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YIELD ATTRIBUTES, YIELD AND ECONOMICS OF MAIZE AS INFLUENCED BY PRE AND POST EMERGENCE HERBICIDES IN CHOTANAGPUR PLATEAU REGION OF JHARKHAND, INDIA

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ABSTRACT

A field investigation was carried out at Birsa Agricultural University, Kanke, Ranchi, Jharkhand during *Kharif* seasons of 2019 to study "Yield attributes, Yield and economics of maize as influenced by pre and post emergence herbicides in Chotanagpur Plateau Region of Jharkhand". Results revealed that, weed free treatment gave highest yield attributes (cob length 19.00 cm, cob girth 13.67 cm, number of grains/row 36.80, number of grains row/cob 14.53, number of grains/cob 535.07 and 1000 grains weight 298.19 g), yields (grain yield 68.34 q/ha, cob yield 84.61 q/ha, stover yield 110.85 q/ha, stone yield 16.26 q/ha, harvest yield 38.125 and shelling percentage 80.86%) and gross return Rs. 119216 /- of maize cultivation. Among the herbicidal treatments, Atrazine @1000 ga.i./ha applied as pre-emergence *fb* Topramezone @ 25.2ga.i./ha at 25DAS proved as effective as weed free treatment. Atrazine @1000 ga.i./ha applied as pre-emergence *fb* Topramezone @ 25.2ga.i./ha at 25 DAS recorded highest yield attributes (cob length 18.87 cm, cob girth 13.27 cm, number of grains/row 36.67, number of grains row/cob 14.27, number of grains/cob 523.67 and 1000 grains weight 294.82 g), yields (grain yield 66.65 q/ha, cob yield 82.53 q/ha, stover yield 109.05 q/ha, stone yield 15.87 q/ha, harvest yield 38.01% and shelling percentage 80.81%) and economics (net return Rs. 76736/- and B:C ratio 1.94) of maize.

Key words : Maize, Yield attributes, Yield, Economics, Weed free, Atrazine, Topramezone.

Introduction

Maize or corn (*Zea mays* L.) is a significant annual cereal crop grown worldwide belonging to family Poaceae. Because of its greater adaptability, it can be grown in a wide range of global environmental conditions (Chennankrishnan and Raja, 2012). Because of its many applications, such as human food, animal feed, and biofuel (the creation of ethanol), it is one of the most iconic and ancient grains in the world (Green *et al*., 2018). It is one of the important food sources (Smith *et al*., 2004) and contributes significantly to oil production at a rate of 5–8% (Veljkovic *et al*., 2018 and Barrera-Arellano *et al*., 2019). It has a higher genetic output potential than any other cereal, it is commonly referred to as the "queen of cereals." According to Schnable *et al*. (2009), it is thought to have originated in Mexico and Central America. Approximately it contains 70–72% carbohydrate, 4–4.5% fat and 9.4–11% protein as well as its grain is incredibly nourishing (Larger and Hill, 1991). Over the years, global output of this product has been steadily rising, with a peak of 1,162,352,997 tonnes in 2020 (FAO, 2021). With a production of 1033.74 million metric tonnes from 197 million ha, it is currently the most produced staple grain in the world, behind rice and wheat (Statista, 2018; FAOSTA, 2017). In India the production level of maize is 27.23 million tonnes whereas in Jharkhand the same is 4.55 lakh tones (2018-19). In India, kharif maize is grown in an area of 8.04 million hectares with production of 27.23 million tonnes. In Jharkhand, it occupies 0.26 million hectares of area with 0.45 million tonnes of production and productivity of 1.74 tonnes per hectare (The 3rd advance estimates of production of major crops for 2018-19).

Due to the rapid increase in the world's population, it is necessary to ensure the plant production to meet the nutritional needs (Foley *et al*., 2011). The relevant demand can be ensured with the crop productivity through buffering/alleviating the stress factors available (Demirbas and Ela, 2005). In addition to the abiotic stress factors, biotic factors also critically suppress the growth and performance, which are then translated into the reduced yield of crop productivity. Amid the biotic factors, weeds are one of the critical factors causing yield losses because of competition in the fields for light, nutrients, and water (Swinton *et al*., 2017). A plethora of annual and perennial weed species has been documented to have negative effects on maize yield (Mennan and Isik, 2003).

Therefore, management of weed is considered to be an important factor for achieving higher productivity. Rout *et al*. (1996) revealed that weeds cause enormous damage up to 30 to 50% in maize crop. Uncontrolled weed growth may reduce maize yield as much as 90% (Ratta *et al*., 1991). Weeds also pose severe problems for crop husbandry and infest fallow land, reduce soil fertility and moisture conditions and develop a potential threat to the succeeding crops (Khan *et al*., 2003). Chemical weed management by using pre- and post-emergence herbicides can lead to the efficient and cost-effective control of weeds during critical period of crop weed competition, which may not be possible in manual or mechanical weeding due to its high cost of cultivation (Triveni *et al*., 2017). The present investigation was therefore, done with an objective to study the yield attributes, yield and economics of maize as influenced by pre and post emergence herbicides in Chotanagpur Plateau Region of Jharkhand.

Materials and Methods

The experiment entitled, "Yield attributes, Yield and economics of maize as influenced by pre and post emergence herbicides in Chotanagpur Plateau Region of Jharkhand" was conducted in Agronomical Research Farm of the Birsa Agricultural University, Kanke, Ranchi (23° 17' N latitude, 85°10' E longitude and 625.22 m above mean sea level), Jharkhand during *kharif* season of 2019. The experiment was laid out in a randomized block design with three replications. Treatments comprised of T_1 : Weedy check, T_2 : weed free, T_3: Atrazine @1000ga.i./ha *fb* Hand weeding @ 25 DAS, T_4: Atrazine @750ga.i./ha *fb* Topramezone @ 25.2ga.i./ha at 25 DAS, T_5: Atrazine @750ga.i./ha *fb* Tembotrione @120ga.i./ha at25 DAS, T_6: Atrazine @ 1000ga.i./ha *fb* Topramezone @ 25.2ga.i./ha at 25 DAS, T_7: Atrazine @1000ga.i./ha *fb* Tembotrione @120ga.i./ha at 25 DAS, T_8: Atrazine @ 750ga.i./ha+ Topramezone @25.2ga.i/ha at 15 DAS, T_9: Atrazine @750ga.i./ha+Tembotrione@120ga.i./ha at 15 DAS and T_{10}: Atrazine@1000ga.i/ha and T_{10}: Atrazine @1000ga.i/ha. Maize variety taken for cultivation was BAU MH-5. The experimental maize hybrid was shown on 15th July, 2019 by line sowing using 20kg seeds/ha. Seeds were sown by putting them in furrows opened at a spacing of 70 cm, seed to seed distance was maintained at 20 cm. Seeds were then covered with soil manually. Recommended dose of fertilizer *i.e.* 150:60:40kg NPK/ha was applied to maize crop. A basal dose of full P_2O_5 in the form of diammonium phosphate (DAP), K_2O through muriate of potash (MOP) and 1/3rd of the nitrogen through urea was applied as basal application. The remaining 2/3rd of nitrogen was top dressed in two equal splits at knee-high stage and tasseling stage. Maize crop was sown in east-west direction. The texture of soil (0-15 cm of depth) was sandy-clay-loam. Mechanical analysis was done by Bouyoucos Hydrometer method, bulk density by core sampler method, pH by Glass electrode pH meter, organic carbon by Walkley and Black method, available nitrogen by Alkaline permanganate method, available phosphorus by Bray's P1 method and available potassium by Ammonium Acetate method. The soils were acidic, medium in organic carbon, medium in available nitrogen, available phosphorous and available potassium. The crops received a total rainfall of 1011.5 mm from July 2019 to October 2019 for maize crop. Therefore, the amount of rain fall was suitable for productive growth of maize. The maximum temperature varied between 35.2°C and 26.3°C, while minimum temperature ranged between 24.9°C and 14.3°C during the crop period. The sun shine hours during crop period ranged from 131-236.4 hours/day. The maximum (7am) and minimum (2pm) relative humidity during the crop period for maize (July to October) was 85.9/69.7, 85.1/68.7, 87.0/68.7 and 86.5/68.6%, respectively. Mean monthly wind speed during the crop period for June, July, August, September and October was 3.3, 3.1, 2.9, 3.0 and 2.7 km/hr, respectively. Data on soil parameters were recorded as per normal procedure.

Results and Discussion

Yield attributes of maize

Number of cobs/ha

Examination of the data in Table 1 revealed that different weed control treatments failed to produce significant variation in the number of cobs/ha. In general, the maximum number of cobs/ha was found with weed free treatment (67556), while the minimum number of cobs/ha was recorded with weedy check condition

Table 1 : Effect of weed control measures on yield attributes of maize.

Treatments	Number of cobs/ha	Cob length (cm)	Cob girth (cm)	Number of grains/row	Number of grains row/cob	Number of grains/cob	1000 grains weight (g)
T_1: Weedy check	65556	15.43	11.93	29.27	12.13	354.07	258.00
T_2: Weed free	67556	19.00	13.67	36.80	14.53	535.07	298.19
T_3: Atrazine@1000g a.i./ha *fb* Hand weeding @ 25DAS	67778	18.00	12.71	35.00	13.87	484.60	279.76
T_4: Atrazine@750g a.i./ha *fb* Topramezone @ 25.2ga.i./ha at 25 DAS	67333	18.28	12.73	35.40	14.13	500.93	286.90
T_5: Atrazine@750ga.i./ha *fb* Tembotrione @ 120g a.i./ha at 25 DAS	66889	18.09	12.72	35.07	14.07	493.20	284.52
T_6: Atrazine@1000g a.i./ha *fb* Topramezone @25.2g a.i./ha at 25 DAS	67556	18.87	13.27	36.67	14.27	523.67	294.82
T_7: Atrazine @ 1000ga.i./ha *fb* Tembotrione @120g a.i./ha at 25 DAS	68000	18.67	13.21	35.93	14.20	509.87	290.12
T_8: Atrazine @ 750g a.i./ha + Topramezone @25.2g a.i/ha at 15 DAS	66889	17.95	12.35	34.87	13.60	474.67	276.04
T_9: Atrazine @ 750ga.i./ha + Tembotrione @ 120g a.i./ha at 15 DAS	68000	17.91	12.33	34.80	13.20	458.93	272.16
T_{10}: Atrazine @ 1000g a.i/ha	65778	17.47	11.95	33.93	12.87	436.87	267.08
SEm±	2882	0.76	0.54	1.46	0.75	30.79	12.37
CD (P=0.05)	NS	1.59	1.14	3.06	1.58	64.66	25.97
CV (%)	5.26	5.16	5.22	5.13	6.73	7.90	5.40

(66222). This might be because of the herbicides prevented the weed germination of weed and reduced the growth of weed. This has conformity with Khan *et al*. (2012).

Cob length

Scrutiny of data (Table 1) revealed a significant effect of different weed control measures on cob length. The highest cob length was recorded with weed free treatment (19.00 cm.), which was comparable to other herbicidal treatments. However, all of the weed control treatments including weed free were significantly superior to weedy check in respect of cob length. The better expression of cob length under weed free condition was due to least effect of crop-weed competition (Mahto *et al*., 2020).

Cob girth

Perusal of the data (Table 1) revealed that the cob girth was significantly differed due to different herbicidal treatments. Maximum cob girth was recorded under weed free condition which was 14.58% higher than that of the weedy check treatment (11.93cm). Among the herbicidal treatments maximum cob girth was obtained with the application of Atrazine@1000ga.i./ha as pre emergence followed by Topramezone@ 25.2 g a.i./ha applied at 25 days after sowing, which was significantly superior to pre emergence application of Atrazine @ 1000g a.i/ha. and weedy check but failed to show significant superiority over rest of the herbicidal treatments. Similarly, Atrazine application @ 1000 g a.i./ha as pre emergence followed by Tembotrione @ 120 g a.i./ha applied at 25 days after sowing also proved its superiority over pre emergence application of Atrazine @ 1000 g a.i./ha and weedy check but unable to prove its significance over other herbicidal treatments in respect of cob girth. Highest cob girth in weedy check was due to weed free condition. Whereas, herbicides not only favoured the crop plantsto reduce weed competition in maize with more availability of space, light, moisture and nutrients but also minimized weed interference, facilitating vigorous growth of crop plants. These results are found to be in close conformity with Baruna *et al*. (2019) and Sharma *et al*. (2023).

Number of grains / row

It is evident from the data (Table 1) that number of grains / row was significantly affected due to different weed control methods. The maximum number of grains / row was recorded under weed free treatment which exerted significant enhancement in number of grains/row than that of the weedy check but failed to exhibit significant variation with other herbicidal treatments in respect of number of grains / row. Similarly, different herbicidal treatments were statistically at par among themselves in respect of number of grains / row but exerted significant improvement in number of grains/row over weedy check. However, the highest number of grains / row was observed with Atrazine @ 1000 g a.i./ha followed by Topramezone @ 25.2 g a.i./ha applied at 25 days after sowing, which was closely followed by Atrazine @ 1000 g a.i./ha as pre emergence followed by Tembotrione @ 120 g a.i./ha applied at 25 days after sowing. This might be due to minimal/ zero competition between crop and weeds made possible to perform the crop better under said treatments and in turn recorded superior values of yield attributes. These results are in agreement to the finding of Mastkar *et al*. (2022).

Number of grain rows / cob

A close examination of the data (Table 1) revealed the significant effect of weed control treatments on number of grain rows/cob. The weed control treatments enhanced the number of grain rows/cob and the maximum value was associated with weed free treatment which was significantly superior to Atrazine @ 1000 g a.i./ha as pre emergence and weedy check. However, the former *i.e*, weed free remained at par to other weed control treatments. Further analysis of data showed that among the herbicidal treatments, Atrazine @ 1000 g a.i./ ha as pre emergence application followed by Topramezone @ 25.2 g a.i./ha applied at 25 days after sowing recorded maximum grain rows/cob which was significantly higher than weedy check. However, the former failed to exhibit significant variation with other weed control treatments and comparable between themselves. Singh *et al*. 2017 observed highest number of seed rows per cob (14.9) in weed free (T_{18}) and among herbicidal application treatments, alachlor 2000 g/ha as pre *fb* Tembotrion 120 g/ha + S (T_{11}).

Number of grains/cob

Perusal of the data (Table 1) revealed that the number of grains/cob was significantly influenced by weed control treatments. As such, the different weed control treatments exhibited significant superiority over weedy check in respect of number of grains/cob. The weed free treatment recorded the maximum number of grains/cob followed by application of Atrazine @ 1000 g a.i./ha as pre emergence application followed by Topramezone @ 25.2 g a.i./ha applied at 25 days after sowing (523.67). Both of the treatments significantly enhanced the number of grains/cob over Atrazine @ 750 g a.i./ha applied along with Tembotrione @ 120 g a.i./ha at 15 DAS (458.93), Atrazine @1000g a.i/ha as pre emergence application (436.87) and weedy check (354.07), but failed to cause significant difference with other weed control treatments

in respect of grains/cob and remained statistically at par among themselves (Barla *et al*., 2016).

1000 grain weight

It is apparent from the data (Table 1) that variation in thousands grain weight due to weed control treatments were statistically significant. The maximum thousand grain weight was recorded with weed free treatment and lowest value was associated with weedy check. Among the herbicidal treatments Atrazine @ 1000 g a.i./ha as pre emergence application followed by Topramezone @ 25.2ga.i./ha applied at 25days after sowing brought a significant improvement in thousand grain weight over pre emergence application of Atrazine @ 1000 g a,i./ha and weedy check. However, the former remained at par to other herbicidal treatment and weed free treatment in respect of thousand grain weight Singh *et al*. (2017) reported maximum 1000 grain weight in weed free condition followed by Alachlor *fb* Tembotrione + S.

Yields

Cob yield, grain yield, stover yield and stone yield differed significantly due to various weed control treatments. These parameters were observed highest under weed free condition. Cob and grain yield (Table 2 and Fig. 1) were significantly superior to Atrazine @ 750 g a.i./ha applied along with Topramezone @ 25.2 g a.i / ha at 15 DAS (57.61q/ha), Atrazine @ 750 g a.i./ha + Tembotrione @ 120 g a.i./ha at 15 DAS (56.71q/ha), Atrazine @ 1000g a.i/ha as pre emergence (50.73q/ha) and weedy check (40.66q/ha), but failed to maintain significant statistical difference with other weed control treatments and remained comparable among themselves.

The weed free treatment recorded the maximum stover (Fig. 1) and stone yield which was significantly higher than pe emergence application of Atrazine @ 1000 g a.i./ha (110.85 &12.69q/ha respectively) and weedy check (86.29 & 12.29q/ha, respectively), but the former *i.e*, weed free remained statistically at par with other weed control treatments in respect of stover and stone yield. Similarly, the herbicidal treatments Atrazine @ 1000 g a.i./ha as pre emergence followed by Topramezone @ 25.2 g a.i./ha applied at 25 days after sowing and Atrazine @ 1000 g a.i./ha as pre emergence application followed by Tembotrione @ 120 g a.i./ha applied at 25 days after sowing showed their significant superiority over pre emergence application of Atrazine @ 1000g a.i./ha and weedy check but failed to cause significant statistical variation with other weed control treatments and remained at par between themselves in respect of stover and stone yield.

The highest harvest index and shelling percentage were recorded under weed free condition (38.12 & 80.86%, respectively), while among the herbicidal treatments the highest harvest index and shelling percentage were obtained with application of Atrazine 1000 g a.i./ha as pre emergence followed by Topramezone @ 25.2 g a.i/ha applied at 25 days after sowing (38.01 and 80.81%, respectively). Further analysis of the data revealed that all the weed control treatments including weed free treatment recorded higher shelling percentage than weedy check condition (32.12 and 76.70%, respectively) but failed to cause significant statistical difference in shelling percentage and remained at par among themselves.

The weed free situation gave the highest grain, cob stover and stone yield of maize while, lowest yields were obtained in weedy check as weed dry matter accumulation and weed density are negatively correlated with the yield (Sunitha *et al*., 2010). Among herbicidal treatments, the increase in maize grain, cob, stover and stone yield may attributed to the effect of different weed management treatments that control weeds associated with maize crop and minimizing weed competition, there by facilitating more assimilates synthesis, translocation and accumulation in various plant organs, which gave a good chance of maize growth and improved yield attributing characters which ultimately resulted in higher grain, cob, stover and stone yield of maize (Tagour and Mosaad, 2017).

Economics

The highest gross return was (Table 3) obtained with weed free treatments which was significantly higher than Atrazine @ 750 g a.i./ha applied along with Topramezone @ 25.2 g a.i /ha at 15 DAS, Atrazine @ 750 g a.i./ha + Tembotrione @ 120 g a.i./ha applied at 15 DAS, Atrazine @ 1000g a.i/ha as pre emergence application and weedy check treatments, but failed to establish its significant superiorityover other weed control treatments in respect of gross return and remained at par among themselves. Similarly, among herbicidal treatments, significantly higher gross return was recorded with application of Atrazine @ 1000 g a.i./ha as pre emergence followed by Topramezone @ 25.2 g a.i/ha applied at 25 days after sowing (116290 ` /ha), which was closely followed by Atrazine @ 1000 g a.i./ha as pre emergence followed by Tembotrione @ 120 g a.i./ha at 25 days after sowing being comparable between themselves.

Among the different weed control treatments, application of Atrazine 1000 g a.i / ha. as pre emergence followed by Topramezone @ 25.2 g a.i./ha applied at 25

Table 2 : Effect of weed control measures on maize yield.

Treatments	Grain yield (q/ha)	Cob yield (q/ha)	Stover yield (q/ha)	Stone yield (q/ha)	Harvest index (%)	Shelling percentage (%)
T_1: Weedy check	40.66	52.95	86.29	12.29	32.12	76.70
T_2: Weed free	68.34	84.61	110.85	16.26	38.12	80.86
T_3: Atrazine@1000g a.i./ha *fb* Hand weeding @ 25 DAS	61.35	76.25	104.23	14.89	37.16	80.47
T_4: Atrazine @ 750g a.i./ha *fb* Topramezone @ 25.2g a.i./ha at 25 DAS	63.56	79.01	106.65	15.45	37.34	80.52
T_5: Atrazine @ 750g a.i./ha *fb* Tembotrione @ 120g a.i./ha at 25 DAS	62.42	77.56	105.47	15.13	37.24	80.50
T_6: Atrazine @ 1000g a.i./ha *fb* Topramezone @ 25.2 g a.i./ha at 25 DAS	66.65	82.53	109.05	15.87	38.01	80.81
T_7: Atrazine @ 1000g a.i./ha *fb* Tembotrione @ 120g a.i./ha at 25 DAS	66.19	81.94	108.27.	15.75	37.93	80.74
T_8: Atrazine @ 750 g a.i./ha + Topramezone @ 25.2 g a.i. /ha at 15 DAS	57.61	71.70	99.48	14.09	36.67	80.30
T_9: Atrazine @ 750g a.i./ha + Tembotrione @ 120g a.i./ha at 15 DAS	56.71	70.74	99.08	14.02	36.33	80.15
T_{10}: Atrazine @ 1000ga.i/ha	50.73	63.43	93.09	12.69	35.14	79.92
SEm±	3.97	4.90	6.78	1.48	1.57	1.45
CD (P = 0.05)	8.35	10.30	14.25	3.11	3.31	3.04
CV (%)	8.20	8.11	8.13	12.41	5.27	2.21

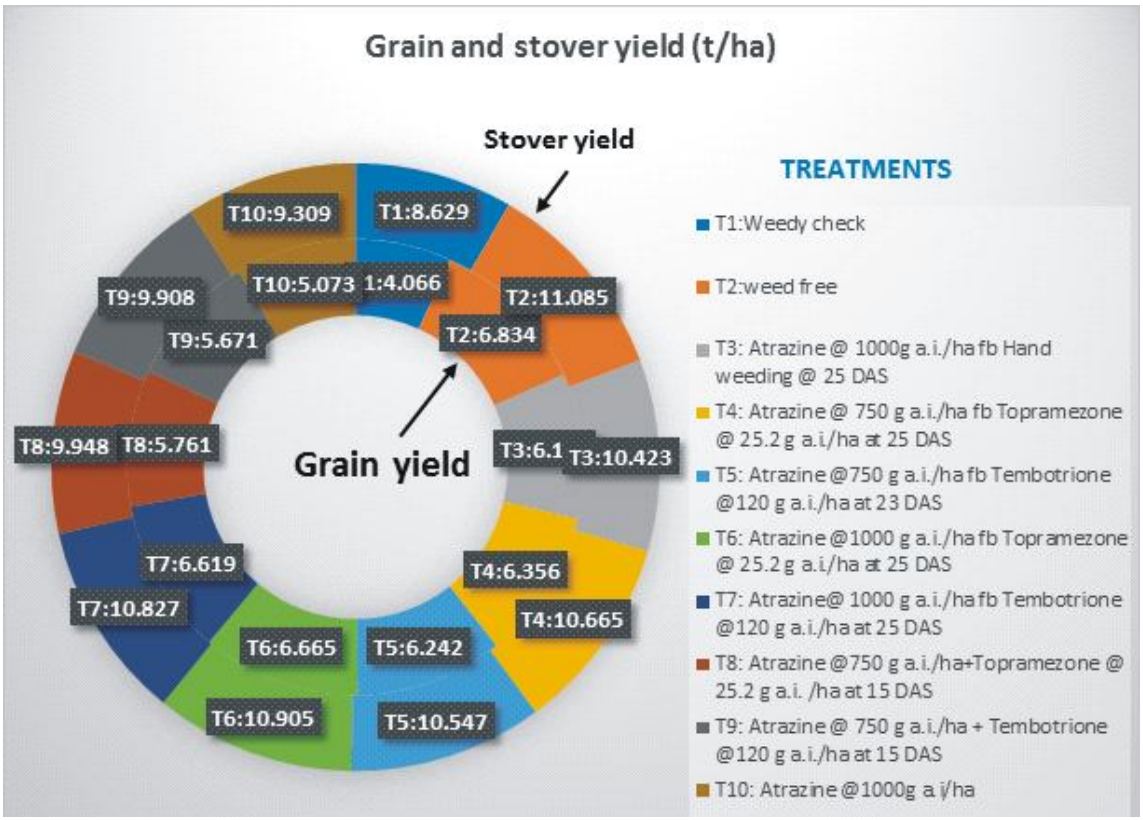
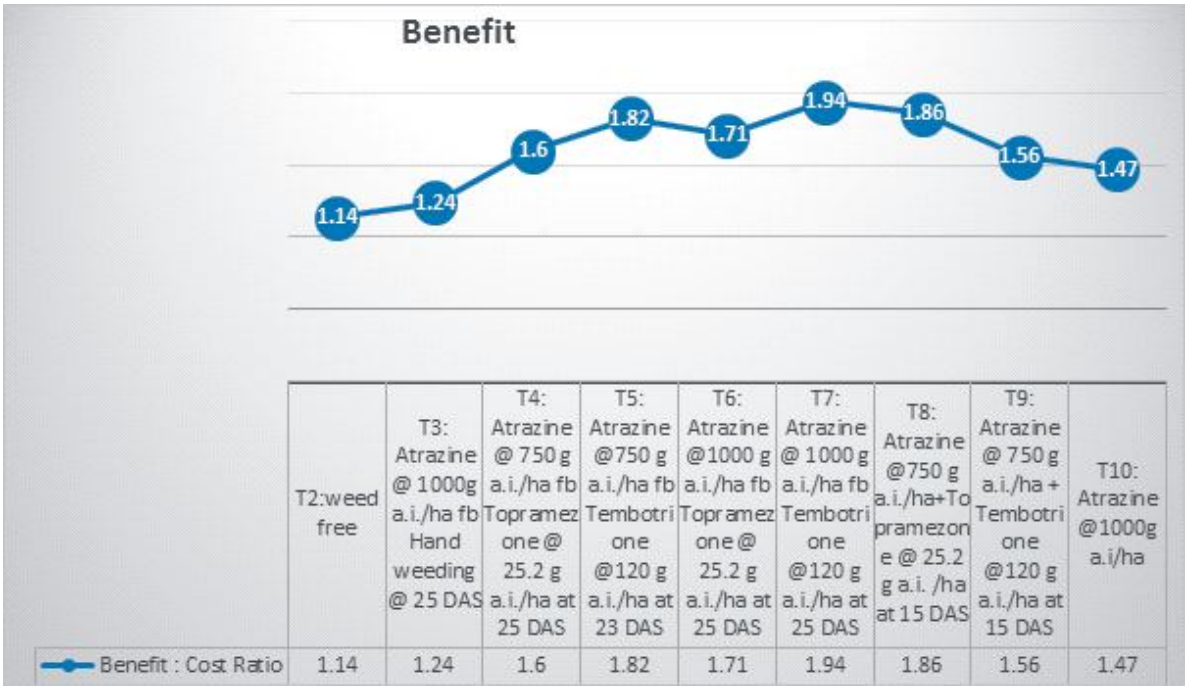


Fig. 1 : Grain and stover yield (t/ha) of maize.



	T2:weed free	T3: Atrazine @ 1000g a.i./ha fb Hand weeding @ 25 DAS	T4: Atrazine @ 750 g a.i./ha fb Topramezone @ 25.2 g a.i./ha at 25 DAS	T5: Atrazine @750 g a.i./ha fb Tembotrione @120 g a.i./ha at 23 DAS	T6: Atrazine @1000 g a.i./ha fb Topramezone @ 25.2 g a.i./ha at 25 DAS	T7: Atrazine @ 1000 g a.i./ha fb Tembotrione @120 g a.i./ha at 25 DAS	T8: Atrazine @750 g a.i./ha+Topramezone @ 25.2 g a.i. /ha at 15 DAS	T9: Atrazine @ 750 g a.i./ha + Tembotrione @120 g a.i./ha at 15 DAS	T10: Atrazine @1000g a.i/ha
Benefit : Cost Ratio	1.14	1.24	1.6	1.82	1.71	1.94	1.86	1.56	1.47

Fig. 2 : Benefit: cost ratio of maize.

days after sowing (76736 `/ha) gave the maximum net return of maize which was significantly superior to Atrazine @ 750 g a.i./ha + Topramezone @ 25.2 g a.i / ha applied at 15 DAS (61267 `/ha), Atrazine @750 ga.i./ ha+Tembotrione @ 120 ga.i./ha applied at 15 DAS (58959 `/ha), Atrazine @1000ga.i/ha. As pre-emergence (54149 `/ha) and weedy check (38146 `/ha) and remained statistically at par with other weed control treatments. Similarly herbicidal application of Atrazine@1000ga.i./ ha as pre-emergence followed by Tembotrione @120ga.i./

Table 3 : Effect of weed control measures on economics of maize.

Treatments	Cost of cultivation (`/ha)	Gross return (`/ha)	Net return (`/ha)	Benefit: Cost Ratio
T_1: Weedy check	33327	71473	38146	1.14
T_2: Weed free	53168	119216	66048	1.24
T_3: Atrazine @ 1000g a.i./ha *fb* Hand weeding @ 25 DAS	41218	107135	65917	1.60
T_4: Atrazine @ 750g a.i./ha *fb* Topramezone @25.2 g a.i./ha at 25 DAS	39366	110964	71598	1.82
T_5: Atrazine @ 750g a.i./ha *fb* Tembotrione @ 120g a.i./ha at 25 DAS	40145	108990	68844	1.71
T_6: Atrazine @ 1000g a.i./ha *fb* Topramezone @ 25.2 g a.i./ha at 25 DAS	39554	116290	76736	1.94
T_7: Atrazine @ 1000g a.i./ha *fb* Tembotrione @ 120 g a.i./ha at 25 DAS	40333	115482	75150	1.86
T_8: Atrazine @ 750g a.i./ha + Topramezone @ 25.2g a.i /ha at 15 DAS	39366	100634	61267	1.56
T_9: Atrazine @ 750g a.i./ha + Tembotrione @ 120g a.i./ha at 15 DAS	40145	99105	58959	1.47
T_{10}: Atrazine @ 1000g a.i/ha	34605	88754	54149	1.56
SEm ±	-	6769	6769	0.18
CD (P = 0.05)	-	14214	14214	0.37
CV (%)	-	7.99	13.02	13.68

ha at 25 days after sowing(75150 `/ha)provedits significant superiority over Atrazine @ 750 g a.i./ha + Tembotrione @ 120 g a.i./ha applied at 15 DAS, Atrazine @ 1000g a.i/ha. and weedy check in respect of net return.

The maximum benefit cost ratio (Table 3 and Fig. 2) was noticed with Atrazine @ 1000 g a.i./ha as pre emergence application followed by Topramezone @ 25.2 g/ ha at 25 days after sowing (1.94), which was significantly superior to Atrazine @ 750 g a.i./ha applied along with Topramezone @ 25.2 g a.i /ha at 15 DAS (1.56), Atrazine @ 750 g a.i./ha + Tembotrione @ 120 g a.i./ha at 15 DAS(1.47), Atrazine @ 1000g a.i/ha. as pre emergence (1.56), weed free (1.24) and weedy check (1.14), but failed to cause a significant increase in benefit: cost ratio with other weed control treatments. Similarly, the weedicide treatment of Atrazine @ 1000g a.i./ha as pre emergence followed by Tembotrione @ 120 g a.i./ha at 25 days after sowing as post emergence application produced significantly higher benefit : cost ratio over Atrazine @ 750 g a.i./ha+ Tembotrione @ 120 g a.i./ha applied at 15 DAS and weedy check.

Economics of maize production depends upon several factors such as input cost, labour requirements and above all the weather conditions prevailing during the crop period. The higher labour usage under weed free treatments led to the higher cost of cultivation and lowest cost of cultivation under weedy check was due to the lower amount of input and labour used. The sequential application of atrazine @ 1000 g a.i./ha as pre-emergence followed by post-emergence application of topramezone @ 25.2 g/haat 25 days after sowing gave the highest net return and B:C ratio. The higher net return and benefit: cost ratio was due to comparatively better increase in yield and lower cost of cultivation due to lower cost of herbicides and lower labour usage over other treatments. This result was found in accordance with findings of Yakadri *et al*. (2015), Hargilas (2019) and Rana *et al*. (2017).

Conclusion

Based on one year experimentation, we can conclude that when labours are easily available Weed Free condition can be preferred but in case of labour scarcity,pre emergence application of Atrazine @ 1000 g a.i/ha. followed by post-emergence application of Topramezone @ 25.2 g a.i./ha at 25 days after sowing may be practiced for maize cultivation as it produced higher yield attributing characters (number of cobs/ha, cob length, cob girth, number of grain rows/cob, number of grains/row, number

of grains/cob and 1000 grain weight), grain yield, cob yield, stover yield, stone yield and economics of maize at Chotanagpur Plateau region of Ranchi, Jharkhand.

Conflicts of interest

The authors state that they have no known financial conflicts of interest or personal ties that might have appeared to have an impact on the work described in this study.

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