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Influence of integrated weed management on growth and yield of maize (*Zea mays* L.)

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Abstract
This research thesis investigates the impact of different weed management strategies, including lemongrass mulch, atrazine, and tembotrione, in conjunction with biodegradable polythene mulch, on the growth, yield, and quality of crops. The study was conducted to evaluate how these treatments influence various agronomic parameters such as plant height, leaf area, chlorophyll content, root length, dry matter production, grain yield, stover yield, and economic returns.

The experimental design included a comparative analysis of these treatments to understand their effectiveness in enhancing plant growth and optimizing yield. The results demonstrated that the integration of lemongrass mulch with atrazine and tembotrione, along with the use of biodegradable polythene mulch, significantly improved key growth indicators and yield parameters. Specifically, plants under these treatments exhibited increased height, enhanced leaf area, and superior chlorophyll content. Furthermore, these treatments contributed to higher dry matter production, improved root development, and increased grain and stover yields.

The study also highlighted the beneficial effects of lemongrass mulch on soil organic carbon content, indicating potential long-term improvements in soil health and fertility. Weed control was notably more effective with these treatments, reducing competition for resources and enhancing crop productivity. The findings suggest that combining organic mulches with selective herbicides and biodegradable materials offers a sustainable approach to crop management, maximizing both yield and economic returns. This research provides valuable insights for farmers and agricultural practitioners seeking to enhance crop performance while promoting sustainable farming practices.

Keywords: Integrated, weed, grains, herbicide, seed index and stover yield

Introduction
Corn, scientifically known as maize (*Zea mays* L.), is believed to have originated from a wild grass in central Mexico around 7000 years ago. Indigenous peoples of the region cultivated maize, enhancing its nutritional value and turning it into a vital food source. Today, maize is recognized for its adaptability and versatility, being grown across various climates and seasons for numerous uses. It ranks as the second most significant cereal crop globally in terms of production, often regarded as the "king of cereals" due to its high genetic yield potential. In peri-urban areas, maize is cultivated for multiple purposes, including grain, fodder, green cobs, sweet corn, baby corn, and popcorn.

In India, maize production is led by Andhra Pradesh, which contributes 20.9% of the total maize yield. Other major maize-producing states include Karnataka (16.5%), Rajasthan (9.9%), Maharashtra (9.1%), Bihar (8.9%), Uttar Pradesh (6.1%), Madhya Pradesh (5.7%), and Himachal Pradesh (4.4%). Maize's adaptability allows it to be grown in various agro- ecological zones, making it a crucial element in crop diversification. It occupies approximately 99 lakh hectares in India, producing around 315 lakh tons with a yield of 3180 kg/ha. Maize plays a significant role in ensuring food security in the state and is used for direct consumption as well as in piggery and poultry. The increase in maize cultivation reflects its potential to boost the state's economy.

Maize is notable for its high starch content of about 72%, protein content of 10%, and fat content of 4%, providing an energy density of 365 kcal per 100 grams. It is widely grown and consumed across the globe, with the United States, China, and Brazil being the top producers.

These three countries together account for roughly 563 million metric tons of the annual global production of 717 million metric tons. Maize is processed into a variety of products, including starch, sugars, oil, industrial alcohol, and ethanol.

Despite its robust physical presence, maize is highly sensitive to weed competition, especially in its early stages (Mabasa *et al*., 1996) [3]. Weed-related losses in maize can exceed 30%, and unchecked weed growth can lead to yield reductions of up to 90% (Madrid and Vega, 1976) [4]. To mitigate these losses and develop effective crop management strategies, understanding the dynamics of crop-weed competition is essential. Weeds and crops vie for vital resources such as moisture, nutrients, and light, which can hinder crop growth and harvesting operations (Ratta *et al*., 1991) [8]. Identifying and managing the critical periods of weed competition is crucial for optimizing input use and minimizing negative impacts on crop yields.

An integrated weed management (IWM) approach is vital for reducing weed-related losses. Manual weeding alone is often insufficient; it should be complemented with chemical methods such as herbicides for effective control. The choice of herbicides is crucial for the success of weed control programs. Pre-emergence and post-emergence herbicides can manage weeds effectively without altering existing agronomic practices. Pre-emergence herbicides are effective in controlling early weed competition and preventing nutrient depletion, while post-emergence herbicides help manage weeds during critical growth stages. Applying post-emergence herbicides between 40 and 45 days after sowing can prevent weed problems during later growth stages.

Farmers often rely on earthing up for weed control due to limited knowledge of more effective methods. Single control measures are rarely sufficient for comprehensive weed management. However, implementing various components of IWM can lead to significant improvements in weed control practices.

Materials and Methods

The experiment was carried out at the Research farm of the Department of Agronomy, School of Agriculture Science, Technology & Research, Sardar Patel University, Balaghat (M.P.). The experiment was conducted in a randomized complete block design with three replications. Different Integrated Weed Management will be allocated to the plots as per treatments. The seed rate used as 15 kg/ha for sowing with 60.0 x 20.0 cm row-to-row and plant-to-plant distance. The treatments were Farmers practice i.e. manual weeding (T_1), Recommended practice (Atrazine 1kg/ha PE) (T_2), Weedy fallow (T_3), PE application of atrazine 0.5 kg/ha followed by PoE application of tembotrione 120 g/h (T_4), Live mulching with cowpea (T_5), Live mulching with green gram (T_6), Mulching with lemongrass (T_7), Mulching with biodegradable polythene (T_8), Weedy check (T_9) and Weed free check (T_{10}). The gross and net plot size was 684 m^2 and 578 m^2, respectively. The fertilizer grades were applied as per RDF. All the other agronomic practices were applied uniformly to all the treatments. The experiment will be consisting of the following factors along with their respective levels.

Results and Discussion

In all the treatments the plant height of maize was found to increase progressively over time and attained the highest value when it was harvested at physiological maturity stage (110 DAS). There was significant variation in plant height at all the growth stages of the crop. The plant height varied significantly due to mulching and the highest values were recorded with mulching with lemongrass leaves (T7). The height of the crop at 25 DAS and 50 DAS was found to be highest under pre-emergence application of atrazine 0.5 kg ha^{-1} f.b. PoE application of tembotrione 120 g ha^{-1}(T4) with 32.13 and 85.20 cm, respectively (Table). This may be due to efficacy of atrazine and tembotrione and lesser weed density and weed biomass during initial days of crop growth, while the highest height of maize at 75 DAS and 100 DAS were found to be recorded under mulching with lemongrass leaves (T7) with 159.03 and 168.47 cm, respectively. It may be due to the capacity of mulches to suppress weeds leading to reduce weed density and biomass of weeds and also minimize evaporation and increase soil water retention (Zong *et al.*, 2021) [11]. The outcome is somewhat comparable to that observed by Kumar *et al*. (2012) [2], who observed that soil mulching increased the amount of moisture that could be stored in the soil profile and considerably improved plant water use efficiency. The application of straw mulch has helped in better moisture conservation in the treated plot and might have helped in more nutrient’s uptake by the crops. This has boosted faster vegetative growth in the plots treated with mulch. The lowest plant height in weedy check (T9) might be due to more competition between crop and weed for moisture, nutrient, light and high weed density and biomass. These results conform with observation of Kaur and Mahal (2012) [1].

The leaf area index was found to increase up to 75 DAS reaching significantly the highest value of 5.52 under mulching with lemongrass (T7) and thereafter a gradual decline (Table). It might be because mulch leads to less crop-weed competition leading to weed suppression and reduce weed density and biomass which allowed for the maintenance of high levels of photosynthesis in the leaves. The decrease in LAI towards the maturity may be due to loss of some older leaves through senescence and slower growth rate towards maturity of the crop.

The effect of lemongrass mulches (T_7) was found to be significantly higher than other weed management practices except farmers’ practice of manual weeding (T_1) and weedy check (T_9) in case of number of cobs/plant, Increased the values of yield attributes under these weed management practices might be due to the minimum competition of the crops with weeds for absorption of water and nutrients from the soil which may have speed up plant growth, boosting the LAI, plant biomass and yield (Qin *et al*., 2012) [7]. Highest no. of cobs/ plant with mulching with lemongrass (T_7) might be due to significant reduction in crop weed competition due to effective control of weeds under this treatment reflected in better growth and development of the crop. These results are in close conformity with the findings of Nadiger *et al.* (2013) [6] and Mandal *et al*. (2004) [5].

The results revealed that the number of grain rows/cob was found to be highest under mulching with lemongrass leaves (T7) and remained at par with pre-emergence application of atrazine 0.5 kg ha^{-1} f.b. PoE application of tembotrione 120 g ha^{-1} (T4) and mulching with biodegradable polythene (T8) and season long weed free management (T10). The present investigation is by Kumar (2012) [2], who found that mulching increased the amount of moisture that could be stored in the soil profile and making availability of more soil moisture during the critical cropping period which considerably improved plant water use efficiency. Also, this might be due to significant reduction in crop weed competition due to effective control of weeds under this treatment reflected in better growth and development of the crop. These results are in close conformity with the findings of

Nadiger *et al.* (2013) [6] and Mandal *et al*. (2004) [5].

The results displayed that cob weight without husk and grain weight/ cob was found to be highest under mulching with lemongrass leaves (T7) which remained at par with pre-emergence application of atrazine 0.5 kg ha^{-1} f.b. PoE application of tembotrione 120 g ha^{-1} (T4), mulching with biodegradable polythene (T8) and weed free check (T10). Highest cob weight without husk and grain weight per cob was found with mulching with lemongrass (T7) might be due to significant reduction in crop weed competition due to effective control of weeds under this treatment reflected in better growth and development of the crop. These results are in close conformity with the findings of Nadiger *et al.* (2013) [6] and Mandal *et al*. (2004) [5]. This might also be due to the availability of more soil moisture under mulching during the critical cropping period. The grain yield, stover yield, biological yield and harvest index were found to be highest under mulching with lemongrass leaves (T_7) and found to be at par with pre-emergence application of atrazine 0.5 kg ha^{-1} f.b. PoE application of tembotrione 120 g ha^{-1} (T_4), mulching with biodegradable polythene (T_8) and weed free check (T_{10}). The increase in grain yield, stover yield, biological yield and harvest index under mulching with lemongrass could be explained based on less crop-weed competition due to reduction in weed density and biomass and also beneficial effect of lower temperature, the mulch treatments led to bigger yield gains compared to other treatments. Also plant residue mulch provided soil macro invertebrates with a lot of food, nutrients to support vegetation growth, and a favourable environment for crop growth and yield (Suseendran *et al*., 2019) [10].

The primary determinant of whether a grower will adopt any enhanced techniques is the cost of production. Another crucial factor that establishes usefulness of a treatment and acceptance by the farmer is its benefit-cost ratio. In the present study, under integrated weed management practices, after estimation of the total cost incurred in each treatment and calculation of yield, it was found that the gross return was found to be highest in mulching with lemongrass leaves (T7) followed by mulching with biodegradable polythene film (T8). But the net return was found to be highest in mulching with lemongrass leaves (T7) and pre- emergence application of atrazine 0.5 kg ha^{-1} f.b. by PoE application of tembotrione 120 g ha^{-1} (T4). This is due to high cost involvement in biodegradable polythene mulch and B-C ratio was found highest in mulching with lemongrass leaves (T7). This is because the only extra cost involved in this treatment is purchase of lemongrass leaves. However, the yield obtained from the treatment was higher which helped in getting the highest B:C ratio of 2.16 (Table) for the treatment. These results are in close conformity with those of Senapati (2022) [9]. Therefore, application of lemongrass leaf mulch (T7) and pre-emergence application of atrazine 0.5 kg ha^{-1} f.b. PoE application of tembotrione 120 g ha^{-1} (T4) are more profitable than other treatments of weed management for cultivation of maize.

Table 1: Influence of integrated weed management on yield potential of maize (*Zea mays* L.)

Treatment	Number of cobs/ plants	Number of grain rows/cob	Cob weight Without husk (q ha^{-1})	Gain weight per cob (q ha^{-1})	Grain yield (q ha^{-1})	Biologiocal yield (q ha^{-1})	Stover yield (q ha^{-1})	HI (%)
Farmers practice *i.e*. manual weeding	1.28	25.06	76.13	53.66	53.66	131.11	77.45	40.80
Recommended practice (Atrazine 1kg ha^{-1} PE)	-	-	-	-	60.59	144.69	84.10	42.66
Weedy fallow	1.68	26.69	82.10	60.59	-	-	-	-
Atrazine 0.5 kg ha^{-1} PE f.b. tembotrione 120 g ha^{-1} PoE	-	-	-	-	64.48	152.31	87.83	43.74
Live mulching with cowpea	1.76	27.41	87.19	64.48	57.91	141.31	83.40	41.33
Live mulching with green Gram	1.72	26.54	80.84	57.91	56.81	141.21	84.40	41.67
Mulching with lemon grass	1.73	26.01	82.96	56.81	69.15	165.12	95.97	46.84
Mulching with biodegradable	1.91	28.93	90.68	69.15	65.70	158.23	92.53	45.41
polythene	1.86	28.84	86.33	65.70	-	-	-	-
Weedy check	1.04	21.97	70.92	48.33	48.33	117.46	69.13	37.45
Weed free check	1.84	27.76	89.64	65.07	65.07	154.14	89.07	44.07
SEm(±)	0.17	1.84	2.21	3.45	3.45	3.71	3.97	1.46
C.D (P=0.05)	0.57	5.63	6.63	9.32	9.32	9.37	9.42	3.10

Conclusion

The study concluded that integrating lemongrass mulch with atrazine and tembotrione treatments and using biodegradable polythene mulch significantly enhanced the growth and yield of the crop. These treatments promoted better plant height, leaf area, chlorophyll content, and dry matter production, leading to superior grain and stover yields. The improved root length and nutrient availability under these conditions further contributed to overall plant health and productivity. Additionally, the effective weed control provided by these treatments reduced competition for resources, resulting in higher grain quality and increased economic returns. The findings highlight the importance of combining organic lemongrass mulch treatment demonstrated the added benefit of enhancing soil organic carbon content, indicating its potential to improve soil health over time. This approach not only maximized yield in the current season but also set the stage for improved fertility and reduced weed pressure in future cropping cycles. Therefore, these strategies are recommended for farmers aiming to optimize both crop yield and economic returns.

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