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Effect of Mesotrione 40% SC on Weed Growth, Yield and Economics of Maize (*Zea mays* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Newer herbicides are required to reduce the losses cause by the weeds in maize crop. Therefore, a field experiment was conducted during *kharif* 2019 at Research Farm, AICRP on Forage Crops, Department of Agronomy, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (Madhya Pradesh) to study the effect of different weed management practices on productivity of Maize (*Zea mays* L.). The experiment was conducted in randomized block design with eight treatments (six herbicidal treatments with hand weeding twice at 20 and 40 DAS and weedy check) replicated thrice. Observations were recorded for various weed parameters and crop growth parameters. All the weed management treatments significantly reduced the total weed density and total dry weight of weeds as compared to weedy check. Among herbicidal treatments, mesotrione 350 g ha^{-1} recorded the lowest total weed density and total dry weight of weeds as compared to other herbicides. While

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highest total weed density and total dry weight were recorded under weedy check treatment. Significantly higher growth parameters and yield attributing traits were recorded with the application of mesotrione 350 g ha^{-1} which resulted in higher grain and stover yields (2447.22 and 21804.72 kg ha^{-1}) followed by mesotrione 300 g ha^{-1}. Maximum net returns and Benefit: Cost ratio was also obtained with the application of mesotrione 350 g ha^{-1}.

Keywords: Grain yield; harvest index; herbicides; leaf area index; mesotrione; weed control.

1. INTRODUCTION

Maize (*Zea mays* L.) is one of the important cereal crops having wider adaptability under diverse soil and climatic conditions. Globally, maize referred as "miracle crop" and has highest genetic yield potential, there is no other cereal on the earth which has immense potentiality and that is why it is called "queen of cereals". In India it is third important food crop after rice and wheat, which accounts nearly 9% to the national food security [1]. It is grown for its dual purpose, both for human consumption and also for poultry feed, corn flakes, popcorn and other industrial uses in India. Since the last decade, maize is being used as vegetable where unfertilized young cob is used for cooking purposes, popularly known as baby corn. 60% of corn is primarily used for feed followed by human food 24%, industrial products (starch) 14%, beverage and seed 1% each [2]. Maize holds potential for diversification and livelihood security as reported elsewhere. It is the highest produced staple cereal followed by wheat and rice in the world with production of 1033.74 million metric tons from 197 million ha [3]. In India, it is grown in 9.47 million hectares area with production of 28.72 million tonnes and average yield of 3032 kg ha^{-1}. India contributes merely about 2.35 percent in world maize production [4]. Karnataka, Maharashtra and Madhya Pradesh are three largest maize producing states. In Madhya Pradesh maize is cultivated in 1.35 million hectares with production of 3.54 million tonnes. In India it contributes 14.28% and 12.32% of total area and production, respectively [5].

There are several reasons for its low productivity, and out of that, losses caused due to weeds is one of the most important [6,7]. Weeds are most severe and widespread biological constraints to crop production [8]. Most of the cereal crops suffer from severe infestation of weeds [9]. Weeds not only decrease crop yield but also harbor insects, pests and diseases. In some cases, they serve as an alternate host for these pests [10]. Weeds create enormous losses not only in terms of crop yields and quality, but they deplete a substantial quantity of plant nutrients from the soil also [11]. They are supposed to be foremost among the various factors responsible for restricting the crop yields [12]. Several efforts are being made to combat with the nuisance of weeds since the primitive agriculture, but aggressivity of weeds in agricultural land is orderly enhancing day by day [13,14]. In organic farming, the weeds are managed by applying mulches, cultural, physical, mechanical and chemical methods as components of integrated weed management (IWM) that helps to promote crop yield [15]. Initial 6 weeks after sowing (WAS) are found very susceptible to weed infestation in maize, significantly decreasing final grain yield [16,17]. Therefore, weed must be properly managed to avoid economic losses in crop production.

Chemical weed control is being recommended instead of manual weeding as it is cost-effective and less labour dependent [18]. With the availability of herbicides and associated weed management technology, it is possible to improve the yield of maize through chemical weed control [19]. Mesotrione is a HPPD-inhibiting herbicide, and is a broad spectrum weed controller, has flexibility in time of application, suitable for tank-mix applications with different herbicides and better crop tolerance [20,21]. This makes necessary use of herbicides with different modes of action to reduce probability of herbicide resistance in weeds. Considering the above facts, the present experiment was conducted to study the effect of mesotrione 40% SC on weeds and seed yield.

2. MATERIALS AND METHODS

A field experiment was conducted during the *kharif* 2019 (July 2019 to October 2019) at Research Farm, AICRP on Forage Crops, Department of Agronomy, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (Madhya Pradesh). The soil of the experimental field was neutral in reaction and analyzing medium in organic carbon as well as with medium available nitrogen, available phosphorus and available potassium contents with normal electrical conductivity. Total eight treatments were laid out on well prepared seed bed in a randomized block design with three replications. The total rainfall received during crop season was 1642.30 mm, which was equally distributed in 56 rainy days from June second week to last week of October. Therefore, crop did not suffer due to adverse effect of rains on the crop. As a whole the weather conditions prevailed during the crop season were almost conducive for proper growth, development and yield of maize crop. Eight treatments consisted with pre-emergence application of atrazine 1000 g ha^{-1} (T_5), pendimethalin 750 g ha^{-1} (T_6) and post emergence application of mesotrione 250 g ha^{-1} (T_1), mesotrione 300 g ha^{-1} (T_2), mesotrione 350 g ha^{-1} (T_3) and tembotrione 286 g ha^{-1} (T_4) and hand weeding twice at 20 and 40 DAS (T_7) and weedy check (T_8) were tested in a randomized block design with three replications. Sowing of maize was done on 1st July, 2019 by using the seed rate 20 kg ha^{-1} as per treatments in the rows 60 cm apart. A uniform dose of 80 kg ha^{-1} N + 40 kg P_2O_5 + 20 kg K_2O ha^{-1} was applied in all plots. The N, P and K were given through urea, single superphosphate and muriate of potash, respectively. Half quantity of N as per treatment along with full quantity of P and K fertilizers were given as basal application at the time of sowing and remaining N was top-dressed at 25 and 45 DAS. Various observations were recorded on weed parameters and crop parameters. In studies on intensity of weeds and dry matter accumulation by weeds were made species wise and finally weed index was determined. In studies on growth parameters (plant height, stem girth and Leaf area index); yield attributing characters (cob per plant, cob size, cob weight, seed rows per cob, seeds per row, seed-index and harvest index) at maturity stage of the crop were recorded. Finally, the grain yield was determined. The data obtained on various parameters are tabulated and statistically analyzed. The significance of the difference between a pair of means was tested by the least significant difference (LSD) test at a significance level of 5% [22].

3. RESULTS AND DISCUSSION

3.1 Effect on Weed Density and Weed Dry Weight

Different weed control treatments significantly reduced the density and dry weight of total weeds compared to the weedy check treatment at 30 and 60 DAS (Table 1). The least number of total weeds were observed under hand weeding (T_7) (7.07 and 8.68/m^2), whereas weedy check accounted for the highest density of the same (16.28 and 18.71/m^2). Among all the herbicidal treatments, the application of mesotrione 350 g ha^{-1} (T_2) exerted the maximum herbicide effect. It recorded the lowest weed density (10.05 and 12.75/m^2), which was statistically at par with mesotrione 300 g ha^{-1} (T_3).

The weed biomass was maximum (15.23 and 16.58 g/m^2) in weedy plots (T_8) where weeds were not controlled at all, which was reduce appreciably in plots receiving weed control treatments at 30 and 60 DAS. The maximum reduction found in hand weeding twice (T_7) (2.90 and 6.59 g/m^2). The post-emergence application of mesotrione 350 g ha^{-1} (T_2) has significant role in dry weight reduction (8.05 and 9.38 g/m^2) which was at par to mesotrione 300 g ha^{-1} (T_3), which were differed from the post emergence application of tembotrione 286 g ha^{-1} (T_4), mesotrione 250 g ha^{-1} (T_1) and pre-emergence application atrazine 1000 g ha^{-1} (T_5) and pendimethalin 750 g ha^{-1} (T_6) at 30 and 60 DAS. Our results confirm the findings of [23,24,25].

3.2 Effect on Growth Parameters

Different weed management practices significantly affected the plant height at 30, 60, 90 DAS and harvest (Fig. 1). The plant height increased slowly during early stage of crop growth (up to 30 DAS) thereafter, increased sharply up to 60 days stage, again growth increased slowly at 60 to 90 days stages. At harvest plant height declined slightly in all the treatments. The height of plants considerably more under weed free plots at 30, 60, 90 and harvest, respectively compared to rest of the treatments as crop was free from weed stress and all the growth resources were optimally utilized by the crop plants. This led to better plant height. Among the herbicidal treatments, long stature plants were recorded under mesotrione 350 g ha^{-1} (T_3) (19.73, 93.96, 237.04 and 233.24 cm) at 30, 60, 90 DAS and harvest which is at par with mesotrione 300 g ha^{-1} (T_2). However, all the herbicidal treatments showed better plant height over weedy check plots. The excellent control of weeds under these treatments led to optimal utilization of growth resources therefore, these treatments have long stature plants. These results are in close conformity with the finding of [26].

Table 1. Effect of different weed control treatments on total weed density and dry weight at 30 and 60 DAS

Treatments	Total weed density (no./m^2)		Total weed dry weight (g/m^2)	
	30 DAS	60 DAS	30 DAS	60 DAS
T_1: Mesotrione 250 g ha^{-1}	12.07^ (145.22*)	14.25 (202.58)	11.06 (121.88)	12.29 (150.44)
T_2: Mesotrione 300 g ha^{-1}	11.00 (120.55)	13.49 (181.58)	9.19 (83.99)	10.11 (101.77)
T_3: Mesotrione 350 g ha^{-1}	10.05 (100.45)	12.75 (162.17)	8.05 (64.32)	9.38 (87.49)
T_4: Tembotrione 286 g ha^{-1}	11.45 (130.63)	13.80 (189.83)	10.22 (103.97)	11.16 (123.98)
T_5: Atrazine 1000 g ha^{-1}	12.27 (149.97)	14.47 (208.92)	12.06 (144.96)	12.98 (167.99)
T_6: Pendimethalin 750 g ha^{-1}	12.60 (158.27)	14.78 (218.08)	12.49 (155.63)	13.79 (189.80)
T_7: Hand weeding	7.07 (49.43)	8.68 (74.93)	2.90 (7.92)	6.59 (42.99)
T_8: Weedy Check	16.28 (264.55)	18.71 (349.58)	15.23 (231.58)	16.58 (284.55)
SEm±	0.30	0.34	0.58	0.67
CD at 5%	0.90	1.02	1.76	2.03

Transformed values $\sqrt{x+0.5}$ are indicated by (^) and Original figures are given in parenthesis (*)

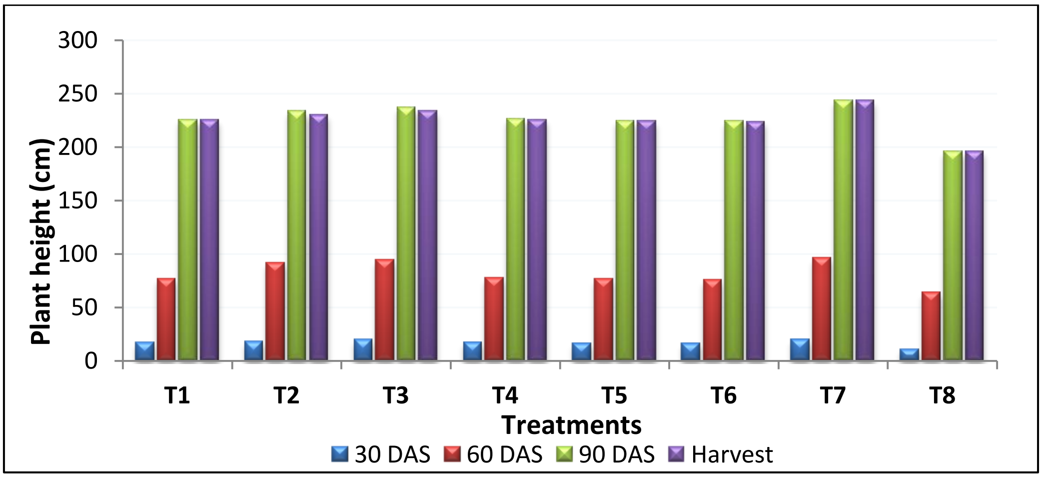

Fig. 1. Effect of different weed control treatments on plant height (cm) at 30, 60, 90 DAS and harvest

LAI differed significantly due to different weed control treatments at 30 and 60 DAS (Fig. 2). The LAI was maximum in weed free plot (3.94 and 7.97) at 30 and 60 DAS among all the weed control treatments, whereas minimum value of LAI was recorded in weedy check plots. Application of post emergence herbicides also produced significantly higher LAI as compared to weedy check but, they were inferior to that of weed free plot. Maximum LAI was recorded in mesotrione 350 g ha^{-1} (3.69 and 7.73) (T_3) followed by mesotrione 300 g ha^{-1} (3.55 and 7.53) (T_2) at 30 and 60 DAS. This may be because of better growth and development of foliage under weed free environment and consequently resulted in more assimilatory area per unit land area.

Stem girth remarkably differed due to different treatments at various growth stages of crop at 30, 60, 90 DAS and harvest stage. Stem girth was less (1.27, 1.52, 1.61 and 1.61 cm) in weedy check plot at 30, 60, 90 DAS and harvest stage, respectively. It was due to poor control of associated weeds. Application of post emergence herbicides resulted in increased in the stem girth at all the stages. But found significantly inferior to that of mesotrione 350 g ha^{-1} (T_3) (1.63, 1.73, 1.88 and 1.88 cm) at 30, 60, 90 DAS and harvest stage, respectively. Because, this treatment provided excellent control of associated weeds, resulting in almost weed free environment throughout the critical period of crop-weed competition which, led to optimum growth and development of crop plants and ultimately resulted in more number of leaves per plant under these treatments. However, highest stem girth was recorded under hand weeding treatment (T_7) (1.70, 1.77, 1.94 and 1.94 cm). Similar findings were made by [27].

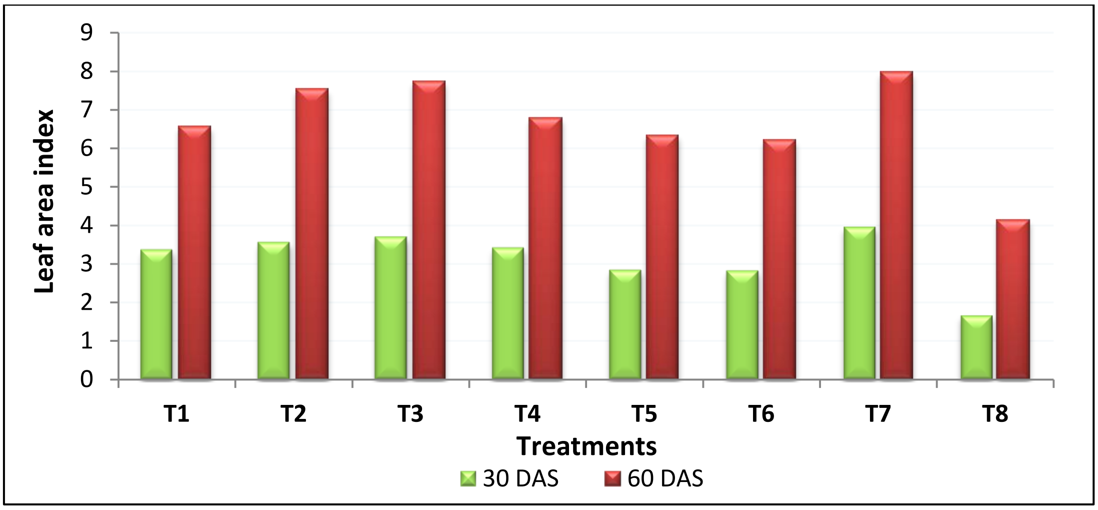

Fig. 2. Effect of different weed control treatments on leaf area index at 30 and 60 DAS

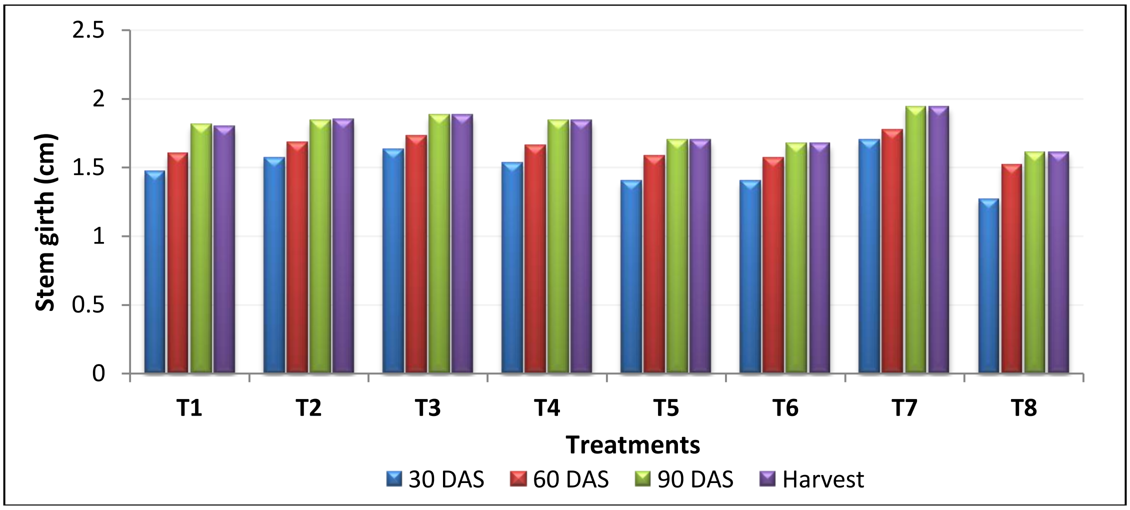

Fig. 3. Effect of different weed control treatments on stem girth (cm) at 30, 60, 90 DAS and harvest

3.3 Effect on Yield Attributing Characters

Among the yield attributes, namely number of cobs per plant, seed rows per cob, seeds per row, cob length, cob girth and cob weight were significantly varied due to different weed management practices (Table 2). The yield attributes were superior in the weed free treatment than other treatments. Excellent growth and development of maize plants under weed free environment during critical period of crop growth might have resulted in higher number of cobs per plant, seed rows per cob, seeds per row, cob length, cob girth and cob weight under weed free treatment as compared to weedy check, which had severe weed competition right from early growth stages and ultimately resulted in most inferior yield attributes. The post emergence application of mesotrione 350 g ha^{-1} (T_3) produced higher yield attributes which was at par to mesotrione 300 g ha^{-1} (T_2) treatment as compared to other treatments on account of maximum reduction in weed growth coupled with no inhibitory effects on maize plants. Thus, these treatments might have resulted in relatively better yield attributing traits. Whereas, poor weed control under weedy check might have produced lower number of cobs per plant, seed rows per cob, seeds per row, cob length, cob girth and cob weight. Almost similar results were obtained by [28,29,30].

3.4 Effect on Grain and Stover Yield

Grain yield under a particular treatment is the resultant of complex phenomenon, which not only depends on the genetic constitution of the crop plants but also on the production technology adopted. Weeds caused considerable damage to the crop depending upon the associated weed species, their density and duration of crop weed competition and their cumulative effect reflected in terms of reduced crop yield. The grain and stover yield were lowest (1394.44 and 16252.78 kg ha^{-1}) in the plots receiving no weed control measures (weedy check) due to severe competition stress right from crop establishment up to the end of critical period of crop growth, leading to poor growth parameters and yield attributing traits and finally the grain yield (Table 3). All the treated plots receiving either manual weeding or herbicidal treatments produced higher yield over weedy check plots. The maximum grain and stover yield (2803.05 and 22528.89 kg ha^{-1}) was noted in hand weeding at 20 and 40 DAS (T_7) than other treatments. The crop under weed free plots attained lush growth due to elimination of weeds from inter and intra row spaces besides better aeration due to manipulation of surface soil and thus, more space, water, light and nutrients were available for the better growth and development, which resulted into superior yield attributes and development, and consequently the highest yield. However, among herbicidal treatment, maximum grain and stover yield were recorded under mesotrione 350 g ha^{-1} (T_3) (2447.22 and 21804.72 kg ha^{-1}). This result corroborates with the findings of [31,32,33].

3.5 Seed Index

Seed index of maize under different treatments are given in Table 3. It is obvious from the data that seed index of maize not much varied under different treatments. Among all the treatments the minimum seed index of maize was recorded under weedy check (20.87). However, it was numerically higher when weed control measure were adopted in maize. Pre emergence application of pendimethalin 750 g ha^{-1} and atrazine 1000 g ha^{-1} and post emergence application of mesotrione 250 g ha^{-1} and tembotrione 286 g ha^{-1} marginally increased the seed weight. But increase was more pronounced when application of mesotrione 300 g ha^{-1} (T_2) (23.87) and mesotrione 350 g ha^{-1} (T_3) (24.83) was done. However, hand weeding twice had highest (29.57) seed index of maize. [34] also reported a similar findings.

Table 2. Effect of weed control treatments on yield attributing characters in maize

Treatments	Cobs plant^{-1}	Seed rows cob^{-1}	Seeds row^{-1}	Cob length (cm)	Cob girth (cm)	Cob weight (g)
T_1: Mesotrione 250 g ha^{-1}	1.37	10.27	20.27	12.09	10.99	83.45
T_2: Mesotrione 300 g ha^{-1}	1.53	10.67	20.53	12.52	11.49	91.38
T_3: Mesotrione 350 g ha^{-1}	1.59	10.87	20.73	12.55	11.52	94.16
T_4: Tembotrione 286 g ha^{-1}	1.45	10.27	20.33	12.43	11.01	90.62
T_5: Atrazine 1000 g ha^{-1}	1.20	10.07	19.80	11.68	10.92	81.85
T_6: Pendimethalin 750 g ha^{-1}	1.17	9.93	18.93	11.65	10.60	75.33
T_7: Hand weeding	1.89	10.97	21.13	12.89	12.16	102.65
T_8: Weedy Check	1.00	9.73	18.13	10.66	10.46	65.19
SEm±	0.08	0.65	0.64	0.40	0.32	1.15
CD at 5%	0.24	1.96	1.96	1.22	0.97	3.50

Table 3. Effect of weed control treatments on grain yield, stover yield, seed index and harvest index in maize

Treatments	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Seed index (g)	Harvest index (%)
T_1: Mesotrione 250 g ha^{-1}	1836.11	19709.17	23.20	8.52
T_2: Mesotrione 300 g ha^{-1}	2188.88	20952.78	23.87	9.46
T_3: Mesotrione 350 g ha^{-1}	2447.22	21804.72	24.83	10.09
T_4: Tembotrione 286 g ha^{-1}	2077.77	20611.39	23.40	9.16
T_5: Atrazine 1000 g ha^{-1}	1766.66	18408.33	23.10	8.75
T_6: Pendimethalin 750 g ha^{-1}	1638.88	17125.00	21.97	8.74
T_7: Hand weeding	2803.05	22528.89	29.57	11.06
T_8: Weedy Check	1394.44	16252.78	20.87	7.90
SEm±	40.69	149.45	0.58	0.22
CD at 5%	123.43	453.31	1.75	0.65

Table 4. Economic analysis of different weed control treatments in maize

Treatments	Cost of cultivation (Rs. ha^{-1})	Gross monetary returns (Rs. ha^{-1})	Net monetary returns (Rs. ha^{-1})	B: C Ratio
T_1: Mesotrione 250 g ha^{-1}	29159	61879	32719	2.12
T_2: Mesotrione 300 g ha^{-1}	29659	69953	40293	2.36
T_3: Mesotrione 350 g ha^{-1}	30159	75778	45618	2.51
T_4: Tembotrione 286 g ha^{-1}	29519	67485	37966	2.29
T_5: Atrazine 1000 g ha^{-1}	27009	58705	31696	2.17
T_6: Pendimethalin 750 g ha^{-1}	27184	54531	27347	2.01
T_7: Hand weeding	36659	83127	46467	2.27
T_8: Weedy Check	26659	48921	22261	1.84

3.6 Harvest Index

Harvest index (the ratio of economic yield to the biological yield) was significantly higher under weed free treatment (T_7) (11.06%) closely followed by mesotrione 350 g ha^{-1} (T_3) (10.09%) and mesotrione 300 g ha^{-1} (T_2) (9.46%) among all the weed control treatments (Table 3). Excellent growth and development of maize plants under weed free environment during critical period of crop growth might have resulted in higher harvest index under these treatments. While, weedy check (T_8) resulted in the lowest value of harvest index (7.90%).

3.7 Economics

Cost of cultivation, gross monetary returns, net monetary returns and benefit cost ratio under different treatments are given in Table 4. The NMR was minimum under weedy check treatment (Rs. 22261 ha^{-1}) where weeds were not controlled. But increased to a maximum level when weeds were controlled by application of mesotrione 350 g ha^{-1} (T_3) (45618 Rs ha^{-1}) and mesotrione 300 g ha^{-1} (T_2) (40293 Rs ha^{-1}) as post emergence and proved better than mesotrione 250 g ha^{-1}(T_1), tembotrione 286 g ha^{-1}(T_4), atrazine 1000 g ha^{-1} (T_5) and pendimethalin 750 g ha^{-1} (T_6) which had lower NMR values. The benefit: cost ratio represents the profitability of the treatments with each rupee of investment. It is remarkable to note that the mesotrione 350 g ha^{-1} was more remunerable (2.51) followed by mesotrione 300 g ha^{-1} (2.36) compared to other treatment. Remaining treatment were not much remunerative with regard to B:C ratio over weedy check except tembotrione 286 g ha^{-1} and atrazine 1000 g ha^{-1} having B:C ratio of 2.29 and 2.17, respectively. Similar findings also reported in maize by [35].

4. CONCLUSION

The most dreadful competitors of crops, weeds, can only be effectively controlled in time with the utilization of proper herbicides. Based on the obtained results, it can be concluded that application of mesotrione 350 g ha^{-1} was best in managing weeds and found effective in enhancing yield of maize with higher net benefits and benefit cost ratio. This weed management strategy can be adopted by farmers to control diverse weeds in maize.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Gul H, Rahman S, Shahzad A, Gul S, Qian M, Xiao Q. Maize (*Zea mays* L.) productivity in response to nitrogen management in Pakistan. American Journal of Plant Science. 2021;12: 1173–1179.
   DOI: 10.4236/ajps.2021.1 28081
2. Kumar R, Bohra JS, Kumawat N, Kumar A, Kumari A, Singh AK. Root growth, productivity and profitability of baby corn (*Zea mays* L.) as influenced by nutrition levels under irrigated eco-system. Research on Crops. 2016;17:41-46.
3. Statista. 2018; Worldwide production of grain in 2017/18, by type (in million metric tons).
   Available:https://www.statista.com/statistics/263977/world-grain-production-by-type/
4. FAOSTAT. 2017; The Food and Agricultural Organization of the United Nations: The statistical database.
   Available:http://faostat.fao.org [Accessed 02.07.2017].

5. Anonymous. 2017. Annual Report 2021-2022, Department of Agriculture and Cooperation, Ministry of Agriculture, Government of Madhya Pradesh.
6. Verma B, Bhan M, Jha AK, Khatoon S, Raghuwanshi M, Bhayal L, Sahu MP, Patel Rajendra, Singh Vikash. Weeds of direct- seeded rice influenced by herbicide mixture. Pharma Innovation. 2022;11(2): 1080-1082.
7. Jha AK, Shrivastva A, Raghuvansi NS, Kantwa SR. Effect of weed control practices on fodder and seed productivity of Berseem in Kymore plateau and Satpura hill zone of Madhya Pradesh. Range Management and Agroforestry. 2014;35(1):61-65.
8. Sahu V, Kewat ML, Verma B, Singh R, Jha AK, Sahu MP, Porwal M. Effect of carfentrazone-ethyl on weed flora, growth and productivity in wheat. The Pharma Innovation Journal 2023;12(3):3621-3624.
9. Sahu MP, Kewat ML, Jha AK, Sondhia S, Choudhary VK, Jain N, Verma B. Weed prevalence, root nodulation and chickpea productivity influenced by weed management and crop residue mulch. AMA, Agricultural Mechanization in Asia, Africa and Latin America. 2022; 53(6):8511-8521.
10. Letourneau DK, Armbrecht I, Rivera BS, Lerma JM, Carmona EJ, Daza MC, Mejía JL. Does plant diversity benefit agroecosystems? A synthetic review. Ecological Applications. 2011;21(1):9-21.
11. Patel Raghav, Jha AK, Verma Badal, Kumbhare Rahul, Singh Richa. Bio-efficacy of pinoxaden as post-emergence herbicide against weeds in wheat crop. Pollution research. 2023;42(1):115-117.
12. Shiv Swati, Agrawal S.B., Verma Badal, Yadav Pushpendra Singh, Singh Richa, Porwal Muskan, Sisodiya Jirtendra and Patel Raghav. Weed dynamics and productivity of chickpea as affected by weed management practices. Pollution Research. 2023;42(2):21-24.
13. Tanisha Nirala, Jha AK, Badal Verma, Pushpendra Singh Yadav, Mahendra Anjna, Lakhan Bhalse. Bio efficacy of pinoxaden on weed flora and yield of wheat (Triticum aestivum L.). Biological Forum – An International Journal. 2022; 14(4):558-561.
14. Jha AK, Yadav PS, Shrivastava A, Upadhyay AK, Sekhawat LS, Verma B, Sahu MP. Effect of nutrient management practices on productivity of perennial grasses under high moisture condition. AMA, Agricultural Mechanization in Asia, Africa and Latin America. 2023;54(3):12283-12288.
15. Karlen DL, Cambardella CA, Bull CT, Chase CA, Gibson LR, Delate K. Producer–Researcher Interactions in On-Farm Research. Agronomy Journal. 2007;99(3):779-790.
16. Das A, Kumar M, Ramkrushna GI, Patel DP, Layek J, Naropongla Panwar AS, Ngachan SV. Weed management in maize under rainfed organic farming system. Indian Journal of Weed Science. 2016; 48(2):168–172.
17. Kantwa SR, Agrawal RK, Jha A, Pathan SH, Patil SD, Choudhary M. Effect of different herbicides on weed control efficiency, fodder and seed yields of berseem (*Trifolium alexandrinum* L.) in central India. Range Management and Agroforestry. 2019;40(2):323-328.
18. Verma B, Bhan M, Jha AK, Singh V, Patel R, Sahu MP, Kumar V. Weed management in direct-seeded rice through herbicidal mixtures under diverse agroecosystems. AMA, Agricultural Mechanization in Asia, Africa and Latin America. 2022;53(4): 7299- 7306.
19. Yadav PS, Kewat ML, Jha AK, Hemalatha K, Verma B. Effect of sowing management and herbicides on the weed dynamics of berseem (Trifolium alexandrinum). Pharma Innovation. 2023;12(2):2845-2848.
20. Walsh MJ, Stratford K, Stone K, Powles SB. Synergistic effects of Atrazine and mesotrione on susceptible and resistant wild radish (*Raphanus raphanistrum*) populations and the potential for overcoming resistance to triazine herbicides. Weed Technology. 2012;26(2): 341–347.
21. Bollman JD, Boerboom CM, Becker RL, Fritz VA. Efficacy and tolerance to HPPD-inhibiting herbicides in sweet corn. Weed Technology. 2008;22(4):666–674.
22. Gomez KA, Gomez AA. Statistical procedures for agricultural research. John wiley & sons; 1984.
23. Radheshyam, Jat SL, Parihar CM, Singh AK, Pooniya V, Singh Raj. Post-emergence herbicides efficacy for weed management in kharif maize (*Zea mays*). Indian Journal of Agricultural Sciences. 2021;91(11):1566–70.

24. Soliman IE, Gharib HS. Response of weeds and maize (Zea mays L.) to some weed control treatments under different nitrogen fertilizer rates. Zagazig Journal of Agricultural Research. 2011;38(2): 249-271.
25. Walsh MJ, Newman P, Chatfield P. Mesotrione: A new preemergence herbicide option for wild radish (Raphanus raphanistrum) control in wheat. Weed Technology. 2021;35(6):924-931.
26. Janak TW, Grichar WJ. Weed control in corn (*Zea mays* L.) as influenced by pre-emergence herbicides. International Journal of Agronomy; 2016. Available:http://dx.doi.org/10.1155/2016/2607671
27. Iqbal, Muhammad Aamir, Ahmad, Zahoor, Maqsood, Qaiser, Afzal, Sher, Ahmad, Mian. Optimizing Nitrogen Level to Improve Growth and Grain Yield of Spring Planted Irrigated Maize (*Zea mays* L.). Journal of Advanced Botany and Zoology. 2015;2:1-4.
28. Sinha SP, Prasad SM, Singh SJ. Nutrient utilization by winter maize (*Zea mays* L.) and weeds as influenced by integrated weed management. Indian Journal of Agronomy. 2005;50(4): 303-304.
29. Sharma CK, Gautam RC. Effect of tillage, Seed rate and weed control methods on weeds and maize (*Zea mays* L.). Indian Journal of Weed Science. 2006;38(1&2): 58-61.
30. Chhokar RS, Sharma RK, Gill SC, Singh RK. Mesotrione and atrazine combination to control diverse weed flora in maize; 2019.
31. Sharma AR, Toor AS, Sur HS. Effect of intercultural operations and scheduling of atrazine application on weed control and productivity of rainfed maize (Zea mays) in shiwalik foothills of Punjab. Indian Journal of Agricultural Sciences. 2000;70(11): 757–761.
32. Singh VP, Guru SK, Kumar A, Banga A, Tripathi N. Bioefficacy of tembotrione against mixed weed complex in maize. Indian Journal of Weed Science. 2012; 44(1):1–5.
33. Sarangi D, Jhala AJ. Biologically effective rates of a new premix (atrazine, bicyclopyrone, mesotrione, and S-metolachlor) for preemergence or postemergence control of common waterhemp [Amaranthus tuberculatus (Moq.) Sauer var. rudis] in corn. Canadian Journal of Plant Science. 2017;97(6): 1075-1089.
34. Sharma Puscal, Duary Buddhadeb, Singh Raghvendra. Tank mix application of tembotrione and atrazine to reduce weed growth and increase productivity of maize. Indian Journal of Weed Science. 2018;50(3):305–308.
35. Kamble TC, Kakade SU, Nemade SU, Pawar RV, Apotikar VA. Integrated weed management in hybrid maize. Crop Research. 2005;29(3):396-400.

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