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Identification of Suitable Mulch for Radish (*Raphanus sativus* L.) to Cope with Temperature Stress

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Abstract: Although mulching provides numerous benefits in cropping activities, very few studies were reported on crop specific influence of different mulching materials. Thus, a pot experiment was conducted in a polytunnel to assess impact of different mulching materials on growth and yield of radish (cultivar, *Beeralu*). Treatments were arranged in two-factorial experiment in Completely Randomized Design with three replicates. Two temperature regimes viz. ambient (32-33°C) and temperature stress (35-36°C) condition and three types of mulching materials *viz*. coir dust (M2), gliricidia (M3) and straw (M4) were used as treatments. Crops without a mulch was the control (M1). Raddish seeds were sown in pots filled using reddish brown earth soil. One week after the emergence of seedlings, mulching materials were applied according to treatments. Growth parameters (number and fresh weight of leaves) and yield parameters (root fresh weight, root dry weight, root length and girth of the root) were measured. Data were statistically analyzed using SAS and mean separation was done by Least Significant Difference test. The results revealed that the temperature and mulching material and their interaction were significantly ($p<0.05$) influenced on most of growth and yield parameters tested. Highest number of leaves (17.2), leaf fresh weight (59.8 g), plant height (45.1 cm), length of tuber (16.1cm), fresh weight of tuber (77.3 g) and dry weight of tuber (18.8 g) were recorded in gilicidia mulch under the temperature stress. Coir dust mulch under the ambient temperature indicated the second best performance among the tested treatments. Lowest performance in raddish crop was recorded in temperature stress condition without having a mulch.

Keywords: Growth, Mulch, Temperature, Yield

Introduction

Agriculture is one of the main sources for income generation in Sri Lanka. When considering agriculture, it mainly depends on climatic conditions. Especially, rainfall and temperature have influence on agriculture. Irregular weather conditions result in decline of yield of agriculture products and drastic changes on cultivation. The temperature is a primary factor affecting the rate of plant development. Due to temperature stress and water stress, the food productivity is decreasing. In general, high temperature may lead to significant losses in crop productivity in many species due to limited vegetative and reproductive growth (Spears *et al.,* 1997; Cross *et al.,* 2003; Godawatte *et al.,* 2014). Yan *et al.* (2008) and Zhou *et al.* (2010) reported that the high temperature stress reduced photosynthetic capacity by accelerated leaf senescence and decreased relative chlorophyll content.

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Net photosynthetic rate was decreased by 50−60% in maize under high temperature conditions of 35/30°C (day/night) and 40/35 °C (day/night) compared to that under low-temperature conditions of 25/20°C (day/night) and 30/25°C (day/night) (Ben-Asher *et al.,* 2008). De Silva (2006) reported that the Sri Lanka's dry zone agricultural output will decline significantly in the next 20 to 30 years because of reduced rainfall and increased temperature. Chandrapala and Fernando (1995) reported that, there has been an increase in temperature in Colombo by 0.0164°C / year during the period of 1961 to 1990. According to a report of the Intergovernmental Panel on Climatic Change (IPCC) (IPCC Expert Meeting Report, 2007) the global mean temperature will rise 0.2°C per decade in the coming years. De Silva *et al.* (2007) predicted using HadCM3 general circulation model that, by 2050, rainfall will decrease by 9% to 17% in the main *Maha* cultivation season.

Radish is one of the popular root vegetables in Sri Lanka and it belongs to the family Brassicaceae. Radish is a good source of vitamin C (ascorbic acid) and minerals of calcium, potassium and phosphorus. It is known to have refreshing and diuretic properties. Radish is also used to treat for neurological, headache, sleeplessness, chronic diarrhoea, urinary complaints and piles (Dhananjaya, 2007). Radish cultivated in many parts of Sri Lanka due to its' short life span. However, only few studies were conducted to evaluate the effect of temperature stress and water stress on plant growth and yield. Shaw *et al.* (2002) reported that the water shortage strongly affects crop growth, root yield and biomass partitioning. Alfaro *et al.* (2006) reported that the maximum temperatures are affected by local conditions, especially soil water content and evaporative heat loss as soil water evaporates. Hatfield and Prueger (2011) reported that an increasing water vapor demand will cause more water to be transpired by the leaf until the water supply becomes limited and the stomatal conductance will decrease leading to a higher leaf temperatures and a reduction in photosynthesis. Evidence shows a strong correlation between climatic conditions and national agricultural growth and the growth rate declined to 1.5% in 2011 due to adverse climatic conditions.

In this study temperature stress and water stress affects the growth and yield of radish. Therefore, solutions are very important to overcome such impacts on radish imposed by high temperature and water stress. As an answer for it, use of mulching material is important to conserve soil moisture and vital to avoid wilting cases due to higher transpiration from plant and evaporation from soil under temperature stress condition. Kumar *et al.* (2014) reported that the use of mulch as a soil cover is effective in improving yield and soil fertility. Yoo-Jeong *et al.* (2003) reported that the mulching as a one of important agronomic practice beneficial in conserving soil moisture, suppressing the weeds, improving soil fertility, and modifying the soil physical and chemical environment. Knavel and Mohar (1967) mentioned that the moisture distribution in the upper soil layer is more uniform compared with un-mulched soil and more roots developed in the upper soil layer which usually has richer nutrients and useful microorganisms. Also, positive response of mulch has been reported. Different mulching materials have different effectiveness for enhancing performance because of their capacities in absorbing moisture due to their aggregate nature in allowing air circulation. Mulching could change the physical and chemical environment of the soil resulting in increased availability of phosphorus and potassium (Muralidharan and Kamalam, 1973).

The study intends to identify the suitable mulch to mitigate the consequences of higher temperature stress due to unexpected weather events by evaluating the effect on growth and yield parameters of Raddish variety *Beeralu rabu*.

Materials and Methods

Collection and preparation of samples

The study was conducted under the conditions of two protected structures i.e. a polytunnel and a net house at the Open University of Sri Lanka (Figure 1). The treatments were designed in a two-factor factorial experiment in Completely Randomized Design with three replicates. One set of plants kept in temperature regulated polytunnel (35 – 36°C) and the other set of plants were kept in ambient air temperature (32- 33°C) at the net house. The average diurnal fluctuation of temperature within the polytunnel and net house interior is shown in the Figure 2. It is indicated that the temperature at the polytunnel was higher than the temperature at the net house. Godawatta and De Silva (2014) reported that there were no significant differences in RH observed in the inside and outside environment although elevated day time air temperatures in the poly tunnel resulted in higher partial pressure of water. This condition was regulated with the open structure of the top vent roof structure. Same polytunnel with similar conditions was used in this study.

The pots (40 cm in diameter with 45 cm depth) were filled using compost and reddish-brown earth soil in the ratio of 1:5. Seed were sown in individual pots and excess plants were removed to maintain 3 plants/pot at one week after seedling emergence. Coir dust, straw and gliricidia were used as mulching materials.

Figure 1: Polytunnel with open top   Front view of the net house

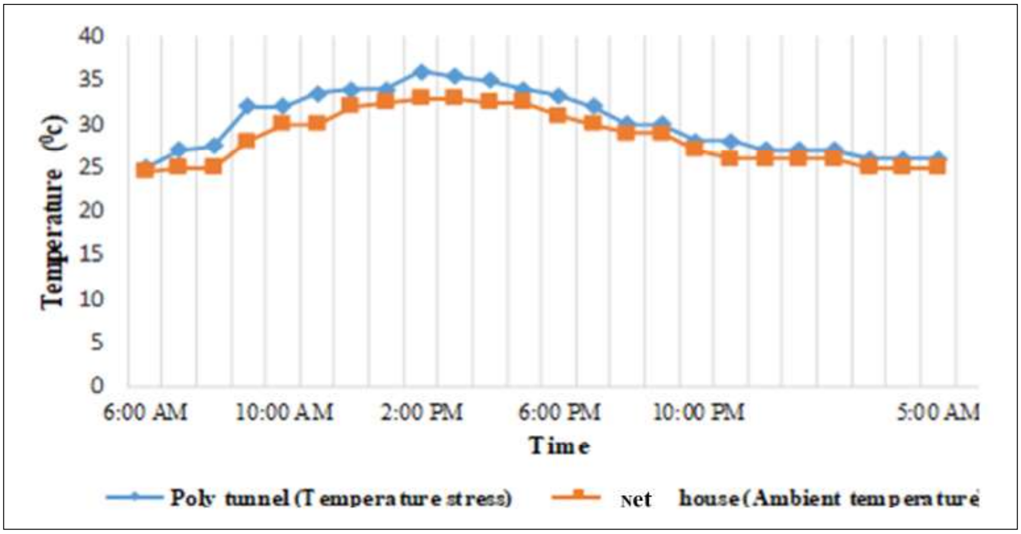

Figure 2: Temperature variations inside of the polytunnel and net house

Mulches were applied as a uniform layers to an average depth of 2.2 inches each on the soil surface. A pot without mulch was used as the control in the experiment. Soil moisture in all pots was maintained at field capacity throughout the growing season to avoid the water stress for plants. Fertilizers were applied according to the recommendation of Department of Agriculture, Sri Lanka. Plot layout of the study is indicated in the Figure 3.

Data collection

Plant growth parameters were measured at two weeks interval. Plant height (cm) was measured from each replicate by measuring the height from ground level to the terminal growing point of the shoot. The number of leaves of the plants, whose plant heights were taken, was recorded on weekly basis. Leaf width was measured by using Vernier caliper in three replicates.

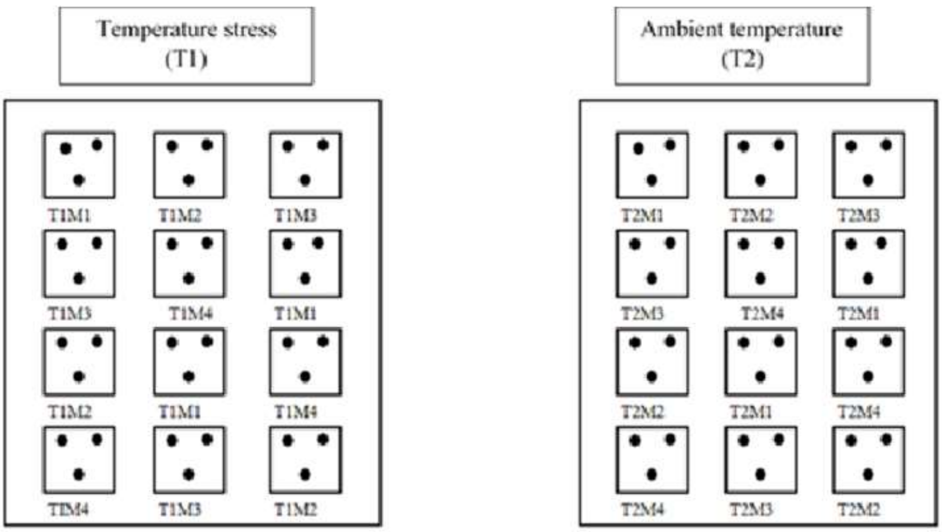

Figure 3: Layout of the study

M1- Control M2- Coir dust M3- Gliricidia M4- Straw

Leaf area was measured from randomly selected leaves from each replicate and grid counting method was used (Chaudhary *et al.,* 2012). Yield parameters were measured after harvest. Fresh weight of root (g) was measured by using electronic balance. Leafy part and other soil and debris were removed to measure fresh weight of roots. Weights of roots in all replicates were measured. The length of root (cm) from each replicate was recorded.

Data Analysis

All the data will be analyzed by using SAS software and multiple comparison of the various means were carried out by LSD (Least Significant Difference) test at P = 0.05.

Results and Discussion

Average number of leaves

Number of leaves has shown an increasing trend pattern during the study period. Effect of temperature stress, mulching material and interaction between temperature and mulching material were significant (p<0.05) on average number of leaves (Figure 4). All the treatment at ambient temperature has shown better performances and the treatment with gliricidia mulch at ambient temperature showed the highest number of leaves.

Treatment with straw at ambient temperature showed the second highest number of leaves. Treatment with gliricidia mulch in temperature stress has shown better performances than the other treatments at temperature stress. Treatments without mulch have shown the lowest number of leaves either at temperature stress or ambient temperature (Figure 4).

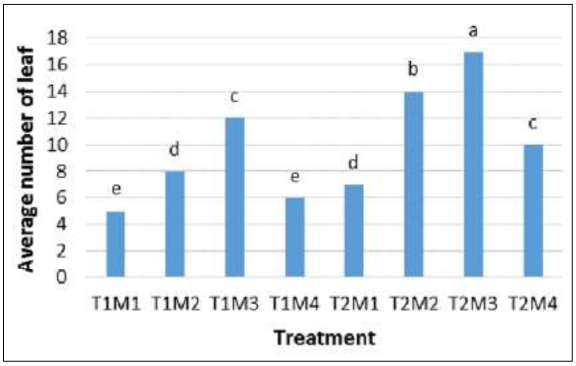

Figure 4: Number of leaves at harvest
T1- Temperature stress T2- Ambient temperature M1- Control M2- Coir dust M3- Gliricidia M4- Straw
Values followed by same letter are not significantly different at p =0.05 level

Average Leaf area

Effect of temperature stress, mulching material were significant (p<0.05) on leaf area (Figure 5). However, effect of interaction between temperature and mulching materials was not significant on measured parameter. Treatments with gliricidia mulch have shown the highest leaf area.

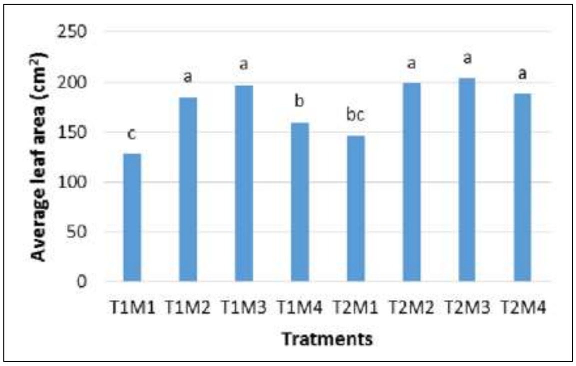

Figure 5: Average leaf area
T1- Temperature stress T2- Ambient temperature M1- Control M2- Coir dust M3- Gliricidia M4- Straw
Values followed by same letter are not significantly different at p =0.05 level

But it was not significantly different from the treatments with coir dust either at temperature stress or ambient temperature and the treatments with straw at ambient temperature. Treatments without a mulch presented the lowest leaf area at temperature stress and as well as at ambient temperature.

Average fresh weight of leaves

Average fresh weight of leaves of radish due to the effect of mulching material, temperature stress and the interaction between temperature stress and mulching material showed a significant variation (Figure 6).

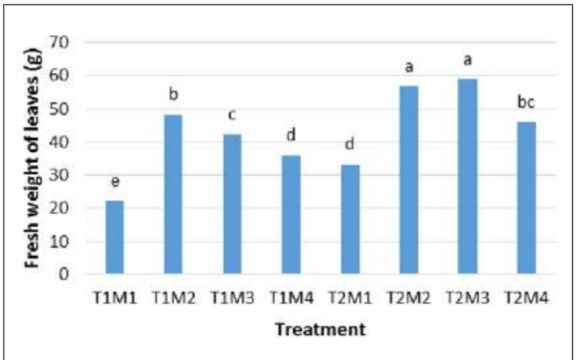

Figure 6: Average fresh weight of leaves
T1- Temperature stress T2- Ambient temperature M1- Control M2- Coir dust M3- Gliricidia M4- Straw
Values followed by same letter are not significantly different at p =0.05 level

All the treatments at ambient temperature have shown the better performances than treatments under temperature stress conditions. Treatment with gliricidia mulch at ambient temperature gave the highest fresh weight of leaves. Maximum fresh weight of leaves has obtained from gliricidia mulch at ambient temperature which was statistically similar to that of coir dust mulch at ambient temperature. Non-mulched treatment at temperature stress as well as at ambient temperature resulted lower weight of fresh leaves.

Plant height

Plant height has shown a pattern of increment. Effect of temperature, mulching material and the interaction effect of temperature and mulching materials were significant ($p<0.05$) on plant height (Figure 7).

The tallest plants were obtained from gliricidia mulch treatment at ambient temperature and it was not significantly different from the treatment with coir dust at ambient temperature. The plants grown without mulch at temperature stress gave minimum plant height (Figure 8). Mohanty *et al.* (1991) reported that the plant height was low in treatment without mulch which agrees with this study.

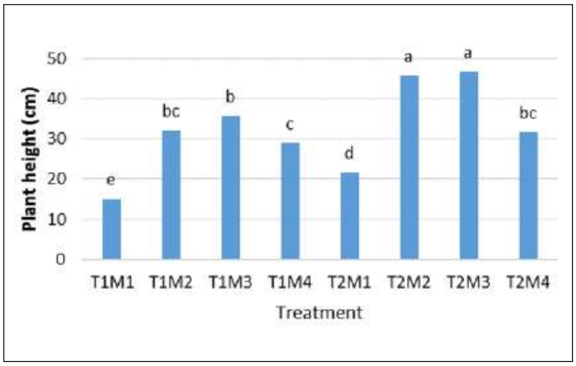

Figure 7: Plant height
T1- Temperature stress T2- Ambient temperature M1- Control M2- Coir dust M3- Gliricidia M4- Straw
Values followed by same letter are not significantly different at p =0.05 level

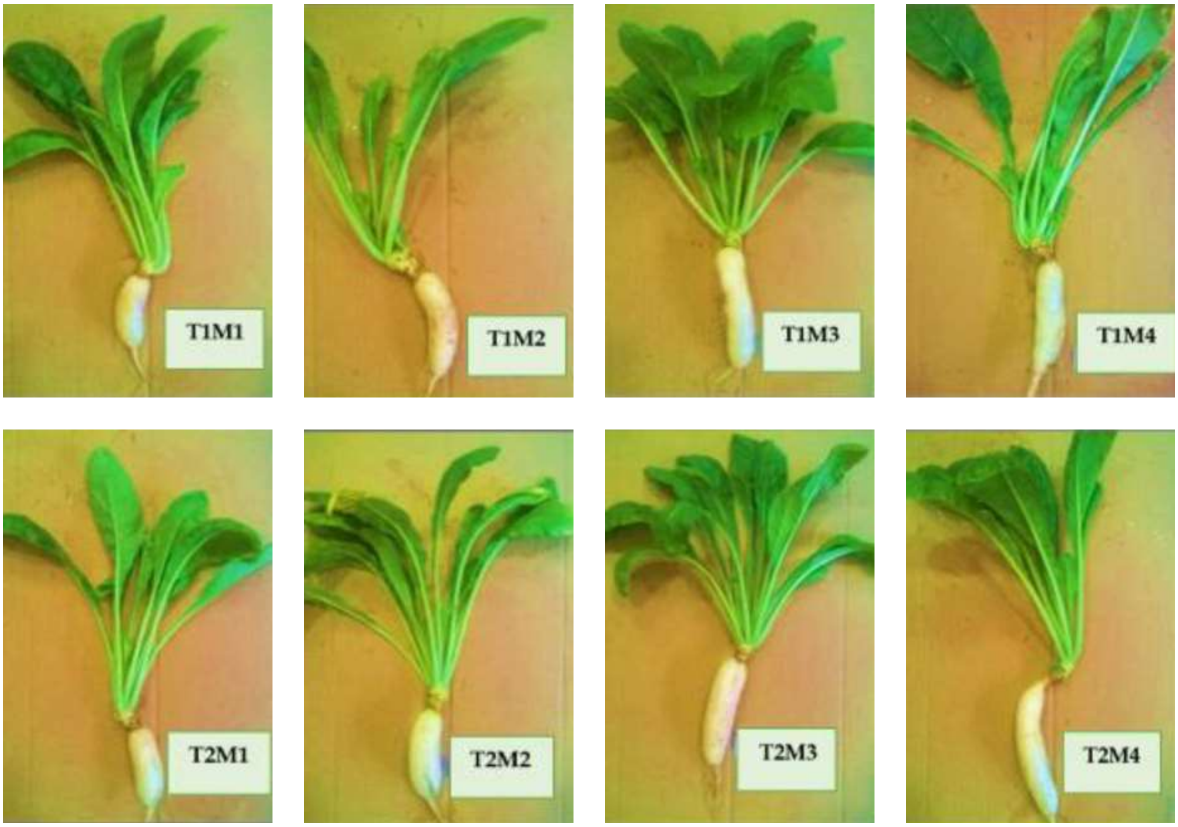

Figure 8: Growth performances of radish at harvest
T1- Temperature stress   T2- Ambient temperature   M1- Control   M2- Coir dust
M3- Gliricidia   M4- Straw

Length of Tuber

Effect of temperature, mulching material and their interaction significantly influenced ($p<0.05$) on length of tuber (Figure 9). Treatment with gliricidia at ambient temperature has shown the longest tuber and it was significantly different ($p<0.05$) from all other treatments. Treatments without mulch at temperature stress showed the lowest tuber length.

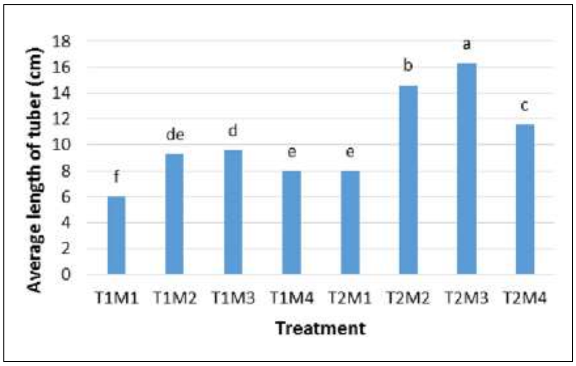

Figure 9: Root length
T1- Temperature stress   T2- Ambient temperature M1- Control   M2- Coir dust
M3- Gliricidia   M4- Straw
Values followed by same letter are not significantly different at p =0.05 level

Girth of the tuber

Girth of the tuber was significantly varied ($p<0.05$) according to temperature and mulching material. However, the interaction effect was not significant ($p>0.05$) on the girth of the tuber

(Figure 10). Treatments at ambient temperature with gliricidia and coir dust have shown the higher value for girth and both of these treatments were not significantly differ from each. Third highest girth of the tuber has shown in temperature stress with gliricidia mulch.

Treatments at ambient temperature have shown higher performances than the treatments at temperature stress. Treatment without mulch at temperature stress has shown the lowest girth of tuber and it was significantly varied from all other treatments.

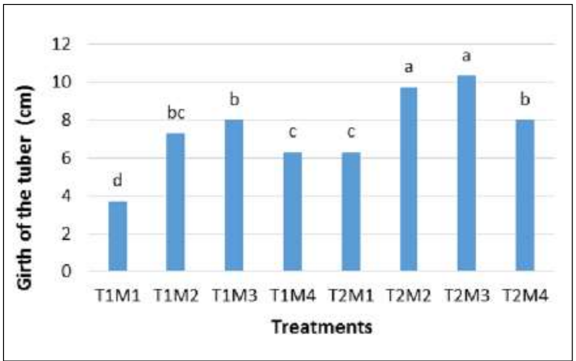

Figure 10: Girth of tuber
T1- Temperature stress T2- Ambient temperature M1- Control M2- Coir dust M3- Gliricidia M4- Straw
Values followed by same letter are not significantly different at p =0.05 level

Fresh weight of tubers

All the treatments at ambient temperature have shown better performances than the treatments at temperature stress. According to Table 1, treatment with gliricidia mulch at ambient temperature has shown the highest fresh weight and it was significantly different ($p<0.05$) from all other treatments apart from the treatment with coir dust at ambient temperature. Treatment with temperature stress and gliricidia mulch showed the third highest fresh weight of tubers.

Kumar *et al.* (2014) reported that the gliricidia mulch was produced pronounced efect ($p<0.05$) with regard to yield of ginger against the other treatments. All the control treatments at temperature stress and ambient temperature have shown the lowest fresh weight due to absence of mulch. Treatment without mulch at temperature stress has shown the lowest fresh weight and it was significantly different from all other treatments.

Dry weight of tubers

Dry weight of tubers also varied approximately same manner as fresh weight (Table 1). Dry weight of tuber also significantly varied ($p<0.05$) according to the both factors (Temperature and Mulching material) and interaction effect of temperature and mulching material. As similar to the fresh weight variation, all the treatments which were kept at ambient temperature have shown better performances than the treatments which were kept at temperature stress.

Treatment at ambient temperature with gliricidia mulch has shown the highest tuber dry weight and it was significantly different from all other treatments apart from the treatment with coir dust mulch at ambient temperature which has shown second highest dry tuber weight. Treatment without mulch at temperature stress has shown the significantly lowest dry weight of roots.

Table 1: Fresh and Dry weight of tubers

Treatment	Tuber fresh weight (g)	Tuber dry weight (g)
T1M1	32.00^{g}	6.00^{f}
T1M2	55.00^{d}	11.55^{de}
T1M3	67.66^{bc}	13.83^{cd}
T1M4	50.00^{e}	9.16^{ef}
T2M1	41.00^{f}	8.73^{f}
T2M2	74.00^{ab}	16.5^{ab}
T2M3	77.33^{a}	18.83^{a}
T2M4	62.00^{cd}	$15.5b^{c}$
CV (%)	5.43	7.158

T1- Temperature stress T2- Ambient temperature M1- Control M2- Coir dust M3- Gliricidia M4- Straw

Values followed by same letter are not significantly different at p =0.05 level

Conclusion

This study showed that the mulches of gliricida, coir dust and straw improved the yield of radish at temperature stress and ambient temperature. All the treatments without mulch have shown the lowest growth and yield performance either at the temperature stress or at ambient temperature. The consistent good results showed under the gliricidia and coir dust mulches for tested parameters in both ambient temperature and temperature stress condition and the crop recorded a significantly higher yield than the other treatments. Even though there is temperature stress to plants, along with gliricidia mulch, yield could be obtained without a significant reduction. These findings of this study will help the farmers in dry zone to cope with temperature stress in coming years due to climate change.

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