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EFFECT OF DIFFERENT CROP ESTABLISHMENT METHODS ON RICE (*ORYZA SATIVA* L): A REVIEW

M.S.Bhagavathi[1], G. Baradhan[1], S.M. Suresh Kumar[1] and S. Arivudainambi[2]
[1]Department of Agronomy, Faculty of Agriculture, Annamalai University,
Annamalai Nagar- 608 002 (Tamil Nadu), India.
[2]Department of Agriculture Entomology, Faculty of Agriculture, Annamalai University,
Annamalai Nagar- 608 002 (Tamil Nadu), India.

Abstract

Rice is an important staple crop in India. Rice is commonly grown by two methods, transplanting one month-old seedlings into puddle soil and direct seeded rice under wet and dry condition. Both these seeding are being performed by manual and mechanical methods. Productivity of rice become reduced in India due to various reasons like improper establishment methods, water scarcity; weed infestation, unpredictable monsoon seasons, poor quality seeds etc. This review article throws light on some important aspects on effect of different rice establishment methods on growth, yield, nutrient uptake and economics rice (*Oryza sativa* L.). References from various research article and literature were compiled systematically with respect to the topic. An attempt has been made to review the effects of different establishment methods on rice crop.

Keywords: Machine transplanting, Drum sowing, SRI and dry seeded rice.

Introduction

Rice is the most important staple food crop of the largest number of people on earth. Developing countries accounts for 94 per cent of the total production, with India and China alone responsible for nearly half of the world output. In India, rice cultivated on about approximately 43.5 m ha area with production of 112 million tonnes and productivity of 2.62 t ha^{-1} (USDA, 2017). Manual transplanting under puddled condition is the most common practices of rice establishment (Baldev *et al*., 2013). Transplanting has many methods like manual line and random planting, mechanical transplanting, system of rice intensification. Direct sown can be classify into wet direct seeding and dry direct seeding. Drum seeding is a method of direct sown rice system. Transplanting and direct seeding are two common methods of rice establishment in the world. The assumption of direct seeded rice system is highly constrained as the crop face severe weed infestation. Rice yield may extremely decline in direct seeded rice system if weed management is not done properly. But the weed problem is not a major issue in transplanted rice because of puddling of soil eliminates the weeds before transplanting. Increasing water scarcity and weeds are becoming real threat to rice cultivation. In such a situation it is a necessary to develop the water saving technology for rice cultivation. SRI method has found to save 22 to 38 per cent of water respectively during dry and wet season over other method of rice establishment (Singh *et al.,* 2015). The system of rice intensification is a one of the method of transplanted rice cultivation by manipulating the genetic potential of rice provides a favorable growing environment to rise the productivity and economic returns. Besides it enhance the soil health with reduction in inputs use such as seeds, water etc. (Shiv Singh Kirar *et al.,* 2018).

Direct sowing under dry condition

Berry *et al*. (2004) reported that the direct seeded rice is more affected to lodging as compared to puddle transplanted rice. When the crop affected by lodging makes the harvesting of the crop difficult and also reduce yield and impairs the quality of rice. Aslam *et al.* (2008) opined that the conventionally transplanted crop obtained the highest plant height (130.2 cm) while the lowest was obtained from direct dry seeding (126.6 cm) because of mutual competition for space, sunlight and nutrient in direct seeding method. Singh *et al.* (2009) found that the agriculture contributes in the emission of carbon dioxide (CO_2) methane (CH_4), and nitrous oxide (N_2O) and these three green house gases contributes to the global warming. The reduction of methane emissions ranged from 30 to 58 per cent in dry direct seeded rice compared to conventional transplanting under puddle condition (Pathak *et al*., 2009). Kreye *et al.* (2009) noticed that yield decline in direct seeded rice which may be due to various reasons like soil sickness, plant autotoxicity and continuously growing direct seeded rice for more than two years. Mahajan and Chauhan (2013) recorded that the in direct seeded rice weed control at initial 30 to 45 days are very crucial owing to slow growth of plants and poor canopy coverage by the crop. Dry sowing rice suffer more from weed infestation than transplanted rice because transplanted seedlings have a competitive advantages over early weeds in early vegetative growth stage (Singh *et al.,* 2016). Chakraborty *et al.* (2017) claimed that the DSR is a labour and water saving cultivation technique, therefore it is not surprising that the overall DSR yield was 12 per cent lower

than transplanted rice. Kumar and Harikesh (2018) stated that the labour requirement for land preparation is lower in DSR saving upto 13-29 per cent compared with conventional transplanting under puddle condition but labour use is higher for controlling weeds in DSR than transplanted rice.

Drum sowing of rice

Singh and Singh (2010) opined that the rice establishment by drum seeding method had minimum NPK uptake by weeds and minimum density of grasses, broad leaved weeds, sedges and maximum weed control efficiency (67.02%). Uday *et al*. (2016) stated that drum seeder is that row-row spacing can be easily maintained and effective mean for timely sowing of rice, dropping of seeds in hills is possible. Revathi *et al*., (2017) found that lower grain yield was obtained with drum seeded rice 3756 kg ha^{-1} at rabi 2011-12 and 3466 kg ha^{-1} at rabi 2012-13 respectively, it was mainly due to that higher weed infestation leads to severe crop weed competition at early stage of crop which resulted in reduced yield. Chinnam *et al.* (2018) evaluated that the direct seeded of rice by using eight row drum seeder at 20 cm row spacing is an alternative method of paddy cultivation, and proven to be good method under late sown conditions.

Machine transplanting

Transplanting of rice is either done by mechanically or by manually. Transplanting rice seedlings by hand is most common practice among Indian farmers. Singh and Vatsa (2006) stated that the transplanting is done with mechanical transplanter seedlings are transplanted at uniform depth and spacing thereby get establishment faster producing more number of tillers (16.8 tillers $hill^{-1}$) when compared to manual transplanting. Gangwar *et al.* (2008) opined that effect of different rice establishment methods on yield of rice crop and stated that yield of rice under mechanical transplanting and manual transplanting was statistically at par however, the grain yield was differ significantly better in mechanical transplanting under puddled condition higher being recorded in mechanical transplanting under non-puddled condition. Aswini *et al.,* (2009) recorded that the twenty days old seedlings were most suitable for machine transplanting method and also it was necessary for optimize the age of seedlings for minimizing root damage for proper functioning of the transplanters. Pasha *et al.,* (2012) estimated that the yangi eight row transplanter recorded highest grain yield (5600 kg ha^{-1}) due to more tillering ability, filled grains $panicle^{-1}$, more number of panicle $hill^{-1}$ compared to conventional transplanting. Mechanized transplanting recorded the highest leaf are index (4.14) which statistically similar to manual transplanting (3.78) (Raj *et al.,* 2013). Manesh *et al.* (2013) observed that the grain yield increased with self propelled walk behind type and self propelled four wheels type transplanters over farmers practices. Baldev *et al.* (2013) noticed that the mechanical transplanted rice produced 3 per cent to 11 per cent higher grain yield compared with conventional puddled transplanted rice.

Gill and Walia (2013) claimed that yield attributes like panicle length (25.8 cm) and test weight (22.6 g) were statistically at par among different establishment methods in rice, but grains $panicle^{-1}$ (142.1) was significantly higher with machine transplanted rice. Vasudevan *et al.* (2014) stated that transplanting of paddy seedling with suitable mechanical transplanter seems to be most appropriate avenue as it save much of the labour requirement minimizes drudgery and attains optimum plant density that contributes to high productivity. Nagalur and Halepyati (2017) reported that the planting of twenty five days old seedlings was found to be the best seedlings age over 20 and 30 days for transplanting by self-propelled mechanical transplanter. Planting of 3 to 4 seedlings per hill was optimum for transplanting with self-propelled mechanical tranplanter when compared to 5 to 6 and 7 to 8 seedlings per hill. Hossen *et al*. (2018) successfully developed a conventional rice transplanter for transplanting which could be used for both puddled and non-puddled condition of soil and also there is no significant yield differences using the transplanter for both puddled and non-puddled transplanting system. The self-propelled eight row transplanter recorded a average value of the unproductive hills, planting efficiency and field efficiency observed were 9.95 per cent, 89 per cent and 68.2 per cent respectively (Samal *et al.,* 2020). Nikita *et al.* (2020) concluded that the machine transplanting worked satisfactorily and it has the ability to perform well in rice transplanting, ploughing and clod crushing with proper way.

SRI planting

San-oh *et al.,* (2002) opined that rice single seedlings $hill^{-1}$ produced better root system and produced more dry matter than three seedlings $hill^{-1}$ and wider the spacing provided the tillers $hill^{-1}$ produced are higher (44) than closer spacing. Barison (2003)noticed that the SRI plants had greater root length density in the lower soil horizons (0-20 cm) compared with roots of plants of the same variety conventionally grown in the same soil and it was 2.5 times more at 30 to 40 cm depth, and 3.9 times more at 40 to 50 cm depth. Hossain *et al.,* (2003) reported that the highest grain yield of SRI planting method was mostly the outcome of higher total number of tillers $hill^{-1}$, highest panicle length and highest number of grains $panicle^{-1}$. Viraktamath (2007) opined that the SRI method has been found to save 22 and 38 per cent water respectively during dry and wet season over conventional method. Rajeshwar and Khan (2008) stated that the highest grain yield of 6735 and 6125 kg ha^{-1} was under the SRI method of planting compared to the conventional method. The crop raised with SRI technique registered yield superiority of 15.47 and 19 per cent over farmers practices during 2006 and 2007 respectively (Hussain *et al.,* 2009).Studies of the Gujja and Thiyagarajan (2009) recorded that SRI method of transplanted rice cultivation by exploting the genetic potential of rice a favorable growing environment

to improve the productivity and economic returns and it enhances soil health with reduction in several inputs like seeds, water etc.

Manjunatha *et al*., 2010 found that the SRI method of transplanting resulted in significantly higher grain yield (6.34 t ha^{-1}) when compared to the conventional method (5.10 t ha^{-1}). Thakur *et al*., (2010) stated that dry weight of above ground parts (56.58 g), root length (73.78 cm), root volume (47.48 cm) of individual hill under modified SRI was greater than that of conventional practices and SRI registered 218 grains $panicle^{-1}$ and 22.6 cm length of panicle. SRI registered a mean grain yield of 6082 kg ha^{-1} which was significantly higher than conventional method of rice cultivation (5223 kg ha^{-1}). Mohanty and Mohanty (2010a) observed that SRI method of establishment with cono weeding at 10 days interval starting from transplanting after 10 days increased the grain yield. Ponni Priya *et al.,* (2010) opined that the length of panicle and number of grains panicle significantly higher under SRI than conventional practices of rice cultivation. Anitha and Chellappan (2011) recorded that the higher yield attributes like number of productive tillers m^{-2}, length of panicle and number of grains $panicle^{-1}$ resulted in higher grain yield in SRI. Karmakar (2011) stated that the SRI is boon for small and marginal farmers as to reduce the input cost of seeds by 62 per cent and irrigation water cost 40 per cent, reduced the fertilizer cost by 31 per cent and improve the production by 36 per cent over the conventional transplanting. Chapagain *et al.* (2011) reported that the SRI practices showed significant response on root number, number of effective tillers $hill^{-1}$and harvest index.

Prabha *et al.* (2011) observed that the management practices followed in SRI method of cultivation produced significantly more number of panicle m^{-2} and number of grains $panicle^{-1}$, the yield was increased by 19.6 per cent when compared to traditional way of rice cultivation. Iswandi *et al.,* (2011) noticed that root mass, root density and root volume were higher with SRI cultivation than conventional transplanting. Sridevi (2011) found that the SRI planting with two way rotary weeder weeding thrice at weekly interval starting from 15 DAT in transplanted rice produced more number of tiller m^{-2}. Dass and Chandra (2012) documented that SRI method of transplanting recorded higher grain yield 2.76 t ha^{-1} over conventional transplanting and better partitioning harvest index. Duttarganvi *et al.* (2014) recorded that significantly higher root length (32 cm), tillers $hill^{-1}$ (36), leaf ara $hill^{-1}$ (320 cm^2), panicle $hill^{-1}$ (24) and grain yield (5.93 t ha^{-1}) were recorded under SRI as compared to conventional transplanting method. Rajiv Dubey *et al.* (2017) claimed that the among the rice establishment methods SRI was the most viable and obtained higher grain yield and better weed control than the transplanted rice. Divya Pyngrope *et al.* (2019) opined that the adoption of SRI recorded 638 number of productive tillers m^{-2} which was significantly higher than the conventional method of rice cultivation (507). Santosh *et al.,*(2020) observed that the SRI method of crop establishment exhibited highest average number of tillers m^{-2} (294.4), highest average effective number of $tillers m^{-2}$ (254.8), highest average thousand grain weight (22.87 gm), highest average panicle length (25.53cm), highest grain yield (4.475 t ha^{-1}) and low sterility percentage (16.73).

Effect of nutrient uptake under different rice establishment methods

Revathi *et al.* (2012) reported that the highest removal of N, P, K by weeds in drum seeding method due to the reason that weed growth is faster in direct method of rice establishment. Highest N, P and K in grain yield and straw uptake recorded in SRI which was significantly not difference with conventional transplanted method due to SRI uptake from deeper and proliferate root system to more nutrients (Arunbabu and Satya, 2014). Mitali Kumar Sah *et al.,* (2019) claimed that the grain yield of rice increased with increasing N dose upto 12 kg ha^{-1} in direct seeded rice and transplanted rice. Ranjan and Yadav, (2019) reported that the appropriate doses of N fertilizer and establishment methods are the need for improving nitrogen use efficiency in rice results lowering N fertilizer application with same level of yield.

Economics of the rice under different crop establishment methods

Chaudhary *et al.* (2005) found that the self propelled rice transplanter gave net profit of Rs. 1149 and Rs.1419 ha^{-1} when annual use of machine was 300 h (one season) and 500 h (two season) respectively. Chellamuthu and Sridevi (2006) stated that the combination of young seedlings, single seedlings, square planting and cono weeding registered the highest net return (12, 594 ha^{-1}) and BCR compared to conventional practices. Sanjay *et al.* (2006) opined that the transplanting recorded higher gross income (Rs. 31,158 ha^{-1}) compared to broad casting (Rs. 22,032 ha^{-1}). Sharma *et al.,* (2006) observed that the transplanting of rice by self propelled transplanter gave maximum B:C ratio (1:47) and net monetary return (Rs. 44, 559 ha^{-1}) compared with manual transplanting (Rs. 42,035 ha^{-1}) and proved better than other method of rice establishment. Barah (2009) claimed that the average cost of production has been worked out to be Rs 240 q^{-1} of rice under SRI practice and Rs. 365 q^{-1} under conventional practices with an advantage of 26 per cent in cost of production. Hugar *et al.* (2009) noticed that the maximum total grain productivity (13,750 kg ha^{-1} yr^{-1}), net profit (Rs. 79,912 ha^{-1} yr^{-1}), B:C ratio (2.13) were recorded with SRI method of rice cultivation.

Jayadeva *et al.* (2010) reported that the method of SRI had more economic advantage in terms of gross return and B:C ratio (67,578 ha^{-1} and 2.62) as compared to manual transplanting. Mohanty and Barik (2010b) observed that the BCR of rice transplanter and manually transplanting was 2.88:1 and 1.78:1 respectively, Sajitha Rani and Jayakiran (2010) registered a higher net returns with B:C ratio of 2.81

compared to manual transplanting. Singh and Rao (2012) opined that the average net return were Rs. 19,798 ha^{-1} and Rs. 27,462 ha^{-1} in traditional and self propelled paddy transplanting methods of paddy cultivation. Munnaf *et al.* (2014) reported that the net return of manual and mechanical transplanting method was Rs. 42,310 and Rs. 61,080 ha^{-1}. The benefit cost ratios were 2.26 and 1.79 for mechanical method of transplanting and manual method of transplanting. Choudhary and Suri (2018) found that the SRI has a higher benefit cost ratio than conventional transplanting practices. Saddam *et al.* (2019) claimed that the SRI gross return (Rs. 1,29,000.5 ha^{-1}) and net return(Rs. 67,050.5 ha^{-1}) was higher than the conventional method (gross return Rs. 78,444 ha^{-1} and net return Rs. 27,168 ha^{-1}) of rice cultivation.

Conclusion

Now a days different types of establishment practices are followed for rice cultivation. For example direct methods like 1. Drum sowing, 2. Wetsowing, 3. Drysowing and transplanting methods like 1. SRI and 2. Machine transplanting. Based on the area, climatic condition, availability of the resources it will become varied. Conventional transplanting is the popular establishment method but now a day it was very cost effective due to nursery raising, transporting of seedling to the main field and transplanting. During the peak period time of farm operation the availability of labour become scarce, at the time the farmers are switching to direct seeding rice cultivation methods and machine transplanting is also one of the alternative method at particular period of rice cultivation. Sustainable rice productivity also increased by adopting the new methods like system of rice intensification. SRI is better options of crop raising as it saves considerable labour, time and water requirement and also there is the possibility for increasing the cropping intensity and also recorded significant yield improvement when compare to the conventional practices.

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