*Journal of Agrometeorology 22 (4) : 518-523 (December 2020)*

***Short Communication***

# Seedling vigour enhancement through nursery bed protection and mulching for yield enhancement in *rabi* rice

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Rice is not only a staple food but also one of the most important cereal crops in India which plays a significant role in socio-economy of the country. Enhancing rice production is the key to ensure food security.Low temperature induced rice yield loss is a worldwide problem (Peyman and Hashem, 2010), but it is a major constraint to rice production in mountainous regions of the tropics and in the temperate rice-growing zones of the world (Xie, *et al*., 2012). Northern states of India are cold prone areas of the country. Boro rice is greatly affected by cold during crop establishment stage. Seedling mortality sometimes goes up to 90%. The most common symptoms of cold temperature damage at the germination stage are delayed and lower percentage of germination and lead to poor establishment (Shimono, *et al*. 2007). Slow growth and discoluration of seedlings, stunted vegetative growth characterized by reduced height and tillering, delayed heading, incomplete panicle exertion, prolonged flowering period, degeneration of spikelets, irregular maturity and increased growth duration (Kaned and Beachel, 1974) are other features of cold injury at subsequent growth stages.

Cold injury is common during winter season in the Hirakud Command area of Western Odisha in the popular rice variety 'MTU 1001'. The main visible symptom is the yellowing of the leaves in the seedling stages leading to rotting and complete damage of seedlings. The air temperature in Western Odisha varies from 10.5 to 15.5$^0$C during month of December and January during which farmers raise their seedlings for summer rice. Use of short duration varieties can avoid the cold injury. But yield potential is low inthose varieties. Unless improved rice varieties tolerant to low temperature are adopted and appropriate cultural management practices are followed, there is no other option to protect the summer rice crop in this region. Therefore, studies were conducted to generate nursery protection technique by using mulching materials to improve growth and performances of rice seedlings for *rabi* rice during extremely cold period in Hirakud command areas of Odisha.

A field experiment was conducted during winter season of 2017-18 and 2018-19 at the Regional Research and Technology Transfer Station, Chiplima of Orissa University of Agriculture and Technology under West Central Table Land Zone Odisha. The soil of experimental field was clay loam, porosity 39.28%, infiltration rate 0.26 cmhr$^{-1}$, water holding capacity 25.56% on weight basis, field capacity 19.7% on weight basis, permanent wilting point 10%, acidic (pH 5.65) and lowin organic carbon content (0.47%). The available N, P and K content were 242, 9.2 and 155 kg ha$^{-1}$, respectively. Twenty four treatment combinations of 3 nursery protection measures (SM1 = The farmer's seed bed management practice was employed where the seed bed was submerged, SM2 = Covering nursery bed with paddy straw + keeping standing water by irrigating the nursery bed in evening and drain out the water in the morning, SM3 = Covering thenursery bed with polythene sheet + keeping standing water by irrigating the nursery bed in the evening and drain out the water in the morning,) and 8 mulching materials [T1=Control (without any mulching material), T2= Carbonized rice hull (CRH) @ 0.5 kg m$^{-2}$, T3= Farm yard manure @ 0.5 kg m$^{-2}$ , T4= Fly ash @ 0.5 kg m$^{-2}$, T5= CRH + Farm yard manure @ 0.5 kg m$^{-2}$ each, T6 = FYM + Fly ash @ 0.5 kg m$^{-2}$ each,T7 = CRH + Fly ash @ 0.5 kg m$^{-2}$ each, T8 =CRH +FYM +Fly ash @ 0.5 kg m$^{-2}$ each] were tested in randomized split plot design with three replications

Beds were kept 1.5 m wide to facilitate the fixing of locally available *Ipomoea* sticks for making lower tunnel and simultaneously make it convenient to perform various operations like placing polythene sheets, controlled irrigation, weeding and plant protection sprays. Nursery area had good facilities for drainage.Water from the adjacent canal was applied to the nursery every day in the afternoon and drained out in the morning. Polythene sheets were used

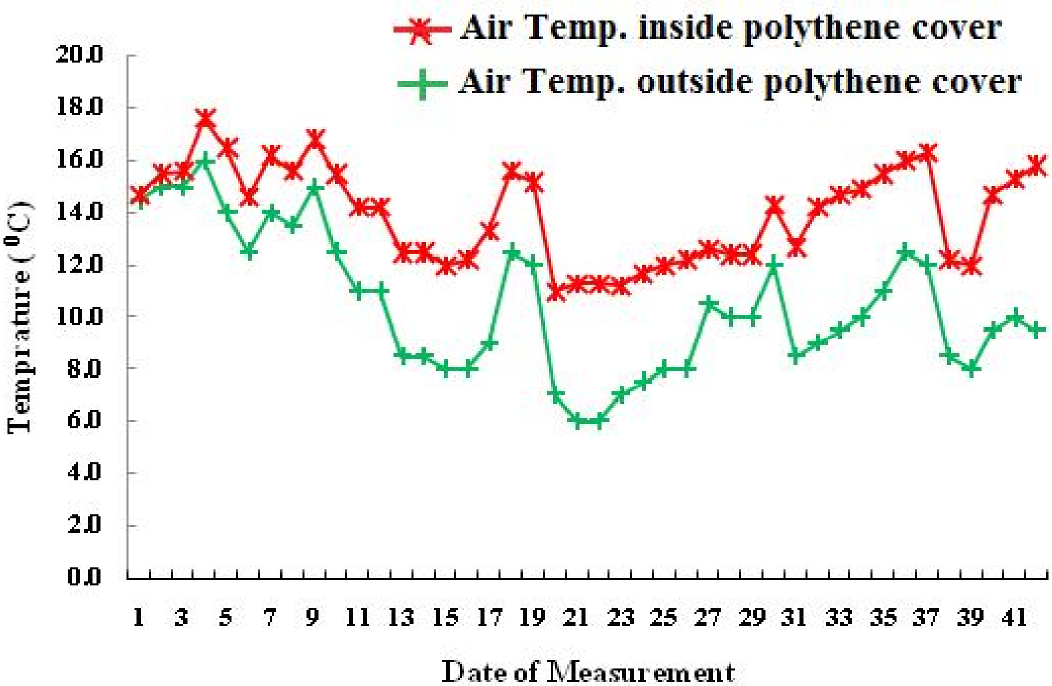


**Fig. 1:** Minimum air temperature inside and outside polythene cover, measured at 8 A.M. during period in December and January averaged for 2017 and 2018.

over locally available *Ipomoea* sticks to make low tunnels temporarily covered with dry soil at edges of the polythene. Nursery was kept covered with polythene during day and night hour. Farmers' practice involved sowing of seed in square bed in the open nursery. All other management practices were kept similar in both the practices.

The germinated seeds were covered with 2-3 cm thick layer with CRH, FYM and fly ash as per the treatments. The size of nursery plot was 1.5x1.5m. The field was demarcated in to 24 plots in each replication and individual plots were separated by bunds and irrigation channels. Seed rate was 50 g $m^{-2}$ for all the seed beds. The recommended dose of N, $P_2O_5$ and $K_2O$ for 1 $m^2$ nursery area is 0.01, 0.005, 0.005 kg, respectively. Nutrient content of carbonized rice hull was collected locally from nearby rice-mill contains $SiO_2$, 80.26%; phosphorus, 0.38%; pH, 8.7; potassium, 1.28%; Magnesium, 0.21% and calcium 0.56%. Nutrient and that of fly ash collected from nearby thermal power plant contains, organic carbon, 0.3%; total N, 0.04%; available N, 67.2 ppm; available P, 4.2 ppm; available K, 88.5 ppm. Farm yard manure (FYM) contains N, 0.5%; $P_2O_5$, 0.4% and $K_2O$, 0.5%., Specific heat = 0.39 J $g^{-10}C^{-1}$. The purpose of utilising carbonized rice hull, fly ash and FYM was to absorb radiation during night. The field was kept moist up to 5 cm height of seedlings. Then it was irrigated during evening and drained out in the morning.

Seedlings raised in the nursery were transplanted at the rate of 2 seedlings $hill^{-1}$ with 20cm x 10cm spacing in plot size of 4x3 m. A common fertilizer dose of 80, 40 and 40 kg of N, $P_2O_5$ and $K_2O$ $ha^{-1}$, respectively was applied through urea, single super phosphate and muriate of potash. Full dose of $P_2O_5$ was applied as basal. Nitrogen was applied in 3 splits of 25, 50 and 25% at basal, tillering and panicle initiation stages, respectively. Potassium was applied in 2 splits as 75 and 25% as basal and panicle initiation stage, respectively. Plant protection measures and irrigations were provided as and when required. Yield and yield attributes of rice were recorded at crop harvest.

Thermometers, which recorded minimum and maximum temperatures, were installed around each experiment to measure ambient air temperature, inside the polythene covers. Daily maximum and minimum temperature for the experiment's duration were collected from meteorological station of Regional Research and Technology Transfer Station of Chiplima. Number of seedlings was counted from four random squares of 100 $cm^2$ area in the nursery at 5 days after sowing. Seedlings shoot and root length and seedling weight (dry) at transplanting were recorded in all experiments. Tiller numbers at harvest, flowering date, grains $panicle^{-1}$ and grain yield (adjusted to 14% moisture) were determined.

Economics was computed using the price of inputs

**Table 1:** Effect of temperature on rice seedling growth sown in Dec.-Jan. and June-July (mean of 2 years)

| Items | Dec | | | Jan. | | |
|---|---|---|---|---|---|---|
| | 10-16 | 17-23 | 24-31 | 1-7 | 8-14 | 15-21 |
| T. Max. ($^0$C) | 27.9 | 23 | 25.5 | 27.5 | 27.1 | 28.4 |
| T. Min. ($^0$C) | 14.4 | 11.4 | 8.6 | 8.7 | 10.4 | 10.6 |
| Duration for rice seedling (15cm) | 50 | 46 | 40 | 32 | 28 | 25 |
| | June | | July | | | |
| | 18-24 | 25-1/7 | 2-8 | 9-15 | 16-22 | 23-29 |
| T. Max. ($^0$C) | 37.9 | 35.7 | 34.4 | 31.7 | 28.1 | 27.4 |
| T. Min. ($^0$C) | 20.4 | 21.1 | 20.3 | 19.4 | 18 | 17.6 |
| Duration for rice seedling (15cm) | 16 | 19 | 21 | 24 | 27 | 30 |

**Table 2**. Effect of management practices on cold injury in rice nurseries (mean of 2 years)

| Treatment | Seedling shoot length (cm) | Seedling root length (cm) | Shoot dry weight (mg seedling$^{-1}$) | Root dry weight (mg seedling$^{-1}$) | Seedlings (m$^{-2}$) |
|---|---|---|---|---|---|
| **Nursery bed protection** | | | | | |
| SM1 | 17.6 | 6.4 | 40.3 | 18.9 | 472 |
| SM2 | 19.3 | 7.3 | 56.6 | 26.7 | 529 |
| SM3 | 23.6 | 9.4 | 80.7 | 38.2 | 599 |
| CD (P=0.05) | 0.08 | 0.07 | 0.13 | 0.09 | 4.9 |
| **Mulching material** | | | | | |
| T1. Control | 15.7 | 5.5 | 24.8 | 12.5 | 400 |
| T2. CRH | 20.9 | 8.1 | 52.5 | 24.6 | 507 |
| T3. FYM | 19.9 | 7.5 | 44.4 | 20.7 | 450 |
| T4. Fly ash | 17.9 | 6.6 | 33.2 | 15.4 | 420 |
| T5. CRH + FYM | 23.3 | 9.3 | 84.2 | 39.7 | 673 |
| T6. FYM + Fly ash | 21.2 | 8.2 | 75.5 | 35.5 | 583 |
| T7. CRH + Fly ash | 18.4 | 6.8 | 55.2 | 25.9 | 492 |
| T8. CRH + FYM + Fly ash | 24.0 | 9.6 | 103.6 | 48.9 | 740 |
| CD (P=0.05) | 0.12 | 0.08 | 0.09 | 0.12 | 23.2 |

and output as per prevailing market rate. The rate of paddy seeds, diammonium phosphate and muriate of potash fertilizer were purchased at the rate of Rs. 35.00, 22.00, 5.50 and 9.00 per kg, respectively. The farm gate price of rice grain and straw were Rs. 17.50 and Rs. 0.80 per kg, respectively. The data generated for both the growing seasons were pooled together and analysed statistically.

***Effect of temperature on growth of rice seedlings***

Growth of rice seedlings is slow during winter season (*rabi*). Thus, a greater number of days is required to get seedlings of 15 cm height. It takes about 40 to 50 days for December sowing during *rabi* and 16-19 days for sowing in June during *kharif* (Table 1). During first 7 days from 17 to 23rd Dec. the mean minimum temperature was 11.4 $^0$C. In the next 7 days from 24th to 31st Dec. the mean minimum temperature was 8.6$^0$C. During next 7 days of 1st to 7th Jan. the mean temperature was 8.7 $^0$C and these temperatures delayed the germination andinhibited the seedling growth

**Table 3**. Effect of seed bed protection and mulching material on yield attributes and yield and economics of *rabi* rice (mean of 2 years)

| Treatment | Plant height (cm) | Effective tillers plant$^{-1}$ | Panicle length (cm) | Grain panicle$^{-1}$ | Sterile grains panicle$^{-1}$ | 1000 grain weight (g) | Grain yield (t ha$^{-1}$) | Straw yield (tha$^{-1}$) | Cost of cultivation (Rs ha$^{-1}$) | Net return (Rs ha$^{-1}$) | B:C ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Nursery bed protection** | | | | | | | | | | | |
| SM1 | 90.2 | 9.1 | 21.6 | 115 | 34 | 21.3 | 4.8 | 5.2 | 39266 | 44613 | 1.14 |
| SM2 | 90.6 | 9.5 | 21.9 | 117 | 32 | 21.5 | 5.2 | 5.8 | 39533 | 52177 | 1.32 |
| SM3 | 91.4 | 9.6 | 22.1 | 120 | 33 | 21.6 | 6.0 | 6.2 | 39866 | 64980 | 1.64 |
| CD (P=0.05) | 0.26 | 0.09 | 0.16 | 0.39 | 0.16 | 0.07 | 0.66 | 0.71 | NS | 10466 | 0.24 |
| **Mulching material** | | | | | | | | | | | |
| T1. Control | 87.7 | 8.1 | 21.4 | 106 | 39 | 21.1 | 4.4 | 4.8 | 38639 | 38361 | 0.99 |
| T2. CRH | 89.4 | 8.8 | 21.5 | 114 | 34 | 21.4 | 5.3 | 5.8 | 39139 | 52590 | 1.35 |
| T3. FYM | 89.3 | 8.5 | 21.4 | 112 | 35 | 21.5 | 5.3 | 5.6 | 39806 | 53207 | 1.35 |
| T4. Fly ash | 88.3 | 8.0 | 21.5 | 111 | 37 | 20.9 | 4.6 | 5 | 38806 | 42667 | 1.09 |
| T5. CRH + FYM | 96.0 | 10.8 | 22.7 | 130 | 27 | 22.1 | 6.0 | 6.7 | 40305 | 64819 | 1.61 |
| T6. FYM + Fly ash | 91.3 | 9.7 | 22.1 | 119 | 29 | 21.3 | 5.7 | 5.9 | 39972 | 59252 | 1.41 |
| T7. CRH + Fly ash | 90.3 | 8.6 | 21.6 | 114 | 35 | 21.4 | 5.3 | 5.6 | 39305 | 51627 | 1.29 |
| T8. CRH + FYM + Fly ash | 93.3 | 12.7 | 22.8 | 132 | 28 | 21.6 | 6.2 | 6.6 | 40472 | 68873 | 1.75 |
| CD (P=0.05) | 0.29 | 0.11 | 0.19 | 0.11 | 0.12 | 0.05 | 0.30 | 0.33 | 1131.5 | 10924 | 0.14 |

**Table 4:** Grain yield (t ha$^{-1}$) as influenced by interaction of seed bed protection and mulching material(mean of 2 years)

| | T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 | Mean T |
|---|---|---|---|---|---|---|---|---|---|
| SM1 | 3.9 | 5.0 | 5.1 | 3.9 | 4.4 | 5.1 | 5.5 | 5.5 | 4.8 |
| SM2 | 4.5 | 4.9 | 4.9 | 4.9 | 5.5 | 5.7 | 5.8 | 5.8 | 5.3 |
| SM3 | 4.8 | 5.9 | 5.9 | 5.2 | 5.8 | 6.3 | 7.3 | 6.7 | 5.9 |
| Mean M | 4.4 | 5.3 | 5.3 | 4.7 | 5.3 | 5.7 | 6.2 | 6.0 | |
| | | | MXT | TXM | | | | | |
| CD (P=0.05) | | | 0.81 | 0.63 | | | | | |

in nursery bed. These findings were in close agreement with the results of Matsubayashi (1963) and Saikia *et al*. (2014).

The minimum air temperature under polythene covering averaged 3.9 $^{0}$C higher than outside polythene cover and never fell below 15 $^{0}$C (Fig.1), even when the outside temperature was 8.6 to 11 $^{0}$C. This higher temperature inside the polythene sheet improved the seedling growth in the nursery bed.

***Growth parameters of rice seedlings***

All the treatments recorded significantly higher shoot and root growth of rice at the time of transplanting over control (Table 2). At the time of transplanting, sizeable seedlings were produced in polythene covering seed bed, whose average seedling shoot length was 23.6 cm, root length was 9 cm, shoot dry weight was 80.7 mg seedling$^{-1}$, root dry weight was 38.2 mg seedling$^{-1}$ and number of seedlings was 599 m$^{-2}$. In farmer's method of raising seedlings, seedling shoot length was 17.6 cm, root length was 6.4 cm, shoot dry weight was 40.3 mg seedling$^{-1}$, root dry weight was 18.9 mg seedling$^{-1}$ and number of seedlings was 472 m$^{-2}$. Under polythene covering, the seedlings reached required height (23.6 cm) at the time of transplanting and reduced the risk of transplanting. Low tunnel polythene protected nursery maintained higher soil, water and air temperature that that rose conventionally. This higher temperature has proved beneficial for producing heavier seedlings in the protected nurseries (Shah *et al*. 2000).

Mulching seeds with CRH+FYM+fly ash recorded highest seedling shoot length (24 cm), seedling root length (9.6 cm), shoot dry weight (103.6 mg) root dry weight (48.9 mg) and 740 seedlings m$^{-2}$ survived. The treatment without any mulching material, seedling shoot length (15.7 cm), seedling root length (5.5 cm), shoot dry weight (24.8 mg) root dry weight (12.5 mg) and 400 seedlings m$^{-2}$ survived. The length of root and shoot of nursery without protection was less than the nursery protected with polythene sheet due to inhibition of vegetative growth at low temperature. As a result, in nursery without protection the 4$^{th}$ leaf did not emerge and required about 2 weeks more for emergence of 1$^{st}$ , 2$^{nd}$ and 3$^{rd}$ leaves. This might have influenced the reduction in root length and seedling dry weight than other treatments. On the other hand seedlings of protected treatments required less number of days for emergence of 4$^{th}$ leaf (22 days) than that of without protection (34 days). The root and shoot length were numerically higher in CRH applied treatments as compared to FYM. The shoot length, shoot and root dry weight of rice was more with combine application of CRH and FYM than that of individual application of CRH or FYM.

***Yield attributes and yield***

More grain yields (6 t ha$^{-1}$) were obtained from plants raised in nursery bed protected with polythene sheet. It might be due to healthier seedlings producingtaller plant (91.4 cm) with higher number of effective tiller plant$^{-1}$ (9.6), panicle length (22.1 cm), grains panicle$^{-1}$ (120), 1000 grain weight (21.6 g) and less number of sterile grains panicle$^{-1}$ (33) in comparison to the farmer's practice (Table 3). Begum *et al*. (2002) found better yield from growing seedlings under polythene cover.The highest 1000 grain weights (21.6 g), grains panicle-1 (132), panicle length (22.8 cm), effective tillers plant$^{-1}$ (12.7) were observed in the treatment where CRH + fly ash + FYM were applied. Use of FYM significantly increased plant height, effective tillers plant$^{-1}$ and number of filled grains panicle$^{-1}$, which led to 16.9% increase in grain yield over control. The combinations of CRH+FYM+Fly ash resulted better yield attributes of rice which increased grain yield over control by 29% and net return by 44%. Combinations of CRH+FYM and FYM +Fly ash resulted in higher growth and yield attributing characters of rice which led to 23 to 27% increase in grain yield over control and 11-19% over CRH, FYM and Fly ash alone. The lowest number of effective tillers plant$^{-1}$ (8.1), shortest panicle (21.4 cm), lowest grains panicle$^{-1}$(106), lowest grain yield (4.4 t ha$^{-1}$), straw yield (4.8 t ha$^{-1}$) were recorded in the seedlings grown without cover with FYM, fly ash or CRH. This might be due to poor growth of root and shoot for uptake of nutrient at seedling stage.

***Interaction effect***

Protecting the nursery bed with polythene and mulching of seeds with carbonized rice hull, FYM and fly ash produced 87.2% more yield (7.3 t ha$^{-1}$) than that of control (3.9 t ha$^{-1}$) (Table 4). Sahu and Nayak (1971) observed that combination of method of raising seedlings and mulching significantly affected number of effective tillers plant$^{-1}$, grain panicle$^{-1}$, grain yield and straw yield of rice.

***Economics***

Polythene protected nursery incurred higher cost of cultivation (Rs. 39,866 ha$^{-1}$) due to polythene sheet cost of poly tunnel. Maximum net return (Rs. 64980 ha$^{-1}$) and B: C ratio (1.64) was recorded in polythene protected nursery followed by straw protected nursery. Among the mulching material CRH + FYM +Fly ash recorded the highest net return (Rs. 68,873 ha$^{-1}$) and B: C ratio (1.75) followed by CRH + FYM treated plot.

It can be concluded that covering the nursery bed with polythene sheet + keeping standing water by irrigating the nursery bed in the evening and drain out water in the morning, recorded higher seedling shoot length (23.6 cm); shoot dry weight (80.7 mg); root dry weight (38.2 mg) and seedling survival (599 m$^{-2}$). Mulching the seeds with carbonized rice hull + FYM + fly ash @ 0.5 kg m$^{-2}$ each recorded higher seedling shoot length (24 cm); shoot dry weight (103.6 mg); root dry weight (48.9 mg) and seedling survival (740 m$^{-2}$). The combinations of carbonized rice hull + FYM + fly ash resulted in increased grain yield of rice over control by 29% and net return by 44%.

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*Received : June 2020; Accepted: September 2020*