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System of Rice Intensification: Impacts on Crop Productivity and Saving Water in Africa

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Abstract

The System of Rice Intensification (SRI) is a package of practices that changes how rice is grown in paddies, which incredibly increases yields. Rather than fully flooded paddy systems, SRI involves among its practices, the alternate wetting and drying of paddies which saves water, use of less seeds, wider crop spacing, transplanting one seedling per hill and use of organic fertilizers, all of which result in a sturdier rice plant. Other benefits include better grain quality, healthier work environments through reduced water-borne disease vectors and as a climate-smart practice. Data from several African counties shows that SRI increases rice yields by between 20% to 80% depending on variety and local conditions, saves water by about 39% and reduces seed requirement by 66%. SRI has been adopted by millions of farmers worldwide, while within Africa, some 25 countries are documented to have adopted SRI. This paper presents the opportunities inherent in enhancing and promoting SRI adoption of the in Africa. To facilitate this, the SRI-Africa knowledge portal was launched in 2018. The portal collates and shares data, information, publications and happenings in SRI from African counties, thus facilitating promotion of SRI in Africa and worldwide (visit https://sri-africa.net/).

Key words: Rice, Intensification, climate change, Africaplatform

Introduction

Importance of Rice to Africa

Rice is grown in 40 African countries and is the principal economic activity for over 35 million smallholder rice farmers. Although Africa accommodates only 13% of the world population, the continent accounts for 32% of world rice imports, amounting to 14-15 million tonnes per year (Africa Rice, 2022). Furthermore, rice is rapidly becoming a major food staple in much of sub-Saharan Africa and is set to overtake maize, cassava, sorghum and other cereals in the future. The demand for rice is growing at over 6% per year, driven by population growth as well as by urbanization. In addition, the high cost of fuel makes rice attractive as it cooks faster, tastes delicious, feeds large groups well and is one of the few foods in the world which is entirely non-allergenic and gluten-free. But increasing rice productivity in Africa faces a number of challenges. Generally, rice yields are low Africa attaining about 0.49 to 4.43 t/ha (Diagne *et al.,* 2013).

Conventional rice production utilizes too much water

For thousands of years, rice has been grown under flooded paddies utilizing too much water. Generally, rice production in flooded paddies utilizes between 3,000 and 5,000 litres of water for each kilogramme of grain produced (Molden *et al.,* 2007). Most irrigation schemes for rice in Africa practice the traditional method of continuous flooding of paddies, taking up about 1-meter depth of water. This is because it is believed that rice is an aquatic plant or at least a hydrophilic one (Satyanarayana *et al.*, 2006). But sometimes, the reason could be simply that flooded paddies conform to the convention or tradition, handed down over generations since it helps to control weeds. The flooded paddies are breeding grounds for water-borne of disease vectors, such as mosquito which spreads malaria (Namfumba *et al*., 2005).

Climate Change is Set to Impact on Rice Production

In some rice-growing countries in Africa, the challenges of water scarcity will be exacerbated by climate change. This could affect rice production differently, as increasing CO_2 concentrations in the atmosphere has a positive effect on crop biomass production, but its net effect on rice yield could be negative. For instance, for every 75 ppm increase in CO_2 concentration rice yields will increase by 0.5 t ha^{-1}, but the yield will decrease by 0.6 t ha-1 for every 1°C increase in temperature (Sheehy *et al.,* 2005). Furthermore, within Sub-Saharan Africa (SSA), rice production is increased by expansion of irrigation schemes rather than intensification. Yet rice could grow and yield well with less water. This is because, whereas the rice plant can withstand water-logging and indeed, it does not have to be grown under water all through. Producing more rice with less water on the same paddy, using the same seed varieties, by the same farmers is possible. This is the promise of the System of Rice Intensification (SRI), a "win-win" climate-smart agronomic practice for growing more rice.

THE SYSTEM OF RICE INTENSIFICATION (SRI)

The System of Rice Intensification (SRI) is a package of practices especially developed to improve the productivity of rice grown in paddies (Uphoff, 2005). SRI was developed with small-scale farmers in Madagascar in the 1980s with the aim of improving paddy yields and reducing poverty and hunger in that country (Laulanié, 1993). Since then, the practice has spread to many countries all over the world. SRI increases the productivity of irrigated rice by changing the management of plants, soil, water and nutrients (Shambu, 2006). The system has also been associated with increased yields in a number of countries where it has been tried (Uphoff, 2005). In practice, SRI involves some combination of the following changes in rice agronomic practices:

1. Raising seedlings in un-flooded nurseries and well-supplied with organic matter. This produces a studier seedling which establishes easily once transplanted.
2. Transplanting young seedlings, i.e. 8-14 days old seedlings, instead of the conventional 21-30 day old ones. Early transplanting optimizes the rice plant tillering potential.
3. Transplanting one seedling per hill (instead of the conventional clumps of 4-12 seedlings). It is the number of tillers a single plant produces which results in good yields, not the quantity of seedlings planted.
4. Transplanting seedlings at wider spacing, in lines and in a square pattern, giving roots and leaves and more space to grow.
5. Alternate wetting and drying of the paddy field (do not continuously flood the soil) to ensure aerating of the root zone, which is beneficial to plant roots, while saving water.
6. Weed control using a mechanical/rotary weeder. This eliminates weeds, aerates the soil and gives better results than either hand weeding or herbicides
7. Use of soil organic manures and fertilizers to improve soil fertility and crop growth.

Evidence from African Countries

A desk study was conducted to gather evidence on the impacts of SRI on rice productivity, utilizing the SRI-Africa knowledge portal, as well as other databases. t was found that compared to conventional flooded paddy systems, SRI has many benefits to the farmer, the irrigation scheme, the environment, to the country and to Africa; for example:

Increased Yields

One of the main benefits of SRI is the fact that the practice increases the yield of rice**,** by various factors depending on crop variety, management and climatic conditions. An assessment of 14 African countries (**Figure 1**) obtained that on average, SRI yields were significantly higher than flooded paddies ranging from 3.9 t/ha under conventional flooded paddies to 7.1 t/ha under SRI, equivalent to an increase in average yields that varied of 81% attributed to SRI. This agrees with another study in Kenya, where 71% increase in rice yields under SRI were obtained (Nyamai *et al.,* 2012). That SRI results in higher yields with has been recorded world-wide (Stoop *et al.,* 2002; Kabir and Uphoff, 2007; Thakur, 2010; Mati *et al.,* 2021).

SRI Saves Water

The wetting and drying practiced under SRI results in less water being applied, and thus savings in water. Data from six African countries, i.e. Burkina Faso, Egypt, Kenya, Morocco, Mozambique, Niger and Tanzania (**Figure 2**) shows that SRI reduces the amount of water used to grow rice by between 30-63% compared with conventional flooded paddies. The wetting and drying of rice paddies has the beneficial effect of enhancing root growth. The rewetting facilitates nitrogen mineralization and this is made available to the plant for growth (Ceasey *et al.,* 2006). Studies in Kenya (Omwenga et a, 2014) showed

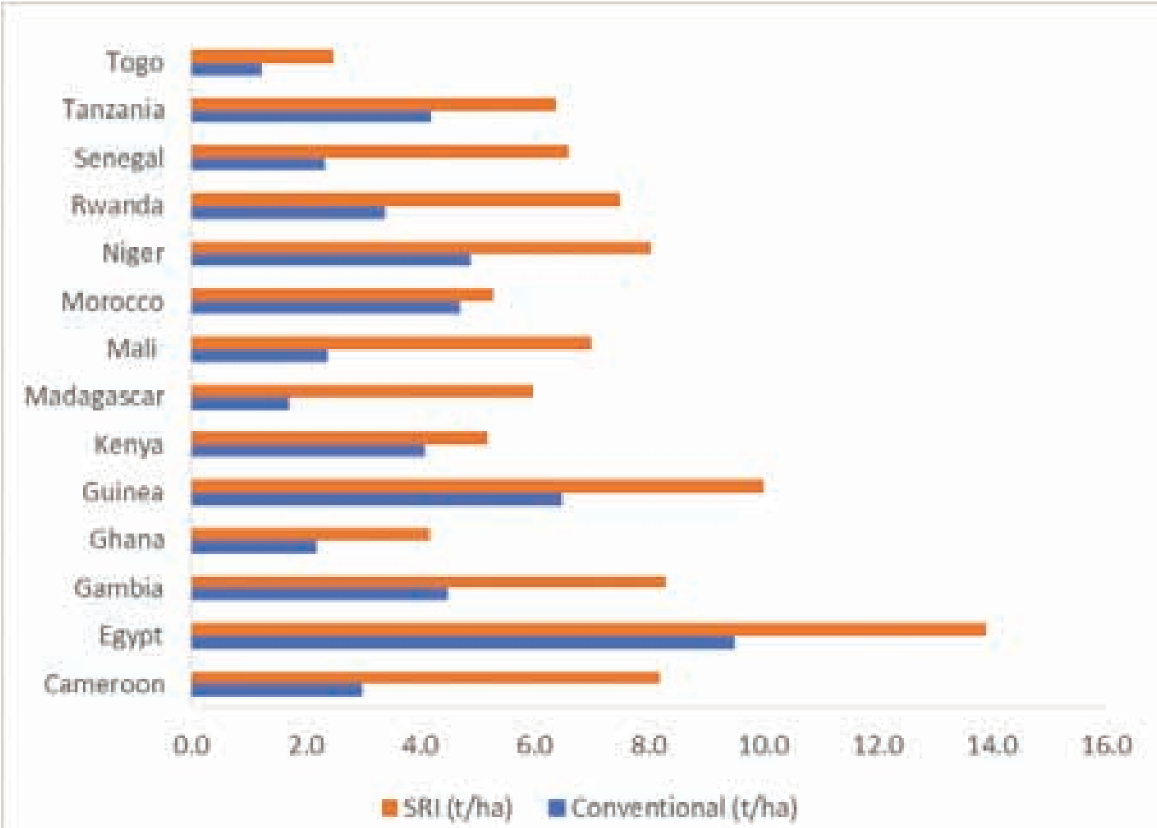

Figure 1: Rice yields from SRI and conventional practice in selected African countries

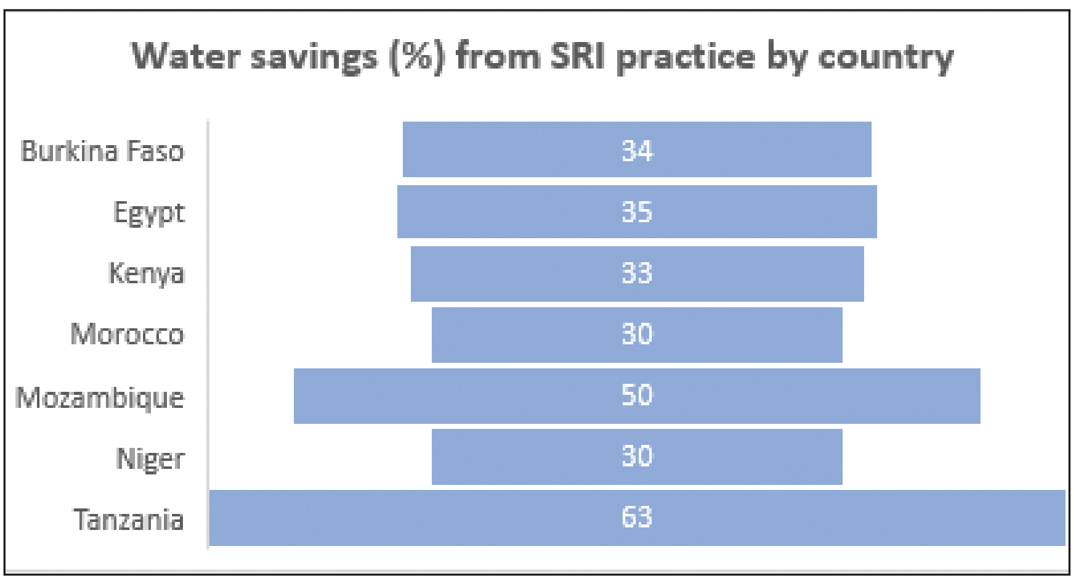

Figure 2: Water savings from SRI practice in selected African countries

that the drying of rice paddies for between 4 and 12 days under SRI has positive impacts on rice yields, resulting in water savings of between 27% and 42%. Ndiiri et al (2012) obtained that SRI crops were irrigated fewer times than with farmer practice because its grain matured earlier by an average of 10 days.

SRI Utilizes Less Seed

SRI uses less seed compared to conventional flooded paddies (Mati *et al.,* 2021). Data from some 14 African counties (**Figure 3**) shows that on average, SRI required only 16 kg/ha as compared to conventional systems that used 73 t/ha. By transplanting just one seedling per hill, it means that less seeds are required in the nursery, and this saves on costs of seeds by about 78% in Africa.

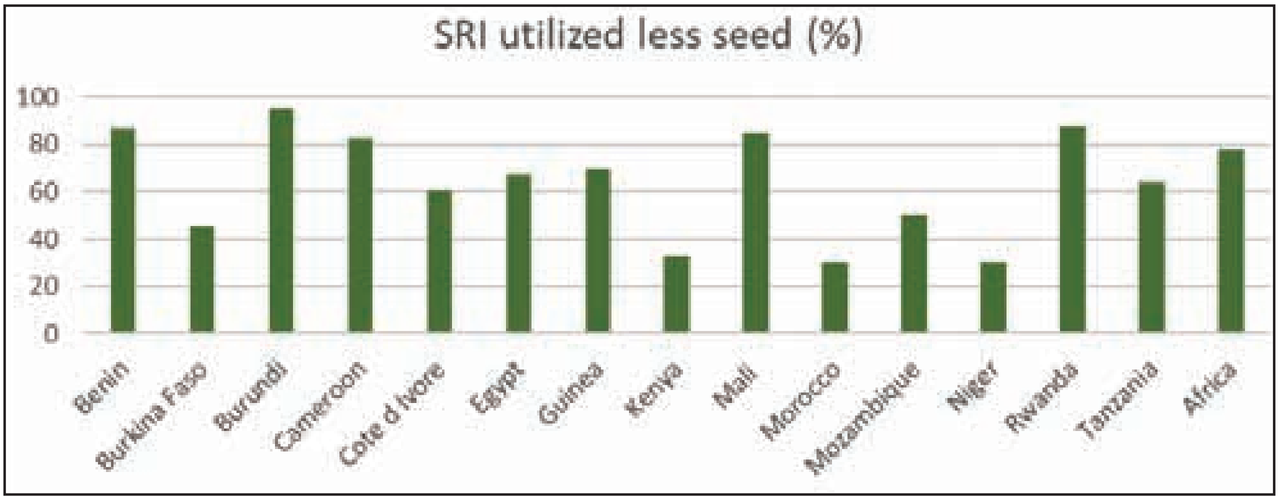

Figure 3: Use of less seed under SRI practice in selected African countries

Weed control under SRI

Although weeds proliferate under SRI, control can be made easier as SRI utilizes mechanical/ rotary weeding. Mechanical weeding has been proven to stimulate root renewal and hence faster root development and crop vigour, further improving tillering of the rice plant. Different viewpoints exist about comparative labour inputs in the SRI method of paddy cultivation. SRI may require more labour in the beginning but once farmers master the technique it leads to labour savings (Uphoff *et al.,* 2002). Studies in Kenya showed that mechanical weeding reduce the cost of weeding by 75% compared to manual weeding under conventional flooded paddies (Kathia *et al.,* 2019).

Better Grain quality

SRI practice results in a harder grain which does not break on milling resulting in a more whole, good quality grain which has higher market value. The cumulative effect of these methods is to raise not only the yield of paddy (kg of un-milled rice harvested per hectare) without relying on improved varieties or agrochemical inputs, but also to increase the outturn of milled rice. This bonus on top of higher paddy yields is due to having fewer unfilled grains (less chaff) and fewer broken grains (less shattering). The harvested SRI paddy is heavier than conventional paddy. Farmers in Kenya have found that the normal bag of paddy weighs about 100-110 kg for SRI, compared to conventional paddy which weighs 80-90 kg per bag of equivalent size.

SRI increases net farm-gate incomes from Rice

SRI increases the overall economic returns to the farmer from rice production. Research at Mwea in Kenya has found that net farm-gate incomes increase by about 20-50% from SRI compared to conventional paddy production. This is due to not only due to higher yields, but also the lower inputs costs. Ndiiri et at (2013) in an economic assessment of SRI and conventional paddy, obtained that a significantly higher benefit–cost ratio of 1.76 and 1.88 compared to 1.31 and 1.35 for flooded paddy in the first and second seasons, respectively. Barah (2009) reported similar ratios and even higher values in some of the districts that he studied in India. A wide range of reductions in cost of production with SRI for different countries is elaborated in Uphoff (2005) and Sinavagari (2006).

Reduction of disease vectors in paddies

SRI reduces the incidence of disease vectors found in conventional rice paddies. Research at Mwea has shown that due to the wetting and drying of paddies under SRI, mosquito larvae are completely eradicated in paddies when left dry for about two days. Omwenga et al (2014) showed from plots studies that alternate wetting and drying of rice paddies under SRI practice interfered with the development process of mosquito larvae, completely eliminating the larvae from SRI plots compared to conventional flooded paddies

Gender equity and youth employment

Gender equity and youth employment in farm labour is enhanced under SRI. This is because in some African cultures, weeding of rice is done by women as bending to pull out weeds is considered "un-manly". With introduction of mechanical/rotary weeding, men and youth find it easier and culturally acceptable to do weeding and thus relieve the women of some of the burdens of farm labour. Moreover, SRI makes use of what the farmer has (land, seed, labour, inputs) and all that is required in the knowledge and a change of attitude to adapt.

Conclusions

In Africa, recurring droughts affect nearly 80% of the potential 20 million hectares of rainfed lowland rice. Therefore, since SRI saves water and results in increased yields, there is need to upscale the practice. Overall, SRI is a better practice scientifically, because it promotes climate-smart practices. The rice plant is a "water loving plant". But SRI has proved that a rice plant requires just adequate water. There is no need to waste water flooding the paddy unnecessarily. SRI can be practiced on nearly all sizes of farms and is especially beneficial to smallholder rice farmers. The SRI-Africa knowledge sharing portal has been useful for collating data, information, publications and happenings in the SRI sub-sector in Africa. Knowledge transfer is a tool through which SRI can be promoted in Africa, as an option to grow more rice to feed the continent, while also saving water. For more details, please visit https://sri-africa.net/

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