System of Rice Intensification (SRI): A Potential Approach to Enhance Rice Productivity and Food Security

*Khem Raj Dahal**

* Department of Agronomy, Institute of Agriculture and animal Science, Tribhuvan University, Nepal
Corresponding Address: d.khemraj@ymail.com

Abstract: Rice is one of the prominent staple cereal crops of Nepal. However, the productivity of rice is low as a result the condition of food security is worsening. Therefore, transformation of conventional rice cultivation practice is an urgent need to address the issue of food security. In this context, System of Rice Intensification (SRI) can be a potential innovative rice farming practice to substantially increase the productivity with less agronomical inputs. SRI is based on three principles: i) Early and quick establishment of healthy plants ii) Reduced plant density: iii) Reduced and controlled water applications. This paper attempts to succinctly review the present situation of SRI in Nepal and its benefits, along with its limitations and criticisms. Several studies have shown that SRI practices have numerous benefits such as increasing productivity; curbing water requirement; reducing the cost of cultivation; offering the crop resistance to biotic and abiotic stresses; improving soil condition; and lowering greenhouse gas emission. However, the practice has some limitations and criticisms, hindering its wider adoptability. Therefore, extensive research and extension programs should be launched to promote SRI among the rice farmers. In addition, government should formulate appropriate policies and regulations to widely establish this system in Nepal.

Key Words: SRI, rice cultivation practice, productivity, food security, control irrigation

INTRODUCTION

Rice is one of the prominent staple cereal crops of Nepal. Rice is grown in 47.98% of the total cultivated area and shares 52% of the total food grain production which contributes around 21% to national AGDP (Upreti *et al.* 2012). Rice farming in Nepal is highly dependent on the time of onset and the pattern of monsoon rain. Monsoon dependent nature of rice farming compounded with other factors has limited the average productivity of rice in around 3 t ha^{-1} for several years and consistently lagging behind as compared to other Asian rice producing countries; India (3.4 t/ha), Bangladesh (4.3 t/ha), Vietnam (5.3 t/ha), Sri Lanka (4.1 t/ha) and China (6.5 t/ha) (FAO 2012; NARC 2013). Similarly, the productivity of rice has not much progressed in last decades in comparison with the increased number people to be fed (ABPSD 2012).

In the context of Nepal, the problem of food insecurity is widely growing; a recent report published by (MOA 2014) indicates that 30 among 75 district of the country are food insecure. On the other hand the import of rice has increased in astronomical scale to address the rice demand in food insecure districts. Practically there are two ways to increase rice production first, by increasing the rice growing area or arable lands, and second by improving its productivity. The first option is almost impossible in the context of expanding urbanization on agricultural lands and the only way to address the problem is to increase the productivity and that also with existing resources through their better management as it is less likely that Nepalese farmers have sufficient external inputs available. This situation indicates that existing method of rice farming needs to be changed towards improving the physiologic ability of rice plant to produce more (Gautam *et al.* 2010). In this context, System of Rice Intensification (SRI), practically considered as an

agronomical approach rather than a technology, has received a fair amount of attention in recent years in most of the rice growing countries including Nepal. SRI has been appreciated as one of the ways of agronomic manipulation for increased yield (Basnet 2005).

SRI is a set of agronomic principles and practices that were proposed originally by civil society actors, Fr. Henri de Laulanie and the farmers in Madagascar, to improve the production of irrigated rice for poor and resource-limited households (SRI-Rice 2014a). It represents an integrated, agro-ecologically responsive and interdisciplinary approach to rice cultivation following three principles (CIFFAD 2012).

i. Early and quick establishment of healthy plants: One of the principles of SRI is to transplant young seedlings which are less than 15 days old with just two leaves to avoid trauma to roots and to minimize transplant shock.
ii. Reduced plant density: The second one is to plant single seedling in a recommended optimal spacing to permit sufficient tillering, enhanced growth and canopy development.
iii. Reduced and controlled water applications: The last and the crucial principle of SRI is the controlled management of water. The field should be kept moist rather than continuously flooded, reducing anaerobic conditions. This situation helps improve root growth and the diversity of aerobic soil organisms.

SRI has been widely accepted by the farmers in South Asia since it is found to increase the yield substantially with less inputs such as water, fertilizer and, pesticide. Thus, SRI is a promising agronomical practice capable of addressing the issue of food security in the context of Nepal. Considering the importance of SRI as a recent innovation that has received considerable attention in scientific and development circles, this paper attempts to succinctly review the present situation of SRI in Nepal and its benefits, along with its limitations and criticisms. This paper also presents a synthesis of empirical knowledge on SRI.

SYSTEM OF RICE INTENSIFICATION (SRI) IN NEPAL

SRI was first introduced in Nepal in 1998 with some initial trials in Khumaltar (Evans *et al.* 2002). Nepal was one of the first countries outside Madagascar where SRI methods were piloted. Most of the early SRI trials did not produce expected results and were not very encouraging, perhaps because there was not adequate water control so that aerobic soil conditions could be maintained (Uphoff 2006). In 2002-2003, Farmer Field Schools in the Sunsari-Morang Irrigation Project undertook replicated SRI trials which produced an average of 8 t/ha of grain yield, more than that produced by either improved or conventional practice. This was a turning point when SRI was given attention as an alternative method in rice farming. The number of research activities grew then after and the results showing the supremacy of SRI over conventional system of rice cultivation regarding the yield, water saving and economic benefit started to appear in scientific writings (Bhatta and Tripathi 2005; Dhakal 2005; Uprety 2006).

People and Resource Dynamics in Mountain Watersheds of the Hindu Kush-Himalayan Region (PARDYP), sponsored by the International Centre for Integrated Mountain Development (ICIMOD), began SRI program in 2004 with few farmers in Jhigu Khola watershed area in central Nepal and expanded the program into 15 villages in 2005 where over 100 farmers participated in SRI Farmer Field Schools (FFS). In 2008, SRI was successfully introduced at Madana (2500 m), southern part of Humla district of Nepal. At the same time, SRI tested in Tarai revealed

that excluding weeding cost, there was 28% yield advantage with 20x20 cm and 33% with 30x30 cm spacing over farmers' practice with manual weeding (NARC 2008).

In 2010, demonstration plots of SRI were established in Kailali and Dolpa districts. Several SRI trainings in early 2011 involving government agencies, UN and bilateral aid groups, and national NGOs increased the spread of SRI in different parts of the country. At the same time study conducted in 4 Village Development Committees in Morang district, farmers were found to achieve 118 per cent increase in rice yield with SRI methods compared to non-SRI methods (Karki 2010). Similarly an experiment conducted in Chitwan showed that grain yield was higher by 49 per cent (8.8t/ha) as compared to farmers' conventional practice (Dhital 2011). In early 2012, the Ministry of Local Development prioritized SRI as an important intervention for food security in Nepal (SRI-Rice 2014b). During 2013, several research articles were published indicating successful adoption and adaptation of SRI over the past few years (Dahal and Khadka 2012; Dhital 2013; Basnet 2013; Khadka and Rawal 2013; Uprety 2013). It is estimated that the total area (as of mid 2013) covered by SRI is around 1,000 hectares stretched over 35 districts in Nepal (SRI-Rice 2014b).

BENEFITS OF SRI

1. Increased productivity: Studies have suggested that productivity of rice under SRI method is higher as compared to conventional agronomic system. A study illustrated that the productivity of the rice was increased by 20-100% in SRI method with less water, seed and chemical fertilizers requirements, enabling farmers to make better use of their already available resources (CIIFAD 2012). SRI methods have been reported now in almost 50 countries in the world to give higher yield than is achieved with usual rice-growing practices not requiring either new, higher-yielding seeds or agrochemical inputs (MSSRF 2006; Rama Rao 2011; Thakur *et al.* 2012; Ramzi and Kabir 2013; Nyamai *et al.* 2012).
2. Water saving: SRI has been proven to be very effective in saving water and increasing rice yields in many parts of the world (Guerra et al. 1998; Dhakal 2005; Swaminathan and Kesavan 2012; Nyamai et al. 2012; Hameed et al. 2013; Katambara et al. 2013; Ndiidri et al. 2013 Ramzi and Kabir 2013). The field trials in India have shown that SRI method requires approximately only 40% water as compared to traditional methods (Swaminathan and Kesavan 2012). In a study done by ICIMOD in Nepal, farmers perceived that SRI consumed 50-75% less water compared to traditional method which reduced the frequency of irrigation, conflict among irrigation water users and terrace riser failure caused by stagnant water (Dhakal 2005).
3. Cost effective: A number of studies suggests that SRI is more cost effective as compared to traditional cultivation method. M.S Swaminathan Research foundation of India has reported a 30% increase in on- farm yield with SRI methods, with a concomitant 18% reduction in the cost of production (MSSRF 2006). A study conducted in 5 villages of Andhra Pradesh with 30 farmers showed that SRI system is more economical than traditional system by saving seeds (2kg vs 30kg/ha); reducing the cost of nursery (Rs. 414 vs Rs.3086/ha); transplanting cost (Rs 3000 vs Rs. 6000); avoiding the use of pesticide, with the profit of Rs 24,647 (Jaypalreddy and Sheony 2013).
4. Resistance to biotic and abiotic factors: Under SRI, rice crop develops profuse tillering, a much stronger and deep-penetrating root

system which is more effective in absorbing nutrients making robust and hardier plants (Swaminathan and Kesavan 2012). Larger root systems and stronger stalks, can be quite dramatic (Uphoff 2008) offering the plants resistance to lodging caused by wind and/or rain. In addition, SRI crops are more resistant to most pests and diseases, and better able to tolerate adverse climatic influences such as drought, storms, hot spells or cold snaps.

5. Enriching soil with organic matter and improving soil aeration: Under SRI condition most microbial organism perform better and more efficiently than in flooded condition as a result decomposition and mineralization rate of organic nutrient sources become faster which affects the readily available nutrient supply and the same applies to the efficiency of biological nitrogen fixation (BNF) process. Similarly, SRI also favors the composition and functioning of beneficial soil biota. For example a study conducted in Thailand indicated that rice grown in SRI managed plot had more diverse arbuscular mycorhizal fungi (AMF) communities than those grown in conventional system plots (Watanarojanaporn et al. 2013) .
6. Reduced green house gas emission: Since SRI relies mostly on organic fertilizers, the decrease in input of nitrogen fertilizer potentially reduces nitrous oxide emission though further investigation is necessary (Susanth 2013). An experiment conducted in Nepal showed that the emission of CH_4 from SRI soil exhibited 4 times less than that of non-SRI soil whereas N_2O flux from SRI soil was 5 times less than non-SRI soil (Karki 2010). Similarly, an experiment in South India has indicated that the level of N02 emission was consistently higher under conventional crop management compared to SRI by 27.8-42.6 per cent during summer season and by 13-43.1 per cent in rainy season. Total methane emission was reduced by 29 per cent and 32 per cent during summer and rainy season, respectively (Gathorne-Hardy et al. 2013)

LIMITATIONS IN ADOPTING SRI

SRI has few important practical and attitudinal limitations. Practical limitations with SRI adoption include the labor cost involved, mainly in weeding and water scarcity/abundance. Initially SRI may be labor intensive; however, with skill and confidence it can become labor-saving over time (Uphoff 2008). Major constraints in practicing SRI method in India were noted to be high labor requirement and weed menace (Reddy and Shenoy, 2013). Similar case has been reported in Nepal by Bhatta and Tripathi(2005). Similarly, too little or too much water both impede the SRI practice. This is a great challenge in adopting SRI in Nepal because the rice season coincides with heavy rainfall and excess water, and there will be no water later (after flowering of rice crop) when a thin layer of water is recommended. In addition, most of our soils are poor in organic matter which also may hinder the successful adoption of SRI technology.

SRI is not a fixed technology to be adopted as a "package", and the practices depend upon the prevailing agro-environment, and so, blanket recommendation cannot be made. When and how to apply water depends on soil characteristics and field position, for example. Probably, this may be one of the reasons why NARC seems not much interested to focus on SRI research. NARC in its Annual Report 2008 had mentioned SRI as pipeline technology but nothing is mentioned about SRI in its latest Annual Report 2013 (NARC 2008, NARC 2013).

SRI FACING CRITICISM

SRI faces serious criticism mainly from the scientific circles as just being unconfirmed field observations (Sinclair and Cassman 2004). The

main basis for this claim is said to be the paucity of empiricism regarding SRI as expected by the scientists (Uphoff 2011). Sinclair and Cassman (2004) referring to Sheehy *et al.* (2004) stated that there was no evidence found for the yield advantage claimed by the SRI system and they even proposed that yield reported in SRI system should not be accepted. Latifa *et al.* (2004) in Bangladesh, after a series of experiments, reported that several of the key management principles stated in SRI had, in fact, have little effect on rice yields and the increased labor demand and poor economic performance may make it an unattractive choice for rice farmers in Bangladesh. Critics of SRI have pointed out correctly that little agronomic research had been done on the new rice methodology at that time to support some of the claims made for it when these were first presented; there were indeed few published articles in the peer-reviewed literature (Uphoff 2011). However, due to the dominance of research paradigm focused on the high yielding agro-chemical responsive varieties and associated technologies, SRI still faces resistance from scientific communities in many countries.

CONCLUSION AND RECOMMENDATION

Currently, production and productivity of rice is low as compare to other rice cultivating South Asian countries even though rice is one of the major cereal crops of Nepal. The low production and productivity of rice has created the situation of grain deficit and worsening the food security of Nepal. Thus, transformation of conventional rice cultivation practice is an urgent need to address the issue of food security. In addition, effect of climate change has the possibility of worsening the condition of food security. Erratic rainfall pattern, drying of rivers and streams, prolonged drought are the consequences of climate change which have direct impact on water availability. Therefore, the practices such as SRI which requires less amount of water could be an appropriate method of rice farming under the adverse situation of climate change.

Several research studies demonstrated that SRI can sustain and enhance rice production and productivity with better management of existing resources. In additions, SRI has several other benefits such as consumption of less water, low external agrochemicals, resistance to external biotic and biotic factors and low emission of green house gases. Despite of few criticism and limitations, SRI has grown popularity among the progressive farmers due to high productivity and cost effective nature.

In the current situation, SRI hasn't been common rice cultivating practice or method among the rice growing farmers in Nepal. Due to lack of adequate awareness and proper technical knowhow, this system is confined among few farmers and in few districts. The practice can be promoted in the place where the soil is rich in organic matter, water is limited and its management is rather easy such as in western Nepal and in hill farming systems where the field is fed by the streams with controlled irrigation system. However, the initiation for promoting SRI extensively among Nepalese farmer from government hasn't been adequate. Therefore, Government of Nepal should undertake SRI as one of the components of enhancing rice productivity and ultimately heading to food security.

Similarly, SRI promoting policies and regulations should be developed based on research findings and knowledge. Moreover, government should also focus on improving institutional arrangements to create an enabling environment to practice SRI and extension services should also be farmer-friendly to adopt SRI at local level. NARC, the leading agriculture research organization of Nepal should prioritize SRI as one of its major

research domain and should increase farmer's participations by establishing farmers' field school and appropriate demonstration research plots in order to make SRI familiar to wider farming areas and communities.

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