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EFFECT OF DIFFERENT MULCHES ON WEED INFESTATION, GROWTH AND YIELD OF MAIZE (*Zea mays* L.) DURING RAINY SEASON

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Abstract

The experiment was conducted at the field of Department of Agronomy, Yezin Agricultural University, Myanmar to study the effect of different mulches on weed infestation, growth, and yield of maize, and to select the suitable mulch in maize cultivation during rainy season. The experiment was conducted by using randomized complete block design (RCB) with three replications. A total of six treatments were comprised of control (no mulch) (T1), legumes living mulches such as cowpea mulch (T2), green gram mulch (T3) and lablab bean mulch (T4), organic mulch such as maize stover mulch (T5) and black plastic mulch (T6). Maize variety of CP 808 was used as the tested variety. Weed infestation were significantly different among the treatments. The weed density in all mulches plots was significantly lower than the control (no mulch, T1) at all sampling times (15 days after sowing (DAS), 35 DAS, 55 DAS and 75 DAS). The minimum weed dry weight was observed from black plastic mulch (T6) and followed by maize stover mulch (T5) at 15 DAS, 35 DAS, 55 DAS and 75 DAS. Among the living mulches, the lowest weed dry weight was attained from cowpea mulch (T2) and followed by lablab bean mulch (T4) and green gram mulch (T3). Total dry matter and leaf area index of maize were significantly different among the treatments at maximum vegetative growth stage, tasseling stage and grain filling stage. The highest total dry matter of maize was obtained from maize stover mulch (T5) at maximum vegetative growth stage and tasseling stage, and cowpea mulch (T2) at grain filling stage. The highest leaf area index was attained from black plastic mulch (T6) at maximum vegetative growth stage and cowpea mulch (T2) at grain filling stage. The maximum crop growth rate from maximum vegetative growth stage to tasseling stage was obtained from black plastic mulch (T6) and from tasseling stage to grain

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filling stage was observed from lablab bean mulch (T4) followed by cowpea mulch (T2) and green gram mulch (T3). The maximum grain yield was recorded from cowpea mulch (T2) and followed by green gram mulch (T3). According to the results, cowpea mulch (T2) is suitable for maize cultivation during rainy season in the study area.

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

1. Introduction

Maize is one of the most important cereal crops of world agricultural economy and globally. Maize is the second most important cereal crop after rice, and it is the main feed crop grown in Myanmar. In Myanmar, the total sown area of maize was 608,000 ha, with average yield of 3.81 MT ha^{-1} and the production was 2.311 million MT [Ministry of Agriculture, Livestock and Irrigation (MOALI), 2022].

Maize yield can be influenced by several factors such as weed infestation, soil fertility, water availability, pest and diseases, climatic conditions and crop management practices. In addition, there are many factors in maize yield during rainy season such as increased weed pressure, nutrient leaching, and soil erosion. The main limiting factor of maize yield is weed infestation during rainy season. A yield reduction of maize up to 20-40% has been faced due to weed infestation (Farooq, Tanneer & Jaboran, 2020). There are many strategies to overcome weed infestation in crop production. Nowadays, herbicides applications had been become popular to control weed infestation. However, herbicide application could have negative effects on the environment, human health and improve the resistance of weeds and it is not ideal for sustainable maize production. Alternatives to herbicides use in sustainable maize cultivation are agricultural practices, mechanical weed control, mulching, biological control and integrated weed management. Mulching has emerged as an effective agronomic strategy in maize cultivation during rainy season. Mulching reduces chemical inputs, aligning with environmentally friendly agricultural practices. There are different types of mulches such as organic mulches, living mulches and inorganic mulches. Organic mulches, such as straw, or maize stover provide a protective cover that block sunlight, suppresses weed germination, conserves soil moisture, and regulates soil temperature (Schonbeck, 2012). Living mulch provides ground cover, preventing soil erosion and legumes living mulch such as cowpea and clover, not only suppress weeds through competition and allelopathy but also contribute to soil fertility by fixing atmospheric nitrogen. These benefits are particularly critical during the rainy season, where rapid weed growth are major challenges. Plastic mulches have the potential to alter soil temperature, crop water use, to improve crop quality and to reduce weed competition thereby improving crop development and increasing yields (Lamont, 2005).

The choice of suitable mulch aligning with the environment, weather and local conditions is also important to reduce weed infestation in maize cultivation during rainy season. Besides, research concerning different mulches is relatively scarce on weed infestation, growth and yield of maize in Myanmar. Therefore, the experiment was conducted with the following objectives.

1. to study the effect of different mulches on weed infestation, growth and yield of maize during rainy season
2. to choose the suitable mulch for maize cultivation during rainy season in Yezin

2. Material and Methods

2.1 Experimental site and design

The experiment was conducted at the field of Department of Agronomy, Yezin Agricultural University (YAU), Myanmar during rainy season in 2024 (from June to October 2024). The soil type of Yezin was sandy loam. The experimental area 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 experiment was carried out in a Randomized Complete Block Design with three replications. There were six treatments: control (no mulch) (T1), cowpea mulch (T2), green gram mulch (T3), lablab bean mulch (T4), maize stover mulch (T5) and black plastic mulch (T6).

Two rows of legumes living mulches (cowpea, green gram and lablab bean) were sown on the same day with the seed rate of 10 kg ha^{-1} by drilling between maize rows after maize sowing. To minimize competition of maize and living mulches for resource utilization during the crop development period, living mulches were cut based on average plant height of living mulches over 30 cm by leaving 10-15 cm from the ground level. After cutting, the fresh weight (green masses) of legume living mulches were covered between maize rows. Maize stover mulches (8 ton ha^{-1}) were uniformly covered on the surface of soil after maize sowing. Black plastic mulches were covered on the soil surface. And then holes were made in the center of black plastic mulch by four inches PVC pipe. Then the maize seeds were sown in the holes of black plastic mulch.

2.2 Crop management

Land preparation was done by two times of ploughing, harrowing and leveling in experimental site. According to the guidelines of Department of Agricultural Research (DAR), the fertilizer was 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} as basal. At 20 and 40 DAS of maize, 28.41 kg N ha^{-1} and 18.53 kg K_2O ha^{-1} were applied as top dressings. Pesticides were sprayed as necessary throughout the crop season.

2.3 Data collection

Weed infestation was measured at 15 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. The weeds were pulled out from each 1 m^2 quadrats, and then counted and determined weed density (number m^{-2}). The collected weeds were oven dried at 70℃ for 72 hours to obtain total weed dry weight (g m^{-2}) (Demjanova et al., 2009).

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

$$\text{Weed control efficiency (WCE)} = \frac{\text{WDC - WDT}}{\text{WDC}} \times 100$$

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

Plant height (cm): Plant height of maize was measured from randomly selected five plants in each plot at ten days intervals starting from 10 to 70 DAS.

Total dry matter (g m^{-2}): The total dry matter of maize was recorded at maximum growth stage, tasseling stage and grain filling stage. The sample plants were dried in the oven at 70ºC for 3 days and then weighted.

Leaf area index (LAI): The leaves area of three selected maize plants were measured at maximum growth stage, tasseling stage and grain filling stage. Leaf area index was calculated by the formula described by Watson (1956).

$$\text{LAI} = \frac{\text{Sum of the leaf area of all leaves}}{\text{Ground area of field where the leaves have been collected}}$$

Crop growth rate (CGR): CGR of maize was measured in g m^{-2} day^{-1} by the formula, Hunt (1978).

$$\text{CGR} = \frac{\text{Total dry matter at second sampling - Total dry matter at first sampling}}{\text{Time between second and first sampling} \times \text{Ground area}}$$

Yield (ton ha^{-1}): Yield of maize was measured from harvest area of (10 m^2) at the center of each plot. Then, the total grain yield from each plot was weighed and converted to ton ha^{-1}.

$$\text{Grain yield (ton ha}^{-1}\text{)} = \frac{\text{(100 – moisture) (Field weight (kg)} \times \text{shelling \%} \times 10{,}000\ \text{m}^2\text{)}}{85 \times \text{harvested area (m}^2\text{)} \times 1000}$$

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

Where, 85 = adjusted factor of grain moisture to 15%
1000 = unit converter of kg to ton (1000 kg = 1 ton)
10,000 sq. meter = conversion factor to an area of one hectare of a plot

Mean daily temperature and rainfall data of Yezin during rainy season, 2024 were presented in Figure 1.

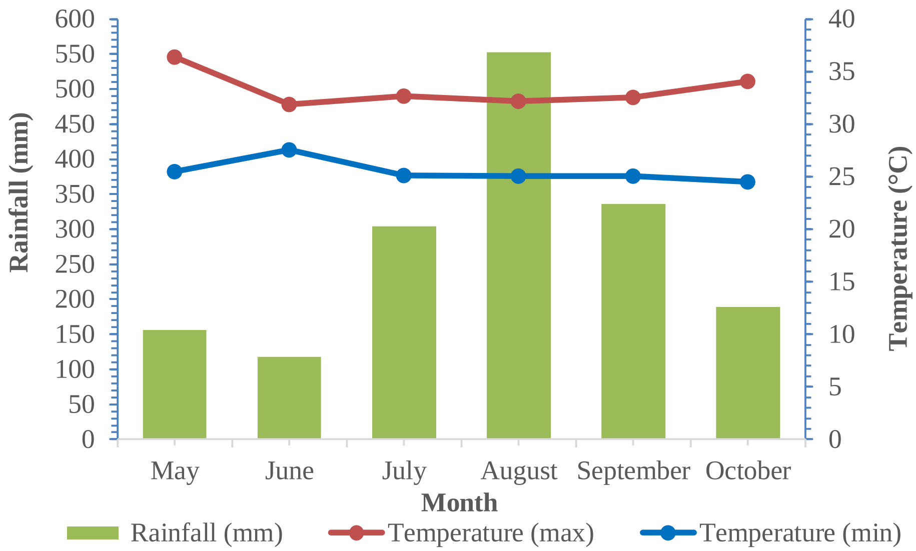


Figure 1. Mean values of temperature and rainfall in Yezin during rainy season, 2024

2.4 Data analysis

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

3. Results and Discussion

3.1 Weed density

There was significantly different in weed density of all treatments at all sampling times (Table 1). The weed density in mulches treatments was significantly lower than the control (no mulch, T1) at all sampling times. Plant with various mulching materials inhibited weed growth substantially more than not mulched (Hatami, Nourjon, Henareh, & Pourakbor, 2012). Among the mulches, black plastic mulch (T6) and followed by maize stover mulch (T5) gave the lower weed density at all sampling times. Black plastic mulch may reduce outgoing radiations and reduce the weed growth. Maize stover mulch may inhibit the light of weeds as a barrier and suppress their growth and development. At 15 DAS, among the living mulch plots, the lowest number of weed density was observed in lablab bean mulch (T4) and followed by cowpea mulch (T2) and green gram mulch (T3) respectively. At 35 DAS, 55 DAS and 75 DAS, the lowest number of weed density among the living mulches was observed in cowpea mulch (T2,) and followed by lablab bean mulch (T4) and green gram mulch (T3) respectively. Because cowpea living mulch formed a dense canopy and growth, and their green masses may cover the soil surface effectively to reduce light availability for weed seeds, thereby suppressing weed germination and growth.

Table 1. Weed density as affected by different mulches during rainy season, 2024

Treatments	Weed density (number m^{-2})			
	15 DAS	**35 DAS**	**55 DAS**	**75 DAS**
T1 (Control, no mulch)	981 a	409 a	386 a	325 a
T2 (Cowpea mulch)	624 c	98 b	92 c	65 c
T3 (Green gram mulch)	650 b	116 b	107 b	81 b
T4 (Lablab bean mulch)	618 c	108 b	98 bc	75 bc
T5 (Maize stover mulch)	334 d	52 c	47 d	45 d
T6 (Black plastic mulch)	62 e	30 d	24 e	20 e
$LSD_{0.05}$	22.17	19.99	14.22	14.81
Pr>F	**	**	**	**
CV%	2.24	8.11	6.22	8.04

DAS = Days after sowing, * and ** = significant at 5% and 1% level

3.2 Weed dry weight

There was significantly different in weed dry weight at all sampling times (Table 2). The weed dry weight in control (no mulch plot, T1) was significantly higher than the mulches plots at all sampling times. This may be due to the lack of physical barrier in no mulch plot to control weeds and direct sunlight exposure to the soil surface creating optimal conditions for weed seed germination. These factors may lead to higher weed dry weight in control (no mulch, T1). Among the mulches, the lowest weed density was found in black plastic mulch (T6) and followed by maize stover mulch (T5), cowpea mulch (T2), lablab bean mulch (T4) and green gram mulch (T3) at all sampling times respectively. Weed dry weight in cowpea mulch during the rainy season was lower than the other living mulches of green gram and lablab bean mulch because of cowpea's ability to form a denser canopy and faster growth, and it could give the higher green masses to suppress weed growth.

Table 2. Weed dry weight as affected by different mulches during rainy season, 2024

Treatments	Weed dry weight (g m^{-2})							
	15 DAS		35 DAS		55 DAS		75 DAS	
T1 (Control, no mulch)	28.96	a	32.25	a	30.36	a	24.42	a
T2 (Cowpea mulch)	12.40	b	8.56	b	8.24	b	5.06	bc
T3 (Green gram mulch)	12.98	b	10.14	b	9.78	b	6.12	b
T4 (Lablab bean mulch)	12.24	b	9.66	b	8.86	b	5.65	b
T5 (Maize stover mulch)	6.65	c	5.35	c	5.38	c	4.08	c
T6 (Black plastic mulch)	1.48	d	1.26	d	1.28	d	1.05	d
$LSD_{0.05}$	0.96		2.89		2.12		1.13	
Pr>F	**		**		**		**	
CV%	4.24		14.20		10.94		8.05	

DAS = Days after sowing, * and ** = significant at 5% and 1 % level

3.3 Weed control efficiency

Weed control efficiency of different mulches was above 50 percent at all sampling time. This indicated that mulching could control weeds over 50% of weed infestation than that of no mulch plots. The highest weed control efficiency was found in black plastic mulch (T6) and followed by maize stover mulch (T5), cowpea mulch (T2), lablab bean mulch (T4) and green gram mulch (T5) respectively (Figure 2). This may be because of the weed suppressing effect of mulch from a limited amount of light reaching the soil surface and as a result reducing the germination and growth of weeds. Plastic mulching significantly reduced weed infestation (Hatami, Nourjon, Henareh, & Pourakbor, 2012)

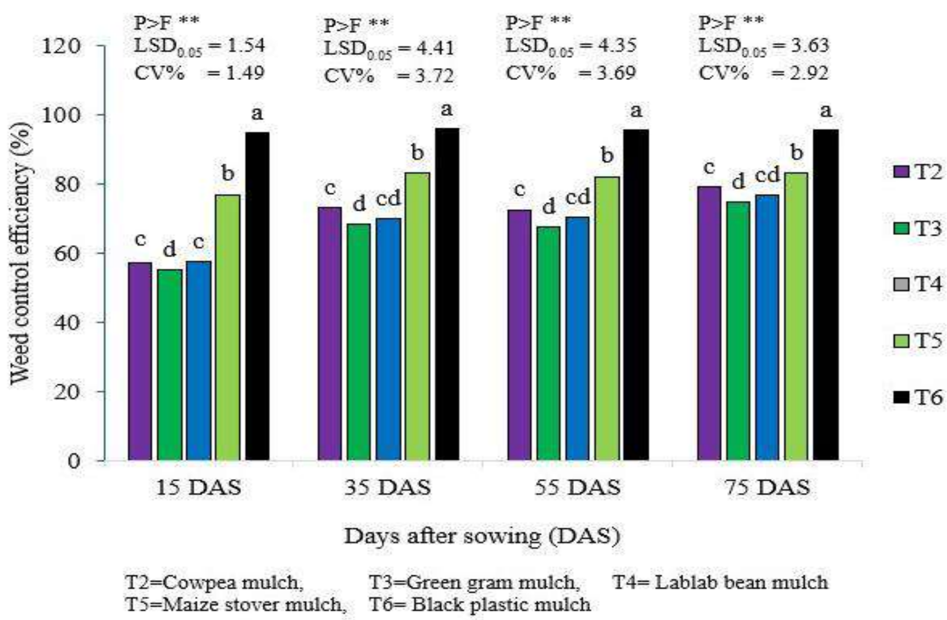


Figure 2. Weed control efficiency of different mulches in maize cultivation at 15 DAS, 35 DAS, 55 DAS and 75 DAS during rainy season, 2024

3.4 Plant height

Plant height of maize increased continuously from 10 to 70 DAS. There was significantly different in plant height among the treatments at 50 to 70 DAS. At 70 DAS, the minimum plant height was found in control (no mulch) (T1, 181.6 cm) (Figure 3). In no mulch plots, weeds may compete with maize for nutrients, water and light, thus, reducing the resources available for the maize crop and leading to shorter plants. The maximum plant height was found in black plastic mulch (T6, 190.32 cm) followed by maize stover mulch (T5, 186.20 cm), lablab bean mulch (T4, 184.68 cm), green gram mulch (T3, 182.93 cm) and cowpea mulch (T2, 182.38 cm) at 70 DAS respectively. Mulching created favorable soil and environmental condition, supporting better growth and resulting in taller maize plants. The taller plant can have greater access to sunlight, reducing the crop-weed competition and maximize the light interception which can produce energy for growth and development.

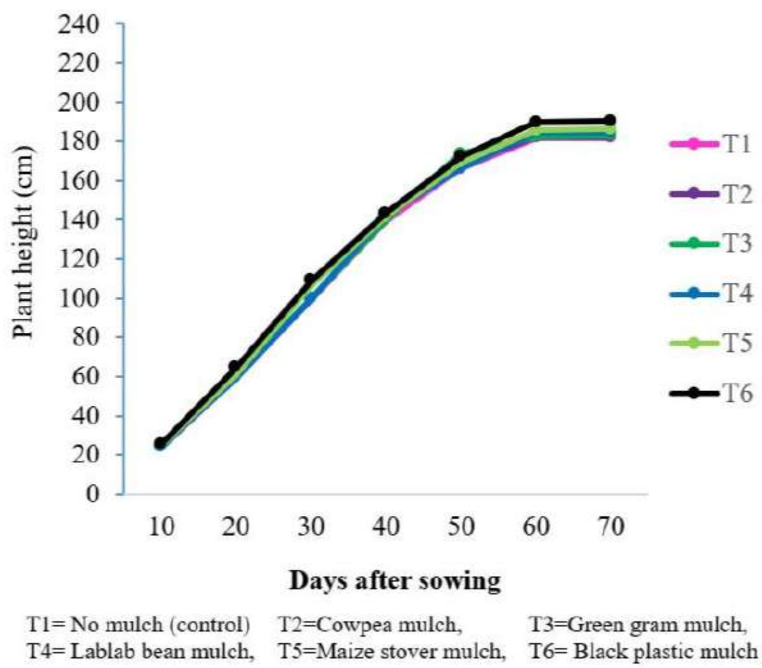


Figure 3. Mean plant height of maize as affected by different mulches during rainy season, 2024

3.5 Total dry matter

The total dry matter of maize under different mulch treatments significantly increased from maximum vegetative growth stage to grain filling stage. Total dry matter of maize was significantly different at maximum vegetative growth stage and highly significantly different at tasseling stage and grain filling stage (Figure 4). The minimum total dry matter of maize (87.99 g, 145.5g and 237.09 g) was observed in control (no mulch) (T1) at three sampling times. Because the soil may expose to unfavorable conditions such as nutrient depletion and weed competition all of which reduce the growth potential and total dry matter production of maize during the rainy season.

Maximum total dry matter of maize was observed in maize stover mulch (T5) and followed by black plastic mulch (T6) and cowpea mulch (T2) at maximum vegetative growth stage and tasseling stage among the different mulches. At grain filling stage, the maximum total dry matter of maize was found in cowpea mulch (T2, 292.9 g) followed by maize stover mulch (T5, 284.06 g) and black plastic mulch (T6, 282.5 g). This may be the sustainable benefits of mulches such as nutrient cycling and weed suppression, which are particularly beneficial during the grain-filling stage of maize.

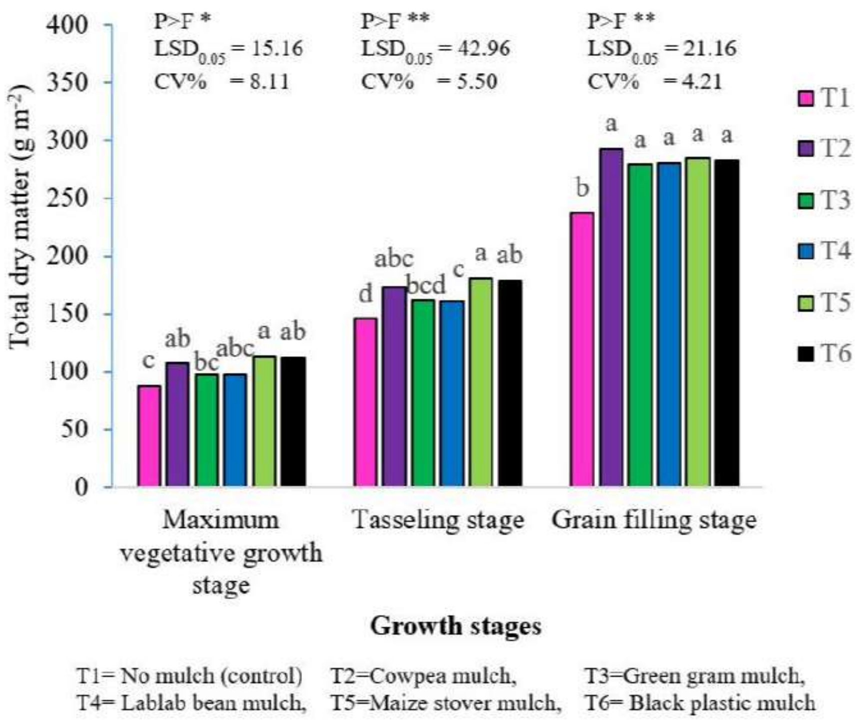


Figure 4. Effect of different mulches on total dry matter of maize at maximum vegetative growth stage, tasseling stage and grain filling stage during rainy season, 2024

3.6 Leaf area index (LAI)

LAI was significantly different among the different mulches at maximum growth stage in all treatments, and highly significant different at tasseling stage and grain filling stage (Figure 5). The significantly higher LAI value was recorded in black plastic mulch (T6, 4.28) and followed by maize stover mulch (T5, 4.14) at maximum vegetative growth stage. At tasseling stage and grain filling stage, the significantly higher LAI value was observed from cowpea mulch (T2, 3.9 and 3.63). This might be the facts that cowpeas provide effective weed suppression through their dense canopy, reducing competition for nutrients, water, and light with maize crop and this may allow maize plants to intercept light and sustain vigorous leaf growth up to the grain filling stage. The value of LAI from all different mulches was higher than the no mulch (T1) (3.7, 3.34 and 2.98) at all growth stages.

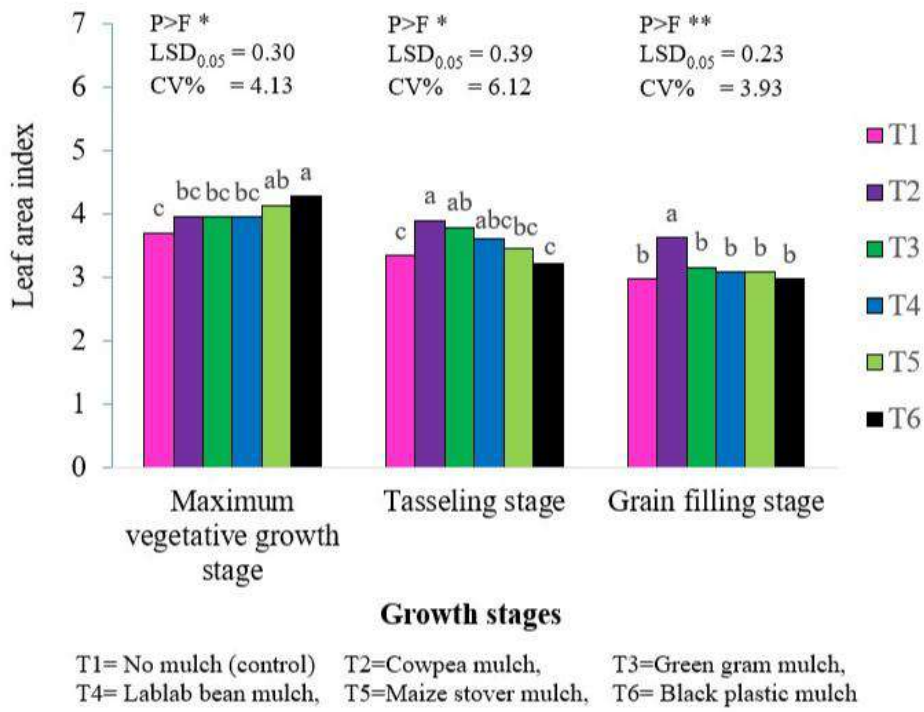


Figure 5. Effect of different mulches on leaf area index of maize at maximum vegetative growth stage, tasseling stage and grain filling stage during rainy season, 2024

3.7 Crop growth rate

Crop growth rate (CGR) was recorded from maximum vegetative growth stage to tasseling stage and from tasseling stage to grain filling stage of maize. CGR of maize was not significantly different among all treatments from maximum growth stage to tasseling stage. From tasseling stage to grain filling stage, CGR was highly significantly different among the treatments (Figure 6). The CGR of maize from mulches plots was higher than the control (no mulch) (T1) at two sampling times. This might be the result of favorable condition of micro-environment around crops. This may lead to the weed suppression and reduce the competition and thus, it could improve the nutrient uptake of plants and improve crop growth. The higher CGR value was observed from lablab bean mulch (T4) (20 g m^{-2} day $^{-1}$) and followed by cowpea mulch (T2) (19.88 g m^{-2} day $^{-1}$) and green gram mulch (T3) (19.49 g m^{-2} day $^{-1}$). Legumes living mulches may cover the soil to reduce the weed competition of maize and may become the additional nutrient for the crop and improve the nutrient uptake of plants and enhance the crop growth.

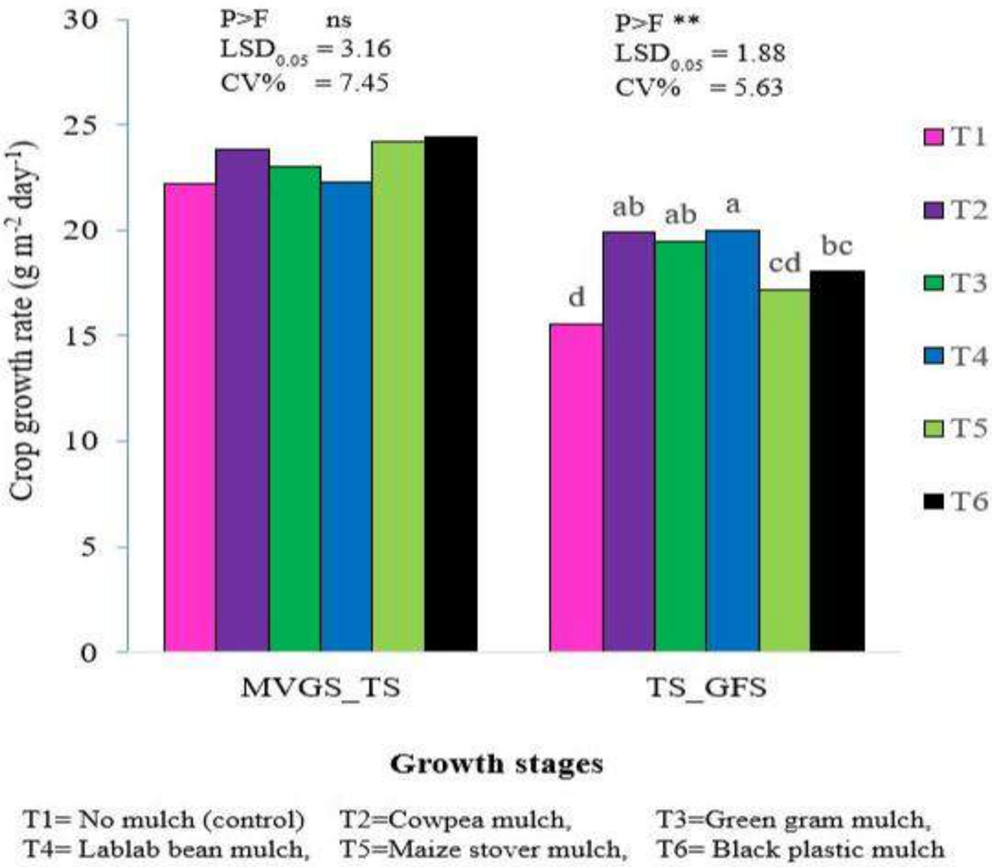


Figure 6. Effect of different mulches on CGR of maize from maximum vegetative growth stage to tasseling stage (MVGS_TS) and from tasseling stage to grain filling stage (TS_GFS) during rainy season, 2024

3.8 Yield of maize

There was highly significant in maize grain yield during rainy season, 2024 (Figure 7). In addition, the yield of maize from mulches plots was higher than the control (no mulch, T1). This may be because of mulches which suppressed weed growth, reducing weed competition for water, nutrients, and sunlight and protecting the soil from nutrient loss and maintaining the favorable condition for maize growth and leading to higher grain yield. The minimum grain yield of maize was found in control (no mulch, T1) (6.21 ton ha^{-1}). The maximum grain yield of maize was observed from cowpea mulch (T2) (7.43 ton ha^{-1}) followed by green gram mulch (T3) (6.93 ton ha^{-1}). Cowpea mulch may have the highly suppressing weed growth because it produced enough green masses to cover the soil surface to suppress weed growth and nitrogen fixing ability of cowpeas, which can improve soil fertility and nutrient cycling which can lead to better growth and higher yields of maize.

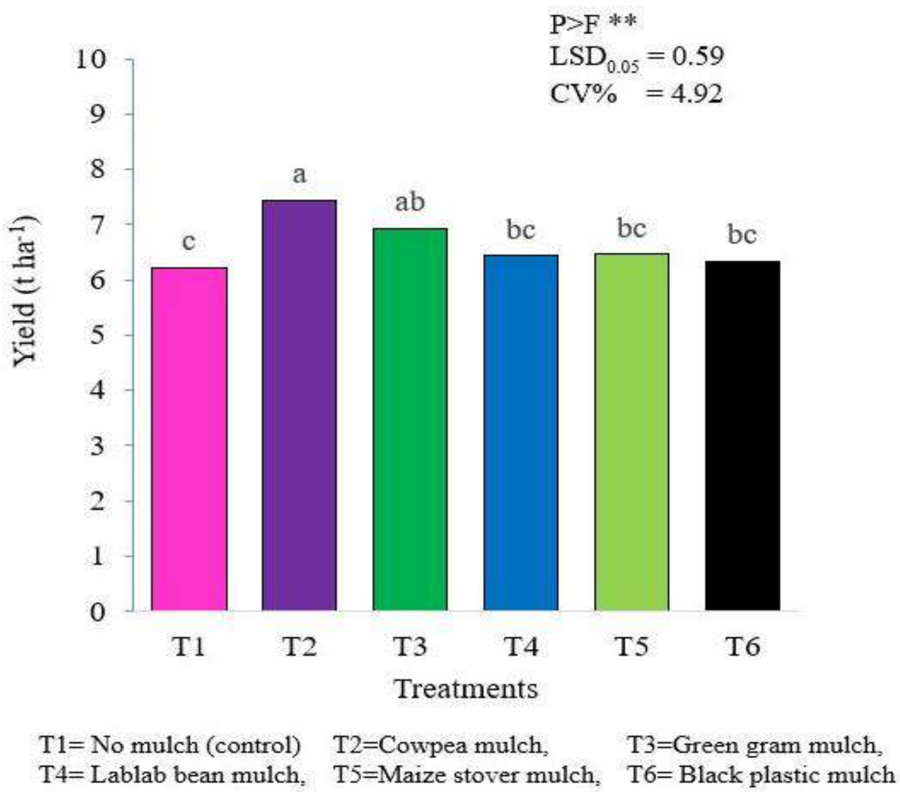
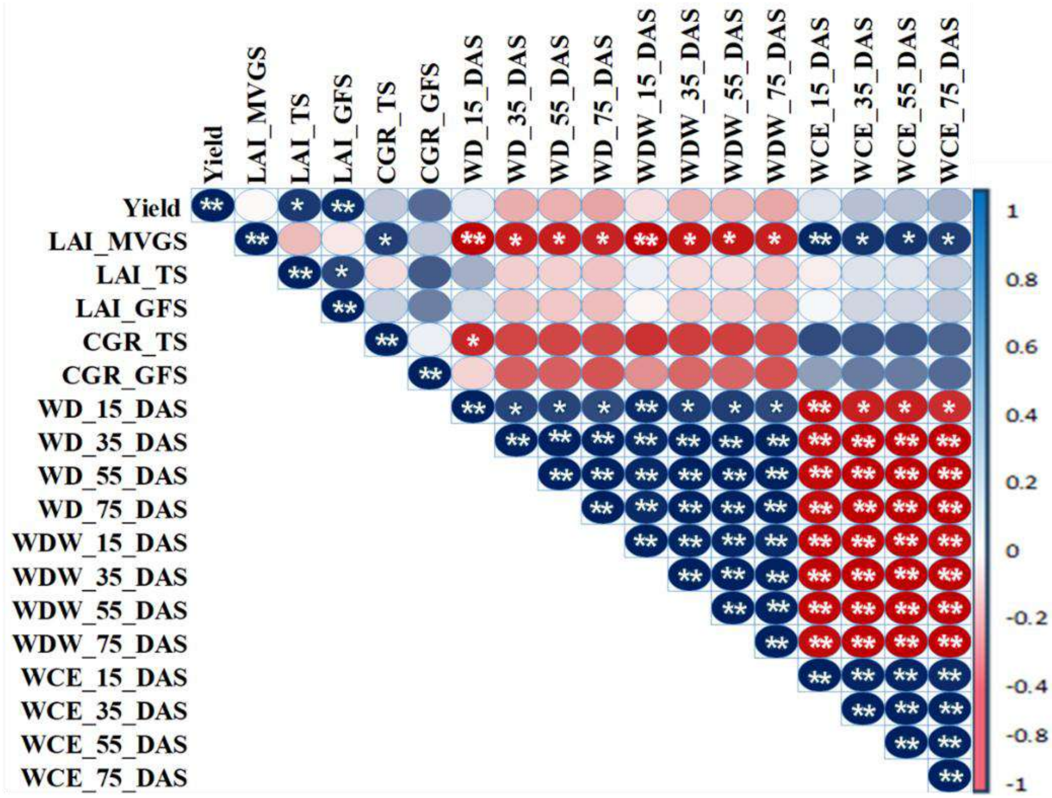


Figure 7. Yield of maize as affected by different mulches during rainy season, 2024

3.9 Correlation analysis of weed infestation, growth and yield of maize

The results of correlation of yield, growth and weed infestation of maize in Yezin during rainy season, 2024 was shown in Figure 8. The blue color showed positive correlation and the red color was negative correlation. Color intensity indicated the value of correlation coefficient. Yield was positively and significantly correlated with LAI and CGR. It could be suggested that the higher values of growth parameters, the higher yield can be achieved. Moreover, yield was negatively correlated with weed dry weight and positively correlated with weed control efficiency at all sampling times. It could be suggested that the higher weed control efficiency, the higher yield can be achieved. In addition, LAI and CGR were negatively and significantly correlated with weed dry weight and positively correlated with weed control efficiency. This indicates that the higher weed control efficiency, the higher LAI and CGR, can be achieved and the higher weed dry weight, the lower LAI and CGR, can be achieved. While the higher weed infestation can result the lower maize grain yield, the higher weed control efficiency can result the higher crop growth and the higher maize grain yield.



LAI_MVGS = Lead area index at maximum vegetative growth stage, LAI_TS = Leaf area index at tasseling stage, LAI_GFS = Leaf area index at grain filling stage, CGR_TS = Crop growth rate from vegetative growth stage to tasseling stage, CGR_GFS = Crop growth rate from tasseling stage to grain filling stage, 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 8. Association of weed infestation, growth and yield of maize during rainy season, 2024

4. Conclusion

Different mulching proved in promoting maize growth and yield during rainy season in the study area, Yezin. The black plastic mulches gave the higher weed suppression and followed by maize stover mulches. However, these mulching materials could not give the highest grain yield of maize because of prolonged waterlogging like no mulch plots due to heavy rainfall in August during rainy season though their weed suppression were greater than the other mulches at weed sampling data collection times. At that time, legumes living mulches plots could not suffer prolong water logging. They may promote better soil aeration by creating different root depth levels which may allow oxygen to penetrate deeper into the soil during heavy rainfall and may reduce the extent of water logging condition in maize, and thereby improve soil fertility through nitrogen fixation, which may support a healthy microbial environment to help break down their green masses as organic matter to be available to maize plants. In addition, legumes living mulches can support maize roots to recover quickly from water logging. Cowpea mulch (T2) gave the higher weed control mulch among the selected living mulches treatments. In addition, the highest maize grain yield was obtained from cowpea mulch. This may be due to enough coverage of its green masses to the soil surface to suppress weed infestation 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 for enhancing maize yield. Therefore, cowpea mulch application is suitable for reducing weed infestation and improving maize growth and yield during rainy season in the study area. Moreover, maize stover mulch should also be used where living mulch is not suitable.

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