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SRI Rice Crop Establishment

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Introduction

Agro-ecological based farming methods are now touted to be the methods of choice to address food security for the poor, decrease environmental degradation and increase resilience to climatic shock. Being a low-carbon, resource-preserving type of agriculture, agro-ecology has proven to be able to double food production within 10 years (UN-HRC, 2010). An alternative rice management system known as System of Rice Intensification or SRI which requires less water, seeds and chemical fertilizers is now recognized internationally as the preferred agro-ecological green technology that employs improved water management and organic inputs and therefore substantially reduces adverse ecological impacts while, at the same time, raising crop yield. The UN-DESA (2011) report has listed SRI as one of the sound examples of creative innovations that has had large-scale impacts on agriculture and natural resource management. This paper discusses the current knowledge of rice crop establishment that may be applied to SRI. The paper also reports some findings on a comparative study between direct seeding and manual transplanting under SRI as well as some initial findings of the use of mycorrhiza in the presence of biochar in augmenting rice crop establishment.

Materials and Methods

The paper highlights the plant physiological advantages of SRI rice crop establishment and the benefits of rice seed treatment. A comparative study between direct seeding and manual transplanting under SRI was conducted based on a completely randomized block experiment of 5 X 5m plots in 4 replication. A second experiment comparing rice seedlings grown in a soil medium inoculated with mycorrhiza and mycorrhiza plus rice husk biochar was conducted based on a split plot experimental design. The mycorrhiza inoculant was a commercial product by FELCRA Research and Development. Both experiments were based on the performance of the rice variety MR219.

Results and Discussion

There are many benefits of good crop establishment and associated practices. SRI is a method of rice planting that focuses on realizing the full genetic potential of the plant through practices that encourage the health of the whole plant and soil health. Many physiological advantages such as more productive tillers per hill, heavier grains, more spikelets per panicle and more efficient photosynthesis and water use are noted for the SRI method (Tables 1 and 2). Mycorrhizal rice root colonization positively influences the uptake of phosphorus and potassium (Hajiboland et al., 2009). Incorporation of well composted rice straw can reduce weeds, supply silica and nutrients for the plant and microorganisms, making the rice plants strong and upright. Additionally, the plants become more photosynthetically efficient with increasing yield, reducing susceptibility to biotic stress such as chewing insects and abiotic stresses such as drought, metal toxicity and salt, whilst increasing phosphate availability (Ma, 2004; Massey and Hartley, 2006). Proper land leveling is a must for SRI cultivation since in most parts of the season, the field is kept just wet without flooding thereby decreasing the risk of dessication and inefficient use of water. Seed treatment for the SRI method, which is vital in reducing seed borne diseases and instrumental in increasing yield, does not include methods that are detrimental to beneficial microrganisms (Table 3).

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In the SRI method, 8-12 days old seedlings are cultivated on dry raised nursery beds or trays, giving enough space between seeds to reduce the possibility of fungal attack. Table 4 lists the various crop establishment practices associated with SRI method. Although SRI manual transplanting is less laborious than conventional manual transplanting, the current scarcity of labour calls for a consideration for other less laborious methods of rice crop establishment. Under conventional rice cultivation, direct seeding is more attractive than transplanting because it is cheaper and can result in an earlier harvest (Balasubramanian and Hill, 2002). The results of the comparative study of manual transplanting and direct seeding under SRI showed that manual transplanting was significantly higher than direct seeding in all the yield components ($p<0.05$) (Table 5). Under manual transplanting, the yield obtained was 12.36 tonne/ha, whereas under direct seeding, the yield was 6.91 tonne/ha. Table 6 shows the results of the productivity analysis of the two methods which reveals that the benefit cost ratio for transplanting was higher (3.39) than direct seeding (2.94). Based on the yield components and productivity, it can be concluded that manual transplanting is better than direct seeding The experimental results of the effect of mycorrhiza on rice seedling establishment indicated that plant height at eight days after sowing was significantly higher for mycorrhiza treated rice seedlings (mean = 10.3 cm) than the control (mean = 5.8cm) at $p<0.05$ (Table 7). In this experiment, biochar does not seem to have a positive effect on the growth of the mycorrhiza treated rice seedlings. While it cannot be assumed that biochar amendments will always result in a net benefit to plant productivity (Warnock et al., 2007), the effect of biochar on rice seedling establishment needs further investigation.

Table 1. Physiological advantages of SRI

Plant Growth Stage	Physiological Advantage
Vegetative stage	More tillers more open plant architecture with more erect and larger leaves Higher xylem exudation rates deeper and better-distributed root systems Higher water use efficiency; higher photosynthetic rate; lower transpiration
Ripening stage	higher leaf chlorophyll content; delayed senescence; greater fluorescence efficiency
Harvest Stage	longer panicles, more grains per panicle and higher % of grain-filling; heavier grains

Source: Thakur et al., 2009

Table 2. Maximum grain weight from organic SRI rice plots

Site	Variety	1000-grain weight+	Source
Beranang	MR219	39.6	Experimental, 2009
Beranang	UKMRC2++	30.2	Experimental, 2009
Tanjung Karang	MR219	29.6	Experimental, 2009
Tanjung Karang	UKMRC2++	28.5	Experimental, 2009
Tunjong	Hijrah	31.0	Farmer's trial, 2011
Tunjong	Sintanur	29.2	Farmer's trial, 2011
Kg. Lintang	MRQ74	22.6	Farmer's trial, 2011

+1000-grain weight at 14% moisture. ++UKMRC2 seeds were provided by Wickneswari Ratnam

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Table 3. Rice seed treatment

Seed Treatment	Action	Advantage
Sunbathing	Exposing the seeds to sunlight for one or two days	Higher transparency of seed skin; higher transpiration; better oxygen supply: reduction in anti-germination substances: better germination rate and speed; ultraviolet light kills germs: eliminates harmful CO_2 gas produced during confinement
Specific gravity selection	Putting seeds in saline water and getting rid of light, floating seeds	Sorting for good quality seeds. Eliminating immature grains and disease infected grains
Seed disinfection	Soaking seeds for 5 min in 45 – 47 °C, then 50 – 52 °C for 10 min and rinsing with cool water immediately	Kills seed borne pathogens (and nematode disease)
Soaking/seed priming	Soaking seeds in water for 24 h	Activates enzymes, hastens changes of the albumen storage component into a soluble component, and reduces germination inhibiting substances
Seed priming	priming in KCl for 48h. osmohardening with KCl or $CaCl_2$ for 24 h, or vitamin priming (ascorbate 10 ppm) for 48 h and seed hardening for 24 h.	Decreases lipid peroxidation and increases superoxide dismutase (SOD), and catalase (CAT) activities, starch breakdown (Ella et al., 2011); ensures rapid and uniform seed germination; improves crop stand establishment, growth, yield and quality; increases in activities of α-amylase
Sprouting at proper temperature	Turning over the sprouts at 90% sprouting. Bring the temperature down to 28-32°C. Turn the seeds everyday and sprinkle water 2-3 times a day to lower the temperature. Adapting to normal temperature: when the length of the roots become 1 - 2 x the length of the seeds, and when the sprouts grow half the size of the seeds, spread the seeds and expose them to ambient temperature.	Bursting out at high temperature for fast seed whitening; bursting usually starts within 12 h.
Others	Soaking in EM solution	Controls various seed, soil and seedling diseases.

Sources: Konayaga (2000), Farooq et al. (2006), IRRI Rice knowledgebank website and AFSC (2009).

Table 4. Crop establishment in SRI

Crop Establishment	Explanation	Place
Manual transplanting	Shallow transplanting of young seedlings, singly and in wide spacing. Most common SRI practice	Most countries where SRI is practised
Machine transplanting	Using machine transplanters modified to plant 1 seedling at shallow depth	Cuba, India
Semi-mechanical transplanting	Several workers aboard a moving tractor conducting the task	Pakistan
Kadiramangalam	Re-transplanting 30 day old seedlings, singly, which were transplanted earlier at 15 days	Cauvery Delta, India
Direct seeding	Direct seeding of pre-germinated seeds, thinning by weeding at 20 days to acquire a square spacing pattern of single plants	Sri Lanka
Broadcasting seedlings	Broadcasting 10 day old seedlings thinning by weeding 10 days later to acquire a square spacing pattern of single plants	Tamilnadu, India
No-till raised beds	Transplanting on no-till raised beds	Sichuan, China

Source: Uphoff (2007).

Table 5. Yield component comparison between transplanting and direct seeding

Crop establishment method	Plant height (cm)	Panicles per hill	Spikelets per panicle	% filled grains	100 grain weight (g)	Yield
Transplanting	116.2(10.1)	25.1(4.1)	175.3(35.2)	87.8(5.80)	2.88(0.11)	12.36(3.21)
Direct seeding	100.1(9.2)	17.8(6.3)	149.5(35.2)	88.2(4.81)	2.62(0.21)	6.91(2.96)
L.S.D $_{0.05}$	4.3*	2.4*	15.7*	2.37 n.s	0.6*	1.4*

Standard deviations are given in parentheses (n = 40, variety MR219) * =significant, n.s = not significant

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Table 6. Productivity comparison between transplanting and direct seeding

Particulars	Transplanting	Direct Seeding
Seed rate kg/ha	5	25
Days to transplant	8-12	0
Cost of raising nursery (RM)	50	0
Labour required for transplanting @RM50/manday	15-20	1
No of effective tillers / sq. meter	279	198
No. of filled grains / panicle	154	133
Average yield (kg/ha)	12.36	6.91
Total cost of cultivation RM / ha	3400	2150
Gross returns (RM) @ RM1000/tonne	12360	6910
Net returns per ha (RM)	8960	4760
Benefit cost ratio	3.39	2.94

Table 7. Influence of mycorrhiza on seedling growth

Treatment	Plant Height (cm)
Control	5.8(1.7)
Mycorrhiza	10.5(2.1)
Mycorrhiza plus biochar	5.4(1.6)
L.S.D $_{0.05}$	0.95

Standard deviations are given in parentheses (n = 29, variety MR219)

Conclusions

In conclusion, proper crop establishment is absolutely essential for the success of SRI cultivation. Based on the yield components and productivity, it can be concluded that manual transplanting is better than direct seeding. These findings also hold promise for the use of mycorrhiza in rice crop establishment to enhance the yield potential of the rice plant.

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