

SYSTEM OF RICE INTENSIFICATION (SRI) AS PERCEIVED BY RICE SCIENTISTS IN SRI LANKA

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ABSTRACT

Since recent past, system of rice intensification (SRI) is promoted by some NGOs as an outstanding system by which extraordinary grain yields as high as 20t/ha or more could be obtained while saving 50% of water in rice cultivation. In view of this the basic principles and the reality of SRI in rice cultivation as perceived by rice scientists in Sri Lanka is discussed. SRI which promotes highest rate of tillers is in one extreme while the high density broadcasting with no tillering is in the other extreme of the range of stand establishment methods in rice. Saving water is not a special advantage of SRI as water can be saved with any of the other stand establishment methods if the standing water is avoided. However, the issue is that SRI is highly sensitive to standing water whereas other methods are not. SRI has no yield advantage over the other stand establishment methods when the grain yield is expressed on area basis as t/ha. However, when the grain yield is expressed on seed basis as t/50kg of seeds used for cultivation, SRI is capable of giving a yield level of 20 or more t/50kg of seeds. This appears extraordinary but obvious because seed rate with SRI is only 10kg/ha. SRI is a method of stand establishment which saves seed by maximally utilizing tillering ability in rice at the expense of labor, with the highest sensitivity and lowest adaptability to changing environment. Popular methods of stand establishment of rice are those that can save labor at the expense of seed. Thus, there is no reason to over emphasize SRI as an outstanding system of rice cultivation.

KEY WORDS: Grain yield, System of rice intensification (SRI), Stand establishment, Tillering.

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the oldest crops cultivated on earth and it is the staple food of about half of the world's population including Sri Lankans. The rice production has not yet met the increasing demand at many of the national

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levels as well as at global level while expansion of area under rice cultivation is limited in almost all the rice growing countries. Therefore, many scientists from all over the world are working on rice to increase its productivity at a reduced cost of cultivation. Concern over the excessive use of water and agro-chemicals including chemical fertilizer in rice cultivation is also becoming increasingly high. In view of this, the System of Rice Intensification (SRI) which is said to be a rice cultivation system rather than a technology (Uphoff, 2001) has been developed in Madagascar with the help of Malagasy farmers. SRI was introduced to Sri Lanka in 1999 with the first systematic testing conducted to evaluate it at the Ambepussa Agricultural Training Center in the Western Province (Batuwiage, 2002).

Since recent past, SRI is being emphasized as an outstanding system in rice cultivation by which a grain yield as high as 20t/ha or more (Uphoff, 2001; CIIFAD, 1999) or 50-200% yield increase over the conventional methods (Uphoff and Fernandes, 2002) could be obtained with reduced use of water and agro-chemicals despite the climatic and edaphic variability. A yield of 17.8t/ha with SRI using an improved inbred line (Uphoff, 2001) and always higher grain yields than that of conventional methods with a maximum of 15.2t/ha with SRI (Batuwiage, 2002) have been reported in Sri Lanka. This has become a great puzzle for Sri Lankan rice scientists who could so far achieved a maximum yield of only 10t/ha in large scale cultivation in farmers fields (Nissanka and Dayaratne, 2002). Although the theoretical yield potential of rice has been estimated to be 23.8t/ha (Yoshida, 1981), a yield of 20t/ha is a dream yield at present particularly under the tropical climate when the rice yield levels so far achieved under the best management (out side SRI) in many rice growing countries covering diverse environmental conditions are considered. No country in the subtropical environment has recorded a grain yield beyond 15t/ha and no country with the tropical climate has recorded a grain yield beyond 11t/ha with inbreds at present (Duwayri et al., 1999). However, the highest recorded rice yield in the world to date is 17.95t/ha with hybrid rice under the subtropical environment in China (Duwayri et al., 1999).

Obtaining extraordinary grain yields as high as 20t/ha or more in rice by adopting SRI with reduced use of water and agro-chemicals is a misconception. Misconceptions and adoption of inappropriate cultivation systems and technology may lead to farmer frustration and discouragement due to yield losses, failures in achieving expectations and increased risk of cultivation. Thus the objective of this

article is to make those who are interested in rice research and development and cultivation aware of the basic principles and the reality of SRI as perceived by Sri Lankan rice scientists.

BASIC PRINCIPLE

Rice is a semi-aquatic annual grass cereal (Rice Almanac, 2002) that can produce many tillers in addition to the mother culm whereas other popularly grown highland cereals such as corn, sorghum, wheat and barley are uni-culm cereals (Abey Siriwardena et al., 2009). This unique feature of tillering ability in rice has led to a range of stand establishment methods between two extreme conditions depending on the utilization of the tillering capacity of rice. A diagrammatic representation of the range of stand establishment methods with their associated seed rates and special features (Abey Siriwardena et al., 2009) is shown in Fig. 1.

In one extreme condition, rice crop is allowed to have only the main culm of the rice plant with the maximum number of mother plants or culms per unit land area (uni culm approach). This is practically achieved by high density broadcasting (250-350 kg of seeds/ha) which is a direct seeding method where no adequate space among plants is allowed for tillering (Abey Siriwardena et al., 2009). Under this situation, competition among plants is maximized so that plant growth is retarded resulting small but comparatively more panicles per unit land area. Microclimate within the crop canopy under high density broadcasting is however very conducive to occurrence of pests and diseases (Rhind, 1950) but the weed growth is minimal due to high plant density (Weerakoon and Abeysekara, 2000). To our knowledge, the only farmers in the world, who are cultivating rice at this extreme, are from Ampara district in Sri Lanka. The practical implication of this extreme method of stand establishment is that it saves cost on labor and herbicides at the expense of seed paddy while obtaining profitable yields (Abey Siriwardena et al., 2009).

In the other extreme condition, rice crop is allowed to have as many effective tillers per plant as possible with the minimum number of mother plants or culms per unit land area. SRI as a method of wide spaced planting with one plant per hill adopting transplanting falls into this extreme (Abey Siriwardena et al., 2009). In this method of stand establishment, competition among plants is minimized by maintaining an ample and uniform space among plants so that

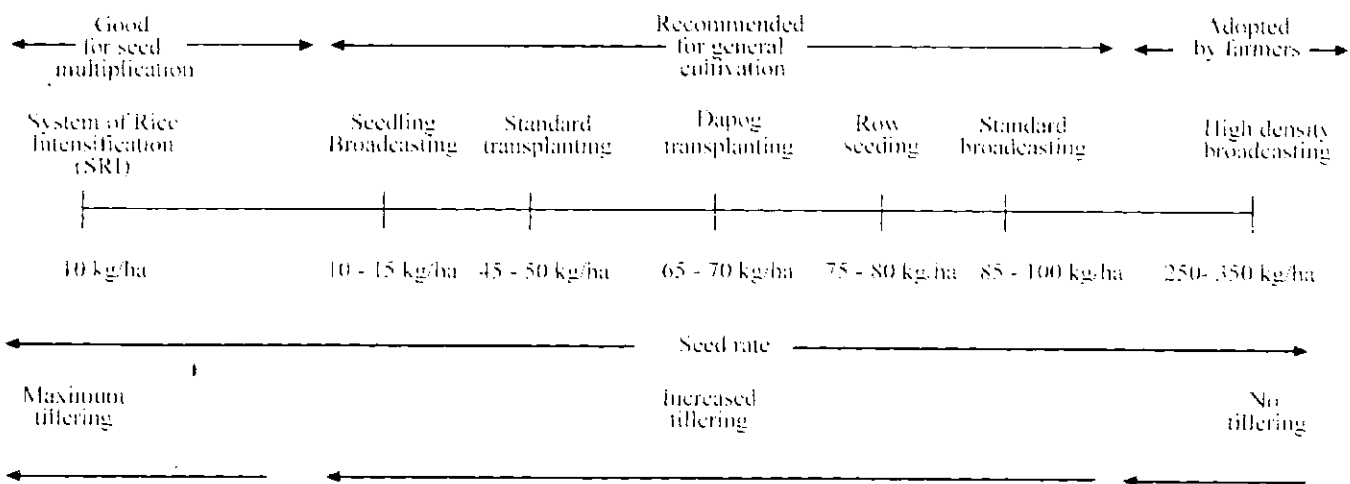


Fig 1. Range of stand establishment methods with seed rates and special features in rice cultivation

individual plant growth is enhanced to the full potential with profuse tillering. Even Uphoff and Fernandes (2002) reported that the basis of SRI is the potential of rice for profuse tillering. The main factor that contributed for relatively higher yield in SRI was its greater number of productive tillers (Nissanka and Bandara, 2004). Therefore, tillering has to be promoted in SRI to achieve its potential yield and specific management practices have been developed (Uphoff and Fernandes, 2002) to promote heavy tillering with the highest uniformity among tiller panicles (Abeyasiriwardena et al., 2009). In this method the panicles are relatively bigger but the number of panicles per unit land area is relatively less (Abeyasiriwardena et al., 2009; Nissanka and Bandara, 2004). Microclimate of the crop under this situation is not conducive to some of the rice pests and diseases such as brown plant hopper, leaf roller and sheath blight due to light penetrating loose canopy of the crop. However, this is not a great advantage of SRI as most of the present day varieties are tolerant to major pests and diseases of rice. On the other hand, under SRI, there is a tendency to occur high incidence of stem borer, a major pest of rice, due to comparatively thick stems and less absorption of silica by the plant due to drying off the fields. The unique feature of SRI is that it saves seed by five times at the expense of 38-54% additional labor (Rakotomalala, 1997) needed for manual transplanting, weed control and water management when compared to standard transplanting in rice (Abeyasiriwardena et al., 2009).

The stand establishment methods that fall mid way between two extreme methods are seedling broadcasting (Yang, 1988), dapog transplanting, standard transplanting, standard broadcasting and row seeding (Victor and Obordo, 1970) which are recommended and commonly adopted in rice growing countries. In these methods, both the mother culms as well as the tillers are considered equally important. However, in broadcasting, emphasis is more towards mother culms than tiller number while in transplanting and seedling broadcasting the emphasis is more towards tiller number than mother culms (Abeyasiriwardena et al., 2009). Seedling broadcasting combines advantages of standard transplanting and broadcasting into one method. This method saves cost on labour by avoiding transplanting and cost on seeds by reducing seed rate (Jayawardena et al., 2004). In addition, this method can also save water over standard broadcasting by avoiding two water issues per rice crop. This method is adopted in some parts of China with hybrid rice as hybrid rice seed is expensive. At present this method is also recommended in Sri Lanka and scientists are working on this to improve its efficiency and practical feasibility.

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None of the extremes (SRI and high density broadcasting) can be recommended for general cultivation of rice because both these extremes have more disadvantages than advantages. As rice is grown over a wide range of diverse ecological conditions, different methods of stand establishment and associated cultural practices have been adopted in different countries depending on traditions and availability of resources. Each of the stand establishment methods, particularly SRI, requires a specific set of management practices unique to each method depending on the tillering requirement to maximize grain yield.

MANAGEMENT PRACTICES FOR SRI

SRI is a unique method of stand establishment in which the seed rate is several times less than that of the standard methods. Therefore, tillering has to be promoted in SRI to achieve its potential yield and specific management practices have been developed to promote heavy tillering and uniformity of maturity among tiller panicles. In addition, high tillering varieties are the most suitable for SRI (Abeyasiriwardena, et al., 2009).

Management practices for SRI have been discussed by Uphoff and Fernandes (2002). SRI is based on the insights that rice has the potential to produce more tillers and grains than now observed and proper crop management can fulfil this potential. Early transplanting of young seedlings (8-12 day old) at the rate of one seedling per hill at a wide spacing, complete drainage during the vegetative growth phase and early and frequent weeding are necessary for SRI to promote plant growth with profuse tillering to its full potential by minimizing plant to plant competition. Quick transplanting preferably within 15 minutes after uprooting the undamaged seedlings from the nursery is recommended. The spacing of 35 × 35 cm has often given the best results but on very poor soils 20 × 20 cm may be better and 50 × 50 cm spacing has also given the highest yields with SRI (Uphoff and Fernandes, 2002). With respect to water management, SRI recommendation has been to add small amount of water to the field daily in the late afternoon during the vegetative growth period to keep the soil moist but unsaturated and draining any excess or standing water in the morning. Keeping standing water in the field until 45 days after planting should strictly be avoided. When there is no standing water in the rice field, other practices to control weeds have to be used. Application of herbicides is not encouraged in SRI because it suppresses

tillering. Hand weeding may be done but 'rotary weeders' or 'cono-weeders' are recommended in SRI as it can also aerate the surface of the soil improving root growth. In SRI, land preparation has to be very good to accommodate small seedlings and also to drain off water if intense rains cause flooding in rice fields. With SRI, although application of organic matter is not an essential practice, the highest yields have been obtained with organic soil amendments; particularly compost (Uphoff and Fernandes, 2002).

GRAIN YIELD

Grain yield of rice can generally be expressed in two ways. They are on seed basis as grain yield per unit amount of seed used for cultivation (t/kg of seeds) and on area basis as grain yield per unit area cultivated (t/ha). The amount of seed required for standard transplanting of one hectare (50 kg) is considered as the base when grain yield is expressed in seed basis. Only 10 kg of seed per hectare is used in SRI whereas 50 kg and 100 kg of seed/ha are used in the standard transplanting and broadcasting, respectively (Abey Siriwardena et al., 2009).

When grain yield was expressed in terms of t/ha, Uprety (2006) reported a lower yield level of 6.3 t/ha with SRI than that of commonly reported and Singh et al., (2006) reported only a marginal increase of 0.79 t/ha grain yield with SRI over that of conventional methods. McDonald et al. (2005) reported that they found no evidence in the empirical record that SRI fundamentally changes the physiological yield potential of rice and exceptional yield advantages from SRI should not be projected beyond Madagascar. In contrast Nissanka and Bandara (2004) reported better plant growth and higher grain yield in SRI than that of conventional transplanting and broadcasting systems in a study conducted in Sri Lanka. However, a detailed yield comparison among SRI, standard transplanting and standard broadcasting with expressing yield on area basis as well as on seed basis has been made by Abey Siriwardena et al. (2009) based on a study conducted at the Rice Research and Development Institute, Sri Lanka. When the grain yield of rice was expressed on area basis as t/ha, grain yields among SRI (6.44 - 6.75 t/ha), standard transplanting (6.68 - 7.35 t/ha) and standard broadcasting (6.50 - 6.95 t/ha) were found to be comparable. According to the authors, reason for this was the autonomous adjustment among yield components of rice as a result of their phenotypic plasticity differently in different stand establishment methods. However, when the grain yield was expressed on seed basis as t/50 kg

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of seed used for cultivation, the yield level of 26.50 – 41.00 t/50 kg of seed of SRI was somewhat miracle when compared to that of 6.68 – 7.35 t/50 kg of seed of standard transplanting and 3.25 – 3.47 t/50 kg of seed of standard broadcasting, irrespective of the variety. Grain yield ratio between t/50 kg of seed used and t/ha was 5, 1 and 0.5 in SRI, standard transplanting and standard broadcasting, respectively. In this context, for example, the yield level of 4-5 t/ha expressed on area basis is equivalent to the yield level of 20-25 t/50kg of seed expressed on seed basis in SRI. These yield levels in SRI expressed on seed basis are, however, comparable to the reported yield levels of 20 t or more (Uphoff, 2001) expressed on area basis in SRI. An intensive method of transplanting, very similar to SRI had been practiced and promoted in Sri Lanka as early as 1907 (Amarasekara, 1907) and a seed basis grain yield of 228 measures per one measure of seed paddy (volume basis) or 11.4 t/50 kg of seed used for planting (weight basis) had been reported with traditional varieties. However, the yield on area basis had been only 0.72 t/ha.

All the stand establishment methods including SRI if managed properly are expected to give the same grain yield if the yield is expressed on area basis (Abey Siriwardena et al., 2009). However, SRI is expected to give five times and ten times more grain yield than that of standard transplanting and standard broadcasting, respectively if the grain yield is expressed on seed basis. This appears extraordinary but is obvious because SRI uses only 10 kg of seed/ha which is five and ten times less than that of standard transplanting (50kg of seed/ha) and standard broadcasting (100kg of seed/ha), respectively while giving comparable grain yield/ha to standard transplanting and broadcasting. The same principle can be applied to compare even two times higher yield in standard transplanting than that of standard broadcasting when the grain yield is expressed on seed basis. In general, the yield level of 4 t/ha is common in rice with moderate management. The yield level of 4 t/ha on area basis is equivalent to 20 t/50 kg of seed used for cultivation on seed basis in SRI. It appears that those who are promoting SRI have misunderstood this point and they express seed basis yield level of 20 t/50 kg of seed of SRI in area basis as 20 t/ha.

WATER SAVING

Standing water in the field is strictly avoided until 45 days after planting and apply only small amount of water as and when needed to maintain soil

moisture without saturation in SRI so that amount of water required by the conventional methods can be saved up to 50% with SRI (Uphoff and Fernandes, 2002). If standing water is maintained without complete drainage during the first 45 days after planting in SRI, tillering is suppressed and the method will fail. Thus, standing water in the field should strictly be avoided and complete drainage has to be assured in SRI, hence comparatively very much less water is needed. However, this fact is interpreted differently by SRI promoters to show that SRI is a method that can save water (Uphoff and Fernandes, 2002). The same amount of water can be saved with any of the other stand establishment methods as well even with a yield improvement, if standing water is not retained in the field or complete drainage is assured. However, the issue is that SRI will fail if a level of standing water is maintained in the field during the tillering phase, whereas other methods of stand establishment will not. In other words, whether standing water is retained or not, other methods will perform equally well whereas standing water has to be strictly avoided in SRI for it to perform well. This point should not be misinterpreted to show that SRI is a method that can save water. Therefore, saving water by avoiding standing water or providing complete drainage is not a special advantage of SRI but the necessity of complete drainage is a severe limitation of SRI for its wide adaptability.

Although drying off the field is good for plant growth, a level of standing water is maintained in rice fields only to control weeds which is comparatively a more serious problem in rice cultivation. Standing water is not necessary for any method of stand establishment as weed can be properly controlled by other methods such as chemical, manual etc. However, except in SRI, performance of other stand establishment methods is not adversely affected by standing water as none of them requires tillering as high as SRI demands. Thus standing water can be used to control weed in all the other stand establishment methods but not in SRI. If there is no standing water during the first 45 days after stand establishment, weeds become a severe field problem in rice and other methods of controlling weeds which are comparatively more expensive have to be used.

Rice is the only economical crop that can be grown in low lying areas where water saturation and submergence is common during peak rains. Thus, as long as drainage is a problem in traditionally rice growing low lying areas, adoption of SRI in these areas will be difficult. As one of the serious problems in rice cultivation is weeds, freely available excess water in low lying rice fields

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is utilized as an environmentally friendly method to control weeds by submerging them. If SRI is practiced without standing water in the areas where drainage is possible, labor intensive and costly weed control methods have to be used just wasting freely available water that could be used to control weeds.

SEED vs LABOR

SRI is a method where seed is saved at the expense of labor with comparatively a higher risk of getting poor yields (Abey Siriwardena et al., 2009). SRI uses about 20 more labor days for careful transplanting and manual or rotary weeding to save 40 kg of seed paddy/ha when compared with standard transplanting. Similarly, SRI uses 30-35 more labor days to save 90 kg of seed paddy/ha when compared with broadcasting. In general, at present, one labor-day is equivalent to 10 kg of seed paddy with respect to the cost in Sri Lankan rupees so that an additional expenditure at least equivalent to the cost of 21 labor days is incurred per hectare with the adoption of SRI. Moser and Barrett (2003) reported that SRI is difficult for most farmers to practice because the method requires significant additional labor input at a time of the year when liquidity is low and labor effort is already high. Rakotomalala (1997) also reported that SRI required an estimated 38-54% more labor than standard methods of stand establishment in rice. Thus, reality is that the SRI is a labor intensive method where seed is saved at the expense of labor.

More than 90% of rice farmers in Sri Lanka adopt broadcasting to save expensive labor and also to overcome the labor shortage during planting time while minimizing the risk of getting low yields due to poor tillering. Hence, a country like Sri Lanka should not worry about saving seed but should concern on saving labor while reducing the risk of getting poor yields in rice cultivation. In this context, SRI without any advantage in grain yield expressed in terms of t/ha would be the least adaptable method of stand establishment in rice cultivation in Sri Lanka.

SUITABILITY OF 'SRI'

Today, the most limiting and expensive factors in rice cultivation are land and labor, respectively but not the seed. Therefore, high yields are expected per unit land area while minimizing the labor cost, but not per unit seed weight at the expense of labor. In almost all the rice growing countries, availability of land and labor are severe problems but availability of seed paddy is not at all a

limitation. Therefore, a method that can save labor while maximizing yield per unit land area with reducing the risk of getting low yields due to poor tillering even at the expense of seed is most appropriate for rice cultivation. In addition, the national average rice yields in Madagascar where SRI is reported to be introduced first by an NGO, Association Tefy Saina and adopted by 10% of the farmers by 2002 (Uphoff and Fernandes, 2002) is now about 2.5 t/ha whereas that of in Sri Lanka where broadcasting is adopted in more than 90% of the rice extent, is now about 4 t/ha. To our knowledge hardly any area is cultivated to SRI at present in Sri Lanka. In addition, the dis-adoption rate of SRI has been estimated to be as high as 40% in Madagascar (Moser and Barrett, 2003). Therefore, general recommendation of a method like SRI for rice cultivation is not advisable. McDonald et al. (2005) also reported that there is no empirical or theoretical basis for promoting SRI as a singular method for maximizing rice productivity on area basis over other forms of intensive management.

The only situation where SRI can be recommended is for the rapid multiplication of rare varieties of which only few seeds are in hand. In addition, farmers having very small holdings and adequate family labor but without sufficient income to buy enough seeds may adopt SRI only if water management is possible (Abeyasiriwardena et al., 2009). Complete drainage during the vegetative phase of rice, which is a requirement for profuse tillering in SRI is practically difficult during peak rains in the majority of low lying rice fields in rice growing countries, particularly in the tropics. Nissanka and Bandara (2004) also concluded to restrict the introduction of SRI only to small scale rice farmers in Sri Lanka considering the practical limitations. Namara et al. (2003) reported that SRI is a niche technology suitable for a limited number of farmers, but that due to high management requirements the spread of SRI will require a concerted extension effort. However, our view is that if a technology is technically sound, practically feasible, economically viable and socially acceptable just making the farmers aware of the technology itself is more than sufficient rather than making a concerted extension effort for the technology to be adopted fast by the farmers.

CONCLUSIONS

SRI is one of the extreme methods of stand establishment in rice. SRI is very sensitive to changing environment because its success is heavily dependent upon profuse and high rate of tillering so that adaptability of this method over diverse farm environments is very limited compared to the other standard

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establishment methods in rice cultivation. In addition, SRI is not a system of cultivation that can save water but it is a method of stand establishment which will fail due to poor tillering if a level of standing water is maintained or excess water is collected in the field during the vegetative period of the crop growth. SRI is practically the least feasible and technically the least adaptable method of stand establishment in rice due to its high labor requirement and high sensitivity to changing environment, respectively. Thus, there is no reason to over emphasize or over publicize SRI with no yield advantage on area basis, as an outstanding system of rice cultivation. It is a method where tillering ability in rice is maximally utilized to save seeds. As SRI is capable of giving the highest grain yield per unit seed weight used for cultivation when compared to the other stand establishment methods, it is good as a method for rapid multiplication of seed.

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