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Perspectives of Perennial Rice Farming in Sub-Saharan Africa

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Abstract: Annual mono cropping which is a commonest agricultural practice in Sub-Saharan Africa (SSA) is now wearing down the land. Moreover, the shorter growing seasons and less extensive root systems of those annual crops facilitated soil erosion, store less Carbon in the soil and less efficiently manage water and nutrients. So as to compromise soil health of the region, it is now important to assess sustainability of the perennial cropping systems. Perennial crops are capable of being harvested multiple times throughout their life span. Hence, incorporating perenniality or integrating perennial crops such as rice into the current agricultural system of SSA is vital for ensuring long-term food security through ensuring healthy soil ecosystem. To capitalize such attributes of perennial rice in SSA, it is important to consider genotypic and environmental variance, design efficient farm management techniques and critically assess their multitude outcomes. This review has therefore provides a comprehensive overview of yield, adaptability, environmental safety and socioeconomic benefits of perennial rice cropping to the marginal lands of the Sub-Saharan Africa.

Key Words: Marginal Lands, Perennial Rice, Socioeconomic Benefits, Soil Ecology, Sub-saharan Africa

1. Perennial system for environmental restoration

Agriculture in SSA is under complex threats of the rising population pressure and climate change. Marginal lands which support majority of the population in the region are at high risk of degradation under annual cropping. The continued climate change along with loss of water and soil were calling for the need of sustainable food security through less energy and limited carbon footprint (Batello et al., 2013).

Rice cultivation in Africa has a long history of more than 3000 years at the lowlands of river deltas, inland valleys and uplands (Sweeney and Mc Couch, 2007). In Sub-Saharan Africa (SSA), rice is the most economically important food crop with an increasing per capita consumption (Muthayya et al., 2014). From 1990 to 2018, rice consumption and production in the region was tripled from 9.2 Mt to 31.5 Mt (USDA, 2018). Over the past 10 years, rice production area is increased nearly by 40% (Yuan et al., 2024). However its yield has been stagnant over the long period (Arouna et al., 2021; Tsujimoto et al., 2019).

For instance, the average paddy rice production by smallholder farmers in SSA (1.87 tonnes/ha)is well below the global average of 4 tons/ha (Norman and Kebe 2006;Tsujimoto et al., 2019 and Arouna et al., 2021). The low productivity of rice in the region can be associated to socio-economic issues, scarce farm inputs, climate change, labor, soil degradation and poor soil fertility management (Bjornlund et al., 2020).

In terms of production, rice is the fourth most important cereal (after sorghum, maize and millet) in SSA (Norman and Kebe 2006). And thesemain grain crops are annuals. Annual cropping systems bring intermittent soil coverage and leaving barren soil (Rabalais et al., 2007; Cilman et al., 2013; Jungers et al., 2019). Due to annual cropping, marginal lands which currently support 50% of the world population are vulnerable to heavy rainfall, soil and nutrients loss, soil infertility with risk of further degradation (FAO, 2009; Monfreda et al., 2008). Despite annual crops provide high yields; extensive tilling, field preparation, crop management, and routine agrichemical application are required for optimal outcomes (Chapman et al., 2022). The high production inputs such as; labor, energy, pesticides, and fertilizers regarded the annual monocrop based agriculture as threat to biodiversity and ecosystem services (Clay, 2004).

In SSA areas where most people are at subsistence income levels, stable cropping systems and increased productivity are basics to control erosion, ensure food security, and stop deforestation (Trung et al 1995). Sustainable production, health and long term viability of marginal lands of the region has to be ensured by ground cover, biodiversity enrichment and in situ retention of soil resources (Zhang et al., 2017).

Perennial grains have been proposed as an eco-friendly alternative to the erodible land (Wagoner 1990). Perennial grains can stabilize land and soil resources of SSA, while contributing grain, grazing and forage in a mixed farming system (Glover at al., 2010). Unlike the annual crops, cropping without tillage reduces soil loss. Along with the longer growing seasons, their deeper rooting promotes interception, retention, and utilization of precipitation (Tilman et al., 2009). The greater root biomass further increases nitrogen retention (Jungers et al., 2019), soil carbon accumulation (van der Pol et al., 2022; de Oliveira et al., 2018) and may ultimately require lower rates of fertilizer, pesticide and labour inputs (Crews et al., 2018). The extended photosynthetic seasons and greater light interception efficiency by perennial crops enhances the above ground biomass and productivity (Frank et al., 2009). In perennial agricultural systems such vital ecosystem services like improved soil microbial community are accompanied by the regulation and resiliency of extreme climate events (Lehmann et al., 2020a; Lehmann et al., 2020b; Leisner, 2020; Sanford et al., 2021).

2. Perennial crops cultivation and its trend

To tackle food insecurity faced by an ever-growing population of SSA countries, there must be an urgent need to develop new forms of highly productive and ecologicallysecure agricultural systems. Perennial grain crops hold the promise of stabilizing fragile lands, while contributing grain and animal feed in mixed farming systems (Huang et al., 2018). Nowadays, researchers have agreed that perennial crops grown for biomass, forage and food production can provide agronomic and environmental benefits from their perennial cover and species diversity (Jackson, 2002). Perennial crops have been part of the agricultural landscape for thousands of years. But in recent decades there has been a concerted effort to expand the application of perennials from more traditional orchard and forage uses to more recently developed perennial grain and oilseeds (Glover et al., 2010).

Research is underway to develop perennial versions of a number of annual grain crops (Batello et al., 2014). And hence, international researchers from numerous countries are engaged with developing commercially viable oilseeds like sunflower and perennial grains such as; wheat, barley, sorghum, buckwheat and rice (Ryan et al., 2018; Larson et al., 2019; Crews and Cattani, 2018).

Pastures and forage crops are well known for their ecosystem service benefits and encompass large ranges of the diverse cropping systems (Aponte et al., 2019; Martin et al., 2020; Teixeira et al., 2021). A perennial grass that has mostly been utilized for forage called intermediate wheatgrass (Thinopyrum intermedium) is now being modified and used as a perennial grain crop (Chapman et al., 2022). Currently, this perennial grain is produced at a small scale in USA and sold under the trade name Kernza R (De Haan and Ismail, 2017). Kernza is one of the potential list perennial crops to improve soil quality and water regulation (Audu et al., 2022; Rakkar et al., 2023; Reilly et al., 2022; van der Pol et al., 2022). The yield potential of intermediate wheatgrass is currently half of that of wheat grown under similar conditions (Culman et al., 2013). The other seed-bearing species that are currently targeted for accelerated domestication are the perennial sunflower relative Silphium integrifolium (Van Tassel et al., 2017), perennial flax (Linum sp.) (Tork et al., 2019), and other perennial legume species (Schlautman et al., 2018).

Breeding programs employed to enhance both agronomic performance and grain yield of the perennial crops used two strategies called de novo domestication and inter-specific hybridisation (DeHaan et al., 2005, 2018, 2020). The use of de novo domestication is a more advanced technique which relies on yield improvement of some perennial grasses such as smooth bromegrass (Bromusinermis) (Knowles et a1 1970), wild rye (Leymusracemosus) and eastern gama grass (Tripsacumdactyloides) (Piper and Towne 1988).Kernza® is also the other grain which bravely exemplifies de novo domestication of the wild intermediate wheatgrass (Thinopyrum intermedium) (DeHaan et al., 2020).

Wide hybridization programs could also produce perennial sorghum [Sorghum bicolour(L.) Moench) / Johnson grass (Sorghum halepense(L.) Pers.], Maximilian sunflower (Helianthus maximiliani Schrad.), perennial sunflower (complex hybrids of Helianthus spp.), Illinois bundleflower (Desmanthusillinoensis (Michaux) MacMillan), and perennial rice (hybrids of Oryza spp.)(Cox et al., 2010). In the next decades, recent advancements in plant breedinglike marker assisted selection, genomic in situ hybridization, transgenic technologies and embryo rescue will be coupled with traditional breeding techniques and make perennial grain crops realistic (Zhang et al., 2011).

3. Perennial rice

Perennial crops can regrow after normal harvest and have been adopted as a long term toolkit for mitigating soil loss and ensuring food security in SSA (Whelchel and Berman, 2011). The less C and N content, strong acidity, limited availability of P,S and Zn along with minimum nutrient-holding potential and nutrient-supply capacity of the soil in SSA affects its fertility potential for rice production (Abe et al., 2010). Likewise, large portions of the global rice growing lands are mainly threatened by soil loss (Batello et al., 2013). Thus, development of high-yielding perennial rice (PR) cultivars would address environmental issues ofthe annual rice (AR) cultivation. PR was originally proposed to stabilize fragile upland farming systems through introgression of novel traits from the wild perennial species into the annual cultivated form (Huang et al., 2018). So far, Yunnan University released PR cultivars; PR23, PR24, PR25 (Yunda25), PR101, and PR107 (Yunda107). Yield related assessment from the four to ten cycles of growth–harvest–regrowth revealed a high and sustainable productivity of such PR varieties (Zhang et al., 2022). Lack of ratooning after the first cycle of those new varieties is also the cause for other economic and environmental merits. Kernza® and PR cultivars are among the first perennial grains to be commercialized.

According toZhang et al. (2023), PR is suited to a broad range of frost-free environments between 40° N and 40° S. It is currently being tested in 17 countries across Asia and Sub-Saharan Africa, particularly in upland regions and terraced fields where conventional rice cultivation contributes to soil erosion through plowing (Stokstad, 2022). According to Huang et al. (2018), PR can successfully survive, regrow, and yield across diverse range of environments in Southern China and Laos. By 2020, PR23 supports more than 11,000 smallholder farms of China. And a year later in 2021, the PR planting area has been raised in to 15,533 ha and 44,752 smallholder farms were cultivating it (Zhang et al., 2022). Along with production potential, the wide-hybrid segregation of perenniality acquired nematode resistance and drought tolerance traits (Sacks and Roxas, 2003; Sacks 2006). From the field performance assessment of perennial farming in different SSA countries, the promising yield, environmental and socioeconomic potential was reported at "**The China-Africa International Symposium on Perennial Rice in Africa**" held on October 16, 2024, at the African Union headquarters in Addis Ababa, Ethiopia.

3.1 Interspecific hybridization and breeding scheme of perennial rice

A greenhouse experiment conducted at IRRI from November 1995 to June 1998 revealed the possible perennial trait transfer from the African wild rice (Oryza longistaminata) into the annual cultivated rice (Oryzasativa) throughan interspecific hybridization (Bennett et al., 1998). In 1996, wide hybridization between the annual domesticated Asian rice O. sativa ssp. indica 'RD23' (a cultivar from Thailand) and an accession of the undomesticated African perennial and rhizomatous O. longistaminata (from Nigeria) was made through embryo rescue technology at Yunnan Academy of Agricultural Sciences and Yunnan University (Hu et al., 2003; Zhang et al., 2014). Multiple reproductive barriers resulting in hybrid inviability and sterility impede an ease development of such interspecific hybrids (Li J. et al., 2020).

The resulted O. sativa/O. longistaminata F_1 plant possessing strong rhizomes, partial pollen fertility and self-compatibility has provided a landmark material for further hybridization and breeding of PR cultivars (Tao and Sripichitt, 2000; Hu et al., 2003). Intercrossing and backcross for generations are proved to be suitable strategies for keeping rhizomes through simultaneous increase of O. sativa genome proportion and its desirable agronomic traits (Bennett et al., 1998). From wide crosses, linkage drag and low frequency could lower the probability of having breeding lines with targeted traits of interest (Hu et al., 2022). For this reason, few numbers of perennial and rhizomatous F_2s with good agronomic characters were obtained (Zhang et al., 2022). To circumvent the impact of linkage drag, pedigree selection for the best single plant in each generation was applied and 7,200 F_2s were screened for identifying individuals with desirable traits combination (Fig. 1).

In 2007, an exceptional F_2 individual possessing a moderately strong rhizome withhigh pollen fertility and seed setting rate was selected and used for subsequent breeding (Zhang et al., 2022). In each generation, from selfing of an exceptional F_2(36-1), only one individual with short rhizomes and good pollen fertility was selected for further self-pollination (Hu et al., 2022). Through assessing rhizome and yield-related traits, a "population" with individuals representing successive generations from F_1 to F_9 was constructed in 2018 (Fig. 1). At the latest generations, agronomic traits were gradually changed in the direction of cultivated rice and both rhizome length and rhizome numbers per plant were decreased (Zhang et al., 2022). Moreover, pollen fertility was gradually increased and plant height, tiller number, grain number per plant, seed-setting rate, panicle length and grain size (grain length, width and weight) were improved to a level of widely-acceptable rice types(Hu et al., 2022). A series of backcrossing to AR, selection and subsequent breeding formed PR lines possessing agronomic traits as domesticated AR with retaining perenniality from the O. longistaminata parent for their vigorous growth after harvest (Huang et al., 2018; Zhang et al., 2019; Hu et al., 2022). Next-generation sequencing of the PR lines also revealed retention of only 16.16% genome of the male parent (O. longistaminata) (Zhang et al., 2022).

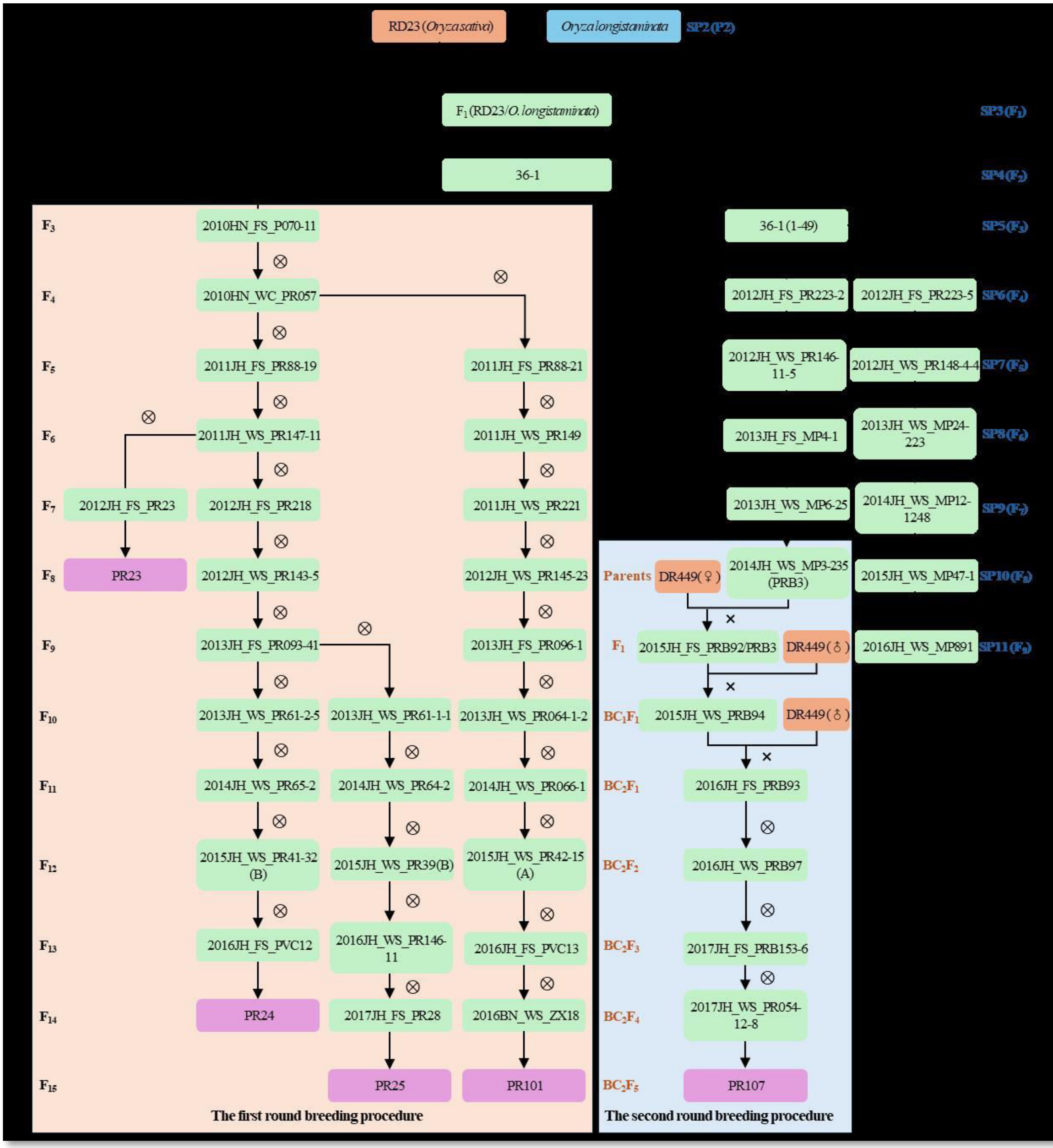

Figure 1. Breeding strategy designed to avoid crossing barrier via maintaining a moderate rhizome expression (Source: Adopted from Zhang et al., 2023). Where, JH and HN referred to Jinghong Station in Yunnan and Hainan Station in Sanya, Hainan, China. FS - first (hot and dry season), WC or WS - second (cold and wet season in double-crop

regions). SP1 is Oryza sativa spp. indicaRD23 (P1), SP2 is O. longistaminata (P2), and SP3 is RD23 / O. longistaminata (F1). SP4 to SP11 are single individuals selected from the previous generation for possessing good fertility and preferable rhizome length. Numbers of plants evaluated in each generation from F_1 to F_{15} were 1, 1, 1, 7,200, 1,250, 57, 78, 104, 384, 864, 100, 1,078, 1,294, 1,572, 1,403, 1,520 and 1,105, respectively.

In multi-year (2012-2017) field trials, Hu et al., (2022) evaluated agronomic and perenniality traits of more than 20 candidate PR lines. The genotype by environment analyses from those ten locations of Yunnan, China and Lao PDR showed higher broad-sense heritability for most traits including yield and regrowth rate. It is therefore indicative that the significantly higher role of genetic factors on regulating most of the trait's variation would make PR more amenable to adopt and perform at SSA countries.

The promising line, subsequently named Perennial Rice 23 (PR23), was the first material subjected for pre-release field testing in farmers' small plots (Zhang et al., 2017). Through further breeding programs, three additional PR lines (PR24, PR25 and PR101) were successfully developed (Hu et al., 2022). PR23, PR24 and PR25 have grain quality traits similar to the O. sativa ssp. Japonica cultivar Zhonghua 11 with a relatively lower grain length/width ratio of 2.13. However, PR101 has grain quality similar to its O. sativa ssp. indicaparent RD23, with a high grain length/width ratio of 3.57 (Zhang et al., 2022).

In another round of breeding, perenniality was introgressed into local elite O. sativa cultivars (Fig. 1). A perennial breeding line MP3-235 (later renamed as PRB3) which is known by its strong perenniality, short rhizomes, about 2-meters height, high seed shattering rate and low grain density was chosen to be crossed with an elite indica cultivar, Dianrui 449 (DR449) (Hu et al., 2022). As shown in Fig. 1, backcrossing was performed by using DR449 as a recurrent parent, followed by several generations of selfing. From this backcross breeding, a new PR cultivar (PR107, DR449/MP3-235//DR449) which is characterized by strong perenniality, high yield and good grain quality was released as 'Yunda107' in China by 2020.In Uganda, rice yellow mottle virus resistant trait was introgressed from its parent O. longistaminata and PR107 was released as NARORICE1by 2021 (Vijayakumar et al., 2025).

3.2 Yield and agronomic performances of perennial rice varieties

PR23 was the first candidate for field-scale assessment by a commercial company. At different locations of Lao PDR, PR23 had a broad adaptation and grain production potential for four successive seasons than its AR cultivar (RD23) which was failed to survive the dry season (Samson et al. 2016). Since PR23 exhibited high and stable grain yields over years with good performance at most locations, PR23 was released to farmers in 2018 (Zhang et al., 2017; Huang et al., 2018;Zhang et al., 2021).

In each of the four to ten cycles of the released PR cultivars (PR23, PR25 and PR107), overall yield was equivalent to the preferred AR cultivars like RD23 and HXR7 (Zhang et al., 2022). In particular, PR23 was comparable to the annuals in terms of phenology, grain quality, yield, plant height, milling and cooking quality (Huang et al., 2018). That is why its adoption rate showed a fourfold increase in area coverage and number of farmers per year (Zhang et al., 2022). Even at 65% regrowth rate, grain yield of PR23 (6.13 t ha^{-1}) is still satisfactory.

In 2018, yield assessment of the other lately released cultivars (PR25 and PR107) was conducted for at least two years and four seasons of a single planting. Under the different environmental conditions, the yield potential of PR25 and PR107 was alike with the yield of PR23 (Zhang et al., 2022). Here maintenance of high and stable grain yield across seasons can be associated with a high regrowth rate (>75%) and stable agronomic traits. The two years data of PR23 and PR25 at Mbe, Cote ˆ d′Ivoire and PR107 at Ndiaye, Senegal showed the higher grain yield, labor productivity, and economic profitability of rice–ratoon–ratoon system of PR farming over the conventional AR system Dossou-Yovo et al. (2024).

3.3 Ecological benefits of perennial rice farming

Stable soil and water resources along with sustainable ecology can buffer agricultural productivity against the fluctuating climatic condition of SSA. PR has been shown to improve soil functioning and water regulation through their extensive root system, long term coverage, and lack of annual tillage or soil disturbance (Asbjornsen et al., 2014). Thus, growing PR on marginal soils of SSA has the potential to repair soil quality and structure, enhance water holding capacity, prevent desertification and provide opportunity for having more productive lands (Barbosa et al., 2015; Fernando et al., 2018;Monti &Zegada-Lizarazu, 2016;Wayman et al., 2014).

No- tillage after the initial cropping of PR and/or loss of soil disturbance between PR cycles can provide soil benefits over the annual counterparts. At 0–40 cm soil layer, PR cropping over four years has increased soil organic carbon (SOC) and total nitrogen (TN) by 0.95 and 0.11 Mg ha^{-1} yr^{-1}, respectively (Zhang et al., 2022). In the same study, the C/N ratio was significantly declined at the topsoil and in turn stimulates microbial decomposition of organic matter and facilitates N cycling in the soil. According to Zhang et al. (2022), no tillage and increase in organic matter under PR promoted fundamental soil properties such as soil pH, plant-available soil-water capacity and porosity. Besides, retention of soil structure from lack of tillage in PR farming system enhanced oxidative capacity of soil methane-oxidizing bacteria and thereby reduces methane emission (Chauhan et al., 1985; Krishnamurthy, 1988). Thus, minimizing intermittent flooding through PR cultivation could further mitigates global warming.

In a general sense, the extensive root system and greater assimilate reserves of PR in marginal, sloppy and rainfed uplands of SSA can prevent soil disturbance, promoted soil cover, reduce leaching and nutrient loss, and protect run-off and soil loss. Further soil health improvement at SSA can be ensured by PR rotation with legume, pasture, pulses or brassica, support other farm enterprises such as livestock and implementing efficient controlling methods of pests, diseases and weeds.

3.4 Socioeconomic impact of perennial rice cultivation

From social and economicperspectives, perennial grain crops have the potential to improverural economies of SSA through reducing inputs and labor (Dossou-Yovo et al. 2024). It is well understood that prevailing AR cropping system which comprises seedling nurseries, ploughing, transplanting, crop management and harvesting at every season is labor intensive. The non-labour costs of AR farming for seed, pesticides, herbicides and fertilizers are also affecting profitability and directly insecure livelihoods (Huang et al., 2018; Zhang et al., 2021). It is therefore necessary to involve ratooning as an economically attractive option for irrigated production under adverse and multiple environmental conditions of SSA countries.

Economic analysis through aggregating grain yield, labor requirement, input costs and returns showed a greater economic return from PR23 farming than the preferred AR cultivars like RD23 and HXR7 (Huang et al., 2018). The predominant economic advantage of PR farming in SSA was from saving the labor and labor intensity expenditures. For instance, a study from Zhang et al. (2022) reported a significantly higher net profit of US$838. Economic return to farmers growing PR could also be associated with protecting rural drinking water sources through minimizing NO_3 leaching to groundwater (Huddell et al., 2023; Jungers et al., 2019; Reilly et al., 2022).

In SSA countries labor cost is a significant issue for rice production (Norman and Kebe 2006). Because of its sustainable yield, acceptable grain and milling quality, cost efficiency, merit on ensuring soil health, ecological sustainability, and flexible farming system, PR23 is proposed for its release to farmers (Zhang et al., 2022). Since PR23 doesn't need taskssuch as; tillage, sowing, and transplanting in its subsequent cycles, farmers preferred it in prior to the annual types (Huang et al., 2018). Interestingly, season round regrowth or regeneration of PR23 minimizes women and children burden (Aryal and Kattel, 2019). Rice blast, which has caused serious damage in rice fields of SSA countries is now included as a prerequisite for rice cultivar release. SSA farmers inhabiting terraced and fragile farmlandare therefore recommended to cultivate the blast resistant PR23 with supplementary benefits such as; simple management technique, limited labor requirement and improved livelihood (Huang et al., 2018; Zhang et al., 2022).

4 Challenges and opportunities for commercial-scale perennial rice production in SSA

Along with Kernza®, the first three commercialized PR cultivars (PR23, PR25 and PR107) bring a paradigm shift in agriculture and popularize ratooning as an economically attractive option for irrigated production under adverse environmental conditions. These PR cultivars were certified for commercialization due to their multifaceted benefits of meeting farmers need, ensuring food security and favoring environmental protection. Like other emerging crops, market of PR is not as such intensive. This marketing gap can be associated with the limited varieties available for the vast consumer preference. In order to meet demands from multiple stakeholders (farmers, society and markets) of SSA, there must be a means to improve germplasm, genepool, agronomics, agricultural practices, and understand a gene to environment interaction of PR.

Given the recent development of PR, numerous and important research questions are getting attention. As an example, the higher herbicidal application during regrowth cycles of PR than in the transplanted AR calls for a safe and efficient weed-management practice (Vijayakumar et al., 2025). The high N applications in PR farm lands could also evolve pests and insect-transmitted viruses that threats irrigated systems (Zhang et al., 2022). Pests, weeds and diseases manifestation while removing PR after eight harvests would also affect wide adoption of PR by farmers at SSA. Hence, advancing weed and pest management practices and maintaining methane to nitrous oxide balance should be an urgent assignment in PR breeding programs and their applicability for large areas of SSA.

The wide hybridization accompanied by strong selection could limit stability, fertility and perenniality of PR. Therefore, genetic enrichment and breeding of stress resilient PR varieties for SSA has to be done. The aim of generating high-yielding PR types through wide hybridization approach is hampered by the complex genetics, low heterozygosity level and self-incompatibility (Schaart et al., 2016). Fortunately, high-quality genome sequences of perennial plants, improved molecular screening methods, and new breeding technologies support the development of highly productive PR cultivars that are capable of fulfilling demands associated with the targeted sustainable agricultural practices at SSA (DeHaan et al., 2020).

To capitalize ecosystem services from PR production, there must be a need to explicitly focus on roots and rooting characteristics (Jungers et al., 2023). Selection and breeding efforts for new PR types should therefore target on root biomass, architecture, and other related traits along with improvement of aboveground agronomic traits. After the release of an irrigated lowland PR, researchers at the perennial rice engineering and technology center of Yunnan University keep on producing PR cultivars that could stabilize fragile lands of SSA and suit rainfed lowland and rainfed upland types (Zhang et al., 2017). Despite many PR lines are promising to survive under diverse environmental stresses like rainfall deficit; there must be a need to come up with feasible PR production strategies by compiling different management dynamics and levels of vulnerability to the rapidly changing climate at SSA.

According to Zhang et al. (2022), regions with an average monthly temperature of 13.5°C or more are suitable for PR plantation. In order to enhance cold adaptability and broaden genetic base of PR, effort is now made to introgress important traits to a range of AR cultivars with diverse origin and adaptation (Zhang et al. 2017). Though traits transfer could provide sufficient segregating populations and thereby form desirable PR varieties, such perennial traits were not tested under different genetic backgrounds and locations of SSA.

Increasing perenniality across the landscape is the major attention to respond to climate change. The multitude benefits from PR cropping require concerted efforts of monitoring ecosystem services, improving crop management, and scaling up the genetic gain. For iteratively expanding PR crops over the SSA landscape, detailed experimental design and analysis coupled with supporting the regional supply chain and technology transfer tools are required.

PR23 was found to be a high yielding and broadly adapted PR cultivar (Zhang et al. 2017). Indeed, further selection of high-yielding perennial rice types for SSA should be done. PR farming systems could therefore provide significant agronomic and ecological benefits to SSA areas through improving plant breeding and fertility management, developing an enabling policy, providing financial support for R&D and establishing strong cooperation among multidisciplinary scientists. Recent advancement in plant breeding such as; low-cost DNA sequencing, molecular marker-assisted selection, genomic selection and gene editing are also expected to further accelerate the development of PR in SSA countries. For doing so, convergence among plant breeders, communication among a wider range of stakeholders and collaboration to develop a robust system of PR production for SSA is recommended.

5 Conclusion

Rice cultivation supports the livelihoods of approximately 100 million people globally, including an estimated 20 million farmers in sub-Saharan Africa (SSA) who grow rice predominantly on marginal lands. However, the prevailing intensive production systems in these regions have caused severe nutrient depletion, excessive reliance on synthetic fertilizers, and progressive degradation of soil health. Addressing these challenges requires a coherent, regionally coordinated strategy to improve rice productivity while safeguarding environmental sustainability.

This review synthesizes evidence on the agronomic, environmental, and socio-economic benefits of perennial rice (PR) cultivation in SSA. Notably, high-performing varieties such as PR23, PR25, and PR107 have been developed, commercialized and offering multifaceted advantages. Multi-location trials across SSA have consistently demonstrated strong perenniality, high yield, desirable milling and cooking quality, resistance to yellow mottle virus (YMV), and superior grain quality. In West Africa, PR adoption has been linked to higher grain yields, greater labor productivity, and improved household incomes.

Collectively, these findings highlight PR as a promising pathway for sustainable rice production in marginal environments, warranting its strategic promotion and integration into regional rice development programs. Nonetheless, advancing integrated weed and pest management practices and optimizing methane–nitrous oxide emission balances remain critical priorities in PR breeding programs to enable sustainable and large-scale adoption across SSA.

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