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RESEARCH NOTE

Integrated strategies for effective weed management and improved yield of maize

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ABSTRACT

The impact of integrated weed management practices (herbicides and mulching) on weeds and morpho-physiological traits and the yield of maize was evaluated in a field experiment using a split plot design with three replications during rainy (*Kharif*) season 2022. The treatments comprised of three levels of rice straw mulch in main plots and five weed management treatments in subplots. The higher the level of residue (8 t/ha), the greater was the reduction in weed incidence, weed biomass, and weeds nutrient uptake, which ultimately resulted in better maize growth and yield when compared to residue level of 5 t/ha and no residue mulch. Among weed management options, sequential use of atrazine 1.0 kg/ha followed by tembotrione 0.120 kg/ha resulted in grater reduction in weed density, biomass and nutrient uptake per unit area which led to improved maize morphological and physiological parameters, higher yield, harvest index and nutrient uptake.

Keywords: Atrazine, Maize, Mulching, Rice straw, Tembotrione, Topramezone

Maize (*Zea mays* L.), also known as the "Queen of cereals" owing to its higher yield potential, possesses greater adaptability to diverse agroclimatic conditions and has a versatile usage. But wider spacing and slow initial growth results in greater infestation by various types of weeds leading to severe competition from weeds for inputs such as sunlight, moisture, and nutrients resulting in maize yield loss of 28% to 100% (Das 2008, Patel *et al*. 2006). Thus, effective weed management plays crucial role in maize yield enhancement (Ramesh *et al*. 2017). Manual controlling of weeds although provides satisfactory results, is time consuming and expensive due to its higher labour requirement and most often is not practiced by farmers during the most crucial period of competition for resources between crop and weeds as hand weeding is impractical and uneconomical (Das 2001, Rao *et al*. 2020, Kaul *et al*. 2023).

Weed management using herbicides can be done with comparatively lower cost but sole and continuous herbicide use is not environmentally advisable due to the possibility of resistance development and adverse impact of the herbicides. Sequential use of herbicides with different mode of action instead of single pre- or post- emergence herbicide will be able to address this issue. Post-emergence herbicide application also takes care of the competition for resources caused by weeds even at the later stages. Use of rice straw mulch to suppress weeds as a cultural practice is a viable option as well (Singh *et al*. 2022). Therefore, combining the rice straw mulch and herbicides can offer effective weed management to enhance the maize growth and productivity. Thus, a study was conducted to assess the integrated effect of herbicides and mulch as components of integrated weed management options on the weeds as well as the growth and yield of maize.

The field experiment was conducted at Baronda farm of *ICAR- National Institute of Biotic Stress Management, Raipur, Chhattisgarh* during rainy (*Kharif*) season of 2022. The experimental site had a clayey textured soil with 7.4 pH value, 0.62% organic carbon, 188 kg/ha available N (low), 13.4 kg/ha available P (medium) and 210 kg/ha K (medium). Split plot design having 15 treatment combinations with three replications for each treatment was adopted for laying out the experiment. Three levels of rice straw mulch (RSM) *viz*. 8 t/ha, 5 t/ha, no mulch were assigned in main plots and five herbicidal weed

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management options were in the subplot which include: pre-emergence application (PE) of atrazine 1.0 kg/ha (atrazine PE), atrazine 1.0 kg/ha followed by (*fb*) post-emergence application (PoE) of tembotrione 0.120 kg/ha (atrazine PE *fb* tembotrione PoE), atrazine 1.0 kg/ha followed by topramezone 0.030 kg/ha (atrazine PE *fb* topramezone PoE), weed free check and weedy check. Maize hybrid variety *Super 459 Gold* was sown at 0.60 m × 0.25 m spacing on 25th of July, 2022. The pre-emergence application was carried out 2 days after sowing (DAS) while tembotrione and topramezone were applied at 25 DAS, as per the treatments. Recommended N, P and K doses (120 kg, 26.2 kg and 33.2 kg/ha, respectively) were applied using urea, DAP and MOP. Three split applications of N including one basal and full dose of P and K as basal were done. Square-root transformation ($\sqrt{x+0.5}$) of weed density and dry matter (biomass) data was done before statistical analysis (Das 1999). Data analysis was carried out using the analysis of variance (ANOVA) recommended for split plot design in OPStat software and the treatment means were compared by Fisher's least significant difference test at 5% level of significance (Gomez and Gomez 1984).

The experimental plot was dominated by the weed species such as *Echinochloa colona*, *Cynodon dactylon* (grasses), *Physalis minima*, *Alternanthera sessilis*, *Commelina benghalensis*, *Ludwigia parviflora* (broad-leaved) and *Cyperus rotundus* (sedge) at 60 DAS. The highest weed density and biomass were recorded when straw mulch was not applied and were reduced with mulching. RSM 8 t/ha and RSM 5 t/ha lowered the weed density by 45.3% and 34.4%, respectively while weed biomass was reduced by 37.0% and 19.9% (**Table 1**). The highest weed density and biomass were found in weedy check plot. Sequential application of atrazine PE *fb* tembotrione PoE significantly reduced weed density and weed biomass which was statistically at par with atrazine PE *fb* topramezone PoE . Higher weed

Table 1. Effect of rice straw mulch and weed management treatments on weed density, weed biomass and their percent reduction in maize

Treatment	Weed density (no./m^2)	Weed biomass (g/m^2)	Weed density reduction (%)	Weed biomass reduction (%)
Rice straw mulch (RSM)				
RSM 8 t/ha	5.0 (31.1)*^{c}	6.1 (47.6)^{c}	45.4	37.1
RSM 5 t/ha	5.5 (37.3)^{b}	6.8 (60.5)^{b}	34.4	20.0
No mulch	6.6 (56.9)^{a}	7.6 (75.6)^{a}	0.0	0.0
Weed management				
Atrazine PE	6.6 (44.2)^{b}	7.9 (62.6)^{b}	57.7	60.8
Atrazine PE *fb* tembotrione PoE	5.4 (28.4)^{c}	6.2 (38.4)^{d}	72.8	75.9
Atrazine PE *fb* topramezone PoE	5.6 (31.6)^{c}	6.8 (45.7)^{c}	69.9	71.5
Weed free check	0.7 (0.0)^{d}	0.7 (0.0)^{e}	100.0	100.0
Weedy check	10.1 (104.7)^{a}	12.6 (159.5)^{a}	0.0	0.0
Interaction	S	S	-	-

(*Original values are given in the parentheses); *fb* = followed by; PE = pre-emergence application; PoE = post-emergence application

Table 2. Effect of rice straw mulch and weed management treatments on maize morpho-physiological traits at 60 DAS, yield attributes and yield of maize

Treatment	Plant height (cm)	LAI	Dry matter accumulation (g/m^2)	SPAD	CGR (g/m^2/ day)	Cob length (cm)	Grains /row	Grains /cob	Grain yield (t/ha)	Harvest Index (%)
Rice straw mulch (RSM)										
RSM 8 t/ha	179.7^{a}	4.10^{a}	623.2^{a}	48.67^{a}	15.40^{a}	16.5^{a}	35.2^{a}	427.7^{a}	5.68^{a}	44.9^{a}
RSM 5 t/ha	176.0^{b}	3.86^{b}	588.1^{b}	46.78^{b}	14.55^{b}	13.8^{a}	33.7^{a}	392.3^{b}	5.34^{b}	43.5^{b}
No mulch	170.4^{c}	3.28^{c}	575.7^{c}	43.57^{c}	14.08^{c}	12.4^{a}	31.9^{a}	357.6^{c}	4.63^{c}	42.2^{c}
Weed management										
Atrazine PE	173.5^{c}	3.41^{d}	554.0^{d}	37.46^{c}	13.21^{d}	14.0^{c}	31.3^{d}	374.9^{d}	5.04^{d}	42.6^{c}
Atrazine PE *fb* tembotrione PoE	179.6^{b}	4.02^{b}	612.8^{b}	55.96^{b}	15.81^{b}	15.4^{b}	34.0^{b}	397.6^{b}	5.69^{b}	44.2^{b}
Atrazine PE *fb* topramezone PoE	177.3^{b}	3.79^{c}	598.9^{c}	55.02^{b}	14.55^{c}	14.8^{b}	33.3^{c}	385.1^{c}	5.44^{c}	43.7^{b}
Weed free check	182.9^{a}	4.28^{a}	691.7^{a}	58.89^{a}	17.36^{a}	16.3^{a}	38.9^{a}	472.4^{a}	6.18^{a}	45.6^{a}
Weedy check	163.7^{d}	3.23^{e}	520.8^{e}	24.39^{d}	12.45^{e}	11.0^{d}	30.6^{e}	332.7^{e}	3.73^{e}	41.4^{d}
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	S	NS

fb = followed by; PE = pre-emergence application; PoE = post-emergence application

control in the two sequential herbicide treatments was achieved possibly due to activity of atrazine which controlled grassy and broad-leaved weeds in the initial stages while tembotrione and topramezone PoE controlled weeds at later stage due to their broad-spectrum action.

The RSM 8 t/ha recorded the maximum maize plant height among the straw mulch treatments while the lowest plant height was recorded from weedy check due to severe competition caused by the weeds (**Table 2**). Herbicide usage reduced weed density and biomass which favoured greater maize plant growth due to adequate resource availability (Ehsas *et al*. 2016). Height of maize was statistically at par in atrazine PE *fb* tembotrione PoE and atrazine PE *fb* topramezone PoE. Leaf area index (LAI) is the indicator of source size and therefore plays important role in photosynthesis. The greater weed suppression and availability of growth factors resulted in higher LAI and maize dry matter accumulation per unit area and crop growth rate (CGR). RSM 8 t/ha recorded statistically higher values of maize LAI and dry matter accumulation per unit area in comparison with RSM 5 t/ha and no mulch. Atrazine PE *fb* tembotrione PoE recorded significantly higher LAI than atrazine PE *fb* topramezone PoE and atrazine PE. Maximum LAI, however was obtained in weed free check. Level of chlorophyll content in leaves implies variation in photosynthetic efficiency of the crop which influences the crop growth and ultimately the yield. The leaf chlorophyll content (in terms of SPAD value) recorded at 60 DAS was higher in the 8 t/ha straw mulch and it was statistically at par with that of 5 t/ha mulch application. No mulch treatment recorded the lowest value. Atrazine PE *fb* tembotrione PoE recorded significantly higher chlorophyll content in leaves, dry matter accumulation per unit area and CGR which were statistically similar to the value observed in atrazine PE *fb* topramezone PoE. Minimum SPAD reading, dry matter accumulation per unit area, and CGR were recorded from weedy check plots.

Yield attributes such as cob length, no. of grains/row and no. of grains/cob were found to be higher in the 8 t/ha straw mulch. Atrazine PE *fb* tembotrione PoE recorded significantly higher values of aforementioned yield attributes as compared to atrazine PE *fb* topramezone PoE and atrazine PE. The highest maize grain yield was recorded with RSM 8 t/ha which was 22.6% higher compared to no mulch (**Table 2**). Shah *et al*. (2014) also made similar observations. Atrazine PE *fb* tembotrione PoE recorded the highest grain yield (5.69 t/ha) and it was significantly higher than all the other treatments tested. Percentage yield increase in atrazine PE *fb* tembotrione PoE and atrazine PE *fb* topramezone PoE was 52.5% and 45.8% respectively over weedy check. Ghasiram *et al*. (2020) also reported similar results. Harvest index followed similar trend as maize grain yield.

The lowest N, P and K uptake by weeds at harvest and highest uptake by maize was observed with 8 t/ha rice straw mulch due to less weed occurrence and subsequent growth (**Table 3**; **Figure 1**). Likewise, use of atrazine PE *fb* tembotrione PoE and atrazine PE *fb* topramezone PoE recorded the lower nutrient uptake by weeds and higher uptake by maize, which were statistically at par. Profuse weed growth without any control measures caused highest nutrient uptake in weedy check.

It can be concluded that application of rice straw mulch 8 t/ha in combination with sequential application of atrazine 1 kg/ha PE *fb* tembotrione 0.120 kg/ha PoE at 25 DAS recorded better weed control with significantly lower weed density and biomass resulting in improved maize growth parameters, higher maize yield and harvest index.

Table 3. Effect of rice straw mulch and weed management treatments on nutrient uptake by maize crop at harvest

Treatment	N uptake (kg/ha)			P uptake (kg/ha)			K uptake (kg/ha)		
	Grain	Stover	Total	Grain	Stover	Total	Grain	Stover	Total
Rice straw mulch (RSM)									
RSM 8 t/ha	79.2^{a}	30.2^{a}	109.4^{a}	33.4^{a}	20.3^{a}	53.7^{a}	19.8^{a}	73.1^{a}	93.0^{a}
RSM 5 t/ha	73.4^{b}	28.1^{b}	101.5^{b}	30.8^{b}	19.3^{b}	50.1^{b}	17.8^{b}	69.9^{b}	87.7^{b}
No mulch	61.3^{c}	24.3^{c}	85.6^{c}	25.7^{c}	17.7^{c}	43.4^{c}	14.8^{c}	64.2^{c}	79.0^{c}
Weed management									
Atrazine PE	68.1^{d}	25.5^{d}	93.6^{d}	28.4^{d}	18.0^{d}	46.4^{d}	15.8^{d}	66.8^{c}	82.5^{d}
Atrazine PE *fb* tembotrione PoE	78.3^{b}	29.1^{b}	107.4^{b}	33.3^{b}	20.6^{b}	53.8^{b}	19.3^{b}	72.7^{b}	92.0^{b}
Atrazine PE *fb* topramezone PoE	74.2^{c}	28.1^{c}	102.3^{c}	31.1^{c}	18.9^{c}	50.1^{c}	18.1^{c}	70.1^{b}	88.2^{c}
Weed free check	86.6^{a}	35.1^{a}	121.7^{a}	36.9^{a}	24.5^{a}	61.4^{a}	23.2^{a}	82.1^{a}	105.3^{a}
Weedy check	49.2^{e}	19.9^{e}	69.1^{e}	20.2^{e}	13.5^{e}	33.7^{e}	11.1^{e}	53.6^{d}	64.7^{e}
Interaction	S	S	S	S	S	S	S	NS	S

fb = followed by; PE = pre-emergence application; PoE = post-emergence application

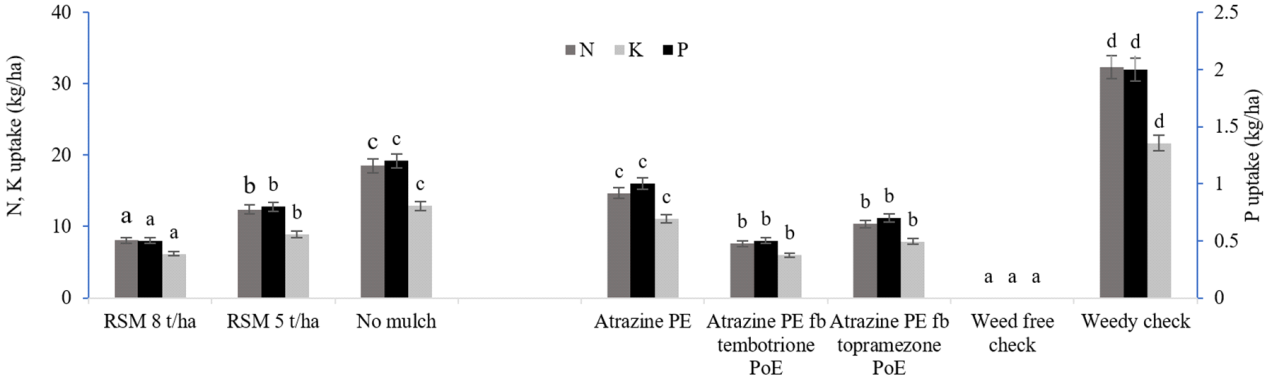

Figure 1. Effect of rice straw mulch and weed management treatments on nutrient uptake by weeds at harvest

RSM = rice straw mulch; *fb* = followed by; PE = pre-emergence application; PoE = post-emergence application

REFERENCES

Das TK. 1999. Is transformation of weed data always necessary? *Annals of Agricultural Research* **20**: 335–341.

Das TK. 2001. Towards better appraisal of herbicide bio-efficacy. *Indian Journal of Agricultural Sciences* **71**(10): 676–678.

Das TK. 2008. Weed Science: Basics and Applications. 1st Edition, Jain Brothers Publishers, New Delhi, Delhi, India.

Ehsas J, Desai LJ, Ahir NB and Joshi JR. 2016. Effect of integrated weed management on growth, yield, yield attributes and weed parameters on summer maize (*Zea mays* L.) under South Gujarat condition. *International Journal of Science, Environment and Technology* **5**(4): 2050–2056.

Ghrasiram KM, Kumar V, Kumar M and Laik, RK. 2020. Effect of alone and tank mix application of herbicides on weed infestation and productivity of kharif maize (*Zea mays* L.). *Journal of Cereal Research* **12**(3): 264–269.

Gomez KA and Gomez AA. 1984. Statistical Procedures for Agricultural Research (2 Ed.). John Wiley and Sons, New York.

Kaul A, Singh B and Singh M. 2023. Weed management with pre-and post-emergence herbicides in Kharif maize in sub-mountainous area of Punjab, India. *Indian Journal of Weed Science* **55**(1): 32–35.

Patel VJ, Upadhyay PN, Patel JB and Meisuriya MI. 2006. Effect of herbicide mixture on weeds in Kharif maize (*Zea mays* L.) under middle Gujarat conditions. *Indian Journal of Weed Science* **38**(1&2): 54–57.

Ramesh K, Rao AN and Chauhan BS. 2017. Role of crop competition in managing weeds in rice, wheat, and maize in India: A review. *Crop Protection* **97**: 14–21

Rao, AN, Singh RG, Mahajan G and Wani SP. 2020. Weed research issues, challenges, and opportunities in India. *Crop Protection* **134**: 104451

Shah FU, Sajid GM and Siddiqui SU. 2014. Evaluation of mulching materials as integrated weed management component in maize crop. *Pakistan Journal of Agricultural Research* **27**(2).

Singh SP, Dash S, Chowdhury MR, Nanda SS, Sar K, Behera B and Gulati JML. 2022. Effect of integrated application of herbicides and straw mulch on productivity and profitability of rainfed upland rice (*Oryza sativa*). *Indian Journal of Agronomy* **67**(3): 316–319.