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Study the Sole and Sequential Application of Herbicides on Zn and Fe content Uptake and Economics of *Kharif* Maize

Gharsiram[1*], Mukesh Kumar[2], Pradeep Kumar[3], Subhash Bijarniya[4] and Monika Shahani[4]
[1]Ph.D. Research Scholar, Junagarh Agricultural University, Junagarh, (Gujarat), India.
[2]Associate Professor, Department of Agronomy, Dr. RPCAU, Pusa, (Bihar), India.
[3]Ph.D. Research Scholar, Navsari Agricultural University, Navsari, (Gujarat), India.
[4]Ph.D. Research Scholar, MPUAT, Udaipur, (Rajasthan), India.

(Corresponding author: Gharsiram)*
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ABSTRACT: To study the effect of sole and sequential application of herbicide on economic benefits of maize crop by reducing the crop-weed competition during entire crop growth period. In kharif season maize, crop suffering from continuous rainfall problems that is why management of weed becomes big challenge front of us that time. These challenge effects to the uptake of nutrients and economics of crop. For this purpose, a field experiment was conducted during the *kharif* 2019 at Agricultural Research farm of TCA Dholi under the RPCAU Pusa, Samastipur (Bihar) in maize crop. The treatments were *viz;* T_1: Weedy check, T_2: Topramezone 25.2 g/ha, T_3: Tembotrione 120 g/ha, T_4: Atrazine 1 kg *fb* HW, T_5: Atrazine 0.75 kg/ha *fb* Topramezone 25.2 g/ha, T_6: Atrazine 0.75 kg *fb* Tembotrione 120 g/ha, T_7: Atrazine 1 kg *fb* Topramezone 25.2 g/ha, T_8: Atrazine 1 kg/ha *fb* Tembotrione 120 g/ha, T_9: Topramezone 25.2 g/ha + Atrazine 0.75 kg/ha, T_{10}: Tembotrione 120 g/ha + Atrazine 0.75 kg/ha, T_{11}: Weed free, allocated in randomized block design with thrice replication. The application of pre-emergence Atrazine 1 kg/ha *fb* Tembotrione 120 g/ha at 25 DAS (T_8) was given the excellent result comparison to other treatment. It reduced the weed population and biomass of weed up to harvesting stage, though; weed free was superior from the all treatments. Mixed application of Topramezone 25.2 g/ha and Tembotrione 120 g/ha with Atrazine 0.75 kg/ha applied at 15 DAS reduced the weed density and biomass of weed up to 25 DAS but thereafter this T_8 superior from the all chemically treated plots. Uptake of nutrient by crop was enhanced with the application of Atrazine 1 kg/ha *fb* Tembotrione 120 g/ha at 25 DAS. Maximum net return was recorded with the T_8 (₹92539 Rs/ha) but highest gross return with the weed free (`130512 Rs/ha). Higher benefit cost ratio was recorded with the T_8 (2.68) and the lowest in weedy check (0.95). From the data recorded in the present experiment it may be concluded that application of Atrazine 1.0 kg/ha *fb* Tembotrione 120 g/ha at 25 DAS effectively controlled the weeds thereby enhanced the productivity and cost-effective weed control practice for maize crop.

Keywords: B: C ratio Cost of cultivation, Net return, Tembotrione, Topramezone.

INTRODUCTION

Crop faces many constraints through the entire life cycle like biotic stress, abiotic stress. Some stresses are manually controlled or managed by farmers but, management of stress before the critical levels then we can get maximum economic benefits from field crop. In crop production constraints weed problem is a major constraint. It reduced yield up-to 10-90% according to crop growth stages and weed population density. In maize crop generally up-to 70% grain yield reduced by weeds. Hence, to overcome the weed problem uses sole and sequential application of herbicide to minimize the weed density and maximize the grain yield and economic benefits. Nevertheless, maize productivity is affected by the weeds due to high competition between the crop and weed in early growth stage of crop. The weed pressure on crop is the most conspicuous in rainy (*kharif*) season due to 2-3 flushed of weed during crop duration. Therefore, study of weed control through the herbicides needed to sustain the productivity of maize. In this experiment three type herbicides have been used viz; Atrazine, Topramezone and Tembotrione in which all are broad spectrum herbicides but Atrazine alone is less effective due to application as a pre-emergence and it could not affect to the weeds up to harvesting stages

or second and third flushes of weeds. The world, as on today would be changed in many ways by the year 2050. The world's human population will be achieved up to 9.0 billion, average global temperature will rise and thereby, the world would be running out of basic necessities like food, fodder and fuel (Shenggen Fan and Brzeska, 2010; Anon., 2013). Further, India can not escape from these problems as country is being populous and its population is increasing at an alarming rate. According to the estimation of National Academy of Agricultural Sciences (NAAS), if the present population growth rate is not curtailed, India may need 301 MT of food grains by 2050 to feed the population (Shankaran *et al.,* 2005). Moreover, the net cropped area of the country is almost stagnant for the past twenty years because cropped area is being used for urbanization, industrialization and infrastructure development. Hence, in the future little or almost no further chance to brought area under the cultivation area. The only solution to fulfill the burgeoning demand of food for population is to increase the productivity per unit area and time. The effective agro-techniques have potential to enhance the productivity. Among the different agro-techniques, effective weed management is the most important for higher agricultural production. Dr. Norman E. Borlaug, a renowned Nobel Laureate stated that "The last four decades saw the green revolution in rice and wheat, the next few decades will be known for maize era". Maize is an important cereal crop occupying a notable position in a global agriculture to subsistence and commercial farming. In India maize covers an area of 9.43 M ha producing 27.82 mt (Ministry of Agriculture, Government of India, 2018-19) and rank third after rice and wheat in terms of production besides it contribute nearly 9% to the national food basket. Bihar is an important maize growing state of country after Karnataka and Andhra Pradesh, cultivated in 0.67M ha of area and production of 3.2 mt with productivity of 4.7 t/ha. Maize in this state is cultivated in all three seasons *i.e.,* during *kharif* in 0.22 M ha, *rabi* in 0.28 M ha and summer/spring in 0.16 M ha area with production of 0.46, 2.1 and 0.63 mt, and productivity of 2.1, 7.5 and 3.9 t/ha, respectively. The lower productivity of *kharif* maize in this state may be due to its cultivation under rainfed condition where drought, heavy rain, water logging conditions occurred frequently. Besides, *kharif* maize is facing tremendous weed infestation which competing severely for growth resources. The yield loss may extend from 33 to 50%, if weeds are not controlled properly (Sharma *et al.,* 2000). Maize has critical time for weed control between 3-6 weeks of crop duration *i.e.,* time before the maximum canopy covered to smother the weeds (Shad *et al.,* 1993). The wider row spacing and slow crop growth rate, initially makes maize highly sensitive to weed competition up to six weeks growth period (Nagalakshmi *et al.,* 2006).

Thus, to get the maximum yield of maize thorough weed management is needed during initial six weeks of crop growth *i.e.,* critical time/period for crop weed competition. Conventional, mechanical and manual hand weeding methods are still popular to control weed in field but in rainy (*kharif*) season where heavy continuous rains coupled with scarcity of labour render the difficult to adopt these weed control methods. Thus, weed control by herbicide assumes significance in the cultivation of maize in *kharif*. Herbicides control the weeds timely and cogently besides it in curring the low cost of weed control notwithstanding the situation. As the *kharif* season maize has observed more than two flushes of weeds, repeated application of herbicides needed for effective control of weeds. It has been reported that application one herbicide or traditional application of herbicides is not sufficient the control weeds in maize (Kumar and Chawla, 2019). Use of pre- and post-emergence herbicides or herbicide mixture will make herbicidal weed control more effective and acceptable to farmers. Chemical weed management in maize by using herbicides is gaining importance now a day due to its effectiveness and economic point of view (Singh *et al.,* 2020). The requirement of sole and sequential application of herbicide is important and would be effective for weed control in maize crop. Pre-emergence application of herbicides will control the weeds up-to 25 days and thereafter post-emergence herbicide application so that further growth of weeds can also be controlled. Therefore, an experiment was carried out to sole and sequential application and mixture of two herbicides in maize during *kharif* season.

MATERIAL METHODS

A field trial was conducted during the *kharif* season 2019 at Agricultural Research Farm of, Trihut college of Agriculture (TCA) Dholi under the RPCAU Pusa, Samastipur (Bihar). This site comes under middle Indo Gangatic Plains, lied at 250.99°N latitude, 850.60°E longitude and altitude of 52.18 MSL. The soil was sandy loam soil having sand silt and clay content 65, 20 and 15%, respectively. The soil was alkaline as it has pH 7.9, low in organic carbon (0.46%), and medium in available N (238 kg ha^{-1}), P (17.4 kg ha^{-1}), available K (126.2 kg ha^{-1}), available zinc (0.31 mg kg^{-1}) and iron available iron (13.12 mg kg^{-1}).

During this experimental season, the total annual rainfall was 935.6 mm, which was distributed well during crop growth period and made environment congenial for proper growth of crop. The prevailing market prices of input and output was the basis for calculation of economic of maize. Cost for production (CP), gross returns (GR), net returns (NR) and benefit-cost ratio (BCR) of each treatment were calculated. From these data the benefit cost ratio, gross returns, net returns were calculated as follows

Gross returns (₹/ha)

Gross return = Economic yield (grain and straw) × market price of produce

Net returns (₹/ha)

Net return = Gross return – Cost of cultivation

Benefit-cost ratio (BCR)

$$\text{Benefit-cost ratio (BCR)} = \frac{\text{Net returns (₹/ha)}}{\text{Cost of cultivation (₹/ha)}}$$

Table 1.

Parameters	Initial value	Methods	Remarks
Sand (%)	65	International Pipette Method (Piper, 1966)	Sandy loam
Silt (%)	20		
Clay (%)	15		
Bulk density (g/cm^3)	1.45	Core sampler method (Black, 1965)	
Electric conductivity (dSm^{-1})	1.15	EC bridge, (Jackson 1973)	
pH	7.48	1:2.5 Soil: water suspension (Jackson 1973)	Alkaline
Organic carbon (%)	0.46	Walkley and Black (1934)	Low
Nitrogen (kg/ha)	238.4	Alkaline $KMnO_4$ method (Subbiah and Asija, 1956)	Low
Phosphorus (kg/ha)	17.4	0.5 M $NaHCO_3$ extractable P (Olsen *et al*., 1954)	Medium
Potassium (kg/ha)	126.2	1N NH_4Oac (Jackson 1973)	Low
Zinc (mg kg^{-1})	0.31	Lindsay, W.L. and Norvell, W.A., 1978. DTPA	
Iron (mg kg^{-1})	13.12	Lindsay, W.L. and Norvell, W.A., 1978. DTPA	

RESULTS AND DISCUSSSION

A. Zn uptake through grain & straw

The highest Zn uptake (216 g/ha) and lowest in weedy check (92 g/ha) in weedy check. Atrazine 1.0 kg/ha *fb* Tembotrione 0.120 kg/ha significantly enhanced in Zn uptake via grain as compared to all weed control treatments except weed free. Remaining all other weed control treatments significantly enhanced in Zn uptake via maize grain compared to unweeded. Tank mixeding of Topramezone 25.2 g/ha and Tembotrione 0.120 kg/ha with Atrazine applied at 15 DAS significantly improved in Zn uptake through grain as compared from sole used of Topramezone 25.2 g/ha and Tembotrione 0.120 kg/ha. Maximum Zn uptake (640 g/ha) through the weed free and the lowest (283.3 g/ha) in weedy check. All weed control treatment significantly enhanced in Zn uptake via straw as compared from unweeded. Atrazine 1.0 kg/ha *fb* Tembotrione 0.120 kg/ha was significantly enhanced in Zn uptake through straw as compared from all weed control treatments except weed free. Sole application of Tembotrione 0.120 kg/ha at 25 DAS was at par of the combined applied of Tembotrione 0.120 kg/ha + Atrazine 0.75 kg/ha but sole application of Topramezone 25.2 g/ha at 25 DAS recorded significantly lower Zn uptake by straw than mix application of Topramezone 25.2 g/ha + Atrazine 0.75 kg/ha after 15 days sowing maximum uptake of Fe via grain (506.9 g/ha) with weed free and lowest uptake by grain (215 g/ha) in weedy check. All treatments significantly increased in Fe uptake by grain as compared than unweeded plot. Atrazine 1.0 kg/ha *fb* Tembotrione 0.120 kg/ha significantly increased the Fe uptake by grain compared from all treatments excluding weed free. Tank mixeding of Topramezone 25.2 g/ha and Tembotrione 0.120 kg/ha with Atrazine applied at 15 DAS significantly enhanced in Fe uptake via grain as compared from sole used of Topramezone 25.2 g/ha and Tembotrione 0.120 kg/ha. The highest Fe uptake by straw (984 g/ha) in weed free and the lesser (435 g/ha) in unweeded plot. All weed control practices significantly enhanced in Fe uptake via straw as compared than unweeded plot. Atrazine 1.0 kg/ha *fb* Tembotrione 0.120 kg/ha was significantly improved in Fe uptake by straw as compared than all other weed control treatments except weed free. Sole application of Tembotrione 0.120 kg/ha after 25 days sowing was almost equal to the combined applied of Tembotrione 0.120 kg/ha + Atrazine 0.75 kg/ha but Topramezone 25.2 g/ha after 25 days sowing applied alone recorded significantly lower Fe uptake by straw than mix application of Topramezone 25.2 g/ha + Atrazine 0.75 kg/ha after 15 days sowing (Table 2).

Table 2: Herbicides effect on Zn and Fe uptake by maize crop.

Treatments	Zn uptake (g/ha)		Fe uptake (g/ha)	
	By grain	By straw	By grain	By straw
T_1: Weedy check	92.0	283.3	215.0	435.7
T_2: Topramezone 25.2 g/ha at 25 DAS	133.7	400.2	312.4	615.5
T_3: Tembotrione 0.120 kg/ha at 25 DAS	166.9	506.9	390.0	779.7
T_4: Atrazine 1.0 kg/ha (PE) *fb* Hand weeding at 25 DAS	195.2	580.2	456.1	892.4
T_5: Atrazine 0.75 kg/ha (PE) *fb* Topramezone 25.2 g/ha at 25 DAS	153.4	442.6	358.4	680.8
T_6: Atrazine 0.75 kg/ha (PE) *fb* Tembotrione 0.120 kg/ha at 25 DAS	193.7	580.1	452.7	892.2
T_7 : Atrazine 1.0 kg/ha (PE) *fb* Topramezone 25.2 g/ha at 25 DAS	188.9	553.5	441.5	851.3
T_8: Atrazine 1.0 kg/ha (PE) *fb* Tembotrione 0.120 kg/ha at 25 DAS	210.9	625.8	492.8	962.6
T_9: Topramezone 25.2 g/ha + Atrazine 0.75 kg/ha at 15 DAS	149.0	452.4	348.2	696.1
T_{10}: Tembotrione 0.120 kg/ha + Atrazine 0.75 kg/ha at 15 DAS	172.3	515.9	402.6	793.4
T_{11}: Weed free check	216.9	640.0	506.9	984.4
SEm(±)	1.64	4.01	3.85	6.16
LSD (P< 0.05)	4.94	12.01	11.56	18.51

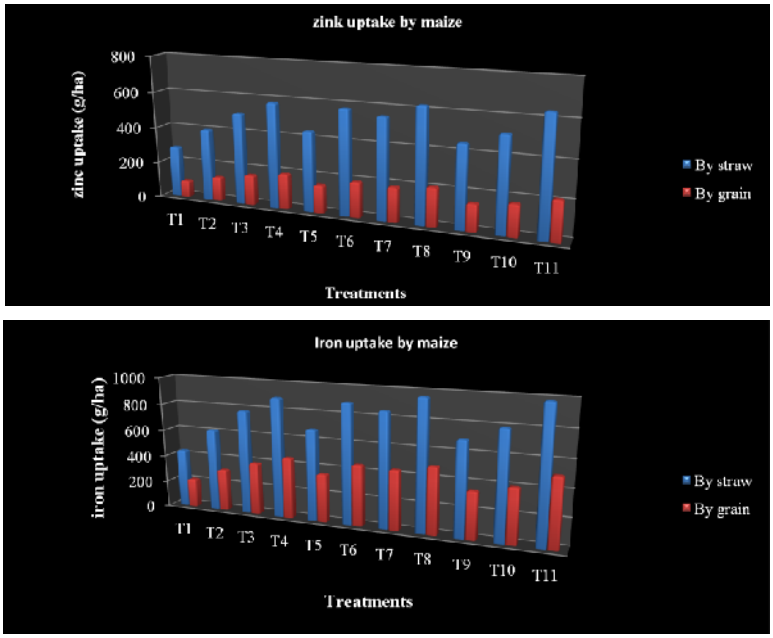

Fig. 1. Herbicides effect on Zn and Fe uptake by maize crop.

B. Herbicides effect on economics of maize

The variation in cost of cultivation, gross and net return and benefit-cost ratio (BCR) has been observed by various herbicides treatments. The highest gross returns (₹ 130512/ha) was obtained with the weed free treatments and the lowest (₹ 55683/ha). The Atrazine 1.0 kg/ha *fb* Tembotrione 0.120 kg/ha after 25 days sowing was the second best treatment with respect to gross returns (₹ 126984/ha). However, the maximum net return was obtained in this treatment. Highest BCR was recorded with the Atrazine 1.0 kg/ha *fb* Tembotrione 0.120 kg/ha at 25 DAS (2.68) followed by Atrazine 0.75kg/ha (PE) *fb* Tembotrione 0.120 kg/ha (2.42) and Atrazine 1.0 kg/ha *fb* Topramezone 25.2 g/ha (2.35).The BCR in sole application of Tembotrione 0.120 kg/ha was (2.05) almost equal to combined applied of Tembotrione 0.120 kg/ha + Atrazine 0.75 kg/ha (2.07) but sole application of Topramezone 25.2 g/ha recorded lower BCR (1.46) than mix application of Topramezone 25.2 g/ha + Atrazine 0.75 kg/ha after 15 days sowing (1.71) (Table 3).

Table 3: Herbicides effect on cost of cultivation, gross and net return and benefit- cost ratio.

Treatments	Total cost (₹/ha)	Gross income (₹/ha)	Net income (₹/ha)	Benefit- cost ratio
T_1: Weedy check	28466	55683	27217	0.95
T_2 : Topramezone 25.2 g/ha at 25 DAS	32684	80594	47910	1.46
T_3: Tembotrione 0.120 kg/ha at 25 DAS	33299	100814	67515	2.02
T_4: Atrazine 1.0 kg/ha (PE) *fb* HW at 25 DAS	33192	117559	84367	2.54
T_5: Atrazine 0.75 kg/ha (PE) *fb* Topramezone 25.2 g/ha at 25 DAS	33514	92020	58506	1.74
T_6: Atrazine 0.75 kg/ha (PE) *fb* Tembotrione 0.120 kg/ha at 25 DAS	34129	116810	82681	2.42
T_7: Atrazine 1.0 kg/ha (PE) *fb* Topramezone 25.2 g/ha at 25 DAS	33830	113574	79744	2.35
T_8: Atrazine 1.0 kg/ha (PE) *fb* Tembotrione 0.120 kg/ha at 25 DAS	34445	126984	92539	2.68
T_9: Topramezone 25.2 g/ha + Atrazine 0.75kg/ha at 15 DAS	33156	90012	56856	1.71
T_{10}: Tembotrione 0.120 kg/ha + Atrazine 0.75 kg/ha at 15 DAS	33771	103882	70111	2.07
T_{11}: Weed free check	42786	130512	87726	2.05
SEm(±)	0.061	873.81	873.8	0.02
LSD (P< 0.05)	21.03	2664.75	2624.7	0.08

DISCUSSION

Management of weed in the crop field significantly affects the nutrients uptake by *kharif* maize. Higher Fe and Zn uptake recorded with the Atrazine 1.0 kg/ha *fb* Tembotrione 0.12 kg/ha at 25 DAS. Nutrients uptake increased with all these treatments was clearly due to cogently weed control from initial stage to at later stages of crop growth which reflect in the crop growth as well as biological yield of crop. The total uptake of nutrients Zn and Fe lowered by weeds because competition posed by weeds with crop for removal of nutrients, these were lower where weeds controlled by treatments and vice versa. Production of maize is increase with the better weed management in the field and due to this, crop uptake more nutrients compare to the unweeded plots. These findings agreed with the result of Nazreen *et al.* (2017); Yakadri *et al.* (2015). Unweeded plots removed maximum nutrients uptake due to highest weed density and its dry weight at the harvesting stage. These led to prove the reduction in nutrient content in maize and ultimately effect on yield. Atrazine 1.0 kg/ha *fb* Tembotrione 0.120 kg/ha after 25 days sowing was obtained lesser nutrient uptake by weed plants due to weeds killed by this treatment. The application of Atrazine 1.0 kg/ha *fb* one HW at 25 DAS also recorded comparative higher nutrient removal by weeds compared to Atrazine 1.0 kg/ha *fb* Tembotrione 0.120 kg/ha after 25 days sowing. Because by hand weeding killed weeds those emerged up to 25 days but those weeds emerged after 25 DAS were not controlled by hand weeding but that was controlled by the post emergence herbicides up to harvest stage. Similar finding was given by Nazreen *et al*. (2017); Yakadri *et al.* (2015); Deewan *et al.* (2018). The highest gross return was recorded with the weed free but net return was found with the applied of Atrazine 1 kg/ha *fb* Tembotrione 0.120 kg/ha compared to the other all treatments. It's only due to cost of cultivation involved in this treatment less (₹ 34445/ha) than normal manually weed practices (Rs 42786/ha.). In our study application of Atrazine 1.0 kg/ha *fb* Tembotrione 0.120 kg/ha was recorded 71.53% highest net returns from the weedy check and 8.22% from the weed free check. Therefore, it is never advisable to keep the crop weed free up to harvest due to its cost effectiveness or it is not economical. These results also related to Sanodiya *et al*. (2013); Nazreen *et al.* (2018); Kumar *et al.* (2017).

SUMMARY AND CONCLUSION

The highest nutrients uptake by the crop with the weed free and Atrazine 1.0 kg/ha *fb* Tembotrione 0.120 kg/ha at 25 days after sowing compare to the weedy check. The highest amount of nutrients removed by the weeds in weedy check and least removal in Atrazine 1.0 kg/ha *fb* Tembotrione 0.120 kg/ha at 25 DAS. The highest gross return (₹ 130499/ha) recorded with weed free but the highest net returns with Atrazine 1.0 kg/ha *fb* Tembotrione 0.120 kg/ha (₹ 92559/ha) followed by weed free (₹ 87713/ha) and the lowest returns in unweeded plot (₹ 27206/ha) in *kharif* maize. Atrazine 1.0 kg/ha *fb* Tembotrione 0.120 kg/ha at 25 days after sowing recorded significantly the highest benefit-cost ratio (2.68) followed by weed free check 2.05) and the lowest with weedy check (0.95).

CONCLUSION

Based on present investigation, it can be concluded that Atrazine 1.0 kg/ha *fb* Tembotrione 0.120 kg/ha effectively controlled the weeds thereby, exhibited higher grain yield of maize, net return and BCR of maize crop.

FUTURE SCOPE

Mainly kharif season maize crop suffering from the continuous rainfall. That time management of weed becomes very difficult because of rainfall. So, application of herbicides reduces the effect of weeds on the crop and it's also increases in the uptake of nutrients and economic value of grain. Herbicide reduces the cost of cultivation that is why farmer can get more profit from the production of crop and increases production level of the crop.

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