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EVALUATION OF MULCHING SYSTEMS FOR MITIGATION OF LOW TEMPERATURE STRESS OF *HEVEA BRASILIENSIS* SEEDLINGS GROWN IN NORTH EAST INDIA

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Different mulching systems using paddy straw, polythene, Farm Yard Manure (FYM), paddy straw along with FYM, polythene overhead cover and FYM plus paddy straw along with polythene overhead cover were evaluated in a polyclonal seedling nursery of *Hevea brasiliensis*. During low temperature stress, the soil temperatures in the morning were 1.74 and 1.92°C higher under the treatments FYM + paddy straw mulching and polythene overhead cover respectively when compared to control. The combination of these two mulching systems increased the soil temperature by 1.94° C over control. Plants under polythene overhead cover showed better photosynthesis and growth. However, with removal of polythene cover and with increase in air temperature during the month of March – May, six month old seedling under both FYM + paddy straw mulching and polythene overhead cover with FYM + straw mulching attained comparable stem diameter. While 46.5 per cent seedlings attained the required stem diameter for budding under FYM + paddy straw mulching and 44 per cent under polythene overhead cover with FYM + paddy straw mulching, only 22.5 per cent seedlings attained similar diameter in control.

Key words: *Hevea brasiliensis*, Low temperature, Mulching, Seedling growth.

INTRODUCTION

Natural rubber (*Hevea brasiliensis*) seedlings experience a low temperature stress during their early growth stage particularly in the north eastern regions. Nursery practice of India that can minimize the adverse effects of low temperature can improve the growth of the seedlings. In peak winter season, the minimum ambient temperature varies from 7.8°C to 12.9°C during early morning followed by high irradiance (Ray *et al.*, 2003). This atmospheric condition in particular is highly detrimental to the young plants. Mulching is reported to be an effective cultural practice to overcome the deleterious effects of low temperature in many crops (Liakatas *et al.*, 1986; El-hassan, 1986; Kim *et al.*, 1988; Chamabasavanna and Setty, 1991). It also conserves soil moisture and improves the soil temperature during winter season (Dey and Hundal, 2003). Soil temperature may be a growth limiting factor for tree seedlings when the mean root zone soil temperature during the growing season is 10 to 18°C with the

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values ranging temporally from 5 to 20°C (Kubin and Kemppainen, 1999). Low temperature affects physiological attributes such as leaf photosynthetic rate leading to poor growth (Day *et al.*, 1990; Alam and Jacob, 2002; Strand *et al.*, 2002). Vulnerability to low temperature stress in *Hevea* seedlings is well established (Jacob *et al.*, 1999; Ray *et al.*, 2004; Alam *et al.*, 2005). It was also reported the growth of roots decreases and biomass allocation to roots diminishes with decreasing soil temperature (Lopushinsky and Max, 1990; Lyr and Garbe, 1995; Lyr, 1996; Iivonen *et al.*, 1999). Low soil temperature can reduce the sink strength of roots as a result of their poor metabolic activity (Farrar, 1988; Lippu, 1999). Seed ripening period of rubber is July – September. However, sometimes seeds are also available up to November. When such seeds are sown, the seedlings may have to survive the winter stress and put up good growth so that they are ready for budding during May/June next year.

As mulching can help to increase soil temperature and support plant growth during winter, different system of mulching were evaluated.

MATERIALS AND METHODS

Study site and plant material

The experiment was conducted at Taranagar Farm, Regional Research Station, Agartala, Tripura, North East India (91°15' E 23°25' N, 30 m MSL). The average maximum and minimum temperature during January and February were 24.3°C and 11.2°C respectively. The average relative humidity was 74% and the rainfall were 4.6 and 12.9 mm respectively in the two months.

Seeds were collected from a mature plantation during the first week of November and immediately sown in germination beds as per standard practices. Germinated seeds were transplanted to nursery beds measuring 1m x 4.5 m with 30cm x 30cm spacing. The soil was sandy loam and all standard cultural practices were followed including irrigation. Finally, 50 seedlings were maintained in each nursery bed by gap filling wherever required. The treatments were replicated three times and randomly assigned to different seedling beds. The experiment was repeated for two years. The details of the treatments are given in Table 1. The irradiance level under the polythene overhead structure was reduced by 40 per cent. The polythene overhead cover was removed who the temperature increased after winter.

Soil and air temperature

Soil temperature at 10 cm depth was recorded at 6.30 hrs everyday during winter season (January-February). Air temperature was recorded as a routine in the meteorological observatory situated at a distance of 100 meters in the same experimental farm.

Relative chlorophyll content

The relative chlorophyll content of the leaves was qualitatively measured by a Chlorophyll meter (CCM-200, Opti-Sciences, USA) which calculates CCI (Chlorophyll Content Index) value proportional to the amount of chlorophyll present in the sample.

Gas exchange

Photosynthesis rate (A), stomatal conductance (g_s) and CO_2 concentration in sub stomatal spaces (Ci) were measured with

Table 1. **Effect of mulching systems on soil temperature in *H. brasiliensis* seedlings during peak winter period (January-February)**

Treatment (mulch/cover)	Average soil temperature (⁰C)	Increase over control (⁰C)
Paddy straw (5kg/bed)	16.4	1.6
Used polythene sheets (1.5 kg/bed)	16.7	1.9
FYM (10kg/bed)	16.2	1.4
FYM (10 kg/bed) + Paddy Straw (5kg/bed)	16.6	1.8
Polythene overhead cover	16.8	2.0
FYM (10 kg/bed) + Paddy straw (5kg/bed) + Polythene overhead	16.9	2.1
No mulch/overhead cover (Control)	14.8	—
CD ($P \leq 0.05$)	0.63	

a portable infrared gas analyzer (CIRAS II, PP system, USA). Measurements were taken between 8 am to 10 am on five physiologically mature leaves from five representative plants of each treatment. The gas exchange measurements were taken under PFD of 1500 µmole $m^{-2}s^{-1}$ and 1.5 Kpa of vapour pressure.

Growth

Shoot diameter at the height of 10 cm from the base was recorded in seedlings of *H. brasiliensis.* Ten randomly selected seedlings were uprooted carefully without damage to the roots and total dry matter per plant was estimated. The sampling was done during February when the seedlings were four month old. Two years data were pooled and the average dry matter per plant calculated.

RESULT AND DISCUSSION

Soil and air temperature

Polythene overhead cover along with FYM and paddy straw mulching recorded higher mean soil temperature of 16.9⁰C with an average overall increase of 1.9⁰C over the control (14.8⁰C) during morning hours (Table 1). The average air temperature record was 12⁰C. The increase in soil temperature was not significantly different among the different mulching system. Soil temperature under mulching was significantly higher when compared to the control during the period.

Low soil temperature reduces sink strength of roots resulting in low metabolic activity (Farrar, 1988). Therefore, any increase in soil temperature will improve the metabolic activity of roots leading to rapid utilization of starch in roots (Lippu, 1999). This will result the reverse feed back effect on leaf photosynthesis and thereby on shoot biomass (Day *et al.*, 1991). An increase in soil temperature would enhance carbohydrate mobilization towards roots for its development without compromising the shoot growth. Plants under polythene overhead cover had an advantage during winter season and could maintain higher soil as well air temperature resulting in better photosynthesis and growth. Rubber plants also remain safe under partial shade which minimizes photoinhibitory damage (Nair *et al.*, 2002).

Relative chlorophyll content

The relative chlorophyll content was significantly higher in plants grown under polythene overhead cover compared to control

Table 2. **Growth and photosynthetic rate of *H. brasiliensis* seedlings grown under different mulching systems during winter season**

Treatment	CCI Values	Photosynthetic rate (μmoles CO_2 $m^{-2}s^{-1}$)	Stem diameter (mm) (4 month old)	Total dry biomass (g) (4 month old)
Paddy straw (5kg/bed)	55.0	5.27	7.79	48.90
Used polythene sheets (1.5 kg/bed)	58.5	6.14	7.61	43.27
FYM (10kg/bed)	54.2	5.06	7.49	38.59
FYM (10 kg/bed) + Paddy Straw (5kg/bed)	50.7	5.76	7.80	65.76
Polythene overhead cover	67.5	8.23	7.79	65.18
FYM (10 kg/bed) + Paddy straw (5kg/bed) + Polythene overhead	68.4	8.57	8.18	68.89
No mulch/overhead cover (Control)	48.0	4.96	6.89	23.62
CD ($P \leq 0.05$)	7.2	2.34	0.82	13.86

plants (Table 2). The CCI values of plants under polythene overhead cover with FYM and paddy straw mulch (68.4) and polythene overhead cover alone (67.5) were higher than that for control plants (48.0). In treatments where the plants were exposed to normal light, CCI value was 54.6 and not significantly different among the treatments. Higher chlorophyll content under partial shade is a general phenomena observed in rubber plants to optimize the light harvest and thereby the process of photosynthesis (Nair *et al.*, 2002). The situation is reverse under full irradiance condition (Anderson, 1986).

Rate of photosynthesis

The plants under polythene overhead cover with FYM and paddy straw mulch recorded the highest photosynthetic rate of 8.57 μmoles CO_2 $m^{-2}s^{-1}$ during winter season followed by 8.23 μmoles CO_2 $m^{-2}s^{-1}$ in polythene overhead cover alone compared to 4.89 μmoles CO_2 $m^{-2}s^{-1}$ in control plants (Table 2). Partial shading might help to alleviate the adverse photoinhibitory effect of the high light intencity and hence the higher photosynthetic rate (Jacob *et al.*, 1999). It was observed in many situations that leaf area per plant increases under shade resulting in an overall increase in photosynthetic assimilation (Nair *et al.*, 2002).

Growth

The highest stem diameter of 8.18 mm and dry matter of 68.9 g/plant were recorded in four months old seedlings under overhead polythene cover with FYM and paddy straw mulch, whereas control plants recorded only 6.89 mm and 23.6 g/plant respectively. However, biomass accumulation under FYM plus paddy straw mulching and polythene overhead cover separately were 65.7 and 65.1 g/plant while the control plants had very low biomass (23.62g/plant) (Table 2). Higher biomass accumulation could be due to efficient utilization of incident radiation (Wall and Kanemasu, 1990).

Increase in soil temperature influences the growth of the seedlings. In all the mulching

Table 3. **Buddable growth of plants after 6 months**

Treatment	Plants with buddable girth at 6 months (%)
Paddy straw (5kg/bed)	37.5
Used polythene sheets (1.5 kg/bed)	40.8
FYM (10kg/bed)	30.4
FYM (10 kg/bed) + Paddy Straw (5kg/bed)	46.5
Polythene overhead cover	29.3
FYM (10 kg/bed) + Paddy straw (5kg/bed) + Polythene overhead	44.0
No mulch/overhead cover (Control)	22.5
CD ($P \leq 0.05$)	6.5

systems, the percentage of seedlings that attained the required growth for bud grafting at the age of 6 months were found to be more than that in the control. Seedlings under both FYM + paddy straw mulching and polythene overhead with FYM + straw mulching attained comparable girth by the end of 6 months. A maximum of 46.5 per cent seedlings attained required girth under FYM + paddy straw mulching and 44 per cent under polythene overhead with FYM + straw mulching (Table 3).

It was evident that mulching improved soil temperature and consequently the growth of the seedlings under cold stress. Polythene overhead cover was useful for increasing soil temperature during winter season. However, FYM plus straw mulching also supported satisfactory growth of the seedlings.

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