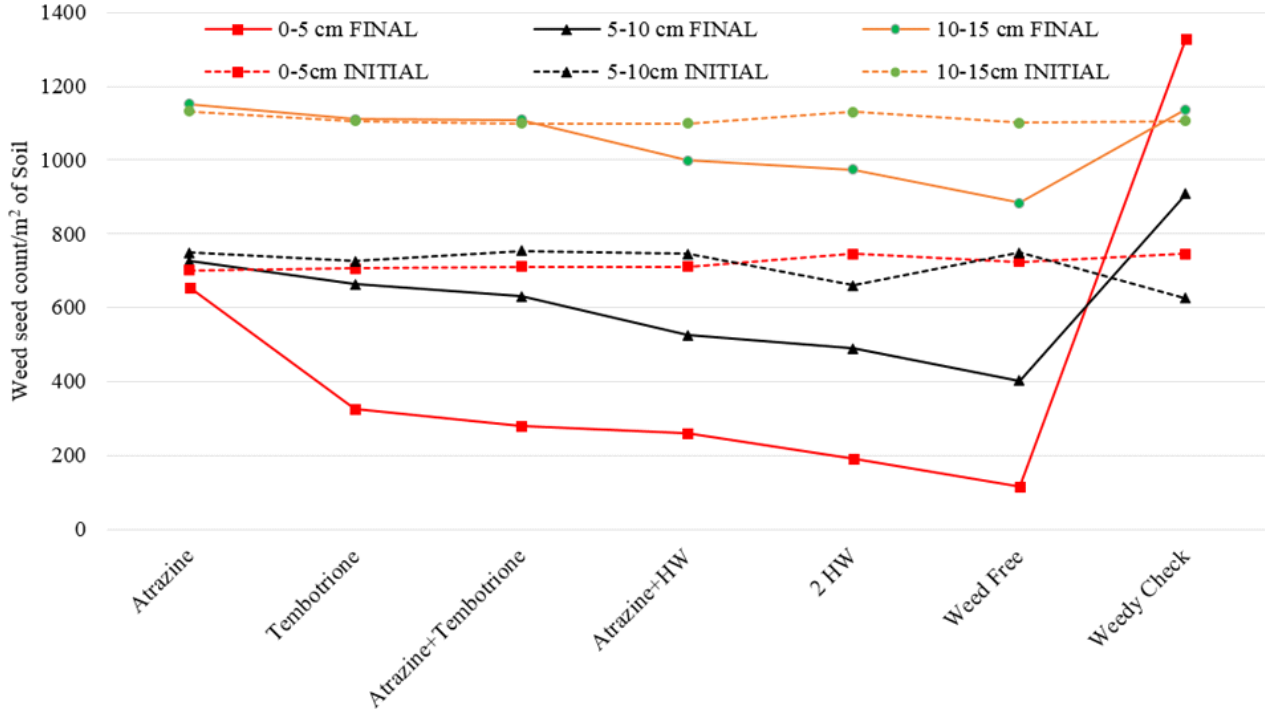

Figure 1. Effect of different weed control treatments on depth wise weed seed count per m² of soil before sowing (initial) and at harvest (final) (pooled data of 2016 and 2017)

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