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# WEED CONTROL TECHNOLOGY FOR ENVIRONMENTALLY, ECONOMICALLY AND SOCIALLY SUSTAINABLE AGRICULTURE

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Weeds grow in the cropped fields and compete with crops for water, nutrients, light and space and thus reduce crop yields significantly. Under uncontrolled situations they cause even 90 per cent damage to the crops. In non- irrigated areas, the competition between weeds and crops is largely for water whereas in irrigated or high rainfall tracts, the competition is severe for nutrients. Weeds also generate a formidable competition with crop plants for light. One of the secrets behind the high yield potential of the dwarf varieties of crop plants is that they can capture solar energy more efficiently. Reduction in crop yield has a direct correlation with weed competition. The extent of yield reduction of rice due to weed alone in India, is estimated to be around 15-20 per cent for transplanted rice, 30-35 per cent for direct seeded rice under puddled condition and over 50 per cent for upland rice (Pillai and Rao, 1974). The potential loss in production of rice in India due to weed infestation is estimated at 15 million tons per annum (Chatterjee and Maity, 1990). IRRI, Phillipines did an extensive research work to study the influence of nitrogen on competition between rice and weeds and reported that grain yield decreases as the amount of nitrogen applied increased. It was reported that there was 95 percent yield reduction of rice cultivar 'IR-8' when 120 Kg N/ha was applied and it appears that in weedy fields, the addition of fertilizers favoured the weeds more than the rice crop. Data further reveal that nitrogen fertilizer should not be used before weeds are controlled. Weeds remove plant nutrients more efficienty than crop plants (Rao, 1983).

Recently weed control through chemical means in the form of herbicide is commonly used to kill the plants or inhibit their growth in many parts of the world. However, intensive herbicide use has raised serious concern about their effect on non-target organisms, environment, ground water and it may create some serious upheavals in the ecosystem. The indiscriminate use of pesticides/herbicides has built up indestructible residues in the soil, turning the dirt barren, structureless and unproductive. The use of herbicides has added toxic residues both in soil and ground water to dangerously high levels. Apart from water and soil pollution, contamination of food grains and food articles with toxic residues, there are environmental hazards regarding the over use of herbicides to kill the weeds. Some herbicides retard root development and develop dangerous effects in the plants (Khan *et al.*,1997). Hence there is a continuous search for newer non-hazardous and eco-friendly methods which may sustain soil health and ecology, eliminate soil and water pollution and reduce the cost of input and increase the income of the farmer.

The technique of trapping solar radiation with transparent LDPE i.e. Soil Solarization is getting much more attention globally and experiments are being conducted since late 1970 in countries like U.S.A, Israel, Greece, Italy, Jordon and Israel etc. Maximum weed loss for a longer period due to longer period of solarization is found. Solarization for 67 days at Torino (Italy) resulted in reduction of dicot weeds by 99 per cent and monocot weeds by 94 per cent. Increase in peanut yield upto 52 percent by weed reduction due to solarization at Jerussalem and also 300 percent increase in tomato yield at Jordon due to reduction in weeds as a result of solarization were reported.

***Soil Solarization*** is a method of heating the soil surface by using the transparent polyethylene sheets (LDPE film) placed on soil surface to trap the solar radiation. This raises the soil temperature to levels lethal for many soil borne pathogens and weed seeds, thus killing weeds before emerging.

The present investigation was carried out for five consecutive wet seasons through a series of experiments with a variety of alternative biological solutions to control weeds which are benign, harmless, pollution free, non - hazardous and eco - friendly to control the pre emerging weeds in upland ecosystem through solarization in this high rainfall coastal region of eastern India.

## Materials and Methods

Experiments were conducted in rainfed uplands ecosystem at Research Farm of Water Technology Centre for Eastern Region, Mendhasal (Bhubaneswar) during the five consecutive wet seasons of 1994 to 1998. The soil is acidic (pH 5.2) in the coastal belt of the Bay of Bengal and is situated on the cross point of $85^0$ 52' longitude and $20^0$ 15' latitude at an altitude of 25.90 meters above mean sea level. The experimental soil has about 65.14, 16.60 and 18.26 percent of sand, silt and clay, respectively. It has *in situ* bulk density of 1.55 g $cm^{-3}$, organic matter 0.40 percent, void ratio of 0.71, 1/3 bar moisture 14.30 percent and 15 bar moisture 4.5 percent. The experiment was laid out in randomised block design. The annual rainfall (average of 100 years) of this region is 1432.4 mm which provides a favourable and optimum environment for all types of weeds growth. The seven treatments given below were replicated thrice in a randomised block design. The ultimate plot size of the experiment was 4.6 x 3.2 $m^2$. Rice cultivar IR-36 (seed rate @ 70 kg/ha) was sown. The crop was fertilized with 60: 30: 30 N: $P_2O_5$: $K_2O$. The initial nutrient status of the soil was 220, 11, and 122 kg/ha available nitrogen, available phosphorus and available potassium, respectively. The transparent polyethylene sheets (LDPE films) were placed before sowing as described in following treatments:

$T_1$ - Transparent LDPE sheet of 200 gauge for 30 days.
$T_2$ - Transparent LDPE sheet of 200 gauge for 45 days.
$T_3$ - Transparent LDPE sheet of 400 gauge for 30 days.
$T_4$ - Transparent LDPE sheet of 400 gauge for 45 days.
$T_5$ - Unweeded check (Control)
$T_6$ - Weeded check (hand/mechanical weeding)
$T_7$ - Black LDPE sheet of 400 gauge for one week before planting (Smothering)

## 3. Results and Discussion

The yields and yield components of rice as affected by weed control treatments are presented in Table 1. Dry weight of weeds at panicle initiation stage is presented in Table 2. The prevalent weeds flora in the plots were; (i) Grasses - are monocots having long, narrow, two-ranked flat leaves with parallel venation and round hollow stems: *Echinochloa colonum* (L.) and *Cynodon dactylon* (ii) Sedges – are similar to grasses but have three-ranked leaves and triangular solid stems. They frequently have the modified rhizomes adopted for storage and for propagation: *Cyperus rotundus,* Link, *Digittaria spp* and *Cyperus iria*, Linn. (iii) Broad Leaved – are dicots with neat venation of leaves and are easy to identify: *Eclipta alba* Hassk, *Euphorbia hirta, Phyllanthus niruri* and *Ageratum conyzoides* (L) etc.

From Table 1 (five years pooled data, 1994 to 1998), it is evident that the yield of rice in treatment with transparent LDPE of 400 gauge for 30 days ($T_3$) is higher than the yield of rice in the field of transparent LDPE of 200 gauge for 30 days ($T_1$) and field of black LDPE of 400 gauge (smothering) for one week ($T_7$), though they are statistically at par. However transparent LDPE of 400 and 200 gauges for 45 days ( $T_4$ and $T_2$ ) produced less yield. It seems that covering the soil with LDPE sheets beyond 30 days may be detrimental to the crop growth and yield due to the harmful effects on beneficial microbial growth. Transparent LDPE sheets (200 & 400 gauges) for 30 days and black LDPE sheet application on soil reduced the emergence of different types of weeds at panicle initiation stages (Table 2).

Fig.1 depicts the temperature at two depths of 5 cm and 10 cm under both mulches and non-mulched conditions along with air temperature. The temperatures were recorded four times in a day, i.e. at 8.00 a.m., 12.00 noon, 2.00 p.m. and 4.00 p.m. The maximum of these four values has been considered for comparison as for killing the viability of weed seeds, which is an important factor for weed control. It is evident from the figure that the temperature at 5 cm depth under transparent film mulch was more than 45 $^0$C for most of the summer period. The temperature at 10 cm soil depth under this mulch was above 40$^0$C up to 24$^{th}$ June, beyond which it was around 35 $^0$C. Since most weed seeds do not remain viable for germination at this temperature, the transparent mulch will kill the germination viability of all weed seeds located up to 10-cm depth.

In the case of black film mulch, the temperature at 5-cm soil depth was closer to the temperatures observed in transparent film mulch. However at 10-cm soil depth, it was much less. Thus black film will not be as efficient in killing the germination viability of weed seeds located up to 10-cm soil depth. Thus transparent film mulching will be better for weed control purpose.

The soil temperature difference between the non-mulched and mulched plots is significantly correlated to soil temperature under non-mulched condition at that depth and cumulative solar radiation of that day. The effect of air temperature was found insignificant. A quardatic relationship was developed between temperature difference ($\Delta$T) and soil temperature (ST) and cumulative solar radiation (SR) of the day for all the four treatments, which are presented here.

*5 cm soil depth with transparent film mulch*

$$\Delta T = -3647.98 + 236.37\ ST - 0.0027\ SR - 3.84\ ST^2 + 0.022\ ST.SR + 0.43 \times 10^{-6}\ SR^2$$

$r = 0.86$

*10 cm soil depth with transparent film mulch*

$$\Delta T = -1517.59 + 93.64\ ST - 1.46\ SR - 0.033\ ST^2 - 0.22 \times 10^{-3}\ ST.SR + 0.11 \times 10^{-5}\ SR^2$$

$r = 0.87$

*5 cm soil depth with black film mulch*

$$\Delta T = -4362.65 + 300.30\ ST - 16.69\ SR - 5.15\ ST^2 + 0.55\ SR.ST + 0.71 \times 10^{-7}\ SR^2$$

$r = 0.86$

*10 cm soil depth with black film mulch*

$$\Delta T = 2359.75 - 148.09\ ST + 2.31\ SR + 0.049\ ST^2 - 0.022\ ST.SR + 0.21 \times 10^{-4}\ ST^2$$

$r = 0.37$

While a significant correlation was found for soil temperature difference with transparent film mulch at both depths and 5cm depth with black film mulch, it was very poor for 10-cm depth with black film mulch. This is due to poor radiation transmission quality of black film. These equations will be useful for deciding the best period for mulching to get maximum advantage of soil heating to kill the germination viability of weed seeds and harmful microbes.

From Table 2 it is also clear that transparent LDPE films in treatments $T_1$, $T_2$, $T_3$ and $T_4$ have a long term effect on weed growth in comparison to black LDPE film ($T_7$) and hand weeding ($T_6$). The viability of weed seeds in black LDPE and hand weeding might not be effected as adversely as in transparent LDPE sheets. Soil warms up faster under clear plastic since the incident short wave radiation is transmitted through it and absorbed directly by the soil (Khan, 1983). From the above studies it is evident that weeds can be totally controlled through LDPE films which are ecology friendly and harmless to the soil and environment and save the ecosystem from the hazardous pollution. The crop yield is reasonably good in this rainfed upland ecosystem due to the total control of weeds.

## Conclusion

Weed causes significant damage (up to 90 percent) to the crop yield. Weed control through chemical means in the form of herbicide is commonly used to kill the weed plants or inhibit their growth throughout the world. However, the use of herbicides has added the toxic residues dangerously to non-target organisms, environment and created serious upheavals in the ecosystem. Studies were conducted through a series of experiments for five consecutive wet seasons with a variety of alternative biological solutions to control weeds which are benign, harmless, pollution free, non - hazardous and eco - friendly to control the pre emerging weeds in the rainfed, upland rice ecosystem of high rainfall coastal region of eastern India through s*oil solarization*. This is a method of heating the soil surface by using the transparent polyethylene sheets (LDPE film) placed on soil surface to trap the solar radiation. This raises the soil temperature to a level lethal for many soil borne pathogens and weed seeds, thus killing weeds before crop emergence.

The use of transparent and black LDPE sheets reduces the weed growth and increases the rice yield. Higher yields were found in the treatments of transparent LDPE films of 200 gauges and 400 gauges for 30 days followed by black LDPE film. However, lower yields were recorded from the fields, which were covered with LDPE films (both 200 & 400 gauge) beyond 30 days.


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Table 1
Yield and yield components of rice (CR-1009) as affected by weed control treatments (Mean of 5 years)

| Treatments | Grain yield (kg/ha) | Straw yield (kg/ha) | Grains/ Panicle | Chaffs/ panicle | Length of panicle (cm) | Plant Height (cm) |
|---|---|---|---|---|---|---|
| $T_1$ | 2457 | 7743 | 75 | 11 | 18.13 | 75.98 |
| $T_2$ | 1739 | 7133 | 82 | 10 | 18.20 | 73.66 |
| $T_3$ | 2577 | 8352 | 84 | 11 | 18.25 | 76.29 |
| $T_4$ | 1466 | 5419 | 88 | 09 | 18.51 | 73.63 |
| $T_5$ | 1095 | 7781 | 85 | 10 | 18.65 | 79.95 |
| $T_6$ | 1968 | 5629 | 66 | 08 | 17.16 | 69.38 |
| $T_7$ | 2348 | 7895 | 72 | 14 | 18.50 | 83.32 |
| S.Em ± | 284.30 | 951.52 | - | - | - | - |
| C.D. at 5% | 619.48 | 1143.50 | NS | NS | NS | NS |

Table 2
Weed dry weight at panicle initiation stage (kg/ha)
(Mean of 5 years)

| Treatments | Weed dry weight (kg/ha) | Weed count/$m^2$ | | |
|---|---|---|---|---|
| | | Narrow leaved | Broad leaved | Sedges |
| $T_1$ | 161 | 64 | 17 | 5 |
| $T_2$ | 222 | 156 | 28 | 9 |
| $T_3$ | 120 | 63 | 16 | 4 |
| $T_4$ | 171 | 274 | 36 | 9 |
| $T_5$ | 464 | 123 | 41 | 14 |
| $T_6$ | 308 | 89 | 21 | 11 |
| $T_7$ | 248 | 79 | 21 | - |
| S.Em ± | 124.81 | 101.79 | 12.30 | 17.30 |
| C.D. at 5% | NS | NS | NS | NS |

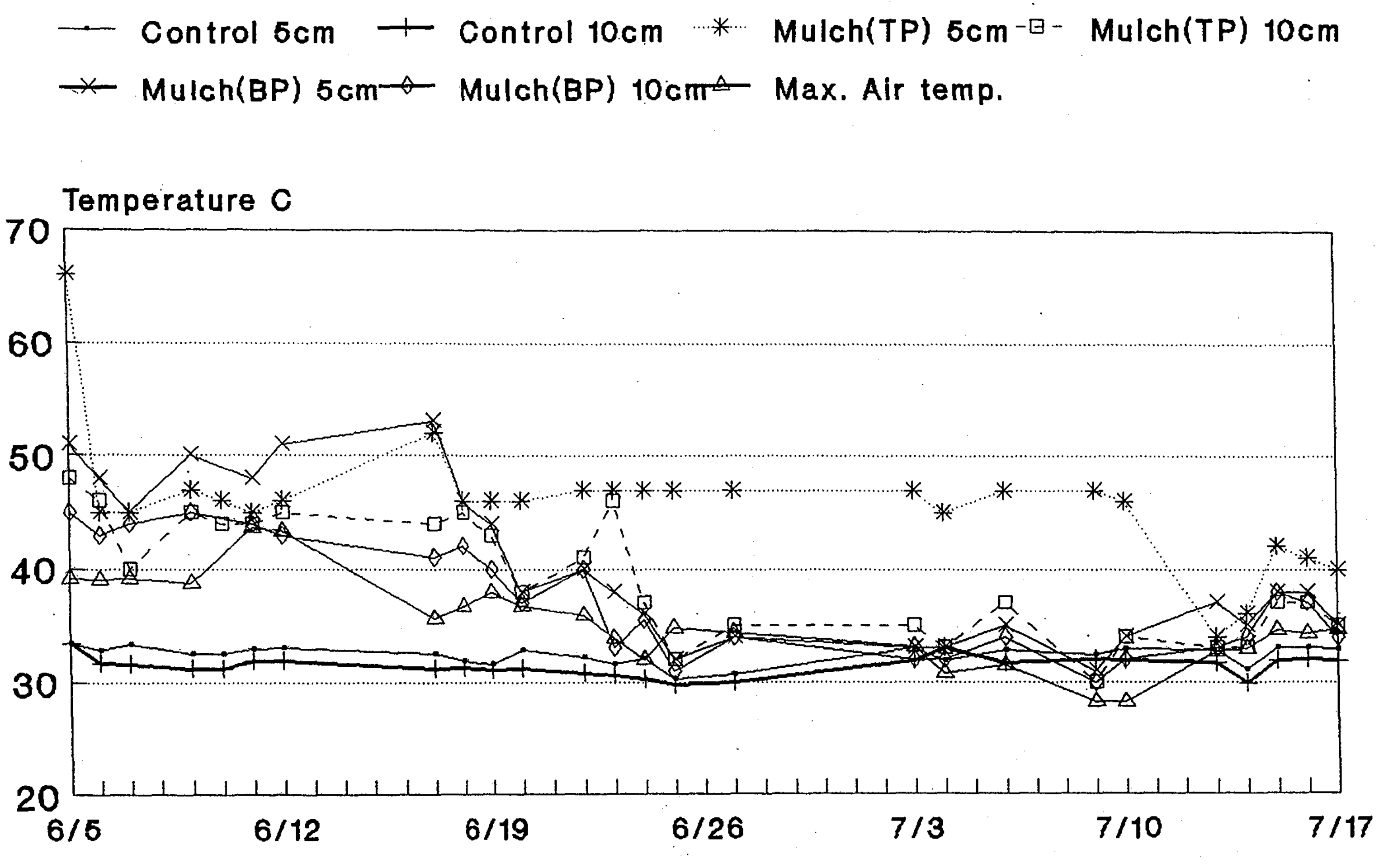


Fig. 1 Maximum soil temperature at different depths under mulch and non-mulch conditions