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SRI-TRAY: BREAKTHROUGH IN NURSERY MANAGEMENT FOR THE SYSTEM OF RICE INTENSIFICATION

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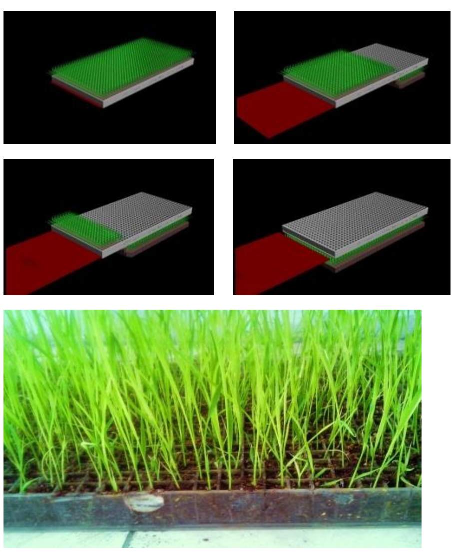
Zubairu Usman Bashar[a,c]*, Aimrun Wayayok[a,b], Amin M. S. M[d], Mohammad Razif Mahadi[a], Bande Y. M.[c]

[a]Department of Biological and Agricultural Engineering, Faculty of Engineering, Universiti Putra Malaysia, 43400 Serdang, Selangor Darul Ehsan, Malaysia
[b]Smart Farming Technology Research Centre, Faculty of Engineering, Universiti Putra Malaysia, 43400 Serdang, Selangor Darul Ehsan, Malaysia
[c]Department of Agricultural and Bio-Environmental Engineering, College of Engineering, Waziri Umaru Federal Polytechnic, B/Kebbi, Nigeria
[d]Faculty of Sustainable Agriculture Universiti Malaysia Sabah, 90509 Sandakan, Sabah, Malaysia

*Corresponding author
zubairug@yahoo.com

Graphical abstract



Abstract

The major challenges envisaged by SRI practitioners to nursery management are high labour requirement and transplanting shock due to traumatic condition at the nursery. This study was aimed at creating innovative techniques for increasing the quality and transplanting potentials of seedlings vis- ǎ –vis to savings on water, seeds, nursery space as well as reducing the transplanting shock. It involved the use of the developed SRI-Tray having 924 square growing cavities with sliding base to facilitate seedling transfer. The parameters used were water requirement (WR), growing media (GM), nursery perimeter (NP) and age of seedling (AS). These were compared with conventional nursery methods (dry-bed, wet-bed and tray) to evaluate the growth performances for 10 days on seedling height [SH], leaf length [LL], leaf number [LN] and root length [RL]. The SAS revealed that SRI-tray had the highest significant values for SH, LL and RL with the mean values of 157.2mm, 110.3 mm and 89 mm. when compared with conventional practices on tray (125mm, 92mm and 52mm), dry-bed (86mm, 64mm and 42mm). The seed rate, nursery area and seedling age to support one hectare of planting area were found as 5.34kg, 36m^2 and 8-10 days on SRI-tray against 15-50kg, 250 – 500m^2 and 15 – 30 days on conventional practices. The water management was found to be high on conventional tray (Flat tray) with a nursery area of 250m^2, if supply at 4cm height for 20 days, and then total water use for conventional flat tray is 200m^3. While a significant saving was observed on SRI-tray with only 18m^3 with a nursery space of about 36m^2 when supplied at 5cm for 10 days.

Keywords: Dry-bed, germination, growing cavities, seedling height, vigor

1.0 INTRODUCTION

The system of rice intensification also known as SRI is not only getting popularity and acceptance in Asia but also to the world at large where over 50 countries are now practicing. It is a system that requires transplanting of single seedling at a very young age of 8 - 10 days after seed germination in a nursery with a very proper lining of 25 x 25 cm; 30 x 30 cm or even 50 x 50 cm spacing patterns depending on climatic and fertility conditions of the paddy field. It is also a system that responds to some prevailing situations of climate change which are increasingly manifesting day by day leading to more insecurity in food supply leading to higher food prices. By 2080, the 40 poorest countries, located in tropical Africa and Latin America, could lose up to 10 to 20 percent of their grain growing capacity due to drought (Kotschi, 2007), as result of climate change. Therefore, innovative contributions to sustainable agriculture become a global mandate in militating against the projected insecurity. Considering the circumstances, the System of Rice Intensification (SRI) opens a new window to improve agricultural practices. This system is aimed at primarily increasing the productivity of land and capital by offering double yields through the use of fewer seeds per hectare, low seedling density and wider spacing pattern (Noltze, *et al*., 2012; Surya *et al*., 2011; Thomas & Ramzi, 2011; Uphoff, *et al*., 2011). Several researchers also regard it as a system that reduces the use of resources such as water, chemical fertilizers and fuel as well as be tolerant to drought, wind and storms due to large and deep root system (Alagesan and Budhar, 2009, Anas *et al*., 2011, Uphoff *et al*., 2011). However, in SRI seedling quality and transplanting skills (single seedling per hill at wider spacing) play a vital role in getting an optimum yield. But the current seedling nursery management practices (mat, wet-bed, dry-bed or tray) in Malaysia and some parts of the world establish traumatic seedlings due to the broadcasting sowing technique and lack of separators between the individual growing seedlings. This results in roots being interconnected as well as high inter-plant competition for nutrients, water, oxygen and sunlight; which eventually endangers the seedling quality and lowers the production. This also makes the transplanting machines to plant more than one seedling per hill at a time (Dewangan *et al*., 2005) as well as leaving some places unplanted in the field, thus making farmers paying for replanting leading to high production cost. Furthermore, the current practices are unable to meet te SRI requirement with respect to spacing due to inefficient seedling preparation technique. Despite that, several studies on methods to raise seedling have been conducted by many researchers (Balasubramanian, 2009; Haytham *et al*., 2010; Rajendran, 1991; Rajesh & Thanunathan, 2003; Randall *et al*., 2004) but the problem of multiple seedlings per hill roots cutting and slow establishment remains a constraint to SRI practitioners; thus, malingering to unsuitable adaption of full SRI mechanization practice. Therefore, to the simple, innovative SRI-tray technique is a good way to nurse individual, young, delicate but healthier and root separated rice seedling with low density. A sliding base was attached to it to accurately transfer and release seedlings to the paddy field for single transplanting per hill.

2.0 MATERIALS AND METHODS

2.1 Seed Sorting and Priming

Seeds were selected based on physical properties and germination test conducted in various laboratories at Universiti Putra Malaysia. This was to ensure ensure a single and quality seed grows in the tray cavity. It involved soaking of MR219 rice seeds in salty water thereby removing the floated as immature or as unfilled seeds with less endosperm and adapting/considering the sunken seeds as selected or best seeds as used by Zubairu *et al*., (2014), Ella *et al.* (2011); Farooq *et al.* (2009). These sorted seeds were later primed for six (6) hours prior to sowing in order to speed up the germination and quick establishment of the seedling (Sun *et al*., 2010).

2.2 Water Management

This aspect dealt with the application schedule and the quantity of water to be used with relate to the principle saving condition as recommended by the SRI planting and spacing principles. Therefore, considering the number of SRI-tray required to transplant one hectare (Table 2), the amount of water was computed based on the nursery area (Table 1) and height of the water to be maintained throughout the nursery management for the period of ten days.

2.3 Determination of the Suitable Growing Media

Two different media were chosen (Soil + Burnt husk [M1] and Soil + Compost [M2]) and growth performance of the samples were monitored for ten (10) days on seedling height (SH), leaf length (LL), leaf number (LN), root length (RL) and loosening index (LI) on both SRI-tray and conventional tray. The loosening index has been considered here as the time taken for the seedling to drop from the SRI-tray after removing the sliding base plate. Three replicates from each media were statistically employed and the average was considered. Data from the readings were obtained through the Random Complete Block Design (RCBD) with three replications and computed with ANOVA using Statistical Analysis Software (SAS, 9.1).

2.4 Age of Seedling

The age of seedling before transplanting still remain as one of causes of seedling transplanting shock and inability to recover on time. The seedlings established from the SRI-tray were set to provide a remarkable recovery when subjected to the field with respect to the growing environment of the tray.

2.4 Seed Placement into SRI-tray

Placement of the seeds into SRI-tray was made possible with the aid of seed picker. Therefore, SRI-seed picker plate was developed with 924 picker tips for gluing and dropping the seeds into the tray. The time taken to place or sow the seeds per tray was observed and recorded. This was repeated five times and the average was considered on the stickiness and loosening of the sprouted seeds between the solution seeds and tray.

3.0 RESULTS

3.1 Placement of seeds into SRI-tray

Seed placement into 924 SRI tray growing cavities manually proved to be tedious and time consuming and also affecting the young sprouting seed. Thus, a better gumming and dropping time were observed on solution mixture at 150g of Tapioca (Starch) flour to one litre of water at 100% efficiency with an average rate of 16 trays per man-hour. Moreover, with this practice, seed rate could practically be saved by more than 300% when compared to the conventional practice of seed spreading or broadcasting when sowing either on the beds and/or in the current tray and whether manual or mechanized methods. Results indicated that only 4.27kg of seeds on SRI tray were required to plant on a hectare with 25 x 25 cm spacing pattern against the conventional practices of 50kg on wet or dry beds nurseries (Tables 1 & 2).

Table 1 SRI tray versus other nursery types

Nursery Type	To plant one ha of main field		optimum seedling age, d (3 Leaves)
	Nursery area, m^2	Seed rate, kg ha	
Wet Bed	400 – 500	50	20 – 25
Dry Bed	500	50	25 – 30
Mat (Dapog)	60 – 75	40 – 50	8 -15
Modified mat	100	9 – 25	15
Conventional tray	250	15- 20	12 – 15
*** SRI-tray**	**36**	**4.27**	**8 – 10**

***** The SRI single seedling nursery tray

Table 2 Summary of basic output to nursery preparation per hectare

		Required germination (%)	Nursery Area (m^2)	No. of Seedling (nos.)	Seed Weight (kg)	No. of Tray (nos.)	Media Volume (m^3)
	SRI tray	100	0.21	924	0.024	1	0.005
Spacing Pattern /ha	20 x 25	100	45.00	200,000	5.340	217	1.172
	25 x 25	100	36.00	160,000	4.272	174	0.940
	30 x 30	100	25.00	111,112	2.967	121	0.653

3.2 Effect of Separated Growing Cavity on Seedling Age

The single seedling nursery tray was designed for the purpose of growing a healthier and viable seedling separately for transplanting into paddy field. Therefore, each seedling is grown in a separated area having a media storage capacity of 5.88 cm3 with a total volume of 0.005m3 per SRI tray (Figure 1 and Table 2). The sliding base located at the bottom serves as retainer valve in holding and releasing the seedling to the planter board for transplanting into the field (Figure 2).

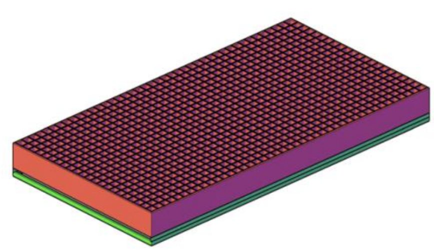


Figure 1 Single seedling nursery tray which consist of 924 well, with a media holding capacity of 5.88 cm^3

3.3 Effect of Growing Media Tray Types

The average seedling height in various growing media is presented in Table 3. At three days after planting, only minimal difference in seedling height was observed between M1 and M2, 52 mm and 53 mm respectively. But a significant influence was demonstrated on seedling height, where the highest recorded value of 155 mm obtained on SRI tray after 10 days of monitoring on M2. While, the growth on conventional tray showed the lowest SH of 125 mm even on the same media. The effect of media was also recorded using Duncan's mean where these values significantly changed with the change in media composition. Table 4 indicated that M2 responded well on all the parameters such as SH, LL, LN and LI but recorded lower reading on RL.

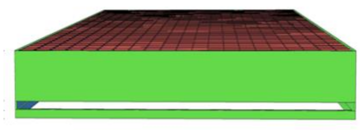


Figure 2 Front view of the single seedling nursery tray

Day	Seedling Height (mm)			
	M_1		M_2	
	SRI tray	Conv. tray	SRI tray	Conv. Tray
1	0	0	0	0
2	0	0	0	0
3	52	52	53	53
4	66	67	59	63
5	94	98	85	77
6	107	113	103	104
7	116	118	114	116
8	125	121	132	119
9	134	124	148	121
10	146	126	157	125

M_1 = Soil + Burnt husk; M_2 = Soil + Compost

3.4 Comparison of Seedlings Root Length With Respect to AWD

One of the basic requirements on SRI practice is root intensification. If the roots are deep and strong, this will enable the rice plant to stand against natural phenomena such as wind, storm and drought. The results revealed that media, irrigation interval as well as separated cavities have a remarkable influence on the root length. Seedling raised under SRI-tray gave high root length of 92 mm recorded at ten days (Table 4) contrary to to only 48 mm observed when grown on conventional trays as presented in 5.

Table 4 Duncan's means grouping at 10 Days for SRI tray

Treatment	Seedling Height (mm)	Leaf Length (mm)	Leaf Number (No.)	Root Length (mm)	Loosening Index (sec)
M_1	145.3^{b}	100.3^{b}	3.0^{a}	92.3^{a}	125.3^{a}
M_2	157.2^{a}	110.3^{a}	3.0^{a}	89.0^{b}	74.3^{b}

Note: * Letter in the same column means significant at 0.05 level
* Different letter in the same column represents significant difference at 0.05

3.5 Influence of Media on Leaf Length and Tray Types

The data obtained indicated that leaf length was significantly affected by the growing media. Tables 6 revealed that M1 on both trays started with the common value on the first three days but a significant variation was recorded on M2 on the same day with 34 mm on SRI-tray and 23 mm on conventional trays. Furthermore, M2 showed the maximum value of 109 mm at 10 days with seedling raised on SRI tray as against the 91 mm with the same media on conventional tray.

3.6 Seedling Preparation Per Planting Area

The transfer of seedlings to the field stands as yet another important aspect to nursery management. As the newly invented SRI tray was set to prepare seedling singly in a separated growing cavity, therefore seedling transfer to the field usually undergoes three stages namely: transporting of the whole tray to the planter board, whereby the sliding base plate will firstly be removed to allow the resting of seedlings to the board; this was followed by lifting of the main tray to facilitate seedlings release to the planter board for dropping into the field for manual or mechanized transplanting (graphical abstract). Contrary to the conventional practice of rolling the root connected seedlings in form of a mat. The total nursery area required per one hectare with developed tray was estimated as 36 m2 on transplanting spacing pattern of 25 cm by 25 cm. This indicated a remarkable decrease when compared with existing nursery practices of occupying 60 – 500 m2 (Table 1) as reported (Balasubramanian, 2009; Dhananchezhiyan, Durairaj, & Parveen, 2013; Noltze *et al*., 2012).

Table 5 SRI tray versus Conventional tray on Root Length for 10Days

Day	Root Length (mm)			
	M_1		M_2	
	SRI Tray	Conv. Tray	SRI Tray	Conv. Tray
1	na	na	na	na
2	na	na	na	na
3	24	26	44	33
4	na	na	na	na
5	53	32	58	32
6	na	na	na	na
7	86	41	72	41
8	na	na	na	na
9	90	48	88	48
10	92	48	89	52

**M_1 = Soil + Burnt husk; M_2 = Soil + Compost*
***na = Readings not applicable*

4.0 DISCUSSION

4.1 SRI-Tray Seeding

The use of seed picker for sowing in SRI-tray significantly reduced time to sowing and also reduced damages to sprouted seeds as a result of brushing between fingers when the manual method was used. Likewise, with this practice seed rate could be saved by more than 300% compared to the conventional practice of spreading or broadcasting. Results indicated that only 4.27kg of seeds on SRI tray were required to plant on one hectare at 25 x 25 cm spacing pattern against the conventional practices of 50kg on wet or dry beds nurseries (Tables 1 & 2). Other research (Balasubramanian, 2009; Dhananchezhiyan, *et al*., 2013; Farooq & Basra, 2006) on seed sowing proved tedious and time consuming with high level likelihood of damaging the seed radicle when placing manually or mechanically when compared to the established seedlings from the SRI-tray.

4.2 Seedling Age

This research revealed that seedlings prepared using SRI-tray were ready for transplanting between 8 – 10 days after sowing in compliance to SRI standard of the appearance of 2 to 3 leaves (Dhananchezhiyan *et al*., 2013; Jayakiran & Sajitha, 2010; Kassam, Stoop, & Uphoff, 2011; Khem & Khadka, 2012; Laulanie', 2003; Misha & Uphoff, 2011; Mishra & Salokhe, 2008; Noltze *et al*., 2012) before tillering initiation when compared with the conventional practice of 15 to 30 days. According to Laulanie' 2003 tillering initiation begins in rice seedling after the appearance of 4th and 5th phyllochron. Therefore, if the seedling can be planted at younger age that will reduce the tillage shock as well as giving enabling environment. This change in aging was due to the fact that seedling raised from this tray appeared to be strong and healthier due to less competition in search of nutrients, water, aeration and sunlight. They were also grown with full chlorophyll potentiality and without weed disturbance. Similarly, the findings of Pasuquin *et al*, (2008) revealed that grain yield was found to be consistently higher when using younger seedlings contrary to older seedlings thus the latter provide low tiller number as well as delay in maturity time. With this it can be concluded that seedling age plays a significant role to high production.

4.3 Influence of Growing Media

The growing media showed significant influence between the SRI tray and conventional practice. The difference was attributed as a result of separated cavities which reduced the competition for nutrients and other growing conditions in Single seedling nursery tray as well as reducing the transplanting shock. Likewise, The findings of Şeniz *et al*. (2011) on Scotch pine (Pinus Sylvestris), Egharevba *et al*. (2005) on African walnut (Plukenetia Conophorum) using amended topsoil, Abirami *et al*. (2010) on nutmeg also indicated relatively similar trends when seedlings were subjected to different growing media. Therefore, it is suggested that compost should be mixed in seedling media preparation when establishing seedling in a nursery in order to obtain vigorous and viable seedlings.

4.4 Influence of Seedlings Root Length on AWD

Root proliferation stands as basic conditions to SRI adoption due to alternate wetting and drying (AWD) policy that encourages plant to develop deep roots in search for water. The results revealed that growing media as well as separated cavities have significant influence on the root length. The difference in RL between the SRI-tray and the conventional practice was attributed to the conducive growing environment received by seedlings prepared in the SRI-tray (Table 5). These readings indicated that growing environmental condition plays a significant role on vigor and quality of rice seedling. It can therefore be concluded that such variation was due to the roots interconnectivity as well as high level of competition for nutrient, water, sunlight and aeration experienced by the establishing seedlings in the conventional practice. Likewise, seedlings produced from the Single seedling tray can be transplanted without any pulling stress when compared to the existing trays that create transplanting shock as well as delay the seedling re-establishment after transplanting. This was attributed to the AWD practice and separated cavities found on SRI-tray resulting to non-interconnectivity of seedling root on conventional trays. Similar findings were reported when the seedlings are planted according to SRI planting and spacing principles.

4.5 Influence of Growing Media on Leaf Length

The data obtained indicated that leaf length was significantly affected by the growing media. Tables 4 revealed that M1 on both trays started with the common value on the first three days but a significant variation was recorded on M2 on the same day with 34mm on tray and 23 mm on conventional. Furthermore, M2 (soil + compost) showed the maximum value of 110 mm 10 days with seedling raised on Single seedling tray as against the 91 mm with the same media on conventional tray.

4.6 Seedlings Per Planting Area

The amount of seeds needed to plant one hectare ranged from 15 to 50 kg/ha when the existing nursery methods are used. However, the use of SRI-tray reduced the seed requirement to only 4.27 kg/ha, a saving of close to 90% compared to conventional practices at SRI spacing pattern of 25 cm by 25 cm. These values have proven a drastic reduction in seeds volume as the spacing pattern widened. Similarly, it also demonstrated a significant change on the seedling age before transplanting. This variation has been validated with a decrease on the age from 12 to 30 days (existing or conventional practices) to a minimal of 8 to 10 days (current SRI tray) as recommended by SRI practice that encouraged transplanting younger seedlings with appearance of two (2) to three (3) leaves (Anas *et al*., 2011; Ceesay, 2010; Kassam *et al*., 2011; Khem and Khadka, 2012). The growth performance evaluation revealed that seedlings raised under Single seedling nursery tray responded significantly well on all the tests when compared with existing seedling nursery practice. Other important advantages of Single seedling nursery tray over other nursery methods are capable of providing 924 viable seedlings with no competition on nutrient and other growing parameters, no weeding is required in the tray, less volume of qualitative growing media is used, facilitate seeds sowing and seedling transfer, reduce the seedling age, transplanting shock as well as encouraging single seedling planting per hill in the field. It can also be concluded that seed ratio per planting area was drastically reduced when using this newly tray when compared to the existing practices to about 80 -90%. Likewise, age to transplanting was also reduced from 30 days to only 8 days.

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References

[1] Abirami, K., Rema, J., Mathew, P. A., Srinivasan, V., & Hamza, S. 2010. Effect Of Different Propagation Media On Seed Germination, Seedling Growth And Vigour Of Nutmeg (Myristica fragrans Houtt). *Journal of Medicine Plants Research*. 4(19): 2054-2058. doi:10.5897/JMPR10.394.

[2] Alagesan, V., & Budhar, M. N. 2009. *System Of Rice Intensification: Exploring The Level Of Adoption And Problems Of Discontinuance*.

[3] Anas, I., Rupela, O. P., Thiyagarajan, T. M., & Uphoff, N. 2011. A Review Of Studies On SRI Effects On Beneficial Organisms In Rice Soil Rhizospheres. *Paddy and Water Environment*. 9(1): 53–64. doi:10.1007/s10333-011-0260-8.

[4] Balasubramanian, V. 2009. *Rice Nursery And Early Crop Management*. *Powerpoint*. IRRI: Rice Production Course.

[5] Ceesay, M. 2010. An Opportunity For Increasing Factor Productivity For Rice Cultivation In The Gambia Through SRI. *Paddy and Water Environment*. 9(1): 129-135. doi:10.1007/s10333-010-0235-1.

[6] Dewangan, K., Thomas, E., & Ghosh, B. 2005. Performance Evaluation of a Laboratory Model Rice Technology. *Agric. Eng. Today*. 29: 38-45.

[7] Dhananchezhiyan, P., Durairaj, C. D., & Parveen, S. 2013. Development Of Nursery Raising Technique For "System Of Rice Intensification" Machine Transplanting. *African J. of Agric. Res*. 8(29): 3873-3882. doi:10.5897/AJAR2013.7465.

[8] Egharevba, R. K., Ikhatua, M. I., & Kalu, C. 2005. The Influence Of Seed Treatments And Growing Media On Seedling Growth And Development Of African Walnut , Plukenetia Conophorum. *African Journal of Biotechnology*. 4(8): 808-811.

[9] Ella, E. S., Dionisio-Sese, M. L., & Ismail, A. M. 2011. Seed Pre-Treatment In Rice Reduces Damage, Enhances Carbohydrate Mobilization And Improves Emergence And Seedling Establishment Under Flooded Conditions. *AoB Plants*, *2011*, plr007. doi:10.1093/aobpla/plr007.

[10] Farooq, M., & Basra, S. 2006. Seed Priming Enhances Emergence, Yield, And Quality Of Direct-Seeded Rice. *Crop Management & Phisiology*. Retrieved from http://agris.fao.org/agris-search/search/display.do?f=2007/QR/QR0705.xml;qr2007000037.

[11] Farooq, M., Kabayashi, N., Wahid, A., & Bassa, O. M. 2009. Strategies For Producing More Rice With Less Water. *Advance in Agronomy*. 101: 351-388.

[12] Haytham, M. E., Hassaanein, M. K., Zahoor, A., & Kotamy, T. M. El. 2010. Rice Straw-Seedbed for Producing Rice Seedling Mat. *Internationa Journal of Sustainable Agriculture*. 2(2): 26-33.

[13] Jayakiran, K., & Sajitha, T. 2010. Evaluation Of Different Planting Techniques For Economic Feasibility In Rice. *Journal of Environmental Agricultural and Food Chemistry*. 9: 150-153.

[14] Kassam, A., Stoop, W., & Uphoff, N. 2011. Review of SRI Modifications In Rice Crop And Water Management And Research Issues For Making Further Improvements In Agricultural And Water Productivity. *Paddy and Water Environment*. 9(1): 163–180. doi:10.1007/s10333-011-0259-1.

[15] Khem, D. R., & Khadka, R. B. 2012. Performance of Rice with Varied Age of Seedlings and Planting Geometry under System of Rice Intensification (SRI) in Farmer's Field in Western Terai, Nepal. *Nepal Journal of Science and Technology*. 13(2): 1-6.

[16] Kotschi, J. 2007. Agricultural Biodiversity Is Essential To Climate Change. *Ecological Perspective for Science and Society*. 16: 98-101.

[17] Laulanie', H. 2003. Le Riz a Madagascar: Un Developpement En Dalogue Avec Les Paysans. In *Karthala* (karthala). Paris.

[18] Misha, A., & Uphoff, N. 2011. System of Rice Intensification: "Less Can Be More" With Climate Friendly Technology. *SATSA Mukhapatra*. 15.

[19] Mishra, A., & Salokhe, V. M. 2008. Seedling Characteristics and the Early Growth of Transplanted Rice Under Different Water Regimes. *Experimental Agriculture*. 44(03): 1-19. doi:10.1017/S0014479708006388.

[20] Noltze, M., Schwarze, S., & Qaim, M. 2012. Understanding the Adoption Of System Technologies In Smallholder Agriculture: The System Of Rice Intensification (SRI) In Timor Leste. *Agricultural Systems*. 108: 64-73. doi:10.1016/j.agsy.2012.01.003.

[21] Pasuquin, E., Lafarge, T., & Tubana, B. 2008. Transplanting Young Seedlings In Irrigated Rice Fields: Early And High Tiller Production Enhanced Grain Yield. *Field Crops Research*. 105(1-2): 141-155. doi:10.1016/j.fcr.2007.09.001.

[22] Rajendran, R. 1991. Nursery Manuring And Its Effect On Seedling Growth And Yield Of Rice. *Andras Agric, Journal*. 78: 73-75.

[23] Rajesh, V., & Thanunathan, K. 2003. Effect Of Seedling Age, Number And Spacing On Yield And Nutrient Uptake Of Traditional Kambanchamba Rice. *Madras Agric. J.* 90: 47-49.

[24] Randall, R. J., Rajendran, R., Balasubramanian, V., Ravi, V., Valliappan, K., & Jayaraj, T. 2004. Nursery technology For Early Production Of Robust Rice Seedlings To Transplant Under Integrated Crop Management. *IRRN*.

[25] Şeniz, V., Tunc, T., Bulut, Y., & Sahin, U. 2011. Effects Of Different Growth Media On Scotch Pine (PINUS SYLVESTRIS) Production. *Jounal of Animal and Plant Sciences*. 21(3).

[26] Sun, Y.-Y., Sun, Y.-J., Wang, M.-T., Li, X.-Y., Guo, X., Hu, R., & Ma, J. 2010. Effects of Seed Priming on Germination and Seedling Growth Under Water Stress in Rice. *Acta Agronomica Sinica*. *36*(11): 1931-1940. doi:10.1016/S1875-2780(09)60085-7.

[27] Surya Prabha, A. C., Thiyagarajan, T. M., & Senthvelu, M. 2011. System-Of-Rice-Intensification-Principles-On-Growth-Parameters,-Yield-Attributes-And-Yields-Of-Rice-(Oryza-sativa-L.). *Journal of Agronomy*. 10(1): 27-33.

[28] Thomas, V., & Ramzi, A. M. 2011. SRI Contributions To Rice Production Dealing With Water Management Constraints In Northeastern Afghanistan. *Paddy and Water Environment*, 9(1): 101–109. doi:10.1007/s10333-010-0228-0.

[29] Uphoff, N., Fisher, L., & Rice, S. R. I. 2011. Report on SRI Visit to Malaysia. July 1-9, 2011.

[30] Zubairu Usman Bashar, Wayayok, A., Amin, M. S. M., & Mahadi, R. M. 2014. Quality Seed : An Innovative Sorting Technique to Sustainable , Uniform and Effective Seedling Establishment in Nursery for System of Rice Intensification. *Journal of Agricultural Science*. 6(7): 1-9. doi:10.5539/jas.v6n7pxx.

Abbreviations

SRI = System of Rice Intensification; **MR219** = Malaysian rice variety; **M_1** = Soil with Burnt husk; **M_2** = Soil with Compost; **SH** = Seedling Height**;** **LL** = Leaf Length; **LN** = Leaf Number; **RL** = Root Length**;** **LI** = Loosening Index; **FAO** = Food and Agricultural Organization**;** **RCBD** = Random Complete Block Design; **ANOVA** = Analysis of Variance; **AWD** = Alternate Wetting and Drying; **NaCl** = Sodium Chloride; **SAS** = Statistical Analysis Software