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Evaluation of different crop establishment methods on the basis of productivity and profitability- a review

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Introduction

Rice (*Oryza sativa* L.) considered as staple food for nearly half of the world's population it occupies second largest cultivated area and holds second position in production the world. It is estimated that rice is primary staple food for around 3.5 billion people across the world (Chakrawarti *et al.* 2022) and 90 % rice is produced and consumed in Asian countries (Clarete 2013, FOA, 2019). In India, rice is cultivated over an area of 43.86 million hectare which is largest over the world (Mubarak *et al.*, 2022). India stands second after China in terms of production and consumption. The increasing population in India poses a significant challenge for food security. Fulfillment of food demand of about 140Mt is a major task for agriculture researcher and farmers that need to be achieved till 2025 (Dinesh *et al.* 2017).

Rice cultivation is highly water consuming, it is estimated that producing one kg rice requires about 3000-4000 liters of water (Hoekstra, 2008), out of total water used 97% water is used for irrigation purpose. Climate change and ground water depletion is a serious challenge and it will negatively impact the irrigation water availability (Mahajan *et al.* 2011) that will drastically affect the sustainable rice production. In rice growing regions, availability of the farm labour during the peak period is challenging which impact the crop production. In response to all these challenges, different new production techniques are developed and implemented by the scientific community. However, the use of chemical fertilizers, pesticides and development of high yielding varieties showed increase in rice production in each successive year, application of these inputs has increased the cost of cultivation for rice. Considering all these challenges, different production techniques are developed such as; system of rice intensification (SRI), Alternate wetting and drying (AWD) and Direct seeded rice (DRS) etc. These techniques are considered to have great influence on rice production and have potential to withstand all these challenges. Any changes in the cultivation practices have their key implications which impact crop management practices like primary and secondary tillage, nutrient management and irrigation management etc.

Crop growth as influenced by crop establishment methods

Considering the importance of agronomic practices modification in crop management practices are being evolved in agriculture with time. Various crop establishment methods offer their advantages

through their management practices in terms of labour, water and fertilizers input etc. System of rice intensification is an improved method for rice cultivation developed by Fr. Henri de Laulanie at Madagascar in 1983. The SRI methods consists several principles and practices like transplanting of young seedling, wider spacing and keeping the soil moist through alternate wetting and drying etc., all these practices offers their advantages in different terms. Rice cultivation through system of rice intensification saves up to 37 % irrigation water (Sigh *et al.* 2013) and have capability to produce 26 % higher yield over conventional methods if basic principle are followed (Barah, 2009). Crop plant absorbs N fertilizer more efficiently under SRI than that of conventional method as a result SRI supports better physiological functioning of plants and reduce fertilizer cost (Thakur *et al.* 2013).

Traditional method is well known and highly practiced methods in India. There are several research evidences that reported cultivation of rice through traditional methods is water demanding, labour intensive and requires higher seed rate and inputs for rice cultivation. Alternate wetting and drying is one of the principle followed in SRI and also considered as a method for rice cultivation. According to Ishfaq *et al.* (2020) alternate wetting and drying is a promising, profitable, and eco friendly technology for rice cultivation across the globe and can be practiced in water scare areas, Al Mamuna *et al.* (2023) reported that AWD utilizes 15.36 per cent reduced irrigation water. Direct seeded rice is a method for rice cultivation where rice is directly sown in field rather than establishing nursery and transplanting. DSR offers advantages in terms of productivity and water saving but there are several disadvantages also. According to Farooq *et al.* (2011) DSR can be an attractive option to replace conventional methods due to global water scarcity and escalating labour prices.

Growth attributes

Plant growth attributes are important components and growth index to assess the crop performance which directly influences the crop productivity. The crop establishment methods and management practices significantly influence the growth parameters like plant height, tillering, leaf area index (LAI), and growth indices such as CGR, RGR and NAR etc. Shridevi *et al.* (2015) system of rice intensification significantly enhanced the plant growth and all the growth attributes over conventional method. SRI and alternate wetting and drying practice in rice improve root development resulted in enhanced physiological growth of crop plant (Veeresh *et al.* 2018). Early transplanting in SRI helps in better seedling establishment and also responsible for higher tiller production. Wider spacing in SRI produce more leaves and higher leaf area which increased the photosynthetic rate and results in increased plant height (Shriame *et al.* 2000).

Transplanting methods had a significant effect on plant growth, Theerthana *et al*, (2021) in their study reported that manual transplanting of rice shows better establishment of seedlings and increased plant growth. The AWD with manual transplanting proved to save water and record significantly higher LAI, CGR, NAR and LAD. Alternate wetting and drying practice keeps the soil moist and aerated which increase the nutrient availability and nutrient uptake. Tillering of rice is major factor that decides leaf area and panicle number per hill. Higher the tiller per hill more will be LAI and effective tiller at maturity. Photosynthesis rate is accounted on the basis of leaf area per hill which is ultimately dependent on number of leaves per hill, higher tillering will produce more number of leaves per hill. AWD is reported to enhance the period of root activity which ultimately increased the tiller number.

According to Kumar *et al.* (2023) transplanted rice produces higher plant height as compared to direct seeded rice during whole growth period and tillers per square meter was produced higher in DSR than that of transplanted rice. Ghasal *et al*. 2014 also reported that 21.8 % and 13.2 % higher effective tillers per square meter were produced in UP-DSR and ZT-DSR respectively over PTR.

Yield attibutes and yield

Yield attributes are important characteristics influencing the final economic yield of the crop. Crop establishment methods affect the yield attributes by various means. Transplanted rice produced greater number of grains per panicle due to sufficient moisture and nutrient availability which results in 11.9 % higher yield over DSR. This is due to loss of water through seepage and percolation and nutrient loss through leaching in DSR whereas; in transplanted rice increased nutrient availability and puddling might have helps to retain water in soil through reduction in percolation losses (Kumar *et al*, 2023). Similarly, Ghasal *et al*. 2014 reported that PTR produced longer panicle, higher number of filler grain panicle but due to higher tiller number, plant height in DSR more competition for nutrient and space may lead to production of shorter panicle length, reduced filled grain and increased number of chaffy grains panicle.

Singh *et al.* (2013) reported that rice cultivated under SRI produce higher grain yield over conventional transplanting. Similarly Al Mamuna *et al.* (2023) also reported that SRI and AWD are capable of producing higher yield over conventional methods and influence the yield attributes positively. Nutrient management practices and crop establishment method make a noticeable impact on growth and yield of rice (Choudhary *et al.* 2022). Establishment methods also influence the input demand of crop, Madhurya *et al.* (2022) normal transplanting with AWD combine with 75% RDN + 25N through poultry manure are effective practices to reduce the water and nutrient input with increasing crop growth and grain, straw yield of the rice.

Nutrient availability in soil is most important factor and directly influences crop growth and yield contributing characteristics. Flooded irrigation or high water level in field affects the rice yield due to sulfide toxins in root zones and reduces the availability of zinc in the soil and ultimately decreases the growth and yield of rice Lan *et al.* (2020). Whereas, nutrient availability is increased in aerated and moist soil conditions. Nutrient extraction from the soil is better in SRI cultivated rice which improves the yield attributes and produce higher yield over conventional method (Barison *et al.* 2011). Moisture content of soil influence behavior of crop according to Sarwar *et al.* (2013) aerobic conditions in rice significantly reduced the crop growth as compared to that of fully-flooded rice. Contrary to these findings Thakur *et al.* (2020) in their study reported that the uptake of macro and micro nutrient was significantly affected by crop management practices implemented. Nutrient concentration was recorded superior in system of rice intensification (SRI) over conventional management practice (CMP). Similar to these findings, Veeresh *et al.* (2018) reported that SRI cultivation method and AWD irrigation management practices in rice contribute to better root growth which contributes to better performance of plant and leading to increased grain yield through enhancing nutrient uptake and increasing the leaf area index which produce more photosynthetic area and wider spacing maximizes the radiation use efficiency.

Relative Economics

The relative economics is important calculation to estimate the net economic return generated from investing on crop cultivation. It represents the efficiency of crop production techniques or any specific treatment combination implemented

for crop production. Various crop establishment methods have their different requirements in terms of inputs required which are subjected to have economic values and accounted as cost of cultivation The cost of cultivation depends on different variables such as, seed rate, labour cost, tillage operation, plant protection and harvesting etc. Basavaraja *et al*. (2008) reported in their study that paddy cultivation through SRI method gives Rs. 23,593 ha^{-1} net returns, whereas, Rs. 9,720 ha^{-1} was recovered in traditional method. Total economic returns depend on current market demand and price for particular crop. According to Padma *et al*. (2023) rice cultivation through SRI require less labour and gives higher productivity offers greater economic returns. Knowing to the fact that seed rate is comparatively less under SRI that also reduces input cost. AWD practices is also subjected to reduce the irrigation water requirement that can also considered for reducing the input cost in rice production through decreasing the labours and electricity charges. Contrary to these results, Sarkar *et al*. (2020) claim that conventional methods is economically feasible, gives higher net return and produced noticeably higher yield over modified SRI and drum seeded rice. In agreement with these findings, Poudle *et al*. (2020) also reported that traditional transplanting method performs better in terms of profitability and productivity. Singh *et al*. (2021) concluded in a study that DSR is more suitable for basmati cultivation in term of economic feasibility than SRI and conventional method.

Conclusion

Various methods for crop establishment offers some advantages and disadvantages that significantly influence the several parameters related to crop growth and economic profit gained from that. From the reviewed paper it can be concluded that SRI performs better in term of plant growth parameters and yield. Among the various crop establishment methods SRI is observed to have higher productivity and economic profitability.

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