
Research Article

Mulching as soil moisture conservation to improve physiological traits in maize (*Zea mays* L.)

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Abstract

Field experiments were conducted at Yezin farm and Sepin research farm, Yamethin, Myanmar to study the effect of different mulching materials on percent reduction of soil moisture content and physiological traits in Yezin and Yamethin. Randomized complete block design (RCB) was used with three replications from October, 2019 to March, 2020. Rice straw mulching (T2), rice husk mulching (T3), maize stover mulching (T4), mung bean stover mulching (T5), soybean stover mulching (T6) and white plastic polyethylene mulching (T7) and no mulching (T1) were tested with NK-621, variety. At Yezin, the minimum percent reduction of soil moisture content (45.89) was obtained from T2 and (76.79, 58.07) was resulted in T7 whereas the maximum percent reduction of soil moisture contents (76.93, 89.00, 83.93) were recorded from T1 at 14 DAI (Days after irrigation). At tasseling stage, the maximum photosynthesis rates (20.45 $\mu\text{mol m}^{-2}\text{s}^{-1}$) and (21.59 $\mu\text{mol m}^{-2}\text{s}^{-1}$) were observed from T2 at Yezin and Yamethin. At two locations, the maximum stomatal conductance (158.36 $\text{mmol m}^{-2}\text{s}^{-1}$) and (204.44 $\text{mmol m}^{-2}\text{s}^{-1}$) was observed from T2 at maximum growth stage. At maximum growth stage, the maximum SPAD values (33.90) and (53.98) were obtained from T6 at Yezin and T2 at Yamethin. The maximum five ears weight (1830.6 g) was recorded from rice straw mulching whereas the minimum five ears weight (1326.0 g) was resulted from no mulching at Yamethin. According to the results, rice straw mulching resulted in the highest physiological traits of maize, and white plastic polyethylene mulching recorded the minimum percent reduction of soil moisture content at Yezin and maize stover mulching at Yamethin.

Introduction

As the world's population increases, more people begin to include higher amounts of meat, poultry, and dairy into their diets. Therefore, maize has become an important crop for the growing population around the world. This needs different strategies, like an

intensification of modern agricultural crop production and increasing farm area. However, this could not be dependent on only rain-fed agriculture as the climate change scenario and limited area to produce a crop in only the rainy season. The difficulty of crop production in rain-fed regions is made worse by the seasonal

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and unique variation of rainfall, which is further accelerated by climate change (Pereira, 2017). However, this could not be dependent on only rain-fed agriculture as the climate change scenario and limited area to produce a crop in only the rainy season. Next to rice, maize stands as the second most important cereal crop in Myanmar. The majority of the country's maize is grown as a seasonal crop in the monsoon and winter in the Shan, Chin, Sagaing, Magway, and Mandalay regions (Ministry of Agriculture, Livestock and Irrigation, 2014).

The stability of food production has been impacted since the late 1980s by increased frequency of droughts during the maize-growing season as a result of high temperatures, high evaporation rates, and uneven rainfall distribution (Hu et al., 2014). By reducing soil temperature, retaining soil moisture, preventing soil erosion, improving soil structure, and increasing the soil's organic matter content, mulching is an efficient way to alter the crop-growing environment to enhance yield and improve product quality. Organic mulches enhance the soil, lower the soil's temperature, prevent weed development, save soil moisture, and enhance the aesthetic appeal of landscapes. The crop, soil type, weather conditions, management strategy, and kind of mulching materials employed all have an impact on how the crop and soil react to the addition of organic mulching materials (Wang et al., 2019). However, research concerning different mulching materials is relatively scarce on physiological traits and percent reduction of soil moisture content of maize in Myanmar. Hence, the experiments were carried out to study the effect of different mulching materials on percent reduction of soil moisture content in maize, to evaluate the effect of different mulching materials on physiological traits of maize and to find out the most suitable mulching materials for maize cultivation at Yezin and Yamethin areas.

Materials and methods

The experiments were conducted at two Locations, namely, Yezin farm, Nay Pyi Taw and Sepin Research Farm, Yamethin Township during dry season, October, 2019 to March, 2020. The soil types of Yezin and Yamethin

experimental site are loamy sand with a pH value of 8.05 and sandy loamy with a pH value of 7.16. The experiments were laid out in randomized complete block design (RCB) with three replications. The experimental area was (46.5 m × 19 m) and each plot size was 5.5 m × 5 m. NK-621 was used as the tested variety. Row and plant spacing were 75 cm and 25 cm. Treatments were assigned to the experimental plots at two different locations such as 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.

Land preparation and crop management

Land preparation was done with ploughing, harrowing and leveling in both locations. The fertilizers were applied according to Department of Agricultural Research (DAR), Myanmar recommended guidelines at basal, 20 DAS (days after sowing) and 40 DAS. The seeds were sown on 11th October, 2019 in Yezin and 2nd November, 2019 in Sepin Research Farms, Yamethin. At 21 DAS, different mulching materials were covered after earthing up the experimental sites. The dry organic mulches of 10 ton ha⁻¹ (10,000 kg ha⁻¹) were covered on the surface of soil as the mulching materials. When the plants from no mulching started to wilt and the leaf started to wilt, irrigation was applied.

Data collection

The percent reduction of soil moisture content was calculated before water irrigation, 7 DAI (Days after irrigation), 14 DAI at both areas. Photosynthesis rate (Pn)(μmol/m²/s), stomatal conductance (g_s) (mmol/m²/s) and intercellular concentration (Int CO₂) (μmol/mol) were measured on the uppermost fully expanded leaf of two selected sample plants for each plot at maximum growth stage (MGS), tasseling stage (MGS) and grain filling stage (GFS) by using CI-340 Handheld Photosynthesis system. The flow rate was 0.75 and measurements were conducted at 9:00 am to 11:00 am on clear sunny days and SPAD value was measured by using SPAD 502 Plus

Chlorophyll Meter. Five ears weight was noted as gram at harvest.

Statistical analysis

The collected data was analyzed for ANOVA by using Statistix (version 8th) software program, treatment means were compared by using least significant difference (LSD) test at 5% level of significance (Gomez & Gomez, 1984) and visualization of data was showed by R program (version 4.1.3).

Results and discussion

Percent reduction of soil moisture content

At first time of irrigation after mulch application, percent reduction of soil moisture content effects among different mulching materials on at Yezin are shown in Table 1. There was significantly different in percent reduction of soil moisture content among the different mulching materials at 7 DAI and 14 DAI. The minimum percent reduction of soil moisture content (17.72) and (45.89) were obtained from T2 whereas the maximum percent reduction of soil moisture content (38.27) and (76.93) were recorded from T1 at 7 DAI and 14 DAI at first time of irrigation. At second time of irrigation, there were significantly different in percent reduction of soil moisture contents among the different mulching materials at 7 DAI and 14 DAI. At 7 DAI and 14 DAI, the maximum percent reduction of soil moisture content (84.80) and (89.00) were observed from T1 while the minimum percent reduction of soil moisture content (28.92) and (76.79) were observed from T7. At third time of irrigation, the effects of different mulching materials on percent reduction of soil moisture content were significantly different at 7 DAI and 14 DAI. At 7 DAI and 14 DAI, the highest percent reduction of soil moisture content (70.24) and (83.93) were found in T1 meanwhile the lowest percent reduction of soil moisture content (45.41) and (58.07) were obtained from T7. Based on the results, white plastic polyethylene mulching and rice straw mulching conserved maximum soil moisture throughout the entire period of growth when compared to other mulching materials and no mulching. These results were similar to the findings of El-Nemr (2006), who found that different types of mulching preserved soil

moisture by reducing evaporation from the soil surface in comparison to bare soil.

Percent reduction of soil moisture content effects among different mulching materials on at Yamethin are shown in Table 2. The percent reduction of soil moisture content was recorded until 35 DAI and the percent reduction of soil moisture contents were significantly different among different mulching materials at first time of irrigation. The highest percent reduction of soil moisture contents (89.21) was observed from T1 meanwhile the lowest percent reduction of soil moisture content (81.22) was resulted from T2 followed by T7, T4 and T6. At second time of irrigation, the percent reduction of soil moisture content was significantly different among different mulching materials and the maximum percent reduction of soil moisture content (31.71) was recorded from T1 while the minimum percent reduction of soil moisture content (15.43) was resulted in T7 at 7 DAI. At 14 DAI, the percent reduction of soil moisture content was not significantly different among different mulching materials. The maximum percent reduction of soil moisture content (52.10) was detected from T1 while the minimum percent reduction of soil moisture content (24.78) was noted from T4 followed by T7. At third time of irrigation, the maximum percent reduction of soil moisture content (28.22) and (40.47) were resulted from T6 at 7 DAI and T1 at 14 DAI although the minimum percent reduction of soil moisture content (12.26) and (22.61) were recorded from T4 at 7 DAI and 14 DAI. Mulched treatments showed lower percent reduction of soil moisture content compared to no mulching. According to Suyana, et al. (2019), applying 4.5 to 9.0 tons of maize straw mulch per hectare can boost plant growth while regulating soil temperature and maintaining soil moisture.

Photosynthesis rate (P_n), stomatal conductance (g_s), intercellular concentration ($Int\ CO_2$) and SPAD value of maize

Physiological growth analysis is a way to evaluate what events occurs during plant growth and eventually it is important in the prediction of yield of crop (Hokmalipour & Darbandi, 2011). At Yezin, photosynthesis rate (P_n) was not significantly different among

different mulching materials at MGS (Table 3). Among all mulching treatments, the maximum Pn ($5.27 \mu\text{molm}^{-2}\text{s}^{-1}$) was recorded from T2 followed by $T3 > T5 > T4 > T7 > T6$ and the minimum Pn ($19.52 \mu\text{molm}^{-2}\text{s}^{-1}$) was resulted in T1. At TS, Pn was significantly different among different mulching materials. The maximum Pn ($20.45 \mu\text{molm}^{-2}\text{s}^{-1}$) was observed from T2 which was followed by $T6 > T3 > T5 > T4 > T7$ whereas the minimum Pn ($12.05 \mu\text{molm}^{-2}\text{s}^{-1}$) was observed T1. Photosynthesis rate (Pn) was significantly different among different mulching materials at GFS. The maximum Pn ($22.44 \mu\text{molm}^{-2}\text{s}^{-1}$) was achieved from T3 followed by $T4 > T2 > T6 > T7 > T5$ meanwhile the minimum Pn ($12.09 \mu\text{molm}^{-2}\text{s}^{-1}$) was recorded from T1. In Pn, all mulching materials were higher than no mulching at every stage. At Yamethin, Pn was not significantly different among different mulching materials at MGS (Table 2). The minimum Pn ($24.97 \mu\text{molm}^{-2}\text{s}^{-1}$) was observed from T1 and the maximum Pn ($31.80 \mu\text{molm}^{-2}\text{s}^{-1}$) was resulted in T2 which was followed by $T4 > T6 > T5 > T7 > T3$. At TS, Pn was significantly different among different mulching materials. The maximum Pn ($23.39 \mu\text{molm}^{-2}\text{s}^{-1}$) was found in T7 followed by $T2 > T3 > T6 >$ whereas the minimum Pn ($15.80 \mu\text{molm}^{-2}\text{s}^{-1}$) was recorded in T1. At GFS, Pn was significantly different among different mulching materials. The maximum Pn ($24.91 \mu\text{molm}^{-2}\text{s}^{-1}$) was achieved from T7 while the minimum Pn ($16.85 \mu\text{molm}^{-2}\text{s}^{-1}$) was observed T1. It was found that the average photosynthesis rate of maize with all mulching material was significantly higher than with no mulching. The raw materials and energy needed for a plant's development and other related biochemical activities are provided by photosynthesis. Under conditions of water deficiency, reduced photosynthesis is often attributed to stomatal restriction. (Shahrokhnia & Sepaskhah, 2017). Bruce, et al. (2009) reported that increase in yield was accompanied by more efficient photosynthesis, as well as improved photosynthetic rate after stress events helps come out from severe stress.

Preservation of water by closing of stomata is an important drought resistance mechanism as continued photosynthesis involves

continuous water loss (Teare, et al., 1973). The timing and completeness of stomatal closure during water stress and reopening after water stress relief, is an important character. At Yezin, stomatal conductance (g_s) was significantly different among different mulching materials at MGS, TS and GFS (Table 1). At MGS, the maximum g_s ($158.36 \text{ mmolm}^{-2}\text{s}^{-1}$) was observed from T2 which was followed by $T7 > T6 > T4$ whereas the minimum g_s ($103.62 \text{ mmolm}^{-2}\text{s}^{-1}$) was achieved from T1. At TS, the minimum g_s ($66.67 \text{ mmolm}^{-2}\text{s}^{-1}$) was obtained from T1 and the maximum g_s ($103.33 \text{ mmolm}^{-2}\text{s}^{-1}$) was resulted in T3 followed by T6 and T2. At GFS, T3 showed the maximum g_s ($99.39 \text{ mmolm}^{-2}\text{s}^{-1}$) followed by T4 while T1 was reported as the minimum g_s ($62.44 \text{ mmolm}^{-2}\text{s}^{-1}$). At Yamethin, stomatal conductance (g_s) was significantly different among different mulching materials at MGS, TS and GFS (Table 4). At MGS, the maximum g_s ($204.44 \text{ mmolm}^{-2}\text{s}^{-1}$) was observed from T2 followed by T4 meanwhile the minimum g_s ($115.50 \text{ mmolm}^{-2}\text{s}^{-1}$) was achieved from T3. At TS, the minimum g_s ($50.00 \text{ mmolm}^{-2}\text{s}^{-1}$) was resulted in T1 while the maximum g_s ($87.32 \text{ mmolm}^{-2}\text{s}^{-1}$) was recorded from T4 followed by T7 with mean value of ($86.56 \text{ mmolm}^{-2}\text{s}^{-1}$). At GFS, T7 was recorded as the maximum g_s ($94.08 \text{ mmolm}^{-2}\text{s}^{-1}$) which was followed by T4 while T1 resulted the minimum g_s ($55.11 \text{ mmolm}^{-2}\text{s}^{-1}$). Numerous researchers have suggested using stomatal conductance (g_s) as an indicator to compare stomatal and non-stomatal constraints to photosynthesis in conditions with restricted water resources (Brini, 2017). Many studies have shown that water deficit can inhibit the photosynthetic rate in plants, mainly due to the increased stomatal resistance under drought stress limiting the diffusion of CO_2 from the air into the leaves (Lavinsky et al., 2016).

Stomata are the entrance of water loss and carbon dioxide absorbability, and stomatal closure is one of the first responses to water stress which result in declined rate of photosynthesis. At Yezin, intercellular CO_2 concentration (Int CO_2) was not significantly different among different mulching materials at MGS and GFS (Table 3). At MGS, the maximum Int CO_2 ($93.92 \mu\text{molmol}^{-1}$) was achieved from T6 and the

minimum Int CO₂ (46.00 μmolmol^{-1}) was observed from T3. At TS and GFS, the minimum Int CO₂ (68.33 μmolmol^{-1}) and (53.90 μmolmol^{-1}) were observed T1 at TS and T7 at GFS whereas the maximum Int CO₂ (103.67 μmolmol^{-1}) and (80.33 μmolmol^{-1}) were recorded from T2. At Yamethin, Int CO₂ was significantly different among different mulching materials at MGS and GFS (Table 4). At MGS, the maximum Int CO₂ (120.42 μmolmol^{-1}) was resulted in T2 followed by T4 whereas the minimum Int CO₂ (61.92 μmolmol^{-1}) was recorded from T1. At TS, the minimum Int CO₂ (73.47 μmolmol^{-1}) was T1 while the maximum Int CO₂ (119.75 μmolmol^{-1}) was obtained from T6. At GFS, the maximum Int CO₂ (34.50 μmolmol^{-1}) was achieved from T7 whereas the minimum Int CO₂ (22.33 μmolmol^{-1}) was observed from T1. Although there is no difference in Int CO₂ between mulching and no mulching, mulching produces more Int CO₂. According to Farquhar and Sharkey (1982), the decrease in Pn can be explained by an increase in stomatal resistance when C and Int CO₂ decrease 55 simultaneously, but if Pn decreases as C increases, it is considered that the main limiting factor for Pn is the decreased photosynthetic activity of mesophyll cells.

At Yezin, SPAD values were not significantly different among different mulching materials at MGS, TS, and GFS (Table 1). At TS and GFS, the minimum SPAD values (23.90) and (20.93) were recorded from T1, whereas the maximum SPAD values (33.73) and (29.92) were derived from T6. At MGS, SPAD value was not significantly different among different mulching materials at Yamethin (Table 2). At TS and GFS, SPAD values were significantly different among different mulching materials. At TS, the maximum SPAD values (57.60) and (47.15) were recorded from T4 at TS and T7 at GFS, while the minimum SPAD value (44.05) and (38.48) were observed from T1. Higher water availability in the mulching treatment plots may be the result of the improved SPAD value working in conjunction with mulch application. Due to a change in leaf water concentration and its impact on SPAD, time of day is another potential source of variance in the samples (Galanti, et al., 2019). A close relationship between leaf chlorophyll content and photosynthetic rate

was observed by Watanabe and Yoshida (1970) and stated that higher chlorophyll content is one of the important factors responsible for higher photosynthetic rate.

Five ears weight (g)

Five ears weight was recorded and the ear weight of maize was not significantly different among different mulching materials at Yezin (Figure 1A). The maximum five ears weight (519.00 g) was observed from T2 followed by T7, T4 and T5, while the minimum five ear weight (384.05 g) was obtained from T1. At Yamethin, the five ears weight was not significantly different among different mulching materials (Figure 1B). The maximum five ears weight (1830.6 g) was recorded from T2 followed by T7, T4, T5, T3 and T6 whereas the minimum five ears weight (1326.0 g) was resulted from T1. The observed increase in ear weight in the mulched plot compared to the no mulching plot may be attributed to greater moisture retention brought on by mulching. Vaezi and Ahmadikhah (2010) investigated how dryness reduces the length of the growing season, disrupts photosynthesis, and assimilates remobilization, all of which lead to a reduction in grain weight. Furthermore, Singh, et al., (2016) found that using rice straw mulch (6 t/ ha) increased maize green cob yield by 37% as compared to flat planting alone.

Association between five ears weight, percent reduction of soil moisture content and physiological traits of maize

Association between five ears weight, percent reduction of soil moisture content and physiological traits of maize at Yezin and Yamethin during dry season, 2019-2020 was shown in Figures 2A and Figure 2B. At Yezin and Yamethin, five ears weight was negatively correlated with soil moisture reduction (First time) ($r = -0.82^*$ and $r = -0.79^*$), soil moisture reduction (second time) ($r = -0.69$ and $r = -0.82^*$), soil moisture reduction (Third time) ($r = -0.57$ and $r = -0.55$) and positively correlated with Pn rate ($r = 0.67$ and $r = 0.89$), g_s ($r = 0.70$ and $r = 0.88$), Int CO₂ ($r = 0.38$ and $r = 0.82^*$) and SPAD value ($r = 0.36$ and $r = 0.95^{**}$). Soil moisture reduction (First time) was positively correlated with soil moisture reduction

(Second time) ($r = 0.97^{**}$ and $r = 0.66^{**}$) and soil moisture reduction (Third time) ($r = 0.68$ and $r = 0.52$) and negatively correlated with Pn rate ($r = -0.75$ and $r = -0.94^{**}$), g_s ($r = -0.73$ and $r = -0.79^{*}$), Int CO₂ ($r = -0.32$ and $r = -0.98^{**}$) and SPAD value ($r = -0.56$ and $r = -0.86^{*}$). Similar to the soil moisture reduction (First time), soil moisture reductions (Second and Third

times) were positively correlated with the soil moisture reduction (First time. Pn rate correlated positively with g_s ($r = 0.94^{*}$ and $r = 0.83^{*}$), Int CO₂ ($r = 0.34$ and $r = 0.90^{**}$), and SPAD value ($r = 0.71$ and $r = 0.88^{**}$), but negatively with the soil moisture reductions (First, Second and Third time). g_s , Int CO₂, and SPAD value were all positively correlated, just like Pn rate.

Table 1. Percent reduction of soil moisture content as affected by different mulching materials at Yezin during dry season, 2019-2020

Treatments	1 st Irrigation		2 nd Irrigation		3 rd Irrigation	
	7 DAI	14 DAI	7 DAI	14 DAI	7 DAI	14 DAI
T1	38.27 a	76.93 a	84.8 a	89.00 a	70.24 a	83.93 a
T2	17.72 d	45.89 d	43.37 e	78.56 bc	55.02 bc	68.93 bc
T3	21.18 cd	61.62 b	59.24 cd	82.66 b	63.13 ab	78.11 ab
T4	25.98 b	48.84 cd	56.32 d	77.00 c	64.06 ab	77.26 ab
T5	25.88 b	57.85 bc	67.98 bc	81.10 bc	57.74 abc	80.12 ab
T6	24.90 bc	56.55 bcd	76.98 ab	81.97 bc	62.02 ab	70.21 bc
T7	24.44 bc	49.38 cd	28.92 f	76.79 c	45.41 c	58.07 c
LSD _{0.05}	13.94	11.84	9.56	5.56	13.35	5.64
Pr>F	<0.0001	0.0016	<0.0001	0.0060	0.0356	0.0102
CV%	8.69	11.73	9.02	3.86	12.58	9.36

DAI – Days after irrigation, 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. Percent reduction of soil moisture content as affected by different mulching materials at Yamethin during dry season, 2019-2020

Treatments	1 st Irrigation					2 nd Irrigation		3 rd Irrigation	
	7 DAI	14 DAI	21 DAI	28 DAI	35 DAI	7 DAI	14 DAI	7 DAI	14 DAI
T1	37.67 a	79.76	87.33	88.29	89.21 a	31.71 a	52.10	28.22	40.47
T2	14.65 e	59.61	76.09	81.56	81.22 c	21.29 bcd	36.65	24.14	31.17
T3	30.80 b	72.44	75.47	84.06	85.37 abc	23.13 bc	33.91	26.62	38.57
T4	21.68 d	69.53	79.73	81.76	83.02 bc	18.83 cd	24.78	12.26	22.61
T5	35.69 a	66.94	83.16	86.36	85.57 ab	22.79 bc	32.77	19.63	28.90
T6	29.81 bc	71.90	79.81	82.57	83.03 bc	26.68 ab	38.80	28.41	35.64
T7	26.15 c	68.30	79.97	83.18	82.97 bc	15.43 d	25.42	24.90	34.95
LSD _{0.05}	3.93	11.41	8.78	5.34	4.35	6.11	17.38	12.16	17.18
Pr>F	<0.0001	0.0650	0.1383	0.1308	0.0322	0.0021	0.0688	0.1239	0.3661
CV%	7.87	9.19	6.15	3.58	2.90	15.04	27.97	29.15	29.10

DAI – Days after irrigation, 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 3. Effect of different mulching materials on photosynthesis rate (Pn), stomatal conductance (g_s), intercellular concentration (Int CO₂) and SPAD value of maize at Yezin during dry season, 2019 - 2020

Treatments	Maximum Growth Stage (MGS)				Tesseling Stage (TS)				Grain Filling Stage (GFS)			
	Pn	g _s	Int CO ₂	SPAD	Pn	g _s	Int CO ₂	SPAD	Pn	g _s	Int CO ₂	SPAD
	μmol m ⁻² s ⁻¹	Mmol m ⁻² s ⁻¹	μmol mol ⁻¹	value	μmol m ⁻² s ⁻¹	Mmol m ⁻² s ⁻¹	μmol mol ⁻¹	value	μmol m ⁻² s ⁻¹	Mmol m ⁻² s ⁻¹	μmol mol ⁻¹	value
T1	19.52	103.62	65.95	31.12	12.05 b	66.67 c	68.33 c	23.90	12.09 c	62.44 c	78.52	20.93
T2	25.27	158.36	66.36	31.20	20.45 a	93.83 ab	103.67 a	30.83	19.45 ab	73.83 bc	80.33	26.07
T3	21.92	107.00	46.00	32.28	20.26 a	103.33 a	102.17 a	30.62	22.44 a	99.39 a	55.92	24.97
T4	21.13	120.94	79.77	33.57	18.94 a	83.17 abc	98.74 a	26.33	19.79 ab	85.33 ab	53.74	25.03
T5	21.58	119.71	69.69	29.60	18.97 a	66.92 c	70.83 bc	29.90	14.25 bc	68.33 bc	79.17	25.58
T6	20.80	128.53	93.92	33.90	20.37 a	100.08 ab	97.00 a	33.73	19.25 ab	80.25 abc	67.50	29.92
T7	21.04	141.00	60.83	29.28	18.54 a	78.08 bc	80.57 b	31.00	17.68 abc	74.92 bc	53.90	27.92
LSD _{0.05}	4.51	38.23	33.96	11.19	4.39	24.27	10.29	13.10	6.09	22.71	31.52	9.03
Pr>F	0.2630	0.0941	0.1714	0.9524	0.0152	0.0272	<0.0001	0.7276	0.0486	0.0679	0.2649	0.5533
CV%	11.72	17.11	27.70	19.93	13.32	16.13	6.52	24.98	19.08	16.41	26.44	19.78

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 4. Effect of different mulching materials on photosynthesis rate (Pn), stomatal conductance (g_s), intercellular concentration (Int CO₂) and SPAD value of maize at Yamenthin during dry season, 2019 - 2020

Treatments	Maximum Growth Stage (MGS)				Tesseling Stage (TS)				Grain Filling Stage (GFS)			
	Pn	g _s	Int CO ₂	SPAD	Pn	g _s	Int CO ₂	SPAD	Pn	g _s	Int CO ₂	SPAD
	μmol m ⁻² s ⁻¹	Mmol m ⁻² s ⁻¹	μmol mol ⁻¹	value	μmol m ⁻² s ⁻¹	Mmol m ⁻² s ⁻¹	μmol mol ⁻¹	value	μmol m ⁻² s ⁻¹	Mmol m ⁻² s ⁻¹	μmol mol ⁻¹	value
T1	24.97	123.75 cd	61.92 c	50.07	15.80 b	50.00 e	73.47	44.05 c	16.85 d	55.11 c	22.33 c	38.48 c
T2	31.80	204.44 a	120.42 a	53.98	21.59 a	80.59 b	100.53	55.02 ab	22.81 ab	79.58 b	30.75 ab	46.52 b
T3	26.73	115.50 d	72.43 c	51.42	20.93 a	72.62 c	97.39	50.53 b	22.48 ab	79.25 b	26.72 bc	40.27 c
T4	30.01	195.33 a	99.53 ab	49.77	21.56 a	87.32 a	101.70	57.60 a	22.62 ab	86.17 ab	25.57 bc	41.50 bc
T5	28.38	166.68 b	82.33 bc	50.42	19.18 ab	63.23 d	103.30	54.20 ab	18.28 cd	64.08 c	22.83 c	43.53 abc
T6	28.91	134.53 c	77.39 bc	48.93	20.47 a	65.94 d	119.75	52.37 ab	20.68 bc	59.49 c	23.56 bc	41.66 abc
T7	27.86	157.00 b	82.25 bc	51.83	23.39 a	86.56 ab	103.61	55.15	24.91 a	94.08 a	34.50 a	47.15 a
LSD _{0.05}	8.15	16.03	24.11	6.42	4.46	6.31	32.76	6.19	2.85	13.08	7.55	5.54
Pr>F	0.6564	<0.0001	0.0040	0.6960	0.0636	<0.0001	0.2134	0.0098	0.0006	0.0002	0.0338	0.0426
CV%	16.13	5.75	15.91	7.09	12.27	4.91	18.42	6.60	7.56	9.94	15.94	7.29

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

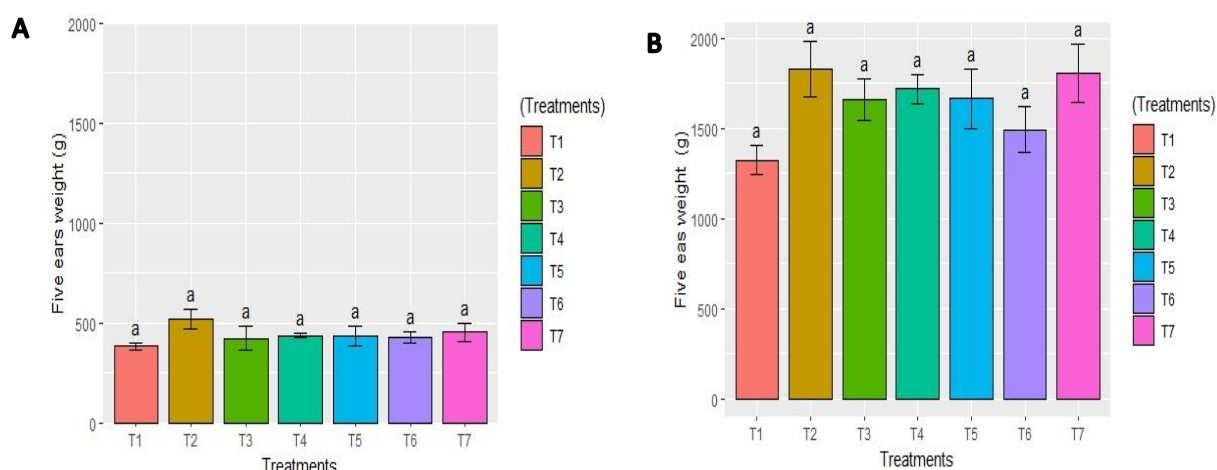


Figure 1. Five ears weight of maize as affected by different mulching materials at Yezin (A) and Yamethin (B) during dry season, 2019-2020

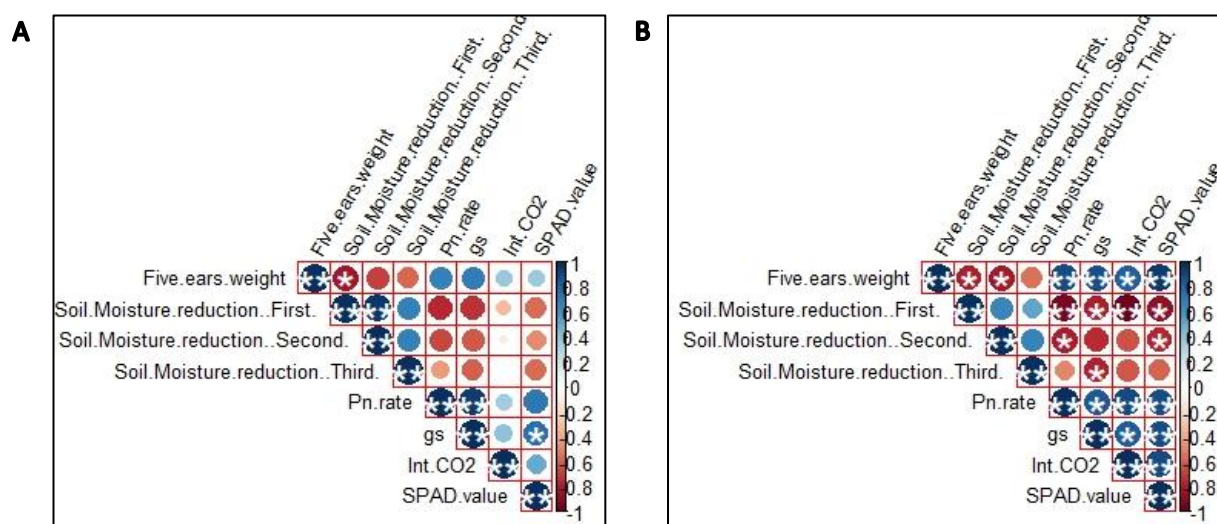


Figure 2. Association of five ears weight, soil moisture reduction (First, Second and Third times) and physiological traits at Yezin (A) and Yamethin (B) during dry season, 2019-2020

Conclusion

The experiments were conducted to study the effect of different mulching materials on percent reduction of soil moisture content and physiological traits in maize and to find out the most suitable mulching materials. Physiological traits such as photosynthesis rate, stomatal conductance, intercellular CO₂ concentration and SPAD value were higher in all mulching materials than no mulching in both sites. All mulching materials showed more conserved soil moisture in maize than no mulching. Among them, White plastic polyethylene mulching, rice straw mulching and maize

stover mulching maintained more soil moisture content than other mulching materials. Rice straw mulching showed the maximum five ears weight, photosynthesis rate, stomatal conductance, intercellular CO₂ concentration and SPAD value at Yezin. Rice straw mulching resulted the maximum five ears weight, photosynthesis rate, stomatal conductance, intercellular CO₂ concentration and SPAD value followed by white plastic polyethylene mulching and maize stover mulching at Yamethin. According to the results, rice straw mulching was the most suitable mulching material for both sites. Therefore, organic or inorganic mulching

should be used instead of no mulching in maize cultivation. However, from the view of climate change, organic mulching is recommended for maize cultivation rather than plastic mulching. Based on the present study, different rates of mulching should be tested in maize cultivation.

Author's declaration

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

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