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EFFECT OF ORGANIC MULCHES AND LIVING MULCHES ON WEED INFESTATION AND YIELD OF MAIZE (*ZEA MAYS* L.) DURING WET SEASON

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Abstract

Mulching provides several benefits to the agro-ecosystem and plays an important role in integrated weed management system. To study the effect of organic mulches and living mulches on weed infestation and yield of maize, the experiments were conducted at the field of Department of Agronomy, Yezin Agricultural University (YAU) and Tatkon Agricultural Research Farm, Department of Agricultural Research (DAR) in Myanmar during wet season, 2023. In both locations, there were six treatments: control (no mulch) (T1), maize stover mulch (T2) and rice straw mulch) (T3) as organic mulches (8 ton ha-1), cowpea mulch (T4), green gram mulch (T5) and lablab bean mulch (T6) with the seed rate of each 10 kg ha-1 as living mulches by using Randomized complete block (RCB) design with three replications. In Yezin, the results showed that the lowest weed infestation was found in T3 followed by T2 among all treatments at all sampling times Among the selected living mulches treatments, the minimum weed infestation was observed in T4. The highest weed infestation was found in control (T1) in both study areas. In Tatkon, weed density was also significantly reduced by T3 and T2 at 15 days after sowing (DAS). After that, at 35 DAS, 55 DAS and 75 DAS, the better weed control efficiency was found in rice straw mulch (T3) followed by cowpea mulch (T4) and lablab bean mulch (T6). The minimum weed infestation was found in T3 followed by T4 and T6. However, the highest maize grain yield was observed in T4 in both study areas. Therefore, the cowpea mulch (T4) is suitable to control weed infestation and to optimize maize grain yield for sustainable maize cultivation of the study areas. Living mulch or

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organic mulch should be used in maize cultivation rather than without using mulch (control). Organic mulches should be used in places where living mulches are not suitable.

Keywords: living mulch, maize, organic mulch, weed, yield

1. Introduction

Maize (*Zea mays* L.) is an important crop after rice in Myanmar and usually grown in the whole country except Mon State and important crop for export market. However, weeds highly infested maize crop both in irrigated as well as rainfed areas. A yield reduction of maize up to 20-40% has been faced due to weed infestation (Farooq, Tanneer & Jaboran, 2020). Nowadays, herbicide application had been become popular as one of the weed control methods. It could have negative effects on the environment, human' health, and may improve the resistance of weeds (Ofori et al., 2017). Agricultural practices with effective weed control methods in accordance with sustainable crop production are precisely important. Mulching is one of the alternative methods to chemical and mechanical weed control for sustainable agriculture (Nwagwu, Okon & Udoidiok, 2020).

Organic mulches can suppress annual weeds and offer other important benefits, such as organic matter, nutrients, moisture conservation, soil protection, and moderation of soil temperature. Living mulches are extension of cover crops used to decrease soil erosion, suppress weeds, improve soil structure and nutrient cycling, and in the case of legumes, supply nitrogen to a grain crop. Legumes living mulches have the potential to form an important component in agro-ecosystems and can be a useful tool for weed suppression in sustainable agricultural systems (Kruidhof, Bastiaans & Kropff, 2008).

Nowadays, to adopt mulching as one of the sustainable agricultural practices related to maintaining agro-ecosystem and to choose the appropriate mulch or living mulch species selection are important to suppress weeds in maize cultivation. In Myanmar, there is paucity of research information on use of living mulches and organic mulches in maize cultivation in wet season. Therefore, the present study was conducted with the following objectives.

Objectives

1. To evaluate the effect of living mulches and organic mulches on weed infestation and yield of maize during wet season
2. To choose the suitable mulch for maize cultivation during wet season in Yezin and Tatkon region, Myanmar

2. Material and methods

2.1 Experimental sites and design

The two experiments were conducted at the field of Department of Agronomy, Yezin Agricultural University (YAU) and Tatkon Agricultural Research Farm at Tatkon Township, the Department of Agricultural Research (DAR) in Myanmar during 2023 wet season (from June to

October 2023). The experimental area for each location was (1075) m^2. Individual plot size was 7 m x 5 m with 1 m distance between plots. Spacing of maize was 75 cm × 25 cm. The maize variety, CP 808 was used as the tested variety. The experiments were carried out in a Randomized Complete Block Design with three replications. In both experiments, there were six treatments: control (no mulch) (T1), maize stover mulch (8 ton ha^{-1}) (T2) and rice straw mulch (8 ton ha^{-1}) (T3) as organic mulches, cowpea mulch (T4), green gram mulch (T5), and lablab bean mulch (T6) as living mulches.

Living mulches (two rows) was sown drilling between maize rows after maize sowing on the same day. Living mulch was applied with the seed rate of 10 kg ha^{-1} for each plot. Organic mulches (8 t ha^{-1}) were uniformly covered on the surface of soil after maize sowing. To minimize competition of maize and living mulches for resource utilization during the crop development period, living mulches were cut 3 times based on plant height of living mulch with the average height was over 30 cm. They were cut by leaving 10-15 cm from the ground level. After cutting, the green masses of legume living mulches were covered between maize rows.

2.2 Crop management

Land was prepared by two ploughing, two harrowing and leveling in both experimental sites. According to the guidelines of Department of Agricultural Research (DAR), as basal, the fertilizer were applied with the rate of 56.81 kg N ha^{-1}, 55.58 kg P_2O_5 ha^{-1} and 37.05 kg K_2O ha^{-1}. At 20 days and 40 days after sowing of maize (20 DAS and 40 DAS), 28.41 kg N ha^{-1} and 18.53 kg K_2O ha^{-1} were applied as top dressings. Pesticides were sprayed 4 times in both experimental sites throughout the growing season of the crop.

2.3 Data collection

Weed infestation was measured at 15 days after sowing (DAS), 35 DAS, 55 DAS and 75 DAS by placing 1 m^2 quadrats randomly twice in the middle of each plot along the diagonal. To determine weed infestation, the weeds were pulled out from each 1 m^2 quadrats, and then counted and determined weed density, weed dry weight, and relative weed density (sedges, grasses and broadleaves). After that, the collected weeds were oven dried at 70℃ for 72 hours to obtain total weed dry weight (gm^{-2}) (Demjanova et al., 2009).

The plots of all treatments were weeded out twice at 15 DAS and 35 DAS after counting weed infestation to avoid crop failure except 55 and 75 DAS.

According to Nautiyal, Bhaskar, and Imran Khan (2015), weed density were calculated as follows.

$$\text{Weed Density} = \frac{\text{Number of individual in all sampling units}}{\text{Total number of sampled units studied}} \times 100$$

Weed control efficiency (WCE) was also determined by formula, Amare et al. (2014):

$$\text{WCE} = \frac{\text{WDC} - \text{WDT}}{\text{WDC}} \times 100$$

Where: WCE = Weed control efficiency, WDC = Weed dry mass from control plot (untreated), WDT = Weeds dry matter from treated plot

Yield of maize was measured from harvest area at the center of each plot. Then, the total grain yield from each plot was weight and converted to ton ha^{-1}.

$$\text{Grain yield (ton ha}^{-1}) = \frac{(100 - \text{moisture})(\text{Field weight (kg)} \times \text{shelling} \times 10000\ \text{m}^2)}{85 \times \text{harvested area (m}^2) \times 1000}$$

(Centro International De Mejoramiento De Maiz Y Trigo [CIMMYT], 1985)

Where, 85 = adjusted factor of grain moisture to 15%

10,000 sq. meter = conversion factor to an area of one hectare of a plot

Shelling % was measured from seed dry weight adjusted at 15% moisture and ear dry weight described by the formula;

$$\text{Shelling \%} = \frac{\text{Seed dry weight}}{\text{Ear dry weight}} \times 100$$

(CIMMYT, 1985)

The soil types of study areas are loamy sand in Yezin and clay loam in Tatkon.

Mean values of maximum and minimum temperature and rainfall data of Yezin and Tatkon during wet season, 2023 were presented in figure 1A and 1B.

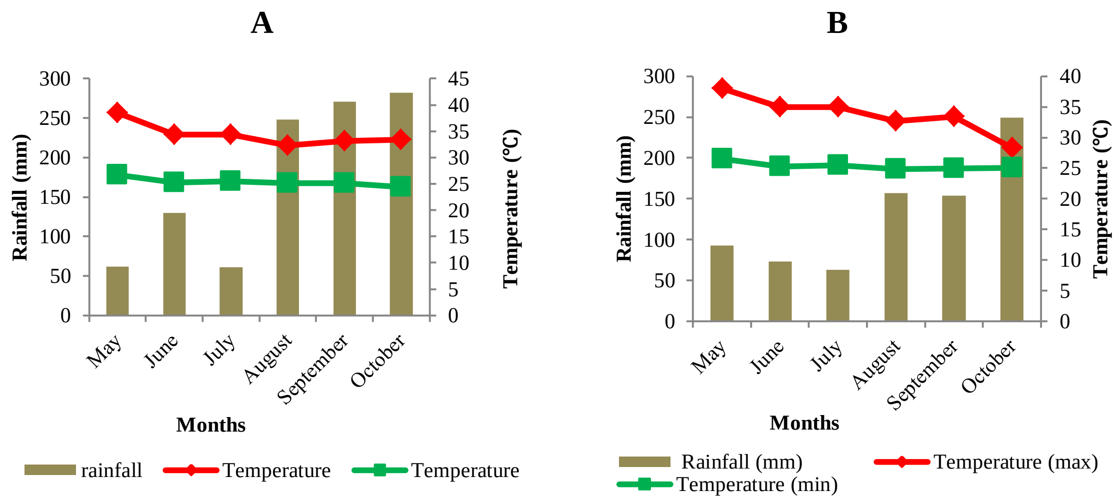


Figure 1. Mean values of temperature and rainfall during wet season at Yezin (A) and Tatkon (B), 2023

2.4 Data analysis

The data were analyzed for analysis of variance (ANOVA) by using Statistix (version 8.0) and treatment means were compared at 5% level of least significant difference (LSD) test (Gomez & Gomez, 1984).

3. Results and Discussion

3.1 Weed density

There was significantly different in weed density at 15 days after sowing (DAS), 35 DAS, 55 DAS and 75 DAS among the treatments in both study areas (Table 1 and 2). At all sampling times, the maximum weed density was observed in control (no mulch, T1) and the minimum weed density was found in rice straw mulch (T3) in both study areas except at 55 DAS in Tatkon.

In Yezin, among the treatment, weed density in living mulches (T4, T5 and T6) was lower than control (T1) though the weed density in living mulches were higher than the organic mulches at all sampling times. This was because the growth of the living mulches, cowpea mulch (T4), green gram mulch (T5) and lablab bean mulch (T6) and their canopy were not enough to cover the soil surface to suppress the weeds at 15 DAS. Nwagwu, Okon and Udoidiok (2020) stated that living mulch required four weeks or more to cover the soil surface sufficiently to smother weeds. Weed density was not found in organic mulches at 55 DAS. Among the living mulches, the lower weed density was found in cowpea mulches. This result stated that mulches may act as physical obstacles in the emergence of weeds.

In Tatkon, weed density in living mulches (T4, T5 and T6) was lower than control (T1) among the treatments at all sampling times. However, it was found that organic mulches could more suppress weed density than living mulches at 15 DAS. Nwagwu, Okon and Udoidiok (2020) who reported that even application and the layer thickness of organic mulches over the soil surface must have enhanced their ability to suppress weeds by impeding weed seedling emergence and denying weed propagules direct sunlight, compared with the living mulches. In living mulches, weed density was lower in cowpea than the others at 15 DAS, 35 DAS and 55 DAS as the cowpea mulches gave more green masses than the others. Thus, it has much more coverage the soil to suppress weed between maize rows. Weed density in selected mulches was lower than the control (T1) at 75 DAS. This may be due to the effective weed control of green masses from living mulches and organic mulches by shading and covering the soil surface to suppress the weeds.

Table 1. Weed density as affected by different mulches in Yezin during wet season, 2023

Treatments	Weed density (units m^{-2})			
	15 DAS	35 DAS	55 DAS	75 DAS
T1 (Control, no mulch)	892.50 a	325.67 a	73.00 a	133.00 a
T2 (Maize stover mulch)	334.67 c	37.00 d	0.00 d	26.67 cd
T3 (Rice straw mulch)	317.83 c	38.00 d	0.00 d	25.00 d
T4 (Cowpea mulch)	657.33 b	79.50 c	27.17 c	29.67 cd
T5 (Green gram mulch)	618.33 b	94.83 bc	33.67 b	32.00 bc
T6 (Lablab bean mulch)	600.17 b	97.83 b	31.67 b	33.33 b
$LSD_{0.05}$	59.61	15.37	4.14	5.68
Pr>F	**	**	**	**
CV%	5.75	7.53	8.25	6.7

Table 2. Weed density as affected by different mulches in Tatkon during wet season, 2023

Treatments	Weed density (units m^{-2})			
	15 DAS	35 DAS	55 DAS	75 DAS

T1 (Control, no mulch)	142.00 a	344.33 a	468.00 a	439.33 a
T2 (Maize stover mulch)	36.33 c	217.33 bc	176.33 b	204.33 c
T3 (Rice straw mulch)	26.00 b	154.67 d	179.00 b	141.33 d
T4 (Cowpea mulch)	60.67 b	195.00 cd	67.00 d	254.33 b
T5 (Green gram mulch)	62.67 b	213.33 bc	187.33 b	175.67 cd
T6 (Lablab bean mulch)	65.00 b	253.67 b	128.33 c	152.33 d
$LSD_{0.05}$	5.87	40.53	12.16	45.87
Pr>F	**	**	**	**
CV%	4.93	9.7	3.33	11.06

3.2 Weed dry weight

There was significantly different in weed dry weight at all sampling times in both experimental sites (Table 3 and 4). The maximum weed dry weight was observed in control at all sampling times in both study areas.

In Yezin, the minimum weed dry weight was found in (T3) followed by (T2) at 15 DAS. At 35 DAS and 55 DAS, the minimum weed dry weight was found in T4. At 75 DAS, weed dry weight were not significantly different among the organic mulches and living mulches although their weed dry weight was less than the control (no mulch). Weed dry weight from living mulches plots was lower than the control (no mulch) although weed density in living mulches were more than the organic mulches in Yezin. This was because the weed growth and development were weak in living mulches treatments due to the green masses and shading by canopy of living mulches' coverage to the soil surface to suppress weed.

In Tatkon, the minimum weed dry weight was found in (T3) at 15 DAS and (T5) at 35 DAS. At 55 and 75 DAS, the minimum weed dry weight was found in cowpea mulch (T4). Weed dry weight from organic mulches and living mulches was lower than the control although weed dry weight were not significantly different among mulches.

Table 3. Weed dry weight as affected by different mulches in Yezin during wet season, 2023

Treatments	Weed dry weight (gm^{-2})			
	15 DAS	**35 DAS**	**55 DAS**	**75 DAS**
T1 (Control, no mulch)	27.88 a	37.41 a	26.71a	22.76 a
T2 (Maize stover mulch)	6.34 d	12.04 b	0.00 d	3.83 c
T3 (Rice straw mulch)	5.66 d	11.14 bc	0.00 d	4.46 b
T4 (Cowpea mulch)	12.79 bc	5.31 d	5.12 c	3.86 c
T5 (Green gram mulch)	14.97 b	8.98 c	5.32 c	3.12 d
T6 (Lablab bean mulch)	11.70 c	9.09 c	6.89 b	4.10 bc
$LSD_{0.05}$	2.54	2.39	1.38	0.54
Pr>F	**	**	**	**
CV%	10.56	9.4	10.4	4.2

Table 4. Weed dry weight as affected by different mulches in Tatkon during wet season, 2023

Treatments	Weed dry weight (gm^{-2})			
	15 DAS	35 DAS	55 DAS	75 DAS
T1 (Control, no mulch)	3.49 a	39.19 a	43.34 a	41.04 a
T2 (Maize stover mulch)	1.03 c	28.06 b	8.00 b	12.38 c
T3 (Rice straw mulch)	0.58 d	25.15 bc	9.86 b	8.31 cd
T4 (Cowpea mulch)	1.74 b	28.04 b	6.09 b	7.68 d
T5 (Green gram mulch)	1.74 b	19.99 c	10.99 b	17.17 b
T6 (Lablab bean mulch)	1.84 b	29.89 b	7.12 b	8.14 cd
$LSD_{0.05}$	0.36	5.72	5.11	4.59
Pr>F	**	**	**	**
CV%	11.26	11.07	19.73	16.01

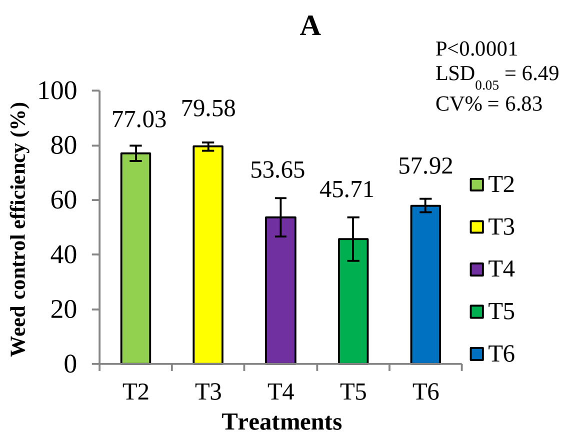
It was also found that the weed density in Yezin was decreasing from 15 DAS to 55 DAS whereas weed density in Tatkon became more infestation at 35 DAS, 55 DAS and 75 DAS compared with at 15 DAS. Moreover, it was also found that weed infestation varieties were not the same in both study areas. This may be due to the different locations and different soil types.

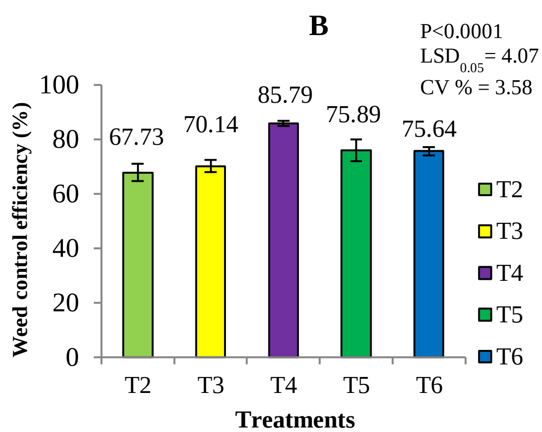
3.3 Weed control efficiency

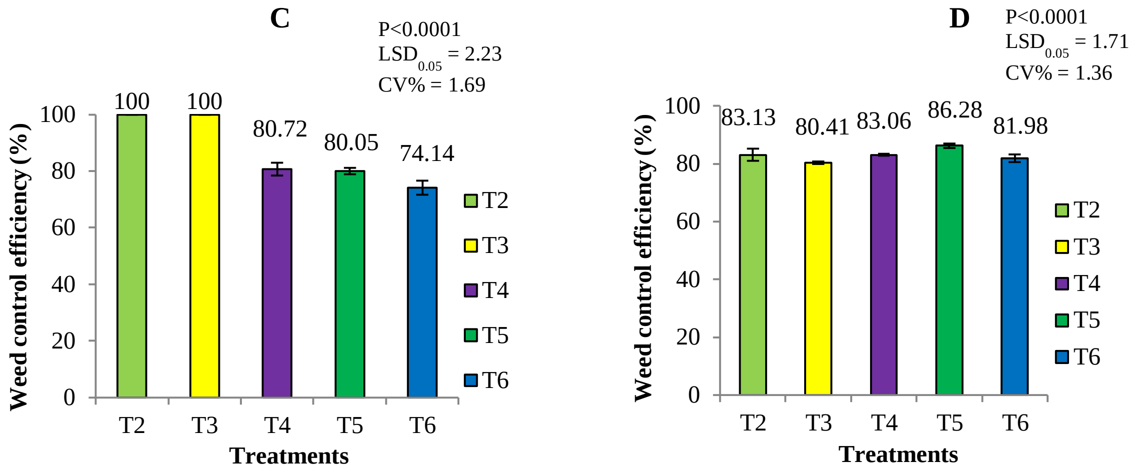
Weed control efficiency of different mulches were highly significant different at all sampling times at both experimental areas (Figure 2 and 3). Organic mulches (T2 and T3) were more efficient than the living mulches among the mulching treatments. Among the organic mulches, rice straw mulch has more efficient than that of maize stover mulches at 15 DAS in both sites.

In Yezin, at 35 DAS, living mulches have more efficient than the organic mulches among the mulching treatments (Figure 2). Moreover, cowpea living mulches have more effective weed control than other living mulches because of its coverage on soil than the others. At 55 DAS, organic mulches had 100% weed control efficiency than the others. At 75 DAS, all treatments had over 80% weed control efficiency. At that times, maize growth was also enough to suppress weed by its canopy shading covering on the soil surface.

In Tatkon, at 35 DAS, green gram mulches have more efficient than other mulches among the mulching treatments (Figure 3). At 55 DAS, all mulches had over 70% weed control efficiency and cowpea living mulches have more effective weed control than others because of its coverage on soil than the others. At 75 DAS, all treatments had over 60% weed control efficiency.

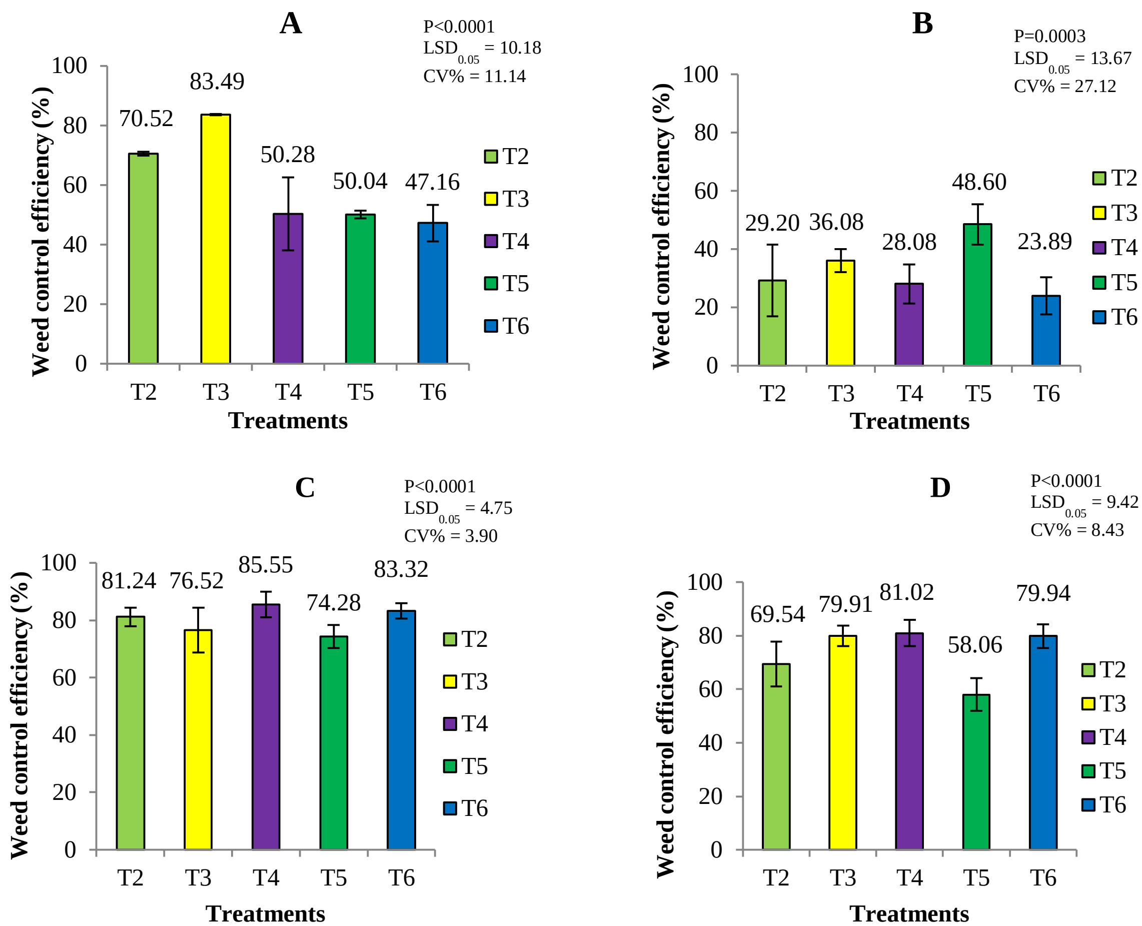






T2= Maize stover mulch, T3= Rice straw mulch, T4= Cowpea mulch,
T5= Green gram mulch, T6= Lablab bean mulch

Figure 2. Weed control efficiency of different mulches in maize cultivation at 15 DAS (A), 35 DAS (B), 55 DAS (C) and 75 DAS (D) in Yezin during wet season, 2023

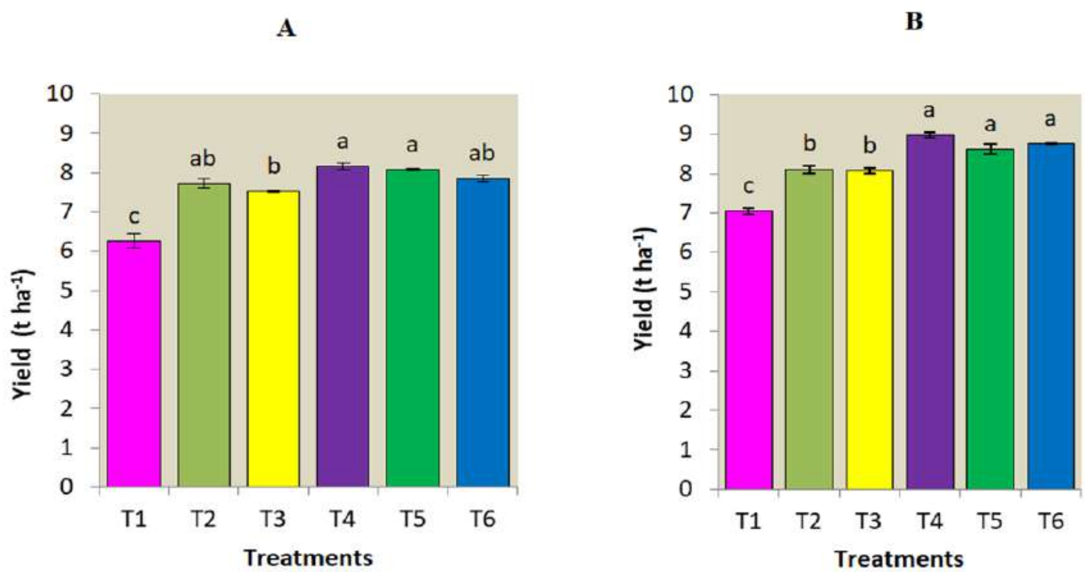


T2= Maize stover mulch, T3= Rice straw mulch, T4= Cowpea mulch,
T5= Green gram mulch, T6= Lablab bean mulch

Figure 3. Weed control efficiency of different mulches in maize cultivation at 15 DAS (A), 35 DAS (B), 55 DAS (C) and 75 DAS (D) in Tatkon during wet season, 2023

3.4 Yield of maize

There was significantly different in grain yield of maize in both study areas during wet season, 2023 (Figure 4A and 4B). The highest grain yield of maize was observed in cowpea mulch treatment (T4) (8.16 t ha^{-1}) in Yezin and (8.97 t ha^{-1}) in Tatkon among the treatments. Moreover, it was found that living mulches treatments gave the higher grain yield of maize than the organic mulches in both study areas. Based on the result, it was observed that cowpea mulches provided the more biomass to the soil and covered the soil to reduce the weed competition of the maize crop and the biomass of cowpea mulches would decompose gradually and then provide the nitrogen to soil and hence, improve the maize growth and development as a consequence, more likely to increase maize yield. Consequently, the yield of maize from cowpea mulches might be more than other mulches. The minimum maize grain yield was observed in control (no mulch, T1) in both study areas because of higher weed infestation and higher competition with the maize crop. Moreover, the green gram mulch (T5) (8.07 t ha^{-1}) and (T6) (7.85 t ha^{-1}) gave more grain yield compared with the organic mulches. It may also be due to addition of nitrogen from the living mulches' green biomass decomposition to the soil. All mulches treatments significantly enhanced maize yield compared with control (no mulch, T1).

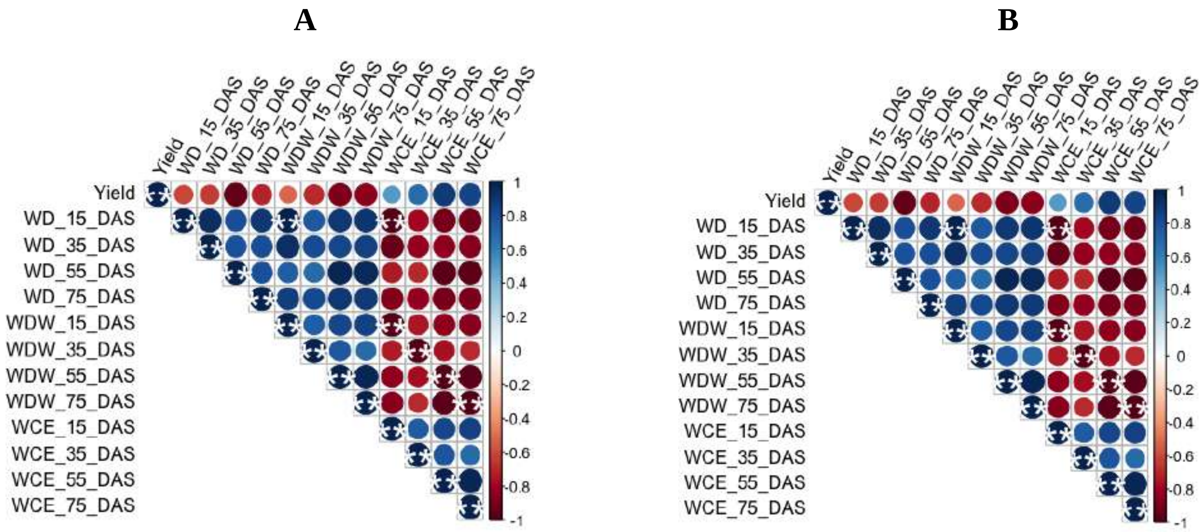


T1= No mulch (control), T2= Maize stover mulch, T3= Rice straw mulch, T4= Cowpea mulch, T5= Green gram mulch, T6= Lablab bean mulch

Figure 4. Yield of maize as affected by different mulches in Yezin (A) and Tatkon (B) during wet season, 2023

3.5 Correlation analysis of weed infestation and yield of maize

The results of correlation of yield and weed infestation of maize in Yezin and Tatkon during wet season, 2023 was shown in Figure 5A and 5B. The blue color showed positive correlation coefficient value and the red color was negative correlation coefficient. The size of cycle indicated the value of correlation coefficient (r). In both experimental sites, weed control efficiency was negatively and significantly correlated with weed dry weight and negatively correlated with weed density at all sampling times. Yield was positively correlated with weed control efficiency at all sampling times and specifically at 55 DAS. It could be suggested that the higher weed control efficiency, the higher yield can be achieved. In addition, yield was negatively correlated with weed density and weed dry weight. Especially, yield was negatively correlated with weed density and weed dry weight at 55 DAS. This indicated that the higher weed infestation can result the lower maize grain yield.



WD = Weed density, WDW = Weed dry weight, WCE = Weed control efficiency, DAS = Days after sowing of maize

* and **; significant at 5 and 1 % level, blue color represents positive correlation, red color represents negative correlation and color intensity indicate the value of correlation coefficient

Figure 5. Association of weed infestation and yield of maize in Yezin (A) and Tatkon (B) during wet season, 2023

4. Conclusion

The findings of present research pointed that rice straw mulches gave the higher weed suppression in Yezin. Cowpea mulch (T4) was the higher weed control mulch among the selected living mulches treatments in Yezin. Weed density in Tatkon was also significantly reduced by all organic mulches application at 15 DAS. After that, at 35 DAS, 55 DAS and 75 DAS, the better weed control efficiency was found in rice straw mulch followed by cowpea mulch (T4) and lablab bean mulch (T6) in Tatkon. However, the highest maize grain yield was observed in cowpea mulch plots (T4) in both study areas. This may be due to the suitable coverage of its green biomass to the soil surface to suppress weed infestation to some extent and its green masses may quickly decompose and it may act as a nitrogen addition to the soil than the other living mulches and hence, might improve maize growth and development and consequently, may enhance maize yield. Based on the results, organic mulches and living mulches applications tended to reduce weed infestation and improve the maize yield. In addition, the selected organic mulches and living mulches are not very costly and can be locally available in both study areas. Therefore, farmer should use the cowpea mulch to control weed infestation effectively and optimize maize grain yield for sustainable maize cultivation in the study areas. Moreover, organic mulches should also be used in places where living mulches are not suitable.

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