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RESEARCH PAPER

Soil temperature, PAR interception and crop phenology of maize (*Zea mays* L.) as influenced by straw mulching and herbicides

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Abstract : A multi location experiment was conducted at Punjab Agricultural University, Ludhiana and Regional Research Station Gurdaspur (PAU) during *Kharif* 2017 to evaluate the effect of straw mulching and herbicides on soil temperature, PAR interception and crop phenology of maize. Application of mulch at 9.0 t ha^{-1} helped to reduce the soil temperature at 5 cm soil depth by 3.8 to 4.6^{0}C at 20 DAS, 1.0 to 1.4^{0}C at 40 DAS, 1.0 to 1.3^{0}C at 60 DAS and 0.7 to 1.2^{0}C at harvest as compared to no mulch treatment, but at 10 cm soil depth the temperature was reduced by 2.2 to 3.7^{0}C at 20 DAS, 1.3^{0}C at 40 DAS, 0.5^{0}C at 60 DAS and 0.4^{0}C at harvest at both the locations. High values of PAR interception and less number of days taken to tasselling, silking and physiological maturity were recorded with application of PSM 9.0 t ha^{-1} as compared to PSM 6.25 t ha^{-1} and no mulching treatments. Mulch application at 6.25 t ha^{-1} also significantly lowered the soil temperature and resulted in significantly higher PAR interception and less number of days to tasselling, silking and physiological maturity as compared to no mulch treatment. Different weed control treatments did not significantly influence the emergence of maize and soil temperature at 5 cm and 10 cm depth at both the locations. Application of tembotrione at 0.088 kg ha^{-1}, tembotrione at 0.110 kg ha^{-1} and weed free treatments recorded statistically similar but significantly higher values of PAR interception and less number of days for tasselling, silking and physiological maturity as compared to atrazine at 0.8 and 1.0 kg ha^{-1} and unweeded check.

Key Words : Atrazine, Crop phenology, Maize, PAR interception, Soil temperature, Straw mulching, Tembotrione

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INTRODUCTION

Maize (*Zea mays* L.), worldwide, was cultivated on 185.7 million hectares and recorded the production of 1075.3 million tonnes of grains with an average grain yield of 5.79 tonnes per hectare during 2016-17. In India, maize was cultivated on 7.66 million hectares and recorded the production of 15.5 million tonnes of grains with an average grain yield of 2.56 tonnes per hectare (Anonymous, 2017). In Punjab, maize is mainly grown during the *Kharif* season and was cultivated on 1.16

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lakh hectares with a production of 4.45 lakh tonnes and average yield of 3.84 tonnes per hectare during 2016-17 (Anonymous, 2018). It is an important source of proteins (10.4%), fat (4.5%), starch (71.8%), fibre (3%), vitamins and minerals like Ca, P, S and small amounts of Na. Due to its low gluten content, its flour is considered a good diet for patients having cardiac problems (Gul *et al.*, 2016). It is also used as green fodder at early stages for animals, baby corn at very early cob stage, green cob at late milk to dough stage, maize grains as pop corn and maize flour for chapatti making. Besides this, crop also provides a good quality feed for piggery, poultry and milch animals. Being a versatile food crop of global importance, it also serves as a source of basic raw material for number of industrial products for food (25%), animal feed (12%), poultry feed (49%), starch (12%), brewery (1%) and seed (1%) (Dass *et al.*, 2008 and Owla *et al.*, 2015). It is one of the most efficient crops which give high biological yield as well as grain yield in a short period of time due to its unique photosynthetic mechanism. The most suitable temperature for the maximum productivity of the crop is 20-27^{0}C but it can also be grown at low temperature of 10^{0}C with a frost free season. Due to its wider adaptability to soil and climatic conditions, there is a lot of scope to increase the present maize yields.

The herbicide use provides effective control of weeds and is economical but their injudicious use has lead to shift in weed flora, resistance in weeds and environment pollution. So, non-chemical approaches of weed management are also gaining importance to reduce dependence on herbicides. Among non-chemical measures, mulch application is an important agronomic practice for controlling the weeds in various crops. Mulches are the crop residues which are left-over above the soil surface after the harvest of preceding crop. The mulches benefit in many ways like reduction in the weed density, regulates soil temperature, increases soil porosity and water infiltration rate during rainy season and controls soil erosion, run-off and insect pest attack (Bhatt and Khera, 2006; Anikwe *et al.*, 2007; Sarkar and Singh, 2007 and Glab and Kulig, 2008). These may selectively provide weed suppression through the physical presence on soil surface (Teasdale *et al.*, 1991). Mulches show positive effects on moisture, heat, air regime of the soil and also cause reduction in the evaporation losses and weed growth (Choudhary and Kumar, 2014). The use of mulches increased the root growth and grain yield of maize by enhancing N-uptake efficiency and reducing N losses as compared to no mulching treatment (Aulakh *et al.*, 2000). Since maize crop is mainly grown during summer season in Punjab, where the temperature sometimes reaches more than 40^{0}C. Under these situations, the mulch application may cause reduction in the soil temperature and will increase the maize yield. The effectiveness of mulching can be further enhanced by the application of post emergence herbicides.

Weed management in any crop must aim at reducing the weed population to a level at which presence of weeds has no effect on farmer's economic and ecological interests. A single weed management approach may not be able to keep weeds below the threshold level of economic damage. Different pre and post-emergence herbicides have been recommended in maize for controlling weeds, that are used alone or in combination (Zaremohazabieh and Hossein, 2011; Chauhan and Abugho, 2013; Kumar and Angadi, 2014; Kaur *et al.*, 2016 ; Barla *et al.*,2016; Sahoo *et al.*, 2016 and Rana *et al.*, 2017). But the knowledge of different levels of mulch application and their combination with either pre-emergence or post-emergence herbicides are lacking in the literature. Therefore, the present investigation was planned to study the effect of straw mulching and herbicides on soil temperature, PAR interception and crop phenology of maize.

MATERIAL AND METHODS

A multi-location field experiment was conducted during *Kharif* 2017 at Research Farm, Punjab Agricultural University, Ludhiana (30^{o}542 N latitude, 75^{o}482 E longitude with the height of 247 metres above mean sea level) and Research Farm, Regional Research Station, Gurdaspur (32° 03' N latitude, 75° 27' E longitude with the height of 265 metres above the mean sea level) to assess the effect of mulching and herbicides on soil temperature, PAR interception and crop phenology of maize. The soil at experimental site of Ludhiana was loamy sand texture with pH 7.5, EC 0.27 dS m^{-2}, available N, P and K of 138.1, 17.2 and 179.1 kg ha^{-1}, respectively whereas at Gurdaspur site it was sandy loam in texture with pH 7.4, EC 0.23 dS m^{-2} and available N, P and K of 136.6, 18.9 and 195.3 kg ha^{-1}, respectively. Eighteen treatments were replicated three times in a Factorial Randomized Block Design with combination of three mulch treatments *i.e.* no mulch (NM), paddy straw mulch at 6.25 t ha^{-1}, (PSM 6.25 t ha^{-1}), paddy straw mulch 9.0 t ha^{-1} (PSM 9.0 t ha^{-1}) and six weed control treatments *viz.*, atrazine 1.0 kg ha^{-1} pre-emergence, atrazine 0.8 kg ha^{-1} pre-emergence, tembotrione 0.110 kg ha^{-1} at 20 DAS, tembotrione 0.088 kg ha^{-1} at 20 DAS, weed free and unweeded check. The field was prepared by giving two cultivations followed by planking and the sowing was done by dibbling method. Maize hybrid PMH 1 was used for sowing maize on June 22, 2017 at Ludhiana and on June 6, 2017 at Gurdaspur at a seed rate of 20 kg ha^{-1} with spacing of 60 cm × 20 cm. Phosphorus, potassium and zinc were applied uniformly before the planking operation through single superphosphate (SSP), muriate of potash (MOP) and zinc sulphate ($ZnSO_4$) at 60, 30 and 25 kg ha^{-1}, respectively. Nitrogen at 125 kg N ha^{-1} was supplied through urea in three equal splits at sowing, 35 and 68 days after sowing (DAS) at both locations. Irrigations were applied depending on the rainfall as per the requirement of the crop. Total three irrigations were applied to the crop at Ludhiana and two irrigations at Gurdaspur during the growing season. Paddy straw mulch (PSM) was applied immediately after the emergence of maize seedlings in between the lines as per the treatments. For controlling the weeds, herbicides Atrataf 50 WP (atrazine) and Laudis 420 SC (tembotrione) with activator at 1000 ml ha^{-1} were applied as pre-emergence (within 2 days of sowing) and post-emergence (at 20 DAS) herbicide, respectively as per treatments with knap sack sprayer using 375 lit of water per hectare through flat fan nozzle. Soil temperature was measured at 5 and 10 cm depth by soil thermometer for all treatments. Line Quantum Sensor (Model MQ-200) instrument was used to measure Photosynthetically active radiation (PAR) interception (wavelength range 400-700 nm) on clear sunny day at 30, 60 and 90 DAS and at harvest. Observations were taken at 2.00-3.00 pm from three places in each plot and per cent interception was calculated as under:

$$\text{PAR interception (\%)} = \frac{\text{PAR (I)} - \text{PAR (T)} - \text{PAR (R)}}{\text{PAR (I)}} \times 100$$

where,

PAR (I) = Total PAR incoming above the canopy, Wm^{-2}

PAR (T) = PAR transmitted to ground, Wm^{-2}

PAR (R) = PAR reflected from the canopy, Wm^{-2}

Days taken to 50 per cent emergence were recorded from sowing to the date when fifty per cent plants were emerged in each plot. The numbers of days taken to tasselling were recorded from sowing to the date when tasselling was observed on fifty per cent plants in each plot. Days taken to 50 per cent silking stage was recorded from sowing to the date when silk emergence was noticed on fifty per cent of the plants in each plot. Days taken to physiological maturity were calculated from sowing date to fifty per cent plants showed drying of cobs husk in each plot. Data were recorded and subjected to analysis of variance (ANOVA) using statistical analysis software (SAS 9.3 GLM procedure) to evaluate differences between treatments. Where the ANOVA indicated that treatment effects were significant, means were separated at P=0.05 by using Duncun's Multiple Range Test (DMRT).

Results and Discussion

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Soil temperature at 5 cm depth:

Soil temperature is an important parameter to check the effect of mulch on weed population and plant growth. The data on soil temperature recorded at 5 cm depth are presented in Table 1 and Fig 1. The values of soil temperature varied with time intervals and a continuous decrease in soil temperature was observed with the advancement of the crop age. The data showed that straw mulch treatments significantly influenced the soil temperature at 5 cm depth. At 20, 40, 60 DAS and at harvest, lowest values of soil temperature (31.7, 31.2, 30.2 and 25.9 ^{0}C, respectively) were observed with 9.0 t ha^{-1} mulch at Ludhiana which were significantly less than that recorded under 6.25 t ha^{-1} mulch (32.3, 31.7, 30.7 and 26.2 ^{0}C) and no mulch (36.3, 32.2, 31.2 and 26.6 ^{0}C) treatments. Later two treatments also differed significantly with respect to the soil temperature at 5 cm. Similarly at Gurdaspur, lowest values of soil temperature (30.5, 30.1, 29.1 and 28.5 ^{0}C) were observed with 9.0 t ha^{-1} mulch at 20, 40, 60 DAS and at harvest, respectively which were significantly less than that recorded under at 6.25 t ha^{-1} mulch (31.5, 30.5, 29.5 and 29.1 ^{0}C) and no mulch (34.3, 31.5, 30.4 and 29.7 ^{0}C) treatments. This showed that application of 9.0 t ha^{-1} mulch reduced the soil temperature by 4.6, 1.0, 1.0 and 0.7 ^{0}C at Ludhiana and 3.8, 1.4, 1.3 and 1.2 ^{0}C at Gurdaspur as compared to no mulch treatment at 20, 40, 60 DAS and at harvest, respectively. Similarly, 6.25 t ha^{-1} mulch also reduced the soil temperature by 4.0, 0.5, 0.5 and 0.4 ^{0}C at Ludhiana and 2.8, 1.0, 0.9 and 0.6 ^{0}C at Gurdaspur as compared to no mulch treatment at 20, 40, 60 DAS and at harvest, respectively.

Different weed control treatments did not significantly influence the soil temperature at 5 cm depth at both the locations. The interaction was not significant with respect to soil temperature at 5 cm depth.

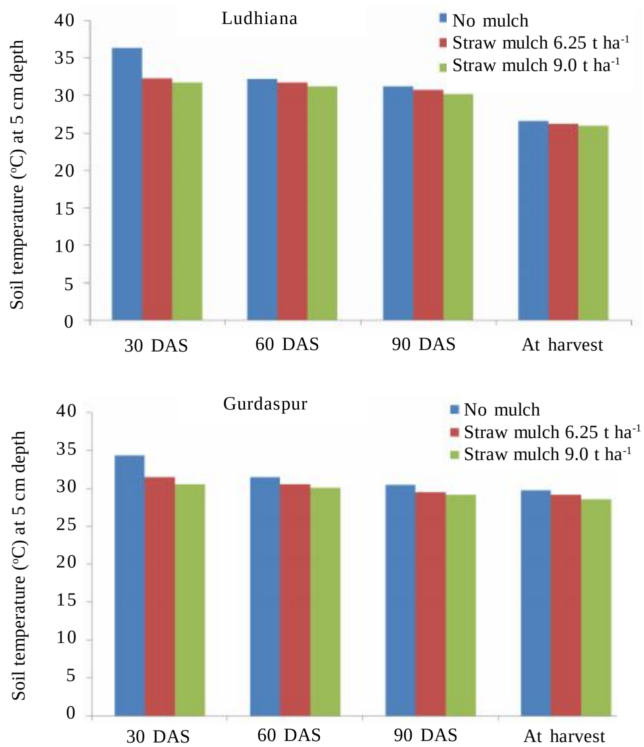

Fig. 1 : Effect of straw mulch on soil temperature at 5 cm depth in maize at Ludhiana and Gurdaspur

Soil temperature at 10 cm:

Soil temperature at 10 cm depth was significantly affected by the straw mulch treatments (Table 2 and Fig. 2). At Ludhiana, the soil temperature was significantly reduced with application of 9.0 t ha^{-1} mulch (31.6, 30.3, 30.6 and 26.9 ^0C) and 6.25 t ha^{-1} (32.1, 30.7, 30.7 and 27.0 ^0C) as compared to no mulch (35.3, 31.6, 31.1 and 27.3 ^0C) treatment at 20, 40, 60 DAS and at harvest, respectively. However, at 20 and 40 DAS, 9.0 t ha^{-1} mulch application recorded significantly lower temperature as compared to 6.25 t ha^{-1} mulch but both above treatments remained on par with each other at 60 DAS and at harvest with respect to the soil temperature at both the locations. Same trend was observed at Gurdaspur where statistically similar soil temperature values of 30.5, 29.6, 29.6, 27.7 and 30.9, 30.3, 29.8 and 27.8 ^0C were observed with the application of 9.0 and 6.25 t ha^{-1} mulch at 20, 40, 60 DAS and at harvest, respectively which were significantly less than that recorded under no mulch (32.7, 30.9, 30.1 and 28.1 ^0C) treatment. This showed that application of 9.0 t ha^{-1} mulch at 20, 40, 60 DAS and at harvest reduced the soil temperature by 3.7, 1.3, 0.5 and 0.4 ^0C at Ludhiana and 2.2, 1.3, 0.5 and 0.4 ^0C, respectively at Gurdaspur as compared to no mulch treatment. Similarly, 6.25 t ha^{-1} mulch also reduced the soil temperature by 3.2, 0.9, 0.4 and 0.3 ^0C at Ludhiana and 1.8, 0.6, 0.3 and 0.3 ^0C at Gurdaspur as compared to no mulch treatment at 20, 40, 60 DAS and at harvest, respectively.

Different weed control treatments did not significantly influenced the soil temperature values at 10

Table 1: Effect of straw mulch and weed control treatments on soil temperature at 5 cm depth in maize

Treatments	Soil temperature at 5 cm depth (^0C)							
	20 DAS		40 DAS		60 DAS		At harvest	
	Ludhiana	Gurdaspur	Ludhiana	Gurdaspur	Ludhiana	Gurdaspur	Ludhiana	Gurdaspur
Straw mulch								
No mulch	36.3c	34.3c	32.2c	31.5c	31.2c	30.4c	26.6c	29.7c
PSM 6.25 t ha^{-1}	32.3b	31.5b	31.7b	30.5b	30.7b	29.5b	26.2b	29.1b
PSM 9.0 t ha^{-1}	31.7a	30.5a	31.2a	30.1a	30.2a	29.1a	25.9a	28.5a
Weed control treatments								
Atrazine at 1.0 kg ha^{-1}	33.6a	32.3a	31.9a	30.7a	30.7a	29.6a	26.3a	29.1a
Atrazine at 0.8 kg ha^{-1}	33.2a	32.0a	31.8a	30.7a	30.6a	29.7a	26.3a	29.0a
Tembotrione at 0.110 kg ha^{-1}	33.4a	31.8a	31.8a	30.6a	30.7a	29.6a	26.4a	29.1a
Tembotrione at 0.088 kg ha^{-1}	33.6a	32.1a	31.8a	30.6a	30.7a	29.7a	26.2a	29.1a
Weed free	33.1a	32.0a	31.8a	30.7a	30.7a	29.7a	26.3a	29.2a
Unweeded check	33.5a	32.3a	31.8a	30.7a	30.7a	29.7a	26.3a	29.1a

In a column, means followed by same letter do not vary significantly at 5% level by DMRT

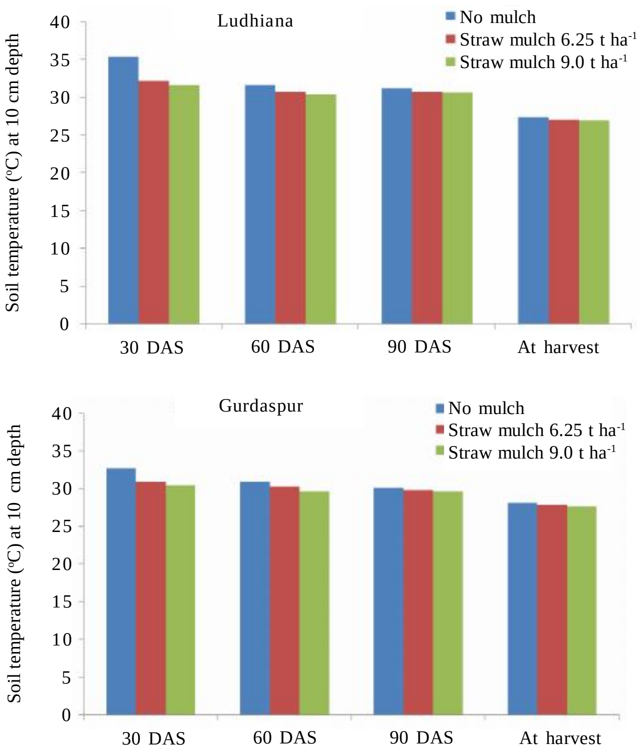

Fig. 2 : Effect of straw mulch on soil temperature at 10 cm depth in maize at Ludhiana and Gurdaspur

cm depth at both the locations. The interaction was not significant with respect to soil temperature at 10 cm depth.

Photosynthetically active radiation (PAR) interception:

PAR interception and its distribution within the crop canopy is an important determinant of photosynthetic activities of the crop. PAR interception within the crop canopy influences the leaf photosynthesis efficiency, which in turn affects the dry matter production and grain yield. The periodic data on PAR interception recorded at 30, 40, 60 and 90 DAS are presented in Table 3 which showed that straw mulch significantly influenced the PAR interception in maize at all the periodic time intervals. Application of 9.0 t ha^{-1} mulch performed significantly better for PAR interception than 6.25 t ha^{-1} mulch and the later treatment also recorded significantly higher PAR interception than no mulch treatment. Maximum PAR interception of 48.73, 61.05, 77.13 and 87.32 per cent at Ludhiana and 47.53, 59.34, 76.65 and 85.19 per cent at Gurdaspur was observed with 9.0 t ha^{-1} mulch at 30, 40, 60 and 90 DAS, respectively. Significantly higher PAR interception under straw mulch treatments was due to better plant growth as compared to no mulch treatment. Since maize leaves are not generally light saturated, more interception of PAR along with more uptake of CO_2 can increase photosynthesis which can contribute towards higher yields through more production of carbohydrates and their subsequent translocation towards sink.

Different weed control treatments significantly influenced the PAR interception in maize at all the time intervals. At 30 DAS, application of tembotrione at both doses (0.088 and 0.110 kg ha^{-1}), atrazine at higher dose (1.0 kg ha^{-1}) and weed free treatments recorded statistically similar values of PAR interception and these treatments were significantly better than atrazine at lower

Table 2 : Effect of straw mulch and weed control treatments on soil temperature at 10 cm depth in maize

Treatments	Soil temperature at 10 cm depth (^{0}C)							
	20 DAS		40 DAS		60 DAS		At harvest	
	Ludhiana	Gurdaspur	Ludhiana	Gurdaspur	Ludhiana	Gurdaspur	Ludhiana	Gurdaspur
Straw mulch								
No mulch	35.3c	32.7c	31.6c	30.9c	31.1b	30.1b	27.3b	28.1b
PSM 6.25 t ha^{-1}	32.1b	30.9b	30.7b	30.3b	30.7a	29.8a	27.0a	27.8a
PSM 9.0 t ha^{-1}	31.6a	30.5a	30.3a	29.6a	30.6a	29.6a	26.9a	27.7a
Weed control treatments								
Atrazine at 1.0 kg ha^{-1}	33.0a	31.4a	30.9a	30.3a	30.9a	29.9a	27.2a	27.8a
Atrazine at 0.8 kg ha^{-1}	32.9a	31.4a	30.8a	30.3a	30.8a	29.9a	27.1a	27.8a
Tembotrione at 0.110 kg ha^{-1}	33.1a	31.1a	30.8a	30.2a	30.7a	29.9a	27.2a	27.9a
Tembotrione at 0.088 kg ha^{-1}	33.1a	31.2a	30.8a	30.3a	30.8a	30.0a	27.0a	27.9a
Weed free	32.9a	31.3a	30.9a	30.2a	30.8a	29.9a	27.0a	27.9a
Unweeded check	33.0a	31.6a	31.0a	30.3a	30.7a	29.9a	27.1a	27.9a

In a column, means followed by same letter do not vary significantly at 5% level by DMRT

dose (0.8 kg ha^{-1}) and unweeded check at both the locations. Similarly at 40, 60 and 90 DAS, application of tembotrione at 0.088 kg ha^{-1}, tembotrione at 0.110 kg ha^{-1} and weed free treatments recorded statistically similar values of PAR interception and all these treatments resulted in significantly higher values of PAR interception than atrazine at both doses and unweeded check at both the locations. Similarly, application of atrazine at 1.0 kg ha^{-1} also registered higher PAR interception than atrazine at 0.8 kg ha^{-1} and unweeded check. Significantly lower PAR interception values were observed under unweeded check as compared to all other treatments at both the locations. The increase in PAR interception might be due to better plant growth under these weed control treatments. The interaction was not significant.

Crop phenology:

Days taken to 50 per cent emergence:

The data presented in Table 4 showed that application of different straw mulch and weed control treatments did not significantly affect the days taken to emergence, thus indicating that crop took almost equal number of days to emerge (5.8 to 5.9 days at Ludhiana and 6.2 to 6.9 days at Gurdaspur) under different treatments. The interaction was also not significant.

Days taken to 50 per cent tasselling:

A perusal of the data given in Table 4 revealed that various straw mulch treatments significantly influenced

Table 3: Effect of straw mulch and weed control treatments on periodic PAR interception in maize

Treatments	PAR interception (%)							
	30 DAS		40 DAS		60 DAS		90 DAS	
	Ludhiana	Gurdaspur	Ludhiana	Gurdaspur	Ludhiana	Gurdaspur	Ludhiana	Gurdaspur
Straw mulch								
No mulch	44.39c	43.16c	56.33c	55.17c	72.79c	72.14c	81.88c	80.37c
PSM 6.25 t ha^{-1}	46.69b	45.37b	58.57b	57.16b	75.36b	75.03b	84.79b	83.08b
PSM 9.0 t ha^{-1}	48.73a	47.53a	61.05a	59.34a	77.13a	76.65a	87.32a	85.19a
Weed control treatments								
Atrazine at 1.0 kg ha^{-1}	48.37a	47.41a	59.71b	58.71b	75.33b	74.93b	85.10b	83.06b
Atrazine at 0.8 kg ha^{-1}	45.20b	44.23b	57.40c	56.24c	73.38c	72.70c	83.11c	81.31c
Tembotrione at 0.110 kg ha^{-1}	48.76a	46.71a	61.24a	59.26a	77.36a	77.35a	86.93a	84.89a
Tembotrione at 0.088 kg ha^{-1}	48.27a	46.56a	61.10a	59.30a	77.84a	77.11a	87.29a	84.87a
Weed free	48.42a	47.17a	61.37a	59.70a	77.92a	77.45a	86.79a	85.16a
Unweeded check	40.61c	40.05c	51.14d	50.11d	68.82d	68.11d	78.76d	78.00d

In a column, means followed by same letter do not vary significantly at 5% level by DMRT

Table 4: Effect of straw mulch and weed control treatments on number of days taken to different phenological growth stages in maize

Treatments	Phenological growth stages							
	50 per cent emergence		50 per cent tasselling		50 per cent silking		Physiological maturity	
	Ludhiana	Gurdaspur	Ludhiana	Gurdaspur	Ludhiana	Gurdaspur	Ludhiana	Gurdaspur
Straw mulch								
No mulch	5.9a	6.8a	55.5b	61.1b	59.8b	65.4b	93.8b	96.8b
PSM 6.25 t ha^{-1}	5.8a	6.6a	53.3a	60.1a	58.4a	64.4a	93.2a	96.1a
PSM 9.0 t ha^{-1}	5.8a	6.6a	53.1a	59.3a	58.1a	63.8a	93.2a	95.7a
Weed control treatments								
Atrazine at 1.0 kg ha^{-1}	5.9a	6.2a	53.8a	60.3a	58.7a	64.6a	93.0a	96.2a
Atrazine at 0.8 kg ha^{-1}	5.9a	6.8a	54.3b	61.5b	58.8a	65.4a	93.2a	96.4a
Tembotrione at 0.110 kg ha^{-1}	5.8a	6.8a	53.6a	59.3a	58.6a	63.4a	93.0a	95.9a
Tembotrione at 0.088 kg ha^{-1}	5.9a	6.7a	53.6a	59.2a	58.4a	63.4a	92.9a	95.9a
Weed free	5.8a	6.7a	53.4a	59.4a	58.4a	63.6a	92.9a	95.9a
Unweeded check	5.9a	6.9a	55.4b	61.7b	59.7b	66.6b	94.6b	97.2b

In a column, means followed by same letter do not vary significantly at 5% level by DMRT

the number of days taken to 50 per cent tasselling stage. At Ludhiana and Gurdaspur, both paddy straw mulch treatments at 9.0 and 6.25 t ha^{-1} took significantly less number of days to tasselling (53.1 and 59.3 days and 53.3 and 60.1 days) as compared to no mulch treatment (55.5 and 61.1 days). This showed that tasselling stage was enhanced by 2.2 to 2.4 days at Ludhiana and 1.0 to 1.8 days at Gurdaspur under both straw mulch treatments as compared to without mulch. This may be attributed to better plant growth under these straw mulch treatments.

The data showed that different weed control treatments showed a significant influence on days taken to tasselling at both the locations. At Ludhiana and Gurdaspur, weed free, tembotrione at both doses (0.110 and 0.088 kg ha^{-1}) and atrazine at higher dose (1.0 kg ha^{-1}) took significantly less number of days to tasselling in comparison to atrazine at 0.8 kg ha^{-1} and unweeded check. Reduction in number of days taken for tasselling stage under different weed control treatments may be attributed to better plant growth resulting in increased energy levels in plants which enhanced the tasselling stage. The interaction was not significant.

Days taken to 50 per cent silking:

Likewise the days taken to 50 per cent tasselling, the number of days taken to 50 per cent silking stage was also significantly affected by different straw mulch treatments (Table 4). At Ludhiana and Gurdaspur, significantly less number of days to silking were taken with 9.0 t ha^{-1} mulch (58.1 and 63.8 days) and 6.25 t ha^{-1} mulch (58.4 and 64.4 days) as compared to no mulch (59.8 and 65.4 days) treatment. This showed that silking stage was enhanced by 1.4 to 1.7 days at Ludhiana and 1.0 to 1.6 days at Gurdaspur under both mulch treatments as compared to no mulch treatment. This may be attributed to better plant growth under these straw mulch treatments.

Different weed control treatments showed significant effect on number of days taken to silking stage. Tembotrione at both doses (0.110 and 0.088 kg ha^{-1}), atrazine at both doses (1.0 and 0.8 kg ha^{-1}) and weed free treatments took lowest number of days for silking stage as compared to unweeded check at both locations. Reduction in number of days taken for silking with different weed control treatments may be attributed to better control of weeds and good plant growth resulting in increased energy levels in plants which enhanced the silking stage. The interaction effect was not significant.

Days taken to physiological maturity:

The data on the number of days taken to reach 50 per cent physiological maturity are presented in Table 4. At Ludhiana and Gurdaspur, significantly less number of days to physiological maturity were taken by the crop with 9.0 t ha^{-1} mulch (93.2 and 95.7 days) and 6.25 t ha^{-1} mulch (93.2 and 96.1 days) as compared to no mulch (93.8 and 96.8 days) treatment. This showed that physiological maturity was enhanced by 0.6 to 0.8 days at Ludhiana and 0.7 to 1.1 days at Gurdaspur under both the mulch treatments as compared to without mulch treatment. Enhanced physiological maturity may be attributed to better plant growth under these straw mulch applied treatments.

Different weed control treatments significantly influenced the number of days taken to 50 per cent physiological maturity. At Ludhiana and Gurdaspur, tembotrione at both doses, atrazine at both doses and weed free treatments took lowest number of days for physiological maturity as compared to unweeded check. Reduction in number of days taken for physiological maturity under different weed control treatments may be attributed to better plant growth and less infestation by weeds which enhanced the physiological maturity stage in maize. The interaction effect due to various treatments was not significant.

It may be concluded that application of paddy straw mulch at 6.25 and 9.0 t ha^{-1} helped to reduce the soil temperature at 5 and 10 cm soil depth, resulted in significantly more PAR interception and took significantly less number of days to tasselling, silking physiological maturity as compared to no mulch treatment. Different weed control treatments did not significantly influence the soil temperature at 5 cm and 10 cm depth at both the locations. However, application of tembotrione at 0.088 kg ha^{-1} was found to be the best option for more PAR interception and enhancing the tasselling, silking and physiological maturity as compared to other herbicide treatments and unweeded check.

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