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EFFECT OF MULCH ON SOIL MOISTURE, TEMPERATURE, WEED INFESTATION AND *RANGEENI* LAC YIELD OF *PALAS (BUTEA MONOSPERMA)* IN JHARKHAND

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ABSTRACT
A study was conducted during 2010-2013 to assess the effect of different mulching materials viz., black polythene, transparent polythene, grass mulch, soil mulch, lac mud and unmulched (control) on soil moisture, soil temperature, weed suppression and summer season *(rangeeni)* lac yield of *palas (Butea monosperma)* under rainfed conditions in the Research farm of ICAR-Indian Institute of Natural Resins and Gums, Ranchi. Results showed the highest soil moisture conservation in black polyethylene by 22.3, 14 and 27.5% over control for the year 2011, 2012 and 2013, respectively. Different mulching materials showed different effects on soil temperature.The maximum mean temperature (22.4°C) was recorded under transparent mulch,while, the lowest soil mean temperature (20.2°C) was recorded under grass mulch. Mean soil temperature under grass mulch was lower by 1.3, 2.5 and 2.8°C compared to transparent polyethylene mulch for three years, respectively. Black polyethylene suppressed the maximum amount of weed (492.33 g m^{-2}), whereas the suppression by transparent mulch was 132.54 g m^{-2}, which was recorded to be the least. Lac yield showed no definite trend in any of the treatments during the study period.

INTRODUCTION

Lac is a natural resin of insect origin which is non nontoxic, biodegradable and its sources are renewable (Pandey and Prasad, 2007). Lac insect is a soft bodied insect belonging to Coccid group of order Homoptera. Two genera and 19 species of lac insects have been observed in India and the most common Indian lac insect of commercial importance is *Kerria lacca* (Kerr). *Rangeeni* and *Kusmi* are two strains of this insect, each of which produces two crops in a year (bi-voltine). *Kusmi* insect grows mainly on *kusum (Schleichera oleosa)* and also on a few other trees but conventionally not on *palas (Butea monosperma),* whereas *rangeeni* strain grows mainly on *palas* and also on a few other trees but not on *kusum.* Out of the entire lac produced in the country about 70% is from *rangeeni* strain which is contributed mainly by *palas* (Srivastava, 2007). *Rangeeni* strain produces two crops in a year known as *katki* (rainy season) and *baisakhi* (summer season) crop. The *katki* crop is inoculated in June/July and harvested in October-November, while *baisakhi* crop is inoculated in October-November and harvested in June-July.

Mulching, as a crop production technique, involves placement of organic or inorganic materials on the soil surface, so as to provide a more favorable environment for plant growth and development (Debashis *et al.,* 2008).The main functions that mulches provide include: weed suppression, soil water conservation, moderation of soil temperature fluctuations (daily and seasonal), increased infiltration of water droplets from precipitation or irrigation, soil protection from traffic compaction, improved soil structure for organic mulches and the slow release of nutrients (Kumar, 2014).

Keramat *et al.* (2011) has also reported that uses of mulches help to reduce waterconsumed.Although much research have been done for understanding the influences of mulch materials on soil moisture, growth and yield of many fruit or vegetable crops, report on effect of mulch with regard to its efficacy on *palas*is missing. Thus, the objectives of the present study were (1) to compare the performance of different mulches with respect to changes in soil moisture regime, soil temperature and weed reduction and also (2) to examine the best mulch option for enhancing lac productivity on *palas* (summer season) under rainfed condition.

MATERIALS AND METHODS

Research Site

The experiment was carried out at the research farm of ICAR-Indian Institute of Natural Resins and Gums Farm, Ranchi (23°23' N, 85°23' E, altitude 650 m) from July 2010 to June 2013. The average annual rainfall was 1326 mm of which an average of 1127 mm (85%) was received from June to September months. Soil of the experimental plot was of sandy loam texture, soil reaction 4.12, organic carbon content 0.34%, bulk density 1.35 g cm^{-3}, available N 146.9, P 17.05 and K 78.15 kg ha^{-1} with 21.1% field capacity, 11% permanent wilting point and 39.6% water holding capacity (WHC).

Experimental Design

72 *palas* trees spaced at 3.6 x 3.6 mwere selected for the

experiment.The experiment was laid out in Randomized Block Design with plot sizes measuring 10.8 m x 3.6 m area replicated four times with six treatments. Each treatment consisted of 12*palas* trees of the same age.Altogether six treatments were applied. The treatments were unmulched control (T_1), black plastic polyethylene film mulch (T_2), transparent polyethylene film mulch (T_3), grass mulch (T_4), soil mulch (T_5) and lac mud mulch (T_6). For polyethylene mulch treatment, black and transparent polyethylene film of 2.20 m diameter with 0.001 mm (100 μ) thickness was spread uniformly in the basin area of individual plant. Grass mulch was applied on the same area at the rate of 10 t/ha. For soil mulch, upper crust of the soil, up to 10 cm depth, was tilled once during the crop cycle. Lac mud, a waste product of lac, was applied at the rate of 10 t/ha.

Evaluation of soil moisture, temperature and weed biomass

The soil moisture was measured at fortnightly interval (13-15 days interval) throughout the year barring monsoon period (June-September) by gravimetric method (Black, 1965)from 0-30 and 30-60 cm depth of soil profile. The soil from different depths was sampled by manual coring and gravimetric moisture content (g/g) of the soil samples was calculated on oven dry weight basis (%). Soil temperature from each treatment at 30 and 60 cm depth was recorded at the time of collecting the soil sample for moisture analysis by digital thermometer with an accuracy of ± 1.0% range.

The quantity of weeds wasrecorded at the time of mulch imposition (October-November) and at the removal of mulch material (1st week of June) every year in a 25 cm X 25 cm quadrant from each treatment-replication combination. The above-ground parts were clipped with a secateur at soil surface, oven dried at 65ºC for 48 hours and weighed with a digital balance to determine the dry matter (DM) per plot (Okugie and Ossom, 1988; Spandl *et al.,* 1999).The difference in the dry matter weight at the time of imposition and removal of mulch material was considered as the weed suppression for that treatment.

The weed suppression percent by weight was calculated by

$$\text{Weed suppression (\%)} = \frac{\text{(Wt. of DM at the time of mulch imposition – Wt. of DM at the time of removal of mulch material)}}{\text{Wt. of DM at the time of mulch imposition}} \times 100$$

Broodlac inoculation and its harvesting

Inoculation of broodlac on *palas*trees for summer season crop was done at the mean rate of 500,500 and 360 g/tree during October in 2010 and 2011 and during November in 2012, respectively and the crop was harvested during April every year as *ari* (immature lac). Lac had to be harvested early as immature in April so that the same set of trees could be ready for broodlac inoculation for summer season crop in October-November every year. Data on *ari* yield ratio and its thickness was recorded.

RESULTS AND DISCUSSION

Soil moisture

Evaporation from the soil accounts for 25-50% of the total quantity of water used (Hu *et al.,* 1995). Mulch prevents soil water evaporation and thus helps retain soil moisture. The amount of moisture stored in the profile to a soil depth of 60 cm was significantly greater under black polyethylene over control (Fig.1). Black polyethylene conserved the highest soil moisture and it was 22.3, 14 and 27.5% greater over control for the year 2011, 2012 and 2013, respectively. Clear transparent sheet was found to be significantly superior over control during 2012 and 2013, while grass mulch was superior in the year 2012. Other treatments e.g. soil mulch and lac mud was at par between them alongside control.

The reason for enhanced soil moisture storage under polyethylene and grass mulch may be attributed to significantly lesser evaporation from the soil surface. This study has shown that during post monsoon period, when there is not much rainfall in the area, the soil moisture on the surface and the upper subsoil of unmulched plots can be reduced from field capacity to wilting point or below, whereas the soil moisture in the mulched plot remains well above the wilting range. The result was in conformity with the findings of Ramakrishna *et al.* (2006) who reported that the amount of moisture stored in the profileto a soil depth of 90 cm was significantly greater under polythene and straw mulch over bare and chemically mulched soil. Mahadeen (2014) also found higher soil moisture content under black plastic mulch plots over un-mulched plots.

Soil temperature

All the mulched soil treatments alongside control had significantly higher temperature ($p \leq 0.05$) at 0-60 cm soil depth during all the years compared to grass treatment consistently. Mean soil temperature under grass mulch was lower by 1.3, 2.5 and 2.8ºC compared to transparent polyethylene sheet (Table 1).Mean soil temperature ranged from 19.1ºC to 21.6ºC under grass mulch, while the range under transparent mulch varied from 21.9 to 22.9ºC. No significant differences in soil temperature were recorded among lac mud, soil mulch and control treatments. Generally, highest soil temperature was recorded in polyethylene mulch followed by control.The prevention of direct contact of solar radiation alongside increased moisture content with the soil by the organic mulches explains the low soil temperature under grass mulch.The high soil temperatures of mulched plots observed in this investigation were in agreement with the results of Choi and Chung (1997), who has observed that thermistors placed at soil surface, recorded increase in soil temperatures by 2.8-9.4ºC and 0.9-7.3ºC at 5 cm depth.The results are also consistent with the results of Hanada (1991) who observed that polythene films (black, green or transparent) markedly increased soil temperature compared to grass mulch in temperate, sub-tropical and tropical regions.Moreno and Moreno (2008) also found the lowest values of temperature under the biodegradable and the highest underthe polyethylene mulches employed for production of tomato crop.Further, the present investigation shows that the polythene mulch offers better insulation than the other mulches and hence the increase in soil temperature.

Weed infestation

Black polyethylene, soil mulch and grass mulch showed the

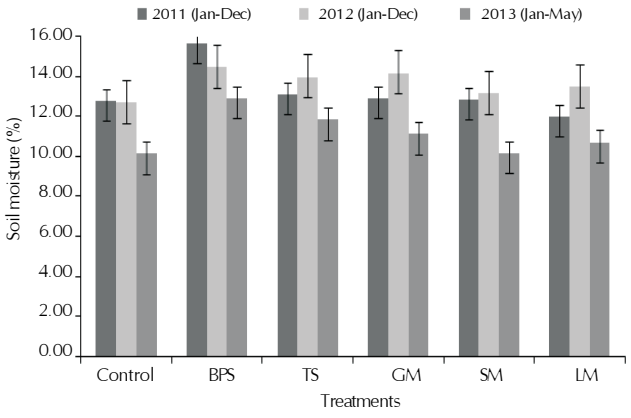
Table 1: Mean soil temperature (°C) under various treatments during different years (2011-13)

Treatment	2011 (Feb-Dec)	2012 (Jan-Dec)	2013 (Jan-May)	Mean
T_1 Control	22.2	21.6	21.4	21.7
T_2- BPS*	22.5	22.1	21.6	22.1
T_3-TS	22.9	22.4	21.9	22.4
T_4-GM	21.6	19.9	19.1	20.2
T_5- SM	22.0	21.3	20.6	21.3
T_6- LM	22.1	21.3	20.9	21.4
SEM (±)	0.10	0.11	0.21	0.13
CD (=0.05)	0.21	0.23	0.45	0.38

*BPS- Black polyethylene sheet; TS- Transparent sheet; GM- Grass mulch; SM- Soil mulch; LM- Lac mud

Table 2: Lac crop yield parameters for *palas* under different kind of mulches (2011-13)

Treatment	*Ari* yield ratio (output: input)			*Ari* thickness (mm)		
	2010-11	2011-12	2012-13	2010-11	2011-12	2012-13
T_1 Control	2.6	2.4	2.3	3.6	3.5	3.0
T_2- BPS*	1.3	5.0	3.2	3.5	3.6	3.2
T_3-TS	1.4	5.2	3.3	3.5	3.8	4.0
T_4-GM	0.6	5.8	3.2	2.2	4.0	3.6
T_5- SM	1.8	2.5	2.2	3.4	3.0	3.4
T_6- LM	1.7	4.7	2.9	3.6	3.5	3.5
SEM (±)	0.82	5.3	1.25	0.67	0.48	0.93
CD (=0.05)	NS	NS	NS	NS	NS	NS



*BPS- Black polyethylene sheet; TS- Transparent sheet; GM- Grass mulch; SM- Soil mulch; LM- Lac mud

Figure 1: Mean Soil moisture (%) under various treatments during different years

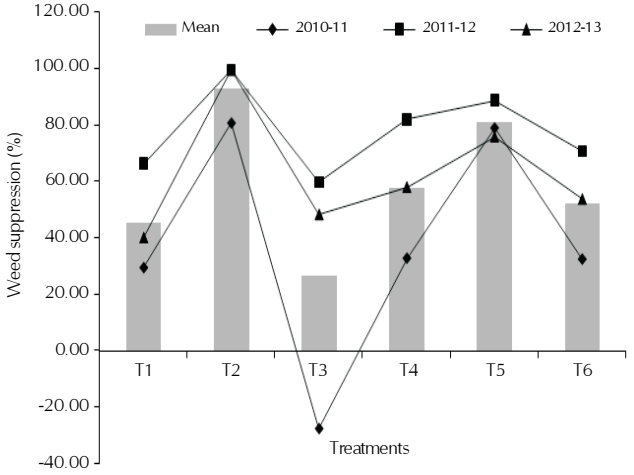


Figure 2: Weed suppression (%) under different mulchesin different years

least weed infestation, while transparent sheet and control showed the maximum (Fig. 2). In fact, transparent mulch showed the highest weed coverage and in the year 2010-11, the weed infestation was 27.5% more under this mulch at the time of removal of the mulch when compared to its imposition, signifying transparent mulch to be highly ineffective in weed suppression. The black polyethylene mulch reduced the highest weight (492.33 g m^{-2})whereas the transparent mulch reduced the least weight (132.54 g m^{-2}). The reason may be attributed to direct entrance of solar radiation through them and as well as due to high soil temperature and soil moisture content under transparent polyethylene Rajablariani *et al.* (2012). Much sunlight penetration inside transparent sheet facilitated photosynthesis of inside grasses, causing abundance of the weeds. The result is consistent with the findings of Grassbaugh *et al.* (2004) who reported weed reduction to the tune of 80% under black plastic mulch. Ngouajio and Ernest (2004) reported that the highest and lowest weed biomass in white and black plastic mulches, respectively.

Lac yield

For the year 2010-11, summer season lac crop *(baisakhi)* was harvested in April 2011 as *ari* (immature lac). The lac yield trend was found to be inconsistent and no definite trend was observed as analysis of data for *palas* revealed maximum yield ratio with control (2.6:1) and the least under grass mulch (0.6:1) (Table 2). Broodlac thickness was also recorded to be highest (3.2 mm) in control, whereas the lowest was observed in grass

mulch (2.2 mm). Analysis of data for the year 2011-12 showed the highest *ari* lac yield (5.8:1) and broodlac thickness (4 mm) in grass mulch and the lowest ari lac yield (2.4:1) in control and *ari* thickness (3.0 mm) in soil mulch conditions. For 2012-13, transparent mulch showed the maximum yield ratio (3.3:1) and thickness (4.0 mm). The lowest yield ratio and thickness was found under control with values of 2.3:1 and 3.0 mm, respectively (Table 2). Inferences can be drawn here that, though, yield ratio was numerically higher in the mulched treatments when compared to control in general; no significant difference was observed among the treatments. There were variations in lac yield between the years, which probably can be partly due to biotic and abiotic factors.

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