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Nutrient uptake as influenced by pre and post emergence herbicide in sweet corn grown in vertisols

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Abstract
Field experiment was conducted at Department of Agronomy, College of Agriculture, Dhule during *Kharif* 2019 to study the effect of pre and post emergence herbicides *viz*., atrazine, halosulfuron methyl, 2-4-D ethyl ester, pendimethalin and tembotrione on nutrient uptake by sweet corn. The weed free treatment (T_2) with two hand weeding recorded significantly higher total N, P and K uptake of 253.16, 84.36 and 259.13 kg ha^{-1}, respectively, by sweet corn. However, significantly lower total N, P and uptake of 104.60, 31.98 and 109.94 kg ha^{-1}, respectively, by sweet corn was recorded in the treatment of weedy check (T_1). Among the treatments of pre and post emergence herbicides, application of pendimethalin @ 1000 g ha^{-1} as pre emergence *fb* tembotrione @ 120 g ha^{-1} as post emergence (T_6) recorded higher total N uptake (230.22 kg ha^{-1}), P uptake (72.37 kg ha^{-1}) and K uptake (240.85 kg ha^{-1}) by sweet corn with 120, 126.29 and 119.07 % increase, respectively, over the treatment of weedy check (T_1) and 9.06, 14.21 and 7.05 % decrease, respectively, over the Weed free (T_2) treatment (Two hand weeding).

Keywords: N uptake, P uptake and K uptake

Introduction
Sweet corn (*Zea mays* L. *saccharata*) is becoming increasingly popular in India and other Asian countries. Sweet corn being heavy feeder requires heavy dose of chemical fertilizers. All plants require 17 essential nutrients for their growth and development and under normal growing conditions, absorb them from the soil solution through their roots. The fate of absorbed nutrients is very important aspect of soil fertility and nutrient management, crop nutrition, determination of produce quality, nutrient balance and nutrient use efficiency (Tandon and Muralidhrudu 2010) [3].
The nutritive value and quality of sweet corn depend upon genetic, climatic, biotic, edaphic, chemical and other factors as well as combinations of these factors. Some ecological, cultural and physical factors including fertilizer management have significant influence on the chemical and nutritional composition of plants as well as their anatomical and morphological structure (Salunkhe and Kadan 2005) [2].
Weed infestation is one of the major constraints for low yield of sweet corn as weeds compete with crop plants for light, space and nutrients. It is reported that severe weed competition results in 30-100 % yield reduction (Dey *et al.* 2017) [7]. Manual weeding is often difficult due to inadequate supply of labour in proper time, higher cost and non-workable condition of the labour (Rana *et al.,* 2013) [1]. In such situation, use of herbicides is an obvious choice.
With this background, the present investigation was carried out with a view to understand the effect of herbicides *viz*., atrazine, halosulfuron methyl, 2-4-D ethyl ester, pendimethalin and tembotrione on N,P and K uptake by sweet corn for their judicious use.

Material and Methods
Field experiment was conducted at Department of Agronomy, College of Agriculture, Dhule during *Kharif* 2019 to study the effect of pre and post emergence herbicides on soil enzymes in sweet corn. The experiment was laid out in randomized block design with ten treatments replicated three times. Treatments composed of T_1 : weedy check, T_2 : weed free (two hand weeding), T_3 : atrazine @ 1000 g ha^{-1} (PE) *fb* halosulfuron methyl @ 90 g ha^{-1} (PoE), T_4 : atrazine @ 1000 g ha^{-1} (PE) *fb* 2,4 D ethyl ester @ 1000 g ha^{-1} (PoE), T_5 : pendimethalin @ 1000 g ha^{-1} (PE) *fb* halosulfuron-methyl @ 90 g ha^{-1} (PoE), T_6 : pendimethalin @ 1000 g ha^{-1} (PE) *fb* tembotrione @ 120 g ha^{-1} (PoE), T_7 : pendimethalin @ 1000 g ha^{-1} (PE) *fb* 2,4 D ethyl ester @ 1000 g ha^{-1} (PoE), T_8 : halosulfuron-methyl @ 90 g ha^{-1} (PoE), T_9 : tembotrione @ 120 g ha^{-1} (PoE) and T_{10} : 2,4 D ethyl ester @ 1000 g ha^{-1} (PoE).

The pre-emergence (PE) herbicides were applied on next day after sowing of sweet corn, however, the post emergence (PoE) hebicides were applied 30 days after sowing of sweet corn.

The soil of experimental site was medium black with the following chemical properties: pH 8.01, electrical conductivity (EC) 0.32 dS m^{-1}, organic carbon (5.60 g kg^{-1}), calcium carbonate (49 g kg^{-1}), available N (202.34 kg ha^{-1}), available (Olsen-P) P (17.32 kg ha^{-1}), available (NH_4OAc-K) K (402.25 kg ha^{-1}).

Plant samples (grain and straw) were collected, cleaned and dried under shade and subsequently in oven at 65^0C till constant weight and ground well to maximum fineness. The processed plant samples were used for plant analysis. Total N in plant was determined by Microkjeldhal (H_2SO_4 + H_2O_2 digestion) method (Jackson 1973) [9]. Total P in plant was determined by Vanado-molybdate yellow colour in nitric acid system (HNO_3+ $HClO_4$ + H_2SO_4 digestion) method (Jackson 1973) [9]. Total K in plant was determined by Flame photometry (HNO_3+ $HClO_4$ + H_2SO_4 digestion) method (Chapman and Pratt 1961) [4].

Result and Discussion

N uptake

The N uptake was significantly affected with the application of pre- and post-emergence herbicides *viz.*, atrazine, halosulfuron methyl, 2-4-D ethyl ester, pendimethalin and tembotrione at harvest of sweet corn (Table 1). The total N uptake by sweet corn was significantly higher (253.16 kg ha^{-1}) in the weed free treatment (two hand weeding). Similar findings are also reported by Choudhary *et al.* (2013) [5], Shalini and Singh (2014) [15] and Samant *et al.* (2015) [14]. However, significantly lower total N uptake of 104.60 kg ha^{-1} by sweet corn was recorded in the treatment of weedy check (T_1). The weed free treatment (two hand weeding) recorded 142 % increase in total N uptake over the treatment of weedy check (T_1). The treatments of application of pre- and post-emergence herbicides (T_3 to T_{10}), recorded 50.35 to 120 % increase in total N uptake over the treatment of weedy check (T_1). Thus, the use of herbicides for weed control has minimized the nitrogen drain by weeds significantly as compared with treatment of weedy check (T_1). These results corroborate with the finding of Kumar *et al.* (2017) [10], Nazreen *et al.* (2017) [11].

Application of pendimethalin @ 1000 g ha^{-1} (PE) *fb* tembotrione @ 120 g ha^{-1} (PoE) recorded only 9.06 % decrease in the total N uptake by sweet corn over the weed free treatment (two hand weeding). The higher uptake of nitrogen by sweet corn in this treatment might be because of effective control of weed by an application of pre-emergence and post emergence herbicide in sweet corn. The effective weed control decreased the competition of weeds with sweet corn crop for nitrogen applied through chemical fertilizer, residual nitrogen in soil, soil moisture, sunlight and cumulatively reflected in higher nitrogen uptake by sweet corn. In the treatments of pre- and post-emergence herbicides (T_3 to T_{10}) the total N uptake by sweet corn was decreased in the range of 9.06 to 37.87 % over the weed free treatment (two hand weeding). However, in the treatment of weedy check (T_1), the total N uptake by sweet corn was decreased by 58.68 % over the weed free treatment (two hand weeding).

P uptake

Results indicated that P uptake was significantly affected with the application of pre- and post-emergence herbicides (Table 2). The weed free treatment (two hand weeding) recorded significantly higher total P uptake (84.36 kg ha^{-1}) by sweet corn. Similar findings are also reported by Choudhary *et al.* (2013) [5], Shalini and Singh (2014) [15] and Samant *et al.* (2015) [14]. However, the treatment of weedy check (T_1) recorded significantly lower total P uptake of 31.98 kg ha^{-1} by sweet corn. The weed free treatment (two hand weeding) recorded 163 % increase in total P uptake over the treatment of weedy check (T_1). The treatments of application of pre- and post-emergence herbicides (T_3 to T_{10}), recorded 57.78 to 126.29 % increase in total P uptake over the treatment of weedy check (T_1).

The total P uptake by sweet corn was decreased in the range of 14.21 to 40.18 % in the treatments of pre- and post-emergence herbicides (T_3 to T_{10}) over the weed free treatment (two hand weeding). The total P uptake by sweet corn was decreased by 62.09 % in the treatment of weedy check (T_1) over the weed free treatment (two hand weeding). Similar observations were also reported by Kumar *et al.* (2017) [10], Nazreen *et al.* (2017) [11].

K uptake

The K uptake was significantly affected with the application of pre- and post-emergence herbicides (Table 3). The total K uptake by sweet corn was significantly higher (259.13 kg ha^{-1}) in the weed free treatment (two hand weeding). Habimana *et al.* (2013) [8] and Sinodiya and Jha (2014) also reported the higher K uptake in the treatment of weed free check. However, significantly lower total K uptake of 109.94 kg ha^{-1} by sweet corn was recorded in the treatment of weedy check (T_1). The weed free treatment (two hand weeding) recorded 135 % increase in total K uptake over the treatment of weedy check (T_1). The treatments of application of pre- and post-emergence herbicides (T_3 to T_{10}), recorded 48.95 to 119.07 % increase in total K uptake over the treatment of weedy check (T_1).

Application of pendimethalin @ 1000 g ha^{-1} (PE) *fb* tembotrione @ 120 g ha^{-1} (PoE) recorded only 7.05 % reduction in the total K uptake by sweet corn over the weed free treatment (two hand weeding). In the treatments of pre- and post-emergence herbicides (T_3 to T_{10}) the total K uptake by sweet corn was reduced in the range of 7.05 to 36.80 % over the weed free treatment (two hand weeding). However, in the treatment of weedy check (T_1), the total K uptake by sweet corn was decreased by 57.57 % over the weed free treatment (two hand weeding). Similar results are also reported by Chopra and Angiras (2008) [6] and Samant *et al.* (2015) [14].

Table 1: Total N content and N uptake by sweet corn as influenced by application of herbicides

Sr. No.	Treatments	N conc. (%)		N uptake (Kg ha^{-1})		
		Cob	Fodder	Cob	Fodder	Total
1.	Weedy	1.55^{c}	1.24^{c}	40.95^{h}	63.65^{i}	104.60^{i}
2.	Weed free (two hand weedings)	1.69^{a}	1.36^{a}	111.71^{a}	141.46^{a}	253.16^{a}
3.	Atrazine @ 1000 g ha^{-1} (PE) *fb* halosulfuron methyl @ 90 g ha^{-1} (PoE)	1.60^{b}	1.33^{ab}	82.25^{e}	111.91	194.16^{f}
4.	Atrazine @ 1000 g ha^{-1} (PE) *fb* 2,4 D ethyl ester @ 1000 g ha^{-1} (PoE)	1.62^{b}	1.32^{b}	90.14^{d}	120.62^{d}	210.76^{d}
5.	Pendimethalin @ 1000 g ha^{-1} (PE) *fb* halosulfuron-methyl @ 90 g ha^{-1} (PoE)	1.60^{b}	1.30^{b}	80.75^{e}	110.57^{f}	191.32^{f}
6.	Pendimethalin @ 1000 g ha^{-1} (PE) *fb* tembotrione @ 120 g ha^{-1} (PoE)	1.62^{b}	1.32^{b}	100.87^{b}	129.34^{b}	230.22^{b}
7.	Pendimethalin @ 1000 g ha^{-1} (PE) *fb* 2,4 D ethyl ester @ 1000 g ha^{-1} (PoE)	1.62^{b}	1.32^{b}	95.47^{c}	124.72^{c}	220.19^{c}
8.	Halosulfuron-methyl @ 90 g ha^{-1} (PoE)	1.58^{bc}	1.31^{b}	62.32^{g}	94.95^{h}	157.27^{h}
9.	Tembotrione @ 120 g ha^{-1} (PoE)	1.61^{b}	1.31^{b}	84.09^{e}	114.65^{e}	198.73^{e}
10.	2,4 D ethyl ester @ 1000 g ha^{-1} (PoE)	1.59^{bc}	1.32^{b}	72.08^{f}	105.01^{g}	177.10^{g}
	SE(m)±	0.012	0.01	1.17	1.18	1.42
	CD at 5 %	0.037	0.03	2.47	3.57	4.34

Table 2: Total P content and P uptake by sweet corn as influenced by application of herbicides

Sr. No.	Treatments	P conc. (%)		P uptake (Kg ha^{-1})		
		Cob	Fodder	Cob	Fodder	Total
1.	Weedy	0.48	0.37	12.76^{g}	19.22^{g}	31.98^{j}
2.	Weed free (two hand weedings)	0.56	0.45	37.33^{a}	47.03^{a}	84.36^{a}
3.	Atrazine @ 1000 g ha^{-1} (PE) *fb* halosulfuron methyl @ 90 g ha^{-1} (PoE)	0.53	0.42	27.24^{d}	35.63^{cd}	62.87^{e}
4.	Atrazine @ 1000 g ha^{-1} (PE) *fb* 2,4 D ethyl ester @ 1000 g ha^{-1} (PoE)	0.52	0.41	29.11^{c}	37.36^{c}	66.47^{d}
5.	Pendimethalin @ 1000 g ha^{-1} (PE) *fb* halosulfuron-methyl @ 90 g ha^{-1} (PoE)	0.51	0.39	25.64^{d}	33.44^{e}	59.09^{g}
6.	Pendimethalin @ 1000 g ha^{-1} (PE) *fb* tembotrione @ 120 g ha^{-1} (PoE)	0.52	0.41	32.09^{b}	40.28^{b}	72.37^{b}
7.	Pendimethalin @ 1000 g ha^{-1} (PE) *fb* 2,4 D ethyl ester @ 1000 g ha^{-1} (PoE)	0.52	0.41	30.92^{bc}	38.65^{bc}	69.58^{c}
8.	Halosulfuron-methyl @ 90 g ha^{-1} (PoE)	0.52	0.41	20.57^{f}	29.88^{f}	50.46^{i}
9.	Tembotrione @ 120 g ha^{-1} (PoE)	0.51	0.40	26.45^{d}	35.10^{de}	61.55^{f}
10.	2,4 D ethyl ester @ 1000 g ha^{-1} (PoE)	0.52	0.41	23.57^{e}	32.62^{e}	56.19^{h}
	SE(m)±	0.009	0.014	0.60	0.66	0.94
	CD at 5 %	NS	NS	1.81	2.02	0.28

Table 3: Total K content and K uptake by sweet corn as influenced by application of herbicides

Sr. No.	Treatments	K conc. (%)		K uptake (Kg ha^{-1})		
		Cob	Fodder	Cob	Fodder	Total
1.	Weedy	1.54^{c}	1.34^{c}	40.79^{h}	69.15^{h}	109.94^{h}
2.	Weed free (two hand weedings)	1.66^{a}	1.44^{a}	109.76^{a}	149.38^{a}	259.13^{a}
3.	Atrazine @ 1000 g ha^{-1} (PE) *fb* halosulfuron methyl @ 90 g ha^{-1} (PoE)	1.61^{b}	1.43^{ab}	82.94^{e}	120.33^{e}	203.27^{e}
4.	Atrazine @ 1000 g ha^{-1} (PE) *fb* 2,4 D ethyl ester @ 1000 g ha^{-1} (PoE)	1.63^{ab}	1.41^{ab}	90.69^{d}	128.80^{d}	219.49^{d}
5.	Pendimethalin @ 1000 g ha^{-1} (PE) *fb* halosulfuron-methyl @ 90 g ha^{-1} (PoE)	1.62^{b}	1.40^{ab}	81.92^{e}	119.34^{e}	201.27^{e}
6.	Pendimethalin @ 1000 g ha^{-1} (PE) *fb* tembotrione @ 120 g ha^{-1} (PoE)	1.64^{ab}	1.42^{ab}	101.70^{b}	139.16^{b}	240.85^{b}
7.	Pendimethalin @ 1000 g ha^{-1} (PE) *fb* 2,4 D ethyl ester @ 1000 g ha^{-1} (PoE)	1.64^{ab}	1.42^{ab}	96.86^{c}	133.83^{c}	230.68^{c}
8.	Halosulfuron-methyl @ 90 g ha^{-1} (PoE)	1.61^{b}	1.39^{b}	63.51^{g}	100.25^{g}	163.76^{g}
9.	Tembotrione @ 120 g ha^{-1} (PoE)	1.63^{ab}	1.41^{ab}	84.97^{e}	123.76^{e}	208.72^{e}
10.	2,4 D ethyl ester @ 1000 g ha^{-1} (PoE)	1.61^{b}	1.39^{b}	73.12^{f}	110.59^{f}	183.72^{f}
	SE(m)±	0.01	0.013	1.21	1.58	2.34
	CD at 5 %	0.03	0.039	3.61	4.77	7.09

Conclusion

Among the treatments of pre and post emergence herbicides, application of pendimethalin @ 1000 g ha^{-1} as pre emergence *fb* tembotrione @ 120 g ha^{-1} as post emergence (T_6) recorded higher total N uptake (230.22 kg ha^{-1}), P uptake (72.37 kg ha^{-1}) and K uptake (240.85 kg ha^{-1}) by sweet corn with 120, 126.29 and 119.07 % increase, respectively, over the treatment of weedy check (T_1) and 9.06, 14.21 and 7.05 % decrease, respectively, over the Weed free (T_2) treatment (Two hand weeding).

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