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Herbicides efficacy & nutrient uptake (N, P_2O_5, K_2O) by weeds in kharif maize (*Zea mays*)

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Abstract
Maize is a vigorous and tall growing plant, it is susceptible to competition from weeds. High rainfall, high humidity and high temperature provide very conducive conditions for the lavish growth of the weeds. Weeds compete with crop plants for light, space, water and nutrients, especially during the early stages of growth as they are more adapted to agro-ecosystems than crop plants. To evaluate the loss of major nutrient (Nitrogen, Phosphorous & Potassium), a field experiment was conducted at College Farm, among ten treatments, weed free treatment attributed more number of leaves, maximum plant height, dry matter production and leaf area per plant followed by treatment of topramezone 33.6% SC @ 25.2 g a.i.ha^{-1} + atrazine 50% WP @ 250 g a.i.ha^{-1}. Poor growth attributes were recorded in weedy check. Significantly maximum values of yield attributes were recorded in treatment of topramezone 33.6% SC @ 25.2 g a.i.ha^{-1} + atrazine 50% WP @ 250 g a,i. ha^{-1} followed by treatment of tembotrione 42% SC @ 105 g a.i.ha^{-1}+ atrazine 50% WP @ 250 g a,i.ha^{-1}. Minimum values of yield attributes were attributed in weedy check. Treatment of topramezone + atrazine @ 25.2 + 250 g a.i ha^{-1} as PoE (T_6) found effective in limiting weed growth and recorded lower weed index, weed dry matter with higher weed control efficiency followed by tembotrione + atrazine @105 + 250 g a.i. ha^{-1} as PoE (T_7) at all growth stages of crop. Lower uptake of nitrogen, phosphorous and potassium by weeds were recorded in treatment of topramezone + atrazine @ 25.2 + 250 g a.i. ha^{-1} as PoE followed by tembotrione + atrazine @ 105 +250 g *a.i.* ha^{-1} as PoE. The benefit cost ratio was highest (2.94) with application of topramezone + atrazine @25.2 + 250 g a.i ha^{-1} followed by tembotrione + atrazine @ 105 + 250 g *a.i* ha^{-1} as PoE (2.81) whereas weedy check recorded significantly lower B:C ratio (1.50) over other treatments.

Keywords: Weed index, weed- control efficiency, weed dry weight, NPK uptake, yield attributes

Introduction
Maize is the third most imperative grain crop in India after rice and wheat with respect to area and productivity. Maize has been major cereal crop and known as 'Queen of Cereals', because of its great productivity potential and adaptability to wide range of environments it occupies an significant place in world's economy. Major maize growing countries are USA, China, Brazil, Mexico, France, Argentina, Italy and India.

The crop requires large amounts of N, P and K in addition to other micro elements. Weed control can increase fertilizer use efficiency of the crop with checking wasteful removal of nutrients by weeds. Topramezone and tembotrione are the selective, post-emergence herbicides that have been recently introduced for use in maize. These herbicides inhibit hydroxy-phenylpyruvate dioxygenase (4-HPPD) and the biosynthesis of plastoquinone, with subsequent carotenoid pigment formation, membrane structure and chlorophyll disruption (Porter *et al*., 2005) [8]. HPPD inhibiting herbicides are most effective in newly developing tissues that emerge bleached, as a consequence of failure to properly assemble photosynthetic units and thus they control weeds. (Schon hammer *et al.*, 2006) [9]. Tank mix application of these herbicides with lower dose of atrazine was reported to be more effective providing broad spectrum weed control than alone application of individual chemicals. So there is a need to evaluate alternate post-emergence herbicide which can provide broad spectrum weed control in maize subsequently help to stop nutrient losses.

Materials and Methods
The experiment, Herbicides Efficacy & Nutrient Uptake (N, P_2O_5, K_2O) By Weeds in Kharif Maize (*Zea mays*.) was carried out during *Kharif* 2019 at Experimental Farm of Agronomy, College of Agriculture Badnapur (India). Soil of the experimental field clay in texture, moderate in available nitrogen and low in available phosphorus with high in available potassium, soil was moderately alkaline in reaction.

The randomized block designs with consist of ten treatments and replicated thrice to get unbiased data. Net plot size and gross plot size of plot was 3.5 x 4.5 and 4.8x 5.1 m respectively. Maize crop variety DKC-9133 was sown with dibbled method at 60 cm row to row and 30 cm plant to plant distance during *Kharif* 2019. The doses of herbicides were calculated as per the treatments simultaneously calibration of knapsack sprayer carried out. The powder or liquid formulation was diluted in the water according to the different doses and 1.2 L of spray solution per plot was applied for each treatment with the help of knapsack sprayer. Treatment consist T_1-Atrazine 50% WP @ 1 Kg a.i/ha (PE), T_2- 2,4 – D Dimethyl Amine salt 58% SL @ 1 Kg a.i./ha (PoE), T_3-Topramezone 33.6% SC @ 67.2 g a.i/ha (PoE at 15 DAS), T_4 – Topramezone 33.6% SC @ 25.2 g a.i/ha (PoE at 15 DAS), T_5-Tembotrione 42% SC @ 105 g a.i/ha (PoE 15 DAS), T_6-Topramezone 33.6% SC @ 25.2 g a.i/ha + Atrazine 50% WP @ 250 g a,i/ha (PoE at 15 DAS), T_7-Tembotrione 42% SC @ 105 g a.i/ha + Atrazine 50% WP @ 250 g a,i/ha (PoE 15 DAS), T_8–One hand weeding at 30 DAS, T_9: Weedy check, T_{10} - Weed free. Fertilizer dose 175:50:50 NPK kg/ha was applied as common to all treatments. Entire dose of P_2O_5, $^1/_3$ of N, ½ of K_2O were applied as basal. Nitrogen was applied in two more splits at knee height stage and at tasselling stage along with ½ of K_2O Common cultural practices such as irrigation, thinning and gap filling was done. The nitrogen content in dried weed samples were determined by Micro kjeldahl distillation method after destroying the organic matter by H_2SO_4 and H_2O_2 (Piper, 1966). The weed samples were digested with a tri- acid mixture consisting of HNO_3:H_2SO_4: $HClO_4$ (9:4:1). The digest was made up to 100 ml. The phosphorus content in the tri- acid digest was determined by developing yellow colour with Barton's reagent. The intensity of yellow colour was determined by using UV visible spectrophotometer at 420nm (Piper, 1966). The potassium content in the tri-acid digest was determined by using flame photometer (Piper, 1966). In case of crop and weeds, the nutrient uptake was calculated using the formula- Nutrient uptake (kg ha^{-1} = Dry matter production (kg ha^{-1}) X Nutrient content (%).

Results and Discussion

Effect of different weed management treatments on weed density: At harvest, there was no broad-leaved weed (BLW), however, the grassy weeds and sedges recorded at all crop stages. This might be due to over-dominance of the grassy weeds and non-shade tolerance of the BLW which resulted in their nil population at maize harvest. Moreover, most of the BLW were annual while some grassy weeds and sedges were perennial. Similar findings of the different weed flora in maize were reported by Madhavi et al. (2014) [6]. weed density at harvest recorded lower in treatment of topramezone + atrazine @ 25.2 + 250 g *a.i/* ha (T_6) as post emergence which was at par with tembotrione + atrazine @ 105 + 250 g *a.i* ha^{-1} (T_7) these were significantly superior over rest of the treatments. Significantly highest population recorded in weedy check. At 90 DAS and at harvest treatment of topramezone + atrazine @ 25.2 + 250 g *a.i* ha^{-1} as PoE (T_6) recorded significantly lower dry matter which was at par with tembotrione + atrazine @ 105 +250 g *a.i* ha^{-1} as PoE (T_7) it was at par with topramezone 33.6% SC @ 67.2 g a.i/ha (T_3) respectively. Significantly highest weed dry matter was recorded in weedy check (T_9). Lowest weed index was recorded significantly with topramezone + atrazine @ 25.2 + 250 g *a.i* ha^{-1} as PoE (T_6) (3.75%) which was at par with tembotrione + atrazine @ 105 + 250 g *a.i* ha^{-1} as PoE (T_7) (7.47%) and topramezone 33.6% SC @ 67.2 g a.i/ha (T_3) (7.59%) respectively. Significantly highest weed index was recorded with weedy check (T_9) (53.58%). At harvest, higher WCE was recorded in topramezone + atrazine @ 25.2 + 250 g *a.i* ha^{-1} (T_6) (78.05%) which was at par with tembotrione + atrazine @ 105 + 250 g *a.i* ha^{-1} as PoE (T_7) (75.26%) and topramezone 33.6% SC @ 67.2 g a.i/ha as PoE (T_3) (74.03%) respectively. Significantly lowest WCE was recorded with one hand weeding at 30 DAS (T_8) (43.88%) at harvest.

N, P_2O_5, K_2O Uptake by weeds: Total uptake of nitrogen by weeds were significantly lower in treatment of topramezone + atrazine @ 25.2 + 250 g *a.i/* ha as PoE (T_6) (19.81 Kg/ha) which was at par with tembotrione + atrazine @ 105 +250 g *a.i* ha^{-1} as PoE (T_7) (22.08 Kg/ha) and topramezone 33.6% SC @ 67.2 g a.i/ha as PoE (T_3) (23.65 kg/ha) respectively. Significantly higher uptake was recorded in weedy check (T_9) (90.59 Kg ha^{-1}). Phosphorous uptake by weeds at harvest were significantly lower in treatment of topramezone + atrazine @ 25.2 + 250 g *a.i/* ha as PoE (T_6) (0.48 Kg/ha) which was at par with tembotrione + atrazine @ 105g a.i/ha +250 g *a.i* ha^{-1} as PoE (T_7) (0.55 Kg/ha) and topramezone 33.6% SC @67.2 g a.i/ha as PoE (T_3) (0.57 kg/ha) respectively. Significantly higher uptake was recorded in weedy check (T_9) (2.21 Kg ha^{-1}). Potassium uptake by weeds at harvest were significantly lower in treatment of topramezone + atrazine @ 25.2 + 250 g *a.i/* ha as PoE (T_6) (11.45 Kg/ha) which was at par with tembotrione + atrazine @ 105 +250 g *a.i* ha^{-1} as PoE (T_7) (12.77 Kg/ ha) and topramezone 33.6% SC @67.2 g a.i/ha as PoE (T_3) (13.67 Kg/ha) respectively. Significantly higher uptake was recorded in weedy check (T_9) (52.03 Kg ha^{-1}). There was no significant difference found in available NPK status of soil in different weed management treatments after harvest of maize crop.

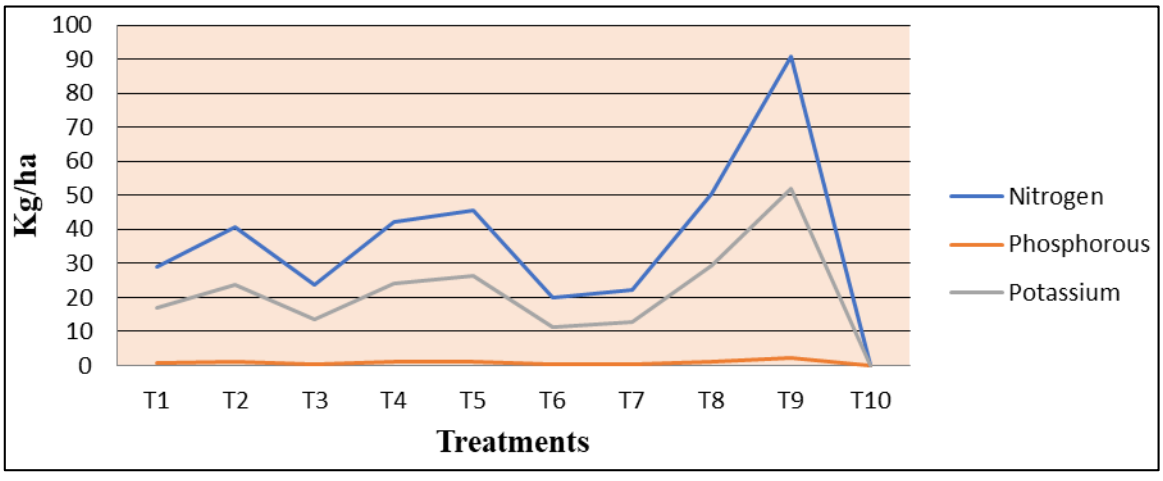
Table 1: Effect of different weed management treatments on weed dry matter accumulation (g/m^2) at various crop growth stages in *kharif* maize]

Treatment	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	SE(m)+	CD at 5%	G.M
Comelina benghalensis													
30 DAS	2.83	3.78	2.35	3.37	3.22	2.09	2.26	0.0	4.90	0	0.09	0.26	2.48
60 DAS	5.26	6.75	3.66	10.03	11.02	3.43	3.63	6.47	23.44	0	0.51	1.51	7.37
90 DAS	7.42	8.61	6.31	12..21	20.23	5.02	5.60	9.65	32.28	0	0.77	2.28	10.73
At harvest	7.69	9.2	6.91	16.72	12.43	5.63	6.5	10.17	34.52	0	0.86	2.56	10.98
Digitaria sangunallis													
30 DAS	2.04	2.36	0.0	1.68	1.36	0	0	0	3.08	0	0.10	NS	1.05
60 DAS	4.39	5.98	2.95	6.78	7.05	2.71	2.94	7.32	7.68	0	0.28	0.83	4.78
90 DAS	4.70	6.79	3.62	7.17	7.41	3.16	3.34	8.10	9.07	0	0.17	0.51	5.34

At harvest	5.80	8.68	5.45	10.88	14.97	4.61	4.97	16.45	20.32	0	0.38	1.14	9.19
Cynadon dactylon													
30 DAS	1.81	2.17	1.76	1.95	2.17	0	1.61	3.21	4.51	0	0.08	NS	1.92
60 DAS	2.70	3.22	2.35	2.08	2.57	0	2.17	3.62	4.07	0	0.15	NS	2.28
90 DAS	-	-	-	-	-	-	-	-	-	-	-	-	-
At harvest	-	--	-	-	-	-	-	-	-	-	-	-	--
Euphorbia geniculata													
30 DAS	-	-	-	-	-	-	-	-	-	-	-	-	-
60 DAS	4.51	5.87	3.89	6.26	6.15	3.61	4.06	7.24	10.53	0	0.13	0.40	5.21
90 DAS	9.03	12.6	6.33	8.17	8.91	5.45	5.47	13.53	18.20	0	0.30	0.88	8.77
At harvest	9.94	13.5	6.83	9.28	10.80	6.12	6.50	15.35	20.70	0	0.35	1.04	9.91
Parthenium hesterophorous													
30 DAS	-	-	-	-	-	-	-	-	-	-	-	-	-
60 DAS	-	-	-	-	-	-	-	-	-	-	-	-	-
90 DAS	4.97	8.86	4.79	6.77	7.59	3.43	4.0	8.32	16.74	0	0.19	0.57	6.58
At harvest	6.38	10.8	5.45	7.25	8.10	4.51	5.23	9.07	18.0	0	0.31	0.91	7.48
Other													
30 DAS	-	-	-	-	-	-	-	-	-	-	-	-	-
60 DAS	2.18	2.71	1.09	1.72	4.07	0.97	1.17	4.52	6.78	0	0.12	0.37	2.51
90 DAS	2.53	3.16	1.35	1.81	5.12	1.23	1.31	5.42	8.12	0	0.15	0.46	3.0
At harvest	3.16	3.78	2.07	3.61	5.42	1.53	1.71	6.32	8.72	0	0.20	0.58	3.63
Total													
30 DAS	6.68	8.31	4.11	6.99	6.75	2.09	2.72	3.21	12.49	0	0.21	0.63	5.45
60 DAS	19.0	24.5	11.54	26.87	30.85	12.84	14.16	29.17	52.50	0	0.66	1.96	22.15
90 DAS	29.1	40.7	21.75	36.31	49.44	18.66	21.20	45.25	85.01	0	1.11	3.31	34.76
At harvest	32.6	46.0	26.54	47.75	51.71	22.43	25.28	57.35	102.2	0	1.86	5.53	41.20

Table 2: Effect of different weed management treatments on weed control effiiciencies indices at various crop growth stages in *kharif* maize

Treatments	Weed Index (%)	WCE (%)	Total dry weight (g/m^2)	Total NPK Uptake (kg/ha)		
				Nitrogen (N)	Phosphorous (P_2O_5)	Potassium (K_2O)
T_1 : Atrazine 50% WP @ 1 Kg a.i/ha (PE)	8.99	68.1	32.6	28.94	0.69	16.8
T_2 : 2,4 –D Dimethyl Amine salt 58% SL @ 1 Kg a.i./ha (PoE).	12.77	54.99	46.0	40.69	1.01	23.69
T_3: Topramezone 33.6% SC @ 67.2 g a.i/ha (PoE at 15 DAS)	7.59	74.03	26.54	23.65	0.57	13.67
T_4 Topramezone 33.6% SC @25.2 g a.i/ha (PoE at 15 DAS)	18.03	53.27	47.75	42.26	1.02	24.2
T_5 : Tembotrione 42% SC @ 105 g a.i/ha (PoE 15 DAS)	21.96	49.40	51.71	45.7	1.1	26.38
T_6: Topramezone 33.6% SC @ 25.2 g a.i/ha + Atrazine 50% WP @ 250 g a,i/ha (PoE at 15 DAS)	3.75	78.05	22.43	19.81	0.48	11.45
T_7 : Tembotrione 42% SC @ 105 g a.i/ha+ Atrazine 50% WP @ 250 g a,i/ha (PoE 15 DAS)	7.47	75.26	25.28	22.08	0.55	12.77
T_8 : One hand weeding at 30 DAS	20.20	43.88	57.35	50.47	1.24	29.26
T_9 : Weedy check	53.58	0.0	102.2	90.59	2.21	52.03
T_{10}: Weed free	0	-	0	0	0	0
SE(m)+	0.82	1.20	1.86	1.62	0.02	0.86
CD at 5%	3.90	4.60	5.53	5.1	0.09	2.70
General mean	15.43	59.70	41.20	40.46	0.98	23.36



NPK uptake by weeds at harvest Kg/ha

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