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EVALUATION OF DIFFERENT WEED MANAGEMENT PRACTICES ON THE YIELD OF SPRING MAIZE IN GAURADAHA, JHAPA

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ABSTRACT

Maize is more likely to have weed infestations due to its steady early growth rate and extensive row spacing, which favor weed development even before crop emergence. As a result, there prevails strong correlation between weed density and maize yield. An experiment was conducted at the Gauradaha Agriculture Campus, Jhapa, in the spring of 2022 to assess the effect of various weed control methods on maize yield. The experiment had three replications and eight treatments (control, cover crops, hand weeding at intervals of 15 days, botanical weedicides, inorganic weedicides, black plastic mulch, straw mulch, and small inter-row spacing). The number of cobs per hectare, sterility%, and shelling% were not significantly affected by various treatments. The use of black plastic mulching for weed management achieved significantly higher numbers of grain/cob (427.83), row/cob (13.40), weight of grain/cob (153.33gm), test weight, and yield (8.46t/ha). Similarly, the lowest test weight was recorded in T8 (111), i.e., the small inter-row spacing plot. While the lowest yield was observed in T4, i.e., botanical weedicides (3.20). This study found that plastic mulching had a positive impact on the majority of yield and yield-attributing indicators in spring maize, which could be helpful in weed-control strategies.

1. INTRODUCTION

Maize (*Zea mays*) belongs to the tribe Maydeae of the Poaceae family. Due to its greater tolerance to a variety of environmental conditions and higher productivity, maize is sometimes known as the “queen of grains” (Begam *et al*., 2018). With the versatility to be used as food, feed, and fodder, maize is Nepal’s second-most significant cereal crop after rice (Karki *et al*., 2015). The grains of the maize crop are very nutritious and include considerable levels of carbohydrates (44.60-69.60%), protein (9.87%), minerals (1.10–2.95%), fat (2.17–4.43%), and fiber (2.10–26.70%) (Enyisi *et al.,* 2014). The most adaptable crop, maize, is grown in more than 166 nations around the world, encompassing tropical, subtropical, and temperate zones (ANGRAU, 2021). In the world, it is grown on roughly 201.98 million ha, yielding 1162.35 million tons and averaging 5.75 tons/ha in productivity (FAOSTAT, 2020). It is estimated that weeds cause 37% of the global yield losses in maize (Sharma *et al.,* 2022). Asia provides 32% of the world’s total maize production and 34% of the world’s total maize-producing land (CGIAR, 2022).

Maize is a versatile crop and has remarkable adaptability under varied agro-climatic conditions (Yadav *et al.*, 2015). With a total yield of 2,997,733 MT and an average productivity of 3.05 MT per ha, maize is grown on 979,776 ha of land. About 6.83% of agricultural GDP comes from maize (MoAD, 2022). The country’s low maize productivity is a result of numerous production restrictions. Among them, weed infestation has been a serious problem limiting maize production globally. Any weed management method, whether cultural, mechanical, biological, or chemical, aims to make the environment unfavorable for weeds (Harker and O’Donovan, 2013). In Nepal, hybrid technology has been introduced to improve maize yield. Nepal, however, lacks a lot of site-specific hybrids (Kandel and Shrestha 2020). The grain production of spring maize was lowered by 37.17% due to weed infestation (Shrivastav *et al.,* 2015). Weeds are typically omnipresent, robust species with rapid growth and deep roots, and they are quite capable of competing with cultivated crops for the available resources, which on the other side actually harms crop growth and productivity. Worldwide yield losses in maize due to weeds are estimated at around 37% (Sharma *et al*.,2022).

An experiment at ARS Pakhribas (in Nepal's eastern mid-hill) found yield reductions of up to 70% in maize grown in weedy environments (Mishra, 2004). Since, maize has a steady early growth rate and wide row spacing in comparison to other cereals, weed encroachment is seen as a severe problem. Wide spacing between maize rows, frequent irrigation, and the intensive use of chemical fertilizers all promote yield loss by creating an atmosphere that is suitable for weed growth (Fanadzo *et al*., 2007; Bajwa *et al.,* 2014). Herbicides are heavily utilized in maize weed control, although there are also a number of cultural and mechanical techniques. As a result, knowledge of the harmful effects of weed competition and contamination as well as their effective control strategies is equally crucial for successful maize production. Early weed interference in maize development would increase plant-to-plant variability in dry matter accumulation, lowering grain production at maturity (Cerrudo *et al*., 2012). Between four and seven weeks after sowing, or the critical period of weed control (CPWC), maize plants are more susceptible to competition from nearby weedy plants (Shrestha *et al*., 2019). For efficient maize production, it is also crucial to comprehend the negative effects of weed competition and contamination, as well as their appropriate control strategies. Therefore, in the present investigation, we carried out a study to evaluate the role of different weed management practices in improving the yield of maize and suppressing weed flora and select the best one for the Gauradaha, Jhapa. The objective of the study was to eliminate weed seed before germination, and develop the best technique for weed management that would increase maize to motivate farmers to continue maize farming and achieve its potential.

2. MATERIALS AND METHODS:

2.1. Experimental site

A field experiment was conducted at the Gauradaha Campus, Institute of Agriculture and Animal Science, Jhapa, during the spring season of 2022. Geographically, the area is located at 26.56° N latitude and 87.72° E longitude, with an elevation of 79 meters above sea level. It was conducted in a Randomized Complete Block Design (RCBD) with eight treatments and three replications.

2.2. Maize sample

The maize seed variety Arun-2 used in this experiment was provided by National Maize Research Program (NMRP), Bharatpur, Chitwan.

2.3. Land preparation and crop management

Land preparation was carried out three days before maize sowing using a power tiller and a spade to break up clods manually. Farm Yard Manure (FYM) was incorporated @ 6 tons per hectare during final land preparation. A series of shallow furrows were dug, dividing the entire field into flat beds of manageable length and width. The size of the individual plot was 4m×3.5m ($14m^2$). The seed rate was 25–30kg per ha with row spacing of 70cm and plant-to-plant distance of 25cm, except for T8 (narrow inter-row spacing), where plant-to-plant distance of 20cm and row-to-row distance of 60cm were maintained. The plots were spaced apart by 0.5meters, while replications were separated by 1 meter. In rows, a single maize seed was sown 3–4cm deep and softly covered with soil. A fertilizer dose of 120kg N, 60kg P_2O_5 and 40 kg K_20 per hectare was applied. A half dose of urea, a full dose of phosphorous, and a full dose of potassium were sprayed during the last land preparation. Each plot received 182.5gm of urea, 525gm of SSP, and 93gm of MOP. A controlled irrigation system was used for the experiment. To help the seeds germinate better, irrigation was done prior to sowing. Throughout the duration of the crop, a total of five irrigations were performed. After emergence, irrigation was provided, and then irrigation was applied at the seedling, knee-height, tasseling, and silking stages. After 45 days after sowing (DAS), the side dressing of the remaining dose of urea and earthing up were done in all plots, with the exception of the ones with black plastic mulch. For plant protection measures, Emamectin benzoate was applied once at a rate of 10grams per sixteen liters during the infestation of Fall Army Worm (*Spodoptera frugiperda*). Harvesting was done manually by pulling the ears from the stalks of plants when black spots on the bottom (side attached to the cob) of the seed were seen in every plot.

2.4. Treatment details

Table 1. Treatment details

Treatment	Treatment details
T1	Control
T2	Cover crops (cowpea 312 variety)
T3	Hand weeding (30DAS,45DAS,-60DAS,75DAS)
T4	Botanical weedicides (5ml/15lit,-30DAS, 45DAS,60DAS, 75DAS)
T5	Inorganic weedicides
	Atrazine: 2.1gm/42m_2 (3DAS)
	2-4D 58%Sl:7.26ml/42m_2 (20DAS)
T6	Plastic mulch: black plastic of 45mm thickness and 18.4 m was used.
T7	Straw mulch: Dry and pest free straw was used, covering the whole plot.
T8	small inter row spacing
	Plant-plant: 20cm
	Row-row:60cm

2.5. Parameters recorded

2.5.1. Yield and yield attributes

- *Weight of individual cob with husk (gm):* Five plants were chosen at random from each net plot and their cobs were cut off. Fresh weight was obtained and the average was recorded.
- *Weight of Individual cob without husk (gm***):** The husk from five randomly selected cobs from each net plot were removed and weighted without husk.
- *Number of grains per cob*: The number of grains per cob was calculated as given below. The total number of grains per cob = Number of grain rows per cob x Number of grains per row
- *Cob length (cm):* The length of the cob was measured from five randomly selected plants each net plot from base to the tip of the cob without husk.
- *Sterile length(cm):* The sterile length of cob was measured from five randomly selected plants each net plot from tip to the initiation of kernels.
- *Sterility*: Sterility % was calculated by following formula.

$$\text{Sterility \%} = \frac{\textit{length of unfilled portion of cob}}{\textit{length of unfilled portion of cob}} \times 100\%$$

- *Grain weight per plant (gm):* Five cobs from each net plot were randomly chosen, and the grains from those cobs were separated and air dried. Records were made on the grain weight.
- *"1000 Grain" Weight (gm):* The weight of 1000 dried grains from five randomly selected cobs from each net plot was recorded.
- *Shelling percentage:* It is the ratio of grains to ear and expressed in percentage. It was calculated as following method.

$$\text{Sterility \%} \quad \frac{\textit{grain yield}}{\textit{cob yield}} \times 100\%$$

- *Grain yield (ton ha^{-1}):* Cobs from each net plot were harvested at physiological maturity. Cobs were separated and air dried, shelled, cleaned and weighed.

$$\text{Grain yield (ton/ha) at 14\%} \frac{\textit{plot yield(kg)*(100-GMC)}}{\textit{(100-14) *net harvested area m2}} \times 10000$$

(100-GMC)/ (100-14) =conversion factor for grain yield at 14 %

(10000/net harvested area (m^2) =conversion factor for Actual harvested area into hectare basis

Where GMC= Grain Moisture Content

2.5.2. Economic analysis

- *Cost of cultivation*

  Based on the inputs required, such as manpower, fertilizer, compost, seed, and other research materials, the cost of cultivation was calculated. It was determined using the Jhapa district's prevailing market pricing.

- *Gross return*

  Based on the current market pricing, total production (including grain and biomass yield) was converted into gross return (Rs/treatment).

- *Net return (Rs/treatment)*

  It was calculated by subtracting the cost of cultivation from the gross return.

  Net return = Gross return- cost of cultivation

- *B:C ratio: It was calculated by the formula*

$$\text{B:C ratio} = \frac{\textit{Gross return}}{\textit{Total cost of cultivation}}$$

2.6. Data collection

The data on yield parameters were taken at the time of harvesting from net plot i.e., 3rd and 4th row of each plot.

2.7. Statistical analysis

Analysis of Variance (ANOVA) for all parameters was analyzed by using R Stat version 4.2.1 at 5% level of significance. All the analyzed data were subjected to Duncan's Multiple Range Test (DMRT) for mean comparison. R-statistics was used to calculate the mean and standard error, while the software Agricolae was used for mean separation.

3. RESULTS AND DISCUSSION

Table 2. Effect of different weed management practices on number of cobs per hectare, number of Grain, row and weight of grain per cob of spring maize in Gauradaha, Jhapa.

Treatments	No. of Cob per ha	No. of Grain per cob	Row per cob	Weight of grain per cob
T1	15238.10 ± 1190	**303.76**^{c} ± 13	10.93^{b} ± 0.52	105.00^{cd} ± 4.36
T2	13095.24 ± 2416	321.16^{bc} ± 7.17	11.26^{b} ± 0.4	105.66^{cd} ± 1.20
T3	15476.19 ± 1448	337.03^{bc} ± 14.4	12.20^{ab} ± 0.2	122.20^{bc} ± 0.987
T4	14524.81 ± 238	303.98^{c} ± 11.1	10.93^{b} ± 0.52	104.33^{cd} ± 8.41
T5	15238.15 ± 1038	342.70^{bc} ± 15.7	12.06^{ab} ± 0.75	114.53^{bcd} ± 9.78
T6	16429.57 ± 412	**427.83**^{a} ± 33.4	**13.40**^{a} ± 0.11	**153.33**^{a} ± 6.17
T7	15952.38 ± 1717	355.58^{b} ± 9.33	12.20^{ab} ± 0.11	126.33^{b} ± 4.49
T8	15476.19 ± 858	320.25^{bc} ±16.1	**10.12**^{b} ± 0.57	**98.00**^{d} ± 6.11
Grand Mean	15178.57	339.28	11.85	116.17
C.V	13.42	7.40	6.56	8.52
MS Error	4151482	631	0.60	98
LSD	3568.125	43.98	1.36	17.33
F Value	0.734ns	7.5***	3.39*	9.74***

C.V.: Coefficient of Variation, LSD: Least Significant Difference, ns: non-significant, (***): Significant at 0.1% level of significance, (*): Significant at 5% level of significance, Figure after ± indicate standard error, Same letter signify no significant difference between treatments.

***3.1. Number of cobs per hectare*:** It was not significantly affected by different weed management practices in spring maize in Gauradaha, Jhapa but highest number of cobs per hectare was seen in T6 i.e., plastic mulch (16429.57) followed by T7 i.e., straw mulch (15952.38), T3 i.e., i.e., hand weeding (15476.19), T8 i.e., Small inter row spacing (15476.19) and lowest number of cobs per hectare was seen in T2 i.e., cover crops (13095.24 ± 2416) is shown in Table 2.

3.2. Grain per cob:

The total number of grains per cob is an important yield component parameter of maize. The data on grain per cob as presented in "Table 2", was significantly different for various weed management practices. Maximum grain per cob was recorded in T6 i.e., plastic mulch (427.83), followed by T7 i.e., straw mulch (355.58), T5 i.e., inorganic weedicide (342.70) and T3 i.e., hand weeding (337.03). This is supported by a field experiment carried out by Hussain *et al*. (2022) affirmed that plastic mulching recorded highest grain per cob (403.67). However, the lowest grain per ear was observed in T1 i.e., control (303.76), which was also supported by (Sharma *et al*., 2019). Number of grains per cob directly relate with the yield of the crop (M.S.I. *et al*., 2012).

Table 3. Effect of different weed management practices on sterility %, shelling %, 1000 grain weight and yield of spring maize in Gauradaha, Jhapa.

Treatments	Sterility%	Shelling%	1000 grain weight	Yield
T1	24.1 ± 4.26	74.2 ± 2.58	112^{bc} ± *2.31*	4.28^{bc} ± *0.562*
T2	20.8 ± 4.26	70.7 ± 3.61	117^{bc} ± *4.83*	3.47^{c} ± *0.864*
T3	20 ± 1.62	72.5 ± 2.41	131^{ab}± *3.84*	5.71^{b} ± *0.712*
T4	24.4 ± 1.82	70.3 ± 2.91	119^{bc} ± *8.48*	3.20^{c} ± *0.443*
T5	20.5 ± 2.77	73.1 ± 0.768	125^{bc} ± *6.58*	4.62^{bc} ± *0.536*
T6	14.6 ± 2.64	78.0 ± 4.76	**146^{a}** ± *9.38*	8.46^{a} ± *0.495*
T7	19 ± 3.64	70.8 ± 1.35	130^{abc} ± *0.69*	5.65^{b}± *0.085*
T8	26.4 ± 7.24	72.9 ± 0.511	**111^{c}** ± *3.64*	5.37^{b} ± *0.168*
Grand Mean	21.22	72.71	123.86	5.09
C.V	30.70	6.65	8.32	19.01
MS Error	42.49	23.45	106.3	0.939
LSD	11.41	8.48	18.05	1.69
F Value	0.96ns	0.866ns	3.83*	8.784***

C.V.: Coefficient of Variation, LSD: Least Significant Difference, ns: non-significant, (***): Significant at 0.1% level of significance, (*): Significant at 5% level of significance, Figure after ± indicate standard error, Same letter signify no significant difference between treatments.

3.3. Row per cob:

Number of grain rows per cob directly affects cob weight and ultimately grain yield of maize. Among various weed management practices, row per cob was significantly higher in T6 i.e., plastic mulch (13.40), which was at par with T3 i.e., hand weeding (12.20), T7 i.e., straw mulch (12.20), and T2 i.e., cover crops (12.06). However, the least row per comb was recorded in T4 i.e., botanical weedicide (10.93), which was also supported by (Sharma *et al*., 2019).

3.4. Weight of grain per cob:

Different weed management techniques had a significant impact on grain weight per cob. Highest grain content per cob was discovered in T6 i.e., plastic mulch (153.33), followed by T7 i.e., straw mulch (126.33) which was at par with T3 i.e., hand weeding (122.20).

3.5 Sterility%:

The various weed management techniques had no significant influence on the sterility %. However, the black polythene mulch treated plot (14.6) and the straw mulch treated plot (19) had the lowest sterility percent.

3.6. Shelling%:

The proportion of shelling did not significantly differ amongst the different weed management techniques. Nonetheless, T6 i.e., black plastic mulch treated plot (78%) had the largest percentage of shelling.

3.7. 1000 grain weight:

Apart from combined effect of all the other individual yield determining elements, the ultimate final grains yield of a cereal crop depends upon the 1000-grains weight. Any variation in the 1000-grain weight will affect the grain yield. It is cleared from the data that the 1000-grain weight of maize grain was significantly influenced by different weed management practices as shown in Table 3. T6 i.e., black plastic mulch treated plot (146) recorded a significantly higher test weight which was at par with T3 i.e., hand weeding (131) and T7 i.e., straw mulch (130). However, the lowest test weight was recorded in T8 i.e., Small inter row spacing (111) small inter row spacing. Also, in a field experiment carried out by Hussain *et al*. (2022) recorded 1000-grain weight (318.33g) in plastic mulching. According to Hussein (1997), the length of weed competitions was correlated with a decline in the weight of 1,000 grains. In an experiment conducted by M.S.I. *et al*. (2012) found that the 1000-grain weight is the most significant of the several yield-related variables as it has a direct correlation with grain yield.

3.8. Yield:

Grain yield is the cumulative behavior of several yield-determining factors, including the number of cobs per plant, cob length, number of grains per cob, and 1000-grain weight, which demonstrated fluctuations owing to present growing conditions and various crop management practices. The yield of maize was highest in T6 i.e., plastic mulching (8.46) at par with T3 i.e., Hand weeding (5.71) and T7 i.e., Straw mulch (5.65) while lowest yield was observed in T4 i.e., Botanical weedicides (3.20). The average yield of Arun 2 variety 5.043 t/ha was recorded by (Koirala K.B., 2004) in Lumle, Nepal and 5.93 t/ha was observed by (Thapa et.al., 2022) in Itahari, Nepal. According to Zhang *et al*. (2007), plastic mulching significantly increased soil water content and temperature, which increased maize's photosynthetic rate primarily through enabling stomatal opening, possibly explaining why plastic mulch-treated plots produced greater yields. Zhang, F. (2022) reported significantly higher grain yield in maize along with increased nitrogen uptake efficiency and nitrogen fertilizer productivity on plastic mulch treated plot. The current findings are consistent with those of Xiukang *et al*. (2015), who claimed that plastic mulching reduces soil evaporation when water moves from a deeper soil layer to the topsoil by capillarity and by maintaining stability of the topsoil water content, which in turn increases transpiration. Higher production was favored by increased transpiration, a higher transpiration to evapotranspiration ratio, and less evaporation.

The result was in consistent with the findings of Hussain *et al*. (2022) in an experiment carried out in Pakistan where highest yield was (9.61 t/ha) in plastic mulching. The reason of more grains yield of maize in plastic mulch might be due to lessened weed competition and improved usage of growth resources for higher crop performance which consequently improved photosynthetic efficiency. A major factor influencing maize yield are the photosynthetic rate, and decreasing net photosynthesis leads to less dry mass accumulation following silking (Yan *et al*., 2021) and (Long *et al*., 2015). Ren *et al*. (2016) further highlighted the fact that increased leaf photosynthetic capacity offers a fundamental path to enhancing maize output. According to Chaiy *et al*. (2022), more vegetative growth improves area and net accumulation of photosynthesis, increasing availability of photosynthetic product for greater spike and kernel formation.

3.9. Economics

3.9.1 Cost of cultivation

The cost of different treatments ranged between Rs 355 to Rs 2155 over production period. The treatment T1 (control) and T4(Botanical weedicides) had the lowest cost, whereas T6 (plastic mulch treated plot) had the highest cost. The maximum benefit of Rs. 476.05 was observed in T7 (Straw mulching) followed by Rs.417.72 on T3 (Hand weeding) whereas, loss of Rs.791.45 was recorded in T6 (plastic mulch treated plot).

3.9.2 Benefit cost ratio (BC)

It ranged from -0.37 to 1.02 with highest BC ratio of 1.02 was obtained in T7 (Straw mulching) while the subsequent higher BC ratio of 0.99 was found in T8 (small inter row spacing). The lowest BC ratio was -0.37 in T6 (plastic mulch treated plot).

Table 4. Effect of different weed management practices on economics of spring maize in Gauradaha, Jhapa

Treatments	Total cost (NRs)	Total Benefit (NRs)	Benefit Cost Ratio (BCR)
T1	355	302.2	0.85
T2	455	104.95	0.23
T3	555	417.72	0.75
T4	355	167.4	0.47
T5	425	308	0.72
T6	2155	-791.45	-0.37
T7	475	476.05	1.02
T8	395	394.25	0.998

4. CONCLUSION

The various weed management practices did not significantly affect number of cobs per hectare, shelling % and sterility%. But was significantly affected by plastic mulching on grain per cob, row per cob, weight of grain per cob, 1000 grain weight and yield. The Benefit Cost Ratio (BCR) was found significantly higher in straw mulching. Overall, the use of plastic mulching can be an effective strategy for enhancing the yield of spring maize in Jhapa. However, taking into consideration the potential environmental impacts of plastic waste, straw mulching can be alternative mulching materials that are locally available, cheaper, more sustainable and environment friendly.

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