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Comparative Efficiency of Different Weed Management Practices on Economics as well as Nutrient Uptake in Maize

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Abstract

A field experiment was conducted at Research Farm of Agricultural Research Station, Ummedganj, Kota (Agriculture University, Kota), Rajasthan, India during kharif 2019 to find out the most effective herbicide combination for limiting the menace of weeds in maize. Results showed that application of herbicides observed highest net returns, B: C ratio and nutrient uptake. Among herbicides, atrazine 500 g *a.i.* ha^{-1} (PE) *fb*topramezone 25.2 g *a.i.*ha^{-1} at 20-25 DAS fetched significantly highest net returns of ₹ 54984 ha^{-1} being at par with atrazine 500 g *a.i.* ha^{-1} (PE) *fb*tembotrione 120.75 g *a.i.* ha^{-1} at 20-25 DAS (₹ 52500 ha^{-1}), over rest of the treatments under investigation. Furthermore, maximum and significantly higher Benefit: cost ratio was obtained in treatment receiving atrazine 500 g *a.i.* ha^{-1} (PE) *fb*topramezone 25.2 g *a.i.* ha^{-1} at 20-25 DAS (3.42).A weedy crop resulted least nutrient uptake than weed free crop.The highest nutrient uptake (kg ha^{-1}) was recorded under treatment receiving two hand weeding at 20 and 40 DAS followed by atrazine 500 g *a.i.* ha^{-1} (PE) *fb*topramezone 25.2 g *a.i.* ha^{-1} at 20-25 DAS. Treatment two hand weeding at 20 & 40 DAS being at par with atrazine 500 g *a.i.* ha^{-1} (PE) + hand weeding at 30 DAS with *in situ* mulching with weeds, atrazine 500 g *a.i.* ha^{-1} (PE) *fb*tembotrione 120.75 g *a.i.* ha^{-1} at 20-25 DAS, and atrazine 500 g *a.i.* ha^{-1} (PE) *fb*topramezone 25.2 g *a.i.* ha^{-1} at 20-25 DAS recorded significantly highest nutrient uptake in grain, stover and total over rest of the treatments under investigation. Minimum nitrogen uptake was obtained under treatment weedy check.Thus, pre-emergence application of atrazine 500 g *a.i.* ha^{-1} (PE) followed by topramezone 25.2 g *a.i.* ha^{-1} at 20-25 DAS is recommended for highest net returns and nutrient uptake of maize.

Keywords: Atrazine, maize, mulching, net return, nutrient uptake, mulching

1. Introduction

Maize (*Zea mays* L.) is one of the important cereal crops of the world, known as "Queen of cereals" due to its great importance in human and animal diet, very efficient utilizer of solar energy and has immense potential for higher yield. It is known for its wider adaptability and multipurpose uses as food, fodder and industrial products (Murdia et al., 2016). Currently, nearly 1148 mt of maize is being produced together by over 170 countries from an area of 194 million ha with an average productivity of 5.75 t ha^{-1}. In India, the maize is grown on 9.2 mha area with the production of 27.8 mt (Anonymous, 2020). Maize is also good feed for piggery, poultry and other animals. Its content about 11.2% protein, 8% oil, 70% carbohydrate, 2.3% crude fiber, 10.4% albumins and 1.4% ash.(Raut*et al*., 2017). It is also an important source of vitamins and minerals like Ca, P, S and small amounts of Na. Its flour is considered to be a good diet for heart patients due to its low gluten (protein) content (Rasool and Khan, 2016). In general, the productivity of maize in India and Rajasthan in particular is relatively very low compared to developed country of world mainly due to poor nutrition, lack of good quality seed, lack of timely weed control, disease and insect management and post-harvest losses (Choudhary et al., 2012). The major yield reducing factors for maize cultivation in India are weeds (Pandey et al., 2001; Gharde et al., 2018). There are about 100 weed species in 66 genera and 24 plant families known to be problematic for maize in the country. Most of the presently available herbicides provide only a narrow spectrum weed control (Patel et al., 2006).The best results of weed control can only be seen in case of integrated weed management practices. Integrated weed management is the need of the day, because of its sustainability and higher productivity (Sharma et al., 2018; Kumawat et al., 2019). Weed control practices in maize resulted in 65 to 90% higher yield than unweeded (Barla et al., 2016; Kumawat et al.,

2019). Maximum uptake by maize was observed *i.e.* 164.01 kg N, 39.45 kg P and 165.17 kg K ha^{-1}, respectively. The same treatment also recorded maximum gross return (₹ 59126 ha^{-1}) and B: C ratio (1.91) with additional net return of ₹ 21690 ha^{-1} as compared to weedy check Samant et al. (2015). Maximum net return (₹ 65346 ha^{-1}) and highest B: C ratio (3.37) were realised by applying atrazine 0.75 kg ha^{-1}+pendimethalin 0.75 kg ha^{-1} pre-emergence (Yadav et al., 2017). Highest net returns (₹ 50297.65 ha^{-1}) and B: C ratio (1.57) was recorded under atrazine 1.5 kg ha^{-1} pre-emergence *fb* tembotrione 120 g ha^{-1} post-emergence at 25 DAS which was found statistically at par with pendimethalin (1000 ml ha^{-1}) pre-emergence *fb*atrazine (750 g ha^{-1})+2,4-D amine 0.4 kg ha^{-1} at 25 DAS as post-emergence in terms of net returns (₹ 50064.04 ha^{-1}) and B: C ratio (1.47) (Barua et al., 2019).Total nutrient uptake by *kharif* maize was maximum (166.6 kg N, 63.5 kg, P and 191.7 kg K ha^{-1}) under the treatment pre-emergence application of alachlor 1000 g ha^{-1} *fb* post-emergence application of halosulfuron-methyl 67.5 g ha^{-1}+tembotrione 100 g ha^{-1} *fb* hand-weeding (165.3 kg N, 62.2 kg P_2O_5 and 118.2 kg, K_2O ha^{-1}) (Nazreen et al., 2018).

Topramezone and tembotrione are the new selective, post-emergence herbicides introduced for use in maize that inhibit hydroxy-phenyl pyruvate dioxygenase (4-HPPD) enzyme and the biosynthesis of plastoquinone (Swetha et al., 2015). There is need for some alternate postemergence herbicide like tembotrione which can provide broad spectrum weed control in kharif maize without affecting the growth and yield of crop (Williams et al., 2011; Yadav et al., 2017). Therefore, this study was conducted to find out the most selective and potent herbicide for limiting the menace of weeds in maize. Keeping these facts in mind, the present investigation was conducted with objective to evaluate the net returns and nutrient uptake of different weed management practices.

2. Materials and Methods

A field experiment was conducted at Research Farm of Agricultural Research Station, Ummedganj, Kota (Agriculture University, Kota) during July-October, 2019. Region falls under the Agro Climatic Zone V of Rajasthan i.e. Humid South-Eastern Plain zone. The experiment comprised with the following treatments- T_1: Weedy check, T_2: One hand weeding (30 DAS) with in situ mulching with weeds, T_3: Two hand weeding (20 and 40 DAS), T_4: Atrazine 500 g *a.i*. ha^{-1} (PE), T_5 : Atrazine 500 g *a.i*. ha^{-1} (PE)+hand weeding (30 DAS), T_6: Atrazine 500 g *a.i*. ha^{-1} (PE)+hand weeding 30 DAS with in situ mulching with weeds, T_7: Tembotrione 120.75 g *a.i*. ha^{-1} (20-25 DAS), T_8 : Topramezone 25.2 g *a.i*. ha^{-1} (20-25 DAS), T_9: Atrazine 500 g *a.i*. ha^{-1} (PE) followed by Tembotrione 120.75 g *a.i*. ha^{-1} (20-25 DAS), T_{10}: Atrazine 500 g *a.i*. ha^{-1} (PE) followed by Topramezone 25.2 g *a.i*. ha^{-1} (20-25 DAS), T_{11}: Atrazine 500 g *a.i*. ha^{-1}+Tembotrione 120.75 g *a.i*. ha^{-1} (20-25 DAS) and T_{12}: Atrazine 500 g*a.i*. ha^{-1}+Topramezone 25.2 g *a.i*. ha^{-1} (20-25 DAS) were assigned in a randomized block design with three replication. All the herbicides alone or in combination were applied uniformly in the experimental plots with the help of knapsack sprayer.The maize variety "PHM-3" was sown at a spacing of 60×25 cm^2 between rows and plants. All the recommended agronomic and plant protection measures were adopted to raise crop.Observation recorded on the following aspects- economics [net returns (₹ ha^{-1}) and B: C ratio] and nutrient uptake [nitrogen, phosphorus and potassium uptake in grain and stover and total uptake (kg ha^{-1})]. The influence of treatment was tested with 'F' test wherever 'F' test shown their significance. The levels of treatment were compared by critical difference at 5% level of probability/ significance.

3. Results and Discussion

3.1. Economics

3.1.1. Net return (₹ ha^{-1})

The data on net return ₹ ha^{-1} of maize as affected by various weed management practices are presented in Table 1. Application of atrazine 500 g *a.i.* ha^{-1} (PE) *fb*topramezone 25.2 g *a.i.* ha^{-1} at 20-25 DAS fetched significantly highest net returns of ₹ 54984 ha^{-1} being at par with atrazine 500 g *a.i.* ha^{-1} (PE) *fb*tembotrione 120.75 g *a.i.* ha^{-1} at 20-25 DAS (₹ 52500 ha^{-1}), atrazine 500 g *a.i*. ha^{-1} (PE)+hand weeding 30 DAS with *in situ* mulching with weeds (₹ 50134 ha^{-1}) over rest of the treatments under investigation. Respective treatment recorded 260.15, 71.89, 7.83, 65.75, 24.11, 9.67, 66.36, 52.32, 4.73, 34.94, 27.94 per cent more net returns over weedy check, one hand weeding at 30 DAS with *in situ* mulching with weeds, two hand weeding at 20 and 40 DAS, atrazine 500 g *a.i.* ha^{-1} (PE), atrazine 500 g *a.i.* ha^{-1} (PE)+hand weeding at 30 DAS, atrazine 500 g *a.i.* ha^{-1} (PE)+hand weeding at 30 DAS with *in situ* mulching with weeds, tembotrione 120.75 g *a.i.* ha^{-1} at 20-25 DAS, topramezone 25.2 g *a.i.* ha^{-1} at 20-25 DAS, atrazine 500 g *a.i.* ha^{-1} (PE) *fb*tembotrione 120.75 g *a.i.* ha^{-1} at 20-25 DAS, atrazine 500 g *a.i.* ha^{-1}+tembotrione 120.75 g *a.i.* ha^{-1} at 20-25 DAS and atrazine 500 g *a.i.* ha^{-1}+topramezone 25.2 g *a.i.* ha^{-1} at 20-25 DAS.

3.1.2. Benefit: cost ratio

Benefit: cost ratio as influenced by different weed management practices are presented in Table 1. Maximum and significantly higher Benefit: cost ratio was obtained in treatment receiving atrazine 500 g *a.i.* ha^{-1} (PE) *fb*topramezone 25.2 g *a.i.* ha^{-1} at 20-25 DAS (3.42) followed by atrazine 500 g *a.i.* ha^{-1} (PE) *fb*tembotrione 120.75 g *a.i.* ha^{-1} at 20-25 DAS (3.32) and atrazine 500 g *a.i.* ha^{-1} (PE)+one hand weeding at 30 DAS with *in situ* mulching with weeds (3.17).Treatment atrazine 500 g *a.i.* ha^{-1} (PE) *fb*topramezone 25.2 g *a.i.* ha^{-1} at 20-25 DAS recorded 81.91, 40.68, 20.00, 20.00, 17.12, 7.89, 37.35, 30.53, 3.01, 22.14 and 18.34 per cent more benefit cost ratio over weedy check, one hand weeding at 30 DAS with *in situ* mulching with weeds,two hand weeding at 20 and 40 DAS, atrazine 500 g *a.i.* ha^{-1} (PE), atrazine 500 g *a.i.* ha^{-1} (PE)+hand weeding at 30 DAS, atrazine 500 g *a.i.* ha^{-1} (PE)+hand weeding

Table 1: Effect of weed management practices on economics

Treatments	Net return (₹ ha^{-1})	B: C ratio
Weedy check	15267	1.88
One hand weeding at 30 DAS with in situ mulching with weeds	30542	2.36
Two hand weeding at 20 and 40 DAS	50992	2.85
Atrazine 500 g *a.i.* ha^{-1} (PE)	33172	2.85
Atrazine 500 g *a.i.* ha^{-1} (PE)+hand weeding at 30 DAS	44301	2.92
Atrazine 500 g *a.i.* ha^{-1} (PE)+hand weeding at 30 DAS with *in situ* mulching with weeds	50134	3.17
Tembotrione 120.75 g *a.i.* ha^{-1} at 20-25 DAS	33052	2.49
Topramezone 25.2 g a.i. ha^{-1} at 20-25 DAS	36098	2.62
Atrazine 500 g *a.i.* ha^{-1} (PE)fbtembotrione 120.75 g *a.i.* ha^{-1} at 20-25 DAS	52500	3.32
Atrazine 500 g *a.i.* ha^{-1} (PE)fbtopramezone 25.2 g *a.i.* ha^{-1} at 20-25 DAS	54984	3.42
Atrazine 500 g *a.i.* ha^{-1}+ tembotrione 120.75 g *a.i.* ha^{-1} at 20-25 DAS	40746	2.80
Atrazine 500 g *a.i.* ha^{-1}+ topramezone 25.2 g *a.i.* ha^{-1} at 20-25 DAS	42978	2.89
SEm±	3595	0.16
CD (*p*=0.05)	10544	0.47
CV (%)	15.42	9.82

at 30 DAS with *in situ* mulching with weeds,tembotrione 120.75 g *a.i.* ha^{-1} at 20–25 DAS, topramezone 25.2 g *a.i.* ha^{-1} at 20-25 DAS, atrazine 500 g *a.i.* ha^{-1} (PE) *fb*tembotrione 120.75 g *a.i.* ha^{-1} at 20-25 DAS, atrazine 500 g *a.i.* ha^{-1}+tembotrione 120.75 g *a.i.* ha^{-1} at 20-25 DAS and atrazine 500 g *a.i.* ha^{-1}+topramezone 25.2 g *a.i.* ha^{-1} at 20-25 DAS.

These finding are close conformity with the Hatti et al., 2014, Samant et al*.,* 2015 and Rao et al*.,* 2016, who also reported higher net returns and benefit: cost ratio with application of atrazine *fb* topramezone in maize.

3.2. Nutrient uptake

3.2.1. Nitrogen uptake

3.2.1.1. Nitrogen uptake in grains

Nitrogen uptakein grains as influenced by different weed management practices are presented in Table 2. The highest nitrogen uptake (55.24 kg ha^{-1}) was recorded under treatment receiving two hand weeding at 20 and 40 DAS followed by atrazine 500 g *a.i.* ha^{-1} (PE) *fb*topramezone 25.2 g *a.i.* ha^{-1} at 20-25 DAS (54.40 kg ha^{-1}) and atrazine 500 g *a.i.* ha^{-1} (PE) *fb*tembotrione 120.75 g *a.i*. ha^{-1} at 20-25 DAS (52.27 kg ha^{-1}). Treatment two hand weeding at 20 & 40 DAS being at par with atrazine 500 g *a.i.* ha^{-1} (PE) + hand weeding at 30 DAS with *in situ* mulching with weeds, atrazine 500 g *a.i.* ha^{-1} (PE) *fb*tembotrione 120.75 g *a.i.* ha^{-1} at 20-25 DAS, and atrazine 500 g *a.i.* ha^{-1} (PE) *fb*topramezone 25.2 g *a.i.* ha^{-1} at 20–25 DAS recorded significantly highest N uptake in grain over rest of the treatments under investigation. Minimum nitrogen uptake (21.47 kg ha^{-1}) was obtained under treatment weedy check.

3.2.1.2. Nitrogen uptake in stover

All the weed management practices enhanced nitrogen uptake by maize stover than weedy check. Nitrogen uptakein stover as influenced by different weed management practices are presented in Table 2. The highest nitrogen uptake (72.54 kg ha^{-1}) by stover was observed under treatment two hand weeding at 20 and 40 DAS followed by atrazine 500 g *a.i.* ha^{-1} (PE) *fb* topramezone 25.2 g *a.i.* ha^{-1} at 20-25 DAS (71.64 kg ha^{-1}) and atrazine 500 g *a.i.* ha^{-1} (PE) *fb*tembotrione 120.75 g *a.i.* ha^{-1} at 20-25 DAS (68.98 kg ha^{-1}). Treatment two hand weeding at 20 and 40 DAS being at par with atrazine 500 g *a.i.* ha^{-1} (PE)+hand weeding at 30 DAS with *in situ* mulching with weeds, atrazine 500 g *a.i.* ha^{-1} (PE) *fb*tembotrione 120.75 g *a.i.* ha^{-1} at 20-25 DAS, and atrazine 500 g *a.i.* ha^{-1} (PE) *fb*topramezone 25.2 g *a.i.* ha^{-1} at 20-25 DAS recorded significantly highest N uptake in stover over rest of the treatments under experimentation. The lowest nitrogen uptake (28 kg ha^{-1}) by stover was recorded under treatment weedy check.

3.2.1.3. Total nitrogen uptake

Total nitrogen uptake as influenced by different weed management practices are presented in Table 2. The maximum total nitrogen uptake (127.78 kg ha^{-1}) by crop was recorded under treatment receiving two hand weeding at 20 and 40 DAS followed by atrazine 500 g *a.i.* ha^{-1} (PE) *fb*topramezone 25.2 g *a.i.* ha^{-1} at 20-25 DAS (126.04 kg ha^{-1}) and atrazine 500 g *a.i.* ha^{-1} (PE) *fb*tembotrione 120.75 g *a.i.* ha^{-1} at 20–25 DAS (121.25 kg ha^{-1}). Statistically minimum total nitrogen uptake (49.47 kg ha^{-1}) was observed under treatment weedy check. Two hand weeding at 20 and 40 DAS treatment recorded 158.3, 50.97, 56.90, 17.93, 8.38, 43.28, 35.56, 5.39, 1.38, 25.82, and 21.30% more total N uptake over weedy check, one hand weeding at 30 DAS with *in situ* mulching with weeds, atrazine 500 g *a.i.*

ha^{-1} (PE), atrazine 500 g *a.i.* ha^{-1} (PE)+hand weeding at 30 DAS, atrazine 500 g *a.i.* ha^{-1} (PE)+hand weeding at 30 DAS with *in situ* mulching with weeds, tembotrione 120.75 g *a.i.* ha^{-1} at 20-25 DAS, topramezone 25.2 g *a.i.* ha^{-1} at 20-25 DAS, atrazine 500 g *a.i.* ha^{-1} (PE) *fb*tembotrione 120.75 g *a.i.* ha^{-1} at 20-25 DAS, atrazine 500 g *a.i.* ha^{-1} (PE) *fb*topramezone 25.2 g *a.i.* ha^{-1} at 20-25 DAS, atrazine 500 g *a.i.* ha^{-1} + tembotrione 120.75 g *a.i.* ha^{-1} at 20–25 DAS and atrazine 500 g *a.i.* ha^{-1}+topramezone 25.2 g *a.i.* ha^{-1} at 20–25 DAS, respectively.

3.3. Phosphorus uptake

3.3.1. Phosphorus uptake in grains

Perceptible increase in phosphorus uptake by grains was brought about by various weed management practices over weedy check. Phosphorus uptakein grains as influenced by different weed management practices are presented in Table 2. The maximum phosphorus uptake (22.98 kg ha^{-1}) was recorded under treatment two hand weeding at 20 and 40 DAS followed by atrazine 500 g *a.i.* ha^{-1} (PE) *fb*topramezone 25.2 g *a.i.* ha^{-1} (PE) at 20-25 DAS (22.35 kg ha^{-1}) and atrazine 500 g *a.i.* ha^{-1} *fb*tembotrione 120.75 g *a.i.* ha^{-1} at 20-25 DAS (21.54 kg ha^{-1}) and minimum phosphorus uptake (8.47 kg ha^{-1}) was obtained under treatment weedy check. Treatment two hand weeding at 20 and 40 DAS being at par with atrazine 500 g *a.i.* ha^{-1} (PE)+hand weeding at 30 DAS with *in situ* mulching with weeds, atrazine 500 g *a.i.* ha^{-1} (PE) *fb* tembotrione 120.75 g *a.i.* ha^{-1} at 20-25 DAS, and atrazine 500 g *a.i.* ha^{-1} (PE) *fb*topramezone 25.2 g *a.i.* ha^{-1} at 20-25 DAS recorded significantly highest P uptake in grain over rest of the treatments under investigation.

3.3.2. Phosphorus uptake in stover

Phosphorus uptakein stover as influenced by different weed management practices are presented in Table 2. All weed management practices under experimentation increased phosphorus uptake by maize stover compared to weedy check. The maximum phosphorus uptake (16.83 kg ha^{-1}) was recorded under treatment receiving two hand weeding at 20 and 40 DAS followed by atrazine 500 g *a.i.* ha^{-1} (PE) *fb*topramezone 25.2 g *a.i.* ha^{-1} at 20-25 DAS (16.60 kg ha^{-1}) and atrazine 500 g *a.i.* ha^{-1} (PE) *fb*tembotrione 120.75 g *a.i.* ha^{-1} at 20-25 DAS (15.91 kg ha^{-1}). Treatment two hand weeding at 20 and 40 DAS being at par with atrazine 500 g *a.i.* ha^{-1} (PE)+hand weeding at 30 DAS with *in situ* mulching with weeds, atrazine 500 g

Table 2: Effect of weed management practices on nutrient uptake by maize crop

Treatments	Nutrient uptake (kg ha^{-1})								
	Grain			Stover			Total		
	N	P	K	N	P	K	N	P	K
Weedy check	21.47	8.47	8.02	28.00	3.99	46.86	49.47	12.46	54.88
One hand weeding at 30 DAS with in situ mulching with weeds	36.41	14.84	13.58	48.23	10.69	77.44	84.64	25.53	91.02
Two hand weeding at 20 and 40 DAS	55.24	22.98	20.84	72.54	16.83	115.72	127.78	39.81	136.56
Atrazine 500 g *a.i.* ha^{-1} (PE)	35.04	14.26	13.07	46.40	10.30	74.65	81.44	24.56	87.72
Atrazine 500 g *a.i.* ha^{-1} (PE)+hand weeding at 30 DAS	46.48	19.12	17.64	61.87	14.18	99.36	108.35	33.30	117.00
Atrazine 500 g *a.i.* ha^{-1} (PE)+hand weeding at 30 DAS with *in situ* mulching with weeds	50.87	20.99	19.26	67.03	15.49	107.75	117.90	36.48	127.01
Tembotrione 120.75 g *a.i.* ha^{-1} at 20–25 DAS	37.82	15.41	14.17	51.37	11.31	82.53	89.18	26.72	96.70
Topramezone 25.2 g a.i. ha^{-1} at 20–25 DAS	40.00	16.38	15.06	54.27	12.03	82.25	94.26	28.41	97.32
Atrazine 500 g *a.i.* ha^{-1} (PE) *fb*tembotrione 120.75 g *a.i.* ha^{-1} at 20-25 DAS	52.27	21.54	19.76	68.98	15.91	110.29	121.25	37.45	130.05
Atrazine 500 g *a.i.* ha^{-1} (PE) *fb*topramezone 25.2 g *a.i.* ha^{-1} at 20-25 DAS	54.40	22.35	20.48	71.64	16.60	114.31	126.04	38.95	134.79
Atrazine 500 g *a.i.* ha^{-1}+tembotrione 120.75 g *a.i.* ha^{-1} at 20-25 DAS	43.71	17.87	16.44	57.85	12.99	92.76	101.56	30.85	109.21
Atrazine 500 g *a.i.* ha^{-1}+ topramezone 25.2 g *a.i.* ha^{-1} at 20–25 DAS	45.33	18.61	17.17	60.01	13.65	96.37	105.34	32.26	113.54
SEm±	2.50	1.05	1.00	3.41	0.84	5.22	5.81	1.83	6.19
CD (*p*=0.05)	7.33	3.07	2.95	10.00	2.45	15.31	17.04	5.38	18.16
CV (%)	10.01	10.21	10.68	10.30	11.29	9.86	10.00	10.39	9.93

a.i. ha^{-1} (PE) *fb*tembotrione 120.75 g *a.i.* ha^{-1} at 20–25 DAS, and atrazine 500 g *a.i.* ha^{-1} (PE) *fb*topramezone 25.2 g *a.i.* ha^{-1} at 20–25 DAS recorded significantly highest P uptake in stover over rest of the treatments under experimentation. Minimum phosphorus uptake (3.99 kg ha^{-1}) was observed under treatment weedy check.

3.3.3. Total phosphorus uptake

In contrast to weedy check, all the weed management practices increase phosphorus uptake by maize crop. Total phosphorus uptake as influenced by different weed management practices are presented in Table 2. The maximum total phosphorus uptake (39.81 kg ha^{-1}) was observed under treatment two hand weeding at 20 and 40 DAS followed by atrazine 500 g *a.i.* ha^{-1} (PE) *fb*topramezone 25.2 g *a.i.* ha^{-1} at 20-25 DAS (38.95 kg ha^{-1}) and atrazine 500 g *a.i.* ha^{-1} (PE) *fb* tembotrione 120.75 g *a.i.* ha^{-1} at 20-25 DAS (37.45 kg ha^{-1}). The minimum total phosphorus uptake (12.46 kg ha^{-1}) by crop was recorded under treatment weedy check. Two hand weeding at 20 and 40 DAS treatment recorded 219.5, 55.93, 62.09, 19.55, 9.13, 48.99, 40.13, 6.30, 2.21, 29.04, and 23.40% more total P uptake over weedy check, one hand weeding at 30 DAS with *in situ* mulching with weeds, atrazine 500 g *a.i.* ha^{-1} (PE), atrazine 500 g *a.i.* ha^{-1} (PE)+hand weeding at 30 DAS, atrazine 500 g *a.i.* ha^{-1} (PE)+hand weeding at 30 DAS with *in situ* mulching with weeds, tembotrione 120.75 g *a.i.* ha^{-1} at 20-25 DAS, topramezone 25.2 g *a.i.* ha^{-1} at 20-25 DAS, atrazine 500 g *a.i.* ha^{-1} (PE) *fb*tembotrione 120.75 g *a.i.* ha^{-1} at 20-25 DAS, atrazine 500 g *a.i.* ha^{-1} (PE) *fb*topramezone 25.2 g *a.i.* ha^{-1} at 20-25 DAS, atrazine 500 g *a.i.* ha^{-1}+tembotrione 120.75 g *a.i.* ha^{-1} at 20-25 DAS and atrazine 500 g *a.i.* ha^{-1}+topramezone 25.2 g *a.i.* ha^{-1} at 20-25 DAS, respectively.

3.4. Potassium uptake

3.4.1. Potassium uptake in grains

Potassium uptakein grains as influenced by different weed management practices are presented in Table 2. All the weed management practices that are tended to increase potassium uptake by grains but with varying margins. The highest potassium uptake (20.84 kg ha^{-1}) was observed under treatment receiving two hand weeding at 20 and 40 DAS followed by atrazine 500 g *a.i.* ha^{-1} (PE) *fb*topramezone 25.2 g *a.i.* ha^{-1} at 20-25 DAS (20.48 kg ha^{-1}) and atrazine 500 g *a.i.* ha^{-1} (PE) *fb*tembotrione 120.75 g *a.i.* ha^{-1} at 20-25 DAS (19.76 kg ha^{-1}) and lowest potassium uptake (8.02 kg ha^{-1}) in grain was recorded under treatment weedy check. Treatment two hand weeding at 20 & 40 DAS being at par with atrazine 500 g *a.i.* ha^{-1} (PE)+hand weeding at 30 DAS with *in situ* mulching with weeds, atrazine 500 g *a.i.* ha^{-1} (PE) *fb*tembotrione 120.75 g *a.i.* ha^{-1} at 20-25 DAS, and atrazine 500 g *a.i.* ha^{-1} (PE) *fb*topramezone 25.2 g *a.i.* ha^{-1} at 20-25 DAS recorded significantly highest K uptake in grain over rest of the treatments under investigation.

3.4.2. Potassium uptake in stover

Potassium uptakein stover as influenced by different weed management practices are presented in Table 2. The highest potassium uptake (115.72 kg ha^{-1}) was observed under treatment receiving two hand weeding at 20 and 40 DAS followed by atrazine 500 g *a.i.* ha^{-1} (PE) *fb*topramezone 25.2 g *a.i.* ha^{-1} at 20-25 DAS (114.31 kg ha^{-1}) and atrazine 500 g *a.i.* ha^{-1} (PE) *fb*tembotrione 120.75 g *a.i.* ha^{-1} at 20-25 DAS (110.29 kg ha^{-1}). Treatment two hand weeding at 20 & 40 DAS being at par with atrazine 500 g *a.i.* ha^{-1} (PE) + hand weeding at 30 DAS with *in situ* mulching with weeds, atrazine 500 g *a.i.* ha^{-1} (PE) *fb*tembotrione 120.75 g *a.i.*ha^{-1} at 20–25 DAS, and atrazine 500 g *a.i.* ha^{-1} (PE) *fb*topramezone 25.2 g *a.i.* ha^{-1} at 20–25 DAS recorded significantly highest K uptake in stover over rest of the treatments under experimentation. Whereas, minimum potassium uptake (46.86 kg ha^{-1}) was recorded under treatment weedy check.

3.4.3. Total potassium uptake

In contrast to weedy check, all the weed management practices increase potassium uptake by maize crop. Total potassium uptake as influenced by different weed management practices are presented in Table 2. The maximum total potassium uptake (136.56 kg ha^{-1}) was observed under treatment two hand weeding at 20 and 40 DAS followed by atrazine 500 g *a.i.* ha^{-1} (PE) *fb*topramezone 25.2 g *a.i.* ha^{-1} at 20-25 DAS (134.79 kg ha^{-1}) and atrazine 500 g *a.i.* ha^{-1} (PE) *fb*tembotrione 120.75 g *a.i.* ha^{-1} at 20–25 DAS (130.05 kg ha^{-1}). Treatment two hand weeding at 20 and 40 DAS being at par with atrazine 500 g *a.i.* ha^{-1} (PE)+hand weeding at 30 DAS with *in situ* mulching with weeds, atrazine 500 g *a.i.* ha^{-1} (PE) *fb*tembotrione 120.75 g *a.i.* ha^{-1} at 20-25 DAS, and atrazine 500 g *a.i.* ha^{-1} (PE) *fb* topramezone 25.2*a.i.* ha^{-1} at 20–25 DAS recorded significantly highest total K uptake by maize crop over rest of the treatments under investigation. Statistically lowest total potassium uptake (54.88 kg ha^{-1}) by maize crop was recorded under treatment weedy check. Two hand weeding at 20 and 40 DAS treatment recorded 148.83, 50.03, 55.68, 16.72, 7.52, 41.22, 40.32, 5.01, 1.31, 25.04, and 20.27% more total K uptake over weedy check, one hand weeding at 30 DAS with *in situ* mulching with weeds, atrazine 500 g *a.i.* ha^{-1} (PE), atrazine 500 g *a.i.* ha^{-1} (PE)+hand weeding at 30 DAS, atrazine 500 g *a.i.* ha^{-1} (PE)+hand weeding at 30 DAS with *in situ* mulching with weeds, tembotrione 120.75 g *a.i.* ha^{-1} at 20-25 DAS, topramezone 25.2 g *a.i.* ha^{-1} at 20-25 DAS, atrazine 500 g *a.i.* ha^{-1} (PE) *fb*tembotrione 120.75 g *a.i.* ha^{-1} at 20–25 DAS, atrazine 500 g *a.i.* ha^{-1} (PE) *fb*topramezone 25.2 g *a.i.* ha^{-1} at 20-25 DAS, atrazine 500 g *a.i.* ha^{-1}+tembotrione 120.75 g *a.i.* ha^{-1} at 20-25 DAS and atrazine 500 g *a.i.* ha^{-1}+topramezone 25.2 g *a.i.* ha^{-1} at 20–25 DAS, respectively.These finding are close conformity with the Samant et al*.,* 2015 and Gaurav et al., 2018, Nazreen et al*.,* 2018.

4. Conclusion

Application of atrazine 500 g *a.i.* ha^{-1} (PE) followed by topramezone 25.2 g *a.i.* ha^{-1} at 20–25 DAS show highest

economic returns (net returns and B: C ratio). The highest NPK uptake was recorded under treatments hand weeding twice at 20 and 40 DAS followed by pre emergence application of atrazine 500 g *a.i.* ha^{-1} *fb*topramezone 25.2 g *a.i.* ha^{-1} and atrazine 500 g *a.i.* ha^{-1} *fb*tembotrione 120.75 g *a.i.* ha^{-1} at 20-25 DAS due to minimum crop-weed competition for light, moisture, nutrients and space for growth and development had concurrently increased in nutrient availability, better crop growth and higher crop dry matter production coupled with more nutrient content.Treatment two hand weeding at 20 and 40 DAS being at par with atrazine 500 g *a.i.* ha^{-1} (PE) + hand weeding at 30 DAS with *in situ* mulching with weeds, atrazine 500 g *a.i.* ha^{-1} (PE) *fb*tembotrione 120.75 g *a.i.* ha^{-1} at 20-25 DAS, and atrazine 500 g *a.i.* ha^{-1} (PE) *fb* topramezone 25.2 g *a.i.* ha^{-1} at 20-25 DAS recorded significantly highest nutrient uptake in grain, stover and total over rest of the treatments under investigation. Minimum nitrogen uptake was obtained under treatment weedy check.

5. References

Anonymous, 2020. Available at http://www.fao.org/faostat/en/?#data/QC. Accessed on October 29, 2020.

Barla, S., Upasani, R.R., Puran, A.N., Thakur, R., 2016. Weed management in maize. Indian Journal of Weed Science 48(1), 67–69.

Barua, S., Lakra, A.K., Bhagat, P.K., Sinha, A.K., 2019. Weed dynemics and productivity of maize (*Zea mays* L.) under pre and post emergence application of herbicide. Journal of Plant Development Sciences 11(7), 409–413.

Choudhary, M., Verma, A., Singh, H., 2012. Productivity and economics of maize (*Zea mays* L.) as influenced by phosphorus management in Southern Rajasthan. Annals of Agricultural Research 33(1–2), 88–90.

Gharde, Y., Singh, P.K., Dubey, R.P., Gupta, P.K., 2018. Assessment of yield and economic losses in agriculture due to weeds in India. Crop Protection 107, 12–18.

Gaurav, Verma, S.K., Meena, R.S., Maurya, A.C., Kumar, S., 2018. Nutrients uptake and available nutrients status in soil as influenced by sowing methods and herbicides in *kharif*maize (*Zea mays* L.). International Journal of Agriculture, Environment and Biotechnology 11(1), 17–24.

Hatti, V., Sanjay, M.T., Prasad, T.V.R., Murthy, K.N.K., Kumar, B., Shruthi, M.K., 2014. Effect of new herbicide molecules on yield, soil microbial biomass and their phytotoxicity on maize (*Zea mays* L.) under irrigated conditions. An International Quarterly Journal of Life Science 9(3), 1127–1130.

Kumawat, N., Yadav, R.K., Bangar, K.S., Tiwari, S.C., Morya, J., Kumar, R., 2019. Studies on integrated weed management practices in maize-A review. Agricultural Reviews 40(1), 29–36.

Murdia, L.K., Wadhwani, R., Wadhawan, N., Bajpai, P., Shekhawat, S., 2016. Maize utilization in India: an overview. American Journal of Food and Nutrition 4(6), 169–176.

Nazreen, S., Subramanyam, D., Sunitha, N., Umamahesh, V., 2018. Growth and yield of maize as influenced by sequential application of herbicides. International Journal of Current Microbiology and Applied Science. 7(5), 2764–2770.

Pandey, A.K., Prakash, V., Singh, P., Prakash, K, Singh, R.D., Mani, V.P., 2001. Integrated weed management in maize. Indian Journal of Agronomy 46, 260–265.

Patel, V.J., Upadhyay, P.N., Patel, B., Patel, B.D., 2006. Evaluation of herbicide mixtures for weed control in maize (*Zea mays* L.) under middle Gujarat conditions. The Journal of Agricultural Science 2(1), 81–86.

Rasool, S., Khan, M.H., 2016.Growth and yield of maize (*Zea mays* L.) as influenced by integrated weed management under temperate conditions of North Western Himalayas. American Journal of Experimental Agriculture 14(1), 1–9.

Rao, C., Prasad, P.V.N., Venkateswarlu, B., 2016. Assesment of different herbicides on yield and economics of *kharif*maize (*Zea mays* L.). International Journal of Agricultural Science and Research 6(6), 409–414.

Raut, V.G., Khawale, V.S., Moharkar, R., Bhadoriya, R., Meshram, D., 2017. Effect of different herbicides on weeds and grain yield of maize. Journal of Soils and Crops 27(1), 248–252.

Samant, T.K., Dhir, B.C., Mohanty, B., 2015. Weed growth, yield components, productivity, economics and nutrient uptake of maize (*Zea Mays* L.) as influenced by various herbicide applications under rainfed condition. Scholars Journal of Agriculture and Veterinary Sciences 2(1B), 79.

Swetha, K., Madhavi, M., Pratibha, G., Ramprakash, T., 2015. Weed management with new generations herbicides in maize. Indian Journal of Weed Science 47(4), 432–433.

Sharma, S., Marahattha, S., Sah, S.K., Karki, T.B., 2018. Efficacy of different tillage and weed management practices on phenology and yield of winter maize (*Zea mays* L.) in Chitwan, Nepal. International Journal of Plant & Soil Science 26(2), 1–11.

Williams, M.M., Boydston, R.A., Peachey, R.E., Robinson, D., 2011. Significance of atrazine as a tank-mix partner with tembotrione. Weed Technology 25(3), 299–302.

Yadav, T.K., Choudhary, R.S., Jat, G., Singh, D., Sharma, N., 2017. Effect of weed management practices on yield attributes, yield and economics of maize (*Zea mays* L.). Chemical Science Review and Letters 6(23), 1452–1456.