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Research Article

Effects of different mulching materials on yield and yield components of maize (*Zea mays* L.)

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Abstract

Two field experiments were conducted during dry season (October, 2019 to March, 2020) at Yezin Agricultural University farm and Sepin research farm, Yamethin, Myanmar to investigate the effect of different mulching materials on yield and yield components of maize. No mulching and six mulching materials (rice straw mulching, rice husk mulching, maize stover mulching, mung bean stover mulching, soybean stover mulching and white plastic polyethylene mulching) were laid in a Randomized Complete Block Design (RCB) with three replications on NK-621 variety. The longest days to 50% tasseling (69.67) at Yezin and (71.67) at Yamethin were obtained in no mulching while the shortest days to 50% tasseling (62.00) at Yezin and (64.33) at Yamethin were observed from rice straw mulching at Yezin and white plastic polyethylene mulching at Yamethin. Number of kernel row^{-1}, rows ear^{-1}, row length, kernels ear^{-1}, thousand grains weight were significantly different among different mulching materials at Yezin. The maximum grain yield (5.72 ton ha^{-1}) and (10.39 ton ha^{-1}) were observed from rice straw mulching at Yezin and Yamethin. According to the results, rice straw mulching resulted in the highest yield and yield components of maize at two locations.

Introduction

Maize (*Zea mays* L.) production in Asia countries is being increasingly important as the demand for both national needs and export is expending quickly. In Asia, maize is grown in Pakistan, India, China and Nepal as a food and fodder crop. Maize is desired for its multiple purposes as human food, animal feed and for pharmaceutical and industrial manufacturing (Huang et al., 2005). Maize has great commercial importance as it is involved in the production of corn oil, corn syrup, corn starch that is used in the textile and paper industry and alcohol as well. It also has a vital role in the leather industries as it supplies tanning materials (Saeed et al., 2014). Chaudhary, Kumar & Yadav (2014) reported that maize has great nutritional value for animal as green fodder contains ample protein content in it. It has also become a key resource for industrial applications and bio energy production (Glencross et al., 2020). Maize is physiologically more efficient, has wider adaptation over a range of environmental conditions and higher grain yield potential.

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Rapid increase of the world population, pollution of natural resources, global warming and climate change are putting increasing pressure on limited water resources (Kader et al., 2017). Agriculture is the largest water consumer in the world that accounts 70% of total use (Kader et al., 2019). Approximately, 80% of worldwide cropland is rainfed (non-irrigated) that produces 60–70% of the world food (Xie et al., 2019). Considering the growing water shortage, rainfed crop cultivation plays a prime role in the worldwide food supply (Wang et al., 2017).

Mulching is an effective method of employing crop growing environments in order to increase yield and advance product quality by controlling weed growth, reducing soil temperature, conserving soil moisture, reducing soil erosion, improving soil structure and enhancing organic matter content of the soil. Mulches are used for several reasons but water conservation and erosion control are the most important objective for its use in agriculture in dry regions. Other reasons for mulch use contains soil temperature modification, soil conservation, nutrient addition, improvement in soil structure, weed control and crop quality control. Mulching reduces deterioration of soil by way of preventing runoff and soil loss, minimizes weed infestation and checks water evaporation. Thus, it facilitates more retention of soil moisture and supports in control of temperature fluctuations, improves physical, chemical and biological properties of soil, as it adds nutrients to the soil and ultimately enhances the growth and yield of crops (Bhatt & Kheral, 2006; Anikwe et al., 2007; Sarkar & Singh, 2007; Glab & Kulig, 2008). However, research concerning with different mulching materials is relatively scarce on yield and yield components of Maize in Myanmar. Hence, these experiments were carried out to investigate the effect of different mulching materials on yield and yield components of maize and to detect the most suitable mulching materials for maize cultivation at Yezin and Yamethin areas.

Materials and methods

Land preparation and crop management

The experiments were conducted at field of Yezin Agricultural University farm and Sepin Research Farm, Yamethin during dry season, October 2019 to March 2020. Yezin is located at 19° 49' 59.6'' N latitude, 96° 16' 30.4'' E longitude and 129 meters above sea level. It is situated in Nay Pyi Taw Union Council. Sepin is located at 20° 56' N latitude, 96° 05' E longitude and 203 meters above sea level. It is situated in Mandalay region. The experimental fields were mechanically ploughed, harrowed and leveled. The experiments were laid out in Randomized Complete Block Design (RCB) with three replications. Maize was sown at a spacing of 75 cm × 25 cm with the total number of 140 maize plants per plot. Total land area measured 883.5 m^2 (46.5 m × 19 m) with 21 plots in all and each plot size measured 5.5 m × 5 m (27.5 m^2) with 1 m alley ways between plots and replicates. The most used variety in Myanmar, NK 621 (120 days) was used as the tested variety. The organic different mulching materials were weighed at the rate of 10 ton ha^{-1} while NPK was applied at the recommended rate of Department of Agricultural Research (DAR), Myanmar. Treatments were included in the following; T_1 = no mulching (control), T_2 = Rice straw mulching, T_3 = Rice husk mulching, T_4 = Maize stover mulching, T_5 = Mung bean stover mulching, T_6 = Soybean stover mulching, T_7 = White plastic polyethylene mulching.

Data collection

The following data were collected during the crop season at the two different locations.

Days to 50% tasseling (days)

Number of days from sowing to when 50% of the plants have shed pollen were recorded in the experimental plots.

Days to 50% silking (days)

Number of days from sowing to when silks have emerged on 50% of the plants were recorded in the experimental plots.

Yield and yield components

At harvest, yield and yield components such as number of row ear^{-1}, number of kernels row^{-1}, row length (cm), number of kernel ear^{-1}, thousand grains weight (g), ear length (cm), ear diameter (cm), ear height (cm), shelling % and harvest index were recorded from randomly selected five sample plants of each plot.

Grain yield was measured from the harvest area (10 m^2) at center of the plots. The total grain yield (at adjusted 15 % moisture content) from each plot were weighed and converted to kg ha^{-1}.

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

(Abd El-Mageed, EI- Samnoudi, Ibrahim & Abd EI- Tawwab, 2018)

$$\text{Shelling \%} = \frac{\text{Seed dry weight}}{\text{Ear dry weight}} \text{x100}$$

(Abdal-Gawad, Abdel- Salam, Mosa & Mostafa, 2018)

Harvest index

$$(\text{HI}) = \frac{\text{Seed yield/ Economic yield (kg ha}^{-1})}{\text{Biological yield (kg ha}^{-1})}$$

(Khalili, Naghavi, Aboghadareh & Rad, 2013)

Statistical analysis

The data analyses were carried out by using Statistix (version 8) software program and treatment means comparison were performed by using least significant difference (LSD) test at 5% level of significance (Gomez & Gomez, 1984) and data visualization was done by R program (version 4.1.3).

Results and discussion

Days to 50% tasseling

Days to 50% tasseling was significantly different among different mulching materials at Yezin and Yamethin (Figure 1A and Figure 1B). The longest days to 50% tasseling (69.67) at Yezin and (71.67) at Yamethin were obtained from T1 while shortest days to 50% tasseling was recorded (62.00) at Yezin and (64.33) at Yamethin were observed in T2 at Yezin and T7 at Yamethin. At both study sites, different mulching materials had a highly significant effect on days to 50% tasseling. It could be could said that Oktem (2008) found that days to tasseling was longer with enhancing water stress.

Days to 50% silking

Different mulching materials showed highly significantly difference in days to 50% silking at Yezin and Yamethin (Figure 2A and Figure 2B). The longer days to silking (75.33) and (75.67) were recorded from T1 whereas the minimum days to silking (66.33) and (68.00) were observed from T2 at Yezin and T7 at Yamethin. The reason might be the sufficient amount of moisture for tasseling and silking that was available throughout the growth period in the mulched plots as compared with no mulching. Mulched treatments also retained significantly greater plant accessible water compared to the bare soil until near anthesis and after anthesis which helped earlier initiation of tassel and silk (Tolk, Hawell & Evett, 1999).

Yield and yield components

Number of rows ear^{-1}

Number of rows ear^{-1} was significantly different among different mulching materials at Yezin and Yamethin (Table 1 and Table 2). The maximum number of rows ear^{-1} (14.07) and (13.87) were resulted in T3 at Yezin and T2 and T4 at Yamethin. Regarding, mulching materials, all mulched treatments showed the larger number of rows ear^{-1} as compared to no mulching. These results are consented with the experimental findings of Otegui, Andrade and Suero (1995) who reported that water stress affected the final grain yield by declining the number of rows ear^{-1}.

Number of kernels row^{-1}

Number of kernels row^{-1} was significantly different among different mulching materials at Yezin and Yamethin (Table 1 and Table 2). The comparison of means observed that the maximum number of kernels row^{-1} (29.02) and (34.20) were obtained from T6 at Yezin and T2 at Yamethin while the minimum number of kernels row^{-1} (13.90) and (29.42) were recorded in T1 at both sites. In case of different mulch materials, the number of kernels row^{-1}

was noted to be higher in all mulch treatments as compared to no mulching. They may be due to less water stress in mulched plot than no mulching. Khodarahmpour (2012) detected that water stress during pollination and grain filling stages can cause reduced kernels number row^{-1}.

Number of kernels ear^{-1}

The total number of kernels ear^{-1} was counted and record mean was computed. Number of grains ear^{-1} was significantly difference among different mulching materials at Yezin and Yamethin (Table 1 and Table 2). The maximum number of kernels ear^{-1} (381.75) and (472.14) were detected from T6 at Yezin and T2 at Yamethin whereas the minimum number of kernels ear^{-1} (176.19) and (371.25) were recorded from T1 at both locations. As far as water is one of the most important components of photosynthesis for plants to create their food, suppling adequate water and could lead to increase number of kernels ear^{-1}. The results given in this study are in accordance with the results Wajid (1990) who reported that mulching materials had a substantial effect on number grains per cob.

Row length (cm)

Row length of ear was significantly different among different mulching materials at Yezin (Table 1). The longest (13.53 cm) was observed from T6 followed by T3, T2, T5, T7 and T4 whereas the shortest (8.83 cm) was obtained T1. At Yamethin, the row length of maize was not significantly different among different mulching materials in Table 2. The shortest row length of maize (15.56 cm) was from T1 while the longest row length of maize (17.77 cm) was obtained from T2. Furthermore, all mulched treatments showed a considerable increase in row length. These findings that Otegui et al. (1995) who found that water scarcity had a major impact on row length.

Thousand grains weight (g)

Thousand grains weight of maize was highly significant affected by using different mulching materials at Yezin (Table 1). The maximum thousand grains weight of maize (289.67 g) was obtained from T6, T3 and T2 while the minimum thousand grains weight (209.70 g) was observed from T1. At Yamethin, thousand grains weight of maize was not significantly different among different mulching matrials (Table 2). The minimum thousand grains weight (272.23 g) was recorded in T1 whereas the maximum thousand grains weight (287.49 g) was resulted in T2. The increase of thousand grains weight of the maize crop by application of plastic mulching and rice straw mulching. Hussein (1997) reported that decline in thousand grains weight was related to the duration of weed competitions.

Ear length (cm)

Ear length of maize was not significantly different among different mulching materials at Yezin and Yamethin (Table 1 and Table 2). The longest ear length of maize (16.88 cm) and (20.47 cm) were observed from T6 at Yezin and T2 at Yamethin while the shortest ear length of maize (11.09 cm) and (18.69 cm) were obtained from T1 at two areas. These results are authenticated by the experimental results of Mupangwa, Twomlow, Walker and Hove (2007) who reported that mulching materials enhanced grain yield by increasing plant height, number of ear plant^{-1} and ear length. Similar findings were reported by Awal and Khan (2000) who reported mulching improves maize growth characteristics such as ear diameter and ear length.

Ear diameter (cm)

Ear diameter of maize was not significantly different among different mulching materials at Yezin and Yamethin (Table 1 and Table 2). The maximum ear diameter (42.30 cm) and (42.51cm) were found in T6 at Yezin and T2 at Yamethin whereas the minimum ear diameter (35.73 cm) and (40.32 cm) were obtained in T1 at both experimental sites. Similar finding was reported by Singh et al., (2016) who reported that application of rice straw mulching increased of yield parameters.

Ear height (cm)

The ear height was significantly different among different mulching materials at Yezin

and Yamethin (Table 1 and Table 2). The highest (80.00 cm) and (112.73 cm) were observed in T2 at Yezin and T4 at Yamethin while the shortest (61.33 cm) and (95.67 cm) were achieved from T1 at both locations. Zsubori et al. (2015) found that the plant and ear height not only influence on the genetic, background of the varieties, but also influenced by several environmental effects and by the growing method.

Shelling %

Shelling percentage of maize was not significantly difference among different mulching materials at Yezin (Table 1). The maximum shelling % (89.75) was observed from T6 while the minimum shelling % (81.73) was obtained from T1. Shelling percentage of maize was significantly difference among different mulching materials at Yamethin (Table 2). The maximum shelling % (85.28) was observed from T2 while the minimum shelling % (76.67) was obtained from T1.

Harvest index (HI)

Harvest index (HI) is significantly different among different mulching materials at Yezin and Yamethin (Table 1 and Table 2). The highest harvest index (0.43) and (0.33) were obtained from T2 at Yezin and T7 at Yamethin while the lowest harvest index ((0.39) and (0.28)) were recorded in T1 at both experimental sites. Higher harvest index value was recorded in rice straw mulching plots. Asif et al. (2020) reported that mulching increased harvest index and main grain yield in all mulch treatment over no mulching may be the reason for good harvest index.

Grain yield (ton ha^{-1})

Grain yield of maize was significantly different among different mulching materials at Yezin and Yamethin (Figure 3A and 3B). The maximum grain yield (5.72 ton ha^{-1}) and (10.39 ton ha^{-1}) were observed from T2 at both sites whereas the minimum grain yield (3.73 ton ha^{-1}) and (5.74 ton ha^{-1}) were obtained from T1 at both locations. A good mulching material with adequate supply of nutrients is required for plants to achieve maximum production. All the mulching plots are better than the control, so the rice straw mulching from them is good. These results confirm the studies done by Khurshid et al. (2006) in which they found that mulching had a significant impact on maize yield.

Relationship of yield and yield components of maize during dry season, 2019-2020

Relationship of yield and yield components of maize at Yezin during dry season, 2019-2020 was shown in Figure 4A and Figure 4B. At Yezin and Yamethin, yield was significantly and positively correlated with number of rows ear^{-1}(0.80 and 0.76), number of kernels row^{-1} (0.74 and 0.90), number of kernels ear^{-1} (0.82 and 0.90), row length (0.77 and 0.69), thousand grains weight (0.83 and 0.47), ear length (0.89 and 0.94), ear diameter (0.86 and 0.72), ear height (0.79 and 0.89), shelling % (0.38 and 0.94) and harvest index (0.97 and 0.31) but significantly and negatively correlated with days to 50 % tasseling (-0.79 and -0.64) and days to 50 % silking (-0.82 and -0.72). Similar to yield, other yield components except days to 50 % tasseling and 50 % silking was positively correlated with each other. Days to 50 % tasseling and days to 50 % silking was negatively correlated with yield components but positive correlated with each other. Therefore, early tasseling and silking date produced higher grain yield. Golam et al. (2011) observed that days to 50% tasseling was highly and positively correlated with days to 50% silking. Number of rows ear^{-1}, number of kernels per row^{-1}, number of kernels ear^{-1}, ear length, ear diameter, ear height, thousand grains weight, shelling % and harvest index was positively correlated with each other. Days to 50 % tasseling and days to 50 % silking was negatively correlated with yield components. Bello and Olaoye (2010) stated that days to 50% silking was significantly and negatively correlated with grain yield.

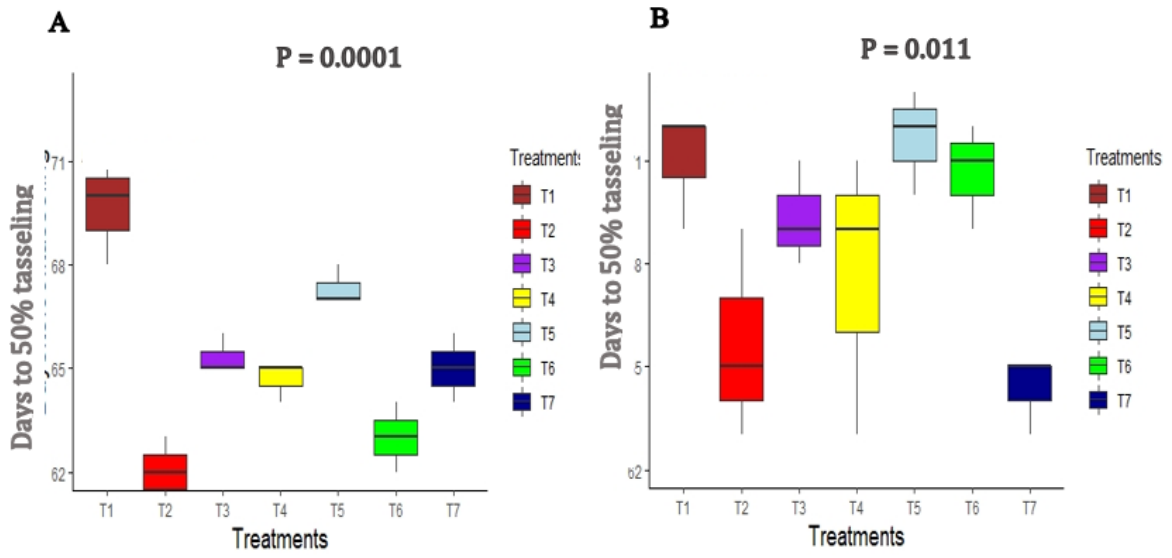

Figure 1. Days to 50% tasseling of maize as affected by different mulching materials at Yezin (A) and Yamethin (B) during dry season, 2019-2020

T1- No mulching, T2- Rice straw mulching, T3- Rice husk mulching, T4- Maize stover mulching, T5- Mung bean stover mulching, T6- Soybean stover mulching, T7- White plastic polyethylene mulching

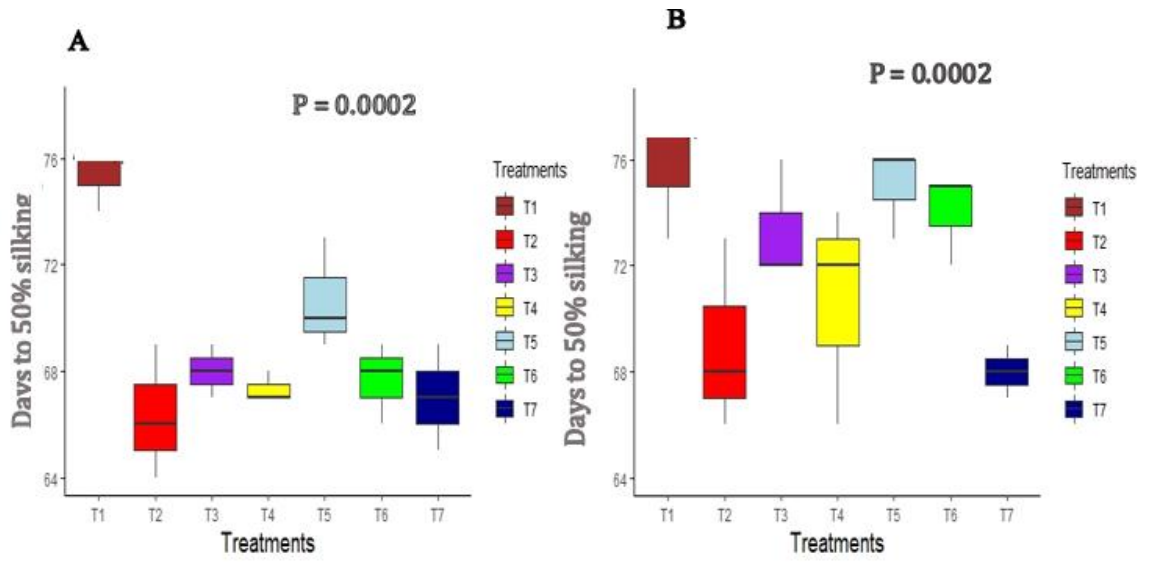

Figure 2. Days to 50% silking of maize as affected by different mulching materials at Yezin (A) and Yamethin (B) during dry season, 2019-2020

T1- No mulching, T2- Rice straw mulching, T3- Rice husk mulching, T4- Maize stover mulching, T5- Mung bean stover mulching, T6- Soybean stover mulching, T7- White plastic polyethylene mulching

Table 1. Yield and yield components of maize as affected by different mulching materials at Yezin during dry season, 2019 – 2020

Treat-ments	No. of row ear^{-1}	No. of kernels row^{-1}	No. of kernels ear^{-1}	Row length (cm)	Thousand grains weight (g)	Ear length (cm)	Ear di-ameter (cm)	Ear height (cm)	Shelling %	Harvest index (HI)
T1	12.00 b	13.90 d	176.19 e	8.83 b	209.70 d	11.09	35.73	61.33 c	81.73	0.39 d
T2	14.00 a	22.87 bc	301.53 c	11.97 ab	272.77 ab	15.17	41.20	80.00 a	84.14	0.43 a
T3	14.07 a	23.33 b	328.12 b	12.47 ab	287.61 a	15.84	39.80	75.07 ab	85.95	0.42 ab
T4	13.60 a	19.98 c	271.79 d	10.45 ab	247.90 c	14.42	39.87	77.27 ab	84.14	0.41 bcd
T5	12.13 b	21.74 bc	269.07 d	11.81 ab	262.75 bc	11.09	38.47	68.80 bc	87.11	0.40 cd
T6	12.93 ab	29.02 a	381.75 a	13.53 a	289.67 a	16.88	42.30	73.00 ab	89.75	0.42 a
T7	13.87 a	20.34 bc	284.19 cd	11.54 ab	258.02 bc	14.16	40.27	69.40 bc	89.44	0.42 abc
$LSD_{0.05}$	1.40	3.04	20.65	2.21	21.56	4.28	6.39	10.53	6.55	734.12
Pr>F	0.0250	<0.0001	<0.0001	0.0138	<0.0001	0.1990	0.4508	0.0364	0.1633	0.0075
CV%	5.96	7.90	4.04	10.79	4.64	16.56	9.05	8.21	4.28	2.75

T1- No mulching, T2- Rice straw mulching, T3- Rice husk mulching, T4- Maize stover mulching, T5- Mung bean stover mulching, T6- Soybean stover mulching, T7- White plastic polyethylene mulching

Mean values in each column having the different letters are significantly different at 5% level

CV = Coefficient of Variation

Table 2. Yield and yield components of maize as affected by different mulching materials at Yamethin during the dry season, 2019 – 2020

Treat-ments	No. of row ear^{-1}	No. of kernels row^{-1}	No. of kernels ear^{-1}	Row length (cm)	Thousand grains weight (g)	Ear length (cm)	Ear di-ameter (cm)	Ear height (cm)	Shelling %	H.I
T1	12.62 b	29.42	371.25	15.56	272.23	18.69	40.32	95.67 c	76.67 c	0.28
T2	13.87 a	34.20	472.14	17.77	287.49	20.47	42.51	112.13 ab	85.28 a	0.31
T3	13.87 a	32.44	449.07	16.80	273.64	19.50	41.88	101.80 abc	80.77 b	0.33
T4	13.87 a	32.03	441.63	16.54	260.05	19.77	40.49	112.73 a	81.43 b	0.32
T5	13.36 a	30.80	412.28	17.17	269.10	19.47	40.49	101.60 bc	80.72 b	0.32
T6	13.33 a	30.44	406.20	16.47	263.74	19.43	40.42	99.73 c	80.37 b	0.31
T7	13.67 a	29.99	410.34	17.47	276.90	19.77	41.27	105.80 abc	81.48 b	0.33
$LSD_{0.05}$	0.70	4.65	66.65	1.80	46.66	1.60	2.37	11.08	2.66	0.03
Pr>F	0.0203	0.4012	0.0950	0.2395	0.8948	0.4457	0.3527	0.0434	0.0009	0.0560
CV%	2.90	8.36	8.85	6.03	9.65	4.60	3.25	5.98	2.66	5.24

T1- No mulching, T2- Rice straw mulching, T3- Rice husk mulching, T4- Maize stover mulching, T5- Mung bean stover mulching, T6- Soybean stover mulching, T7- White plastic polyethylene mulching

Mean values in each column having the different letters are significantly different at 5% level, CV = Coefficient of Variation

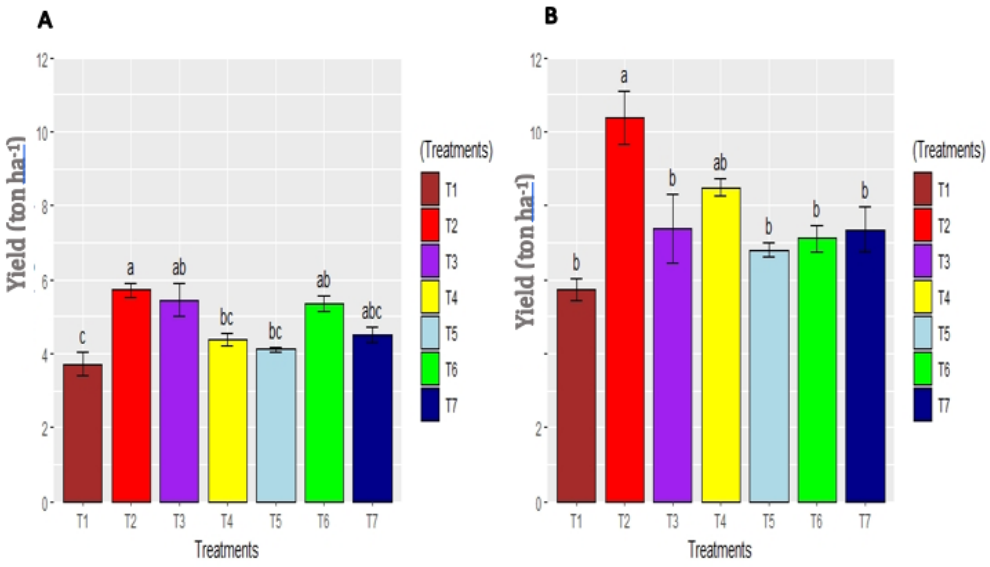

Figure 3. Mean yield of maize as affected by different mulching materials at Yezin (A) and Yamethin (B) during dry season, 2019 - 2020

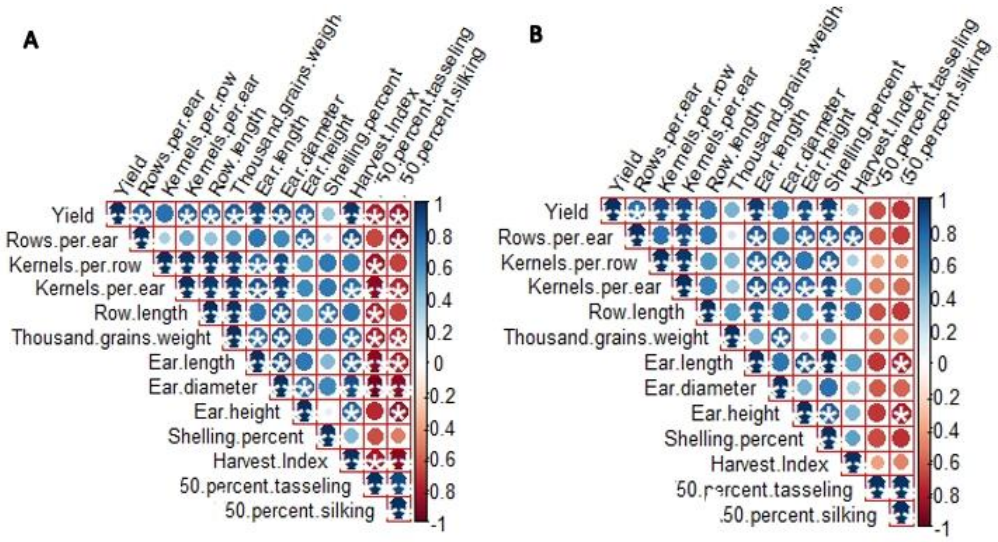

Figure 4. Association of yield and yield components of maize at Yezin (A) and Yamethin (B) during dry season, 2019-2020

Conclusion

The highest number of kernels row^{-1}, number of rows ear^{-1}, row length, number of kernels ear^{-1}, thousand grain weight ear length, ear diameter, sheling %, were observed from soybean stover mulching and ear weight, grain yield and harvest index were achived from rice straw mulching at Yezin. At Yamethin, the maximum yield and yield components were resulted in rice straw mulching expect harvest index. Rice straw mulching showed the maximum yield and yield components followed by rice husk mulching and soybean stover mulching at Yezin and followed by maize stover mulching and white plastic polyethylene mulching at Yamethin. Mulching practices are efficient for maize production, and rice straw is the best in all parameters among the

treatments for Yezin and Yamethin locations. However, from the view of climate change, organic mulching is recommended for maize cultivation rather than plastic mulching.

Author's declaration

Authors declare that there is no conflict of interest. ZMA conducted field experiments, recorded and analyzed field data, and prepared the manuscript. TZ supervised the experiment and conducted manuscript proof-reading before submission. Two authors read and approved the final version of the manuscript.

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