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# **Chapter 01**

# **Introduction**

The Asian rice (*Oryza sativa*) can be classified as the foremost cereal crop in Sri Lanka. The rice cultivation is distributed in most parts of Asian countries which is more than ninety per cent of the lands total cultivated lands extent as the staple food. Rice act as the principal contributor of Sri Lankan rural economy. Sri Lanka is a developing country with estimated total land devoted for cultivation is about 792,000 ha (Central Bank of Sri Lanka, 2017). The national average rice yield of Sri Lanka in kilogram per net hectare is 4,349 in Maha and 3092 in Yala season (Department of census and statistics, 2016). And also the annual per capita consumption of the rice is 105kg (Lanka, 2008). According to the annual report of the Central Bank of Sri Lanka in 2017 about 748,000mt rice imported to our country. The demand for the rice is increasing rapidly due to the increment in the population and the per capita rice consumption. The production and the productivity of the rice should be increased rather than increasing the cultivated land extent through better field practices to meet the increasing demand of rice(Dushani and Sandika, 2009)

The cultivation of rice is practised in all the parts of the country as a wetland crop except at the high altitudes, which act as the principal contributor on the rural economy (Henegedara, G.M., 2002). Mainly two cultivation seasons known as Maha and Yala which are equivalent with two monsoons are practised in Sri Lanka. In generally transplanting and the direct seeding of rice are the two main methods of rice cultivation practised in Sri Lanka considering the variations in different ecological regions at where rice is cultivated. The sowing of seeds directly in the field is practised in direct seeding method and the seedlings are raised in seedbeds and then planted in the field in the transplanting method.

In Sri Lanka DSR is practiced by more than 95% of total land extent devoted for rice cultivation as it is considered as an alternative option to lack of sufficient labour force and high cost for labors at the peak transplanting period which cause delayed transplanting and reduced yield in transplanting method (Weerakoon et al., 2011; Santhi et' al., 1998). The problems associated with DSR are, no proper spacing, management practices are difficult and most disastrous problem is the invasion of weeds and weedy rice (Gunawardana et al., 2013; Marambe, 2009). As a solution for this farmer tends to use agrochemicals to control weeds which is not an environmentally friendly practice.

Transplanting is commonly practised in most parts of the Asian countries (Mabbayad and Bordo, 1971). Transplanting of the seedlings on the puddled soil can be done manually as rows or randomly and through machine transplanting. Transplanting of rice gives a significantly higher yield than the direct seeding as it produces more number of productive tillers which bares panicles with an increased number of spikelet’s than the direct seeded rice plants (Fan et al., 2003). Although the labour intensity and labour costs are high in transplanting compared to the direct seeding of rice, highest yield and income is reported from it(Manjappa and Kataraki, 2004; Rani and Jayakiran, 2010).

As the most feasible solutions to increase the yield from rice cultivation proper nursery management practices which gives vigorous seedlings and transplanting of them at the correct time can be used. Mainly in Sri Lanka transplanting is done using dapog nurseries, parachute nurseries, wet bed and dry bed nurseries.

Mechanical transplanting of rice is the best solution for the problems with transplanting method including high labor intensity and delayed transplanting of seedlings. Mechanical Transplanting is the method of transplanting the seedlings which are raised on trays or mats uniformly with optimum plant density and less transplanting shock compared to other transplanting methods, using self-propelled mechanical transplanter. The self-propelled walk behind type transplanter is considered as a popular transplanter among the farmers in Asian countries which gives significantly increased the rice yield. A plastic tray is introduced to as nursery trays in modified dapog nurseries which is compatible with the dimensions of the feeding platform in the transplanter, to increase the convenience of handling seedlings, rather than using mat type nurseries which needed to be cut into parts according to the size of the feeding platform. Although the Ministry of Agriculture and the Department of Agriculture implemented programmes to promote the Mechanical Transplanting in Sri Lanka, very low adaptability of farmers to this method due to the constraints with nursery establishment, lack of technical knowledge and socio-economic reasons. So, it is a timely requirement to do studies on efficient utilization of the mechanical transplanter and introduced them to the farmers to increase the rice production. As introduced recently there is no recommended seeding rate to be used in the nursery trays used for Mechanical transplanting, it is understudied. Generally, use seeding rate between 60g - 150g per tray (ALIZADEH et al., 2011; Columbia and Division, 2013; Saiful Islam and Khan, 2017).

Seeding rate can be defined as the amount of the seeds from an individual plant species required to achieve optimum seedling density in the nursery with an increment in the vigor of seedlings (Louisiana, 2009). The seedling vigor is the ability of the plant to emerge from the substrate rapidly and cover the ground surface rapidly (Deseo, 2012). Planting of vigorous seedlings is important factor on the early plant growth of the plants after the establishment which increases the number of productive tillers and the rice yield per unit area by decreasing the mortality rate of seedlings due to the transplanting stress (Panda et al., 1991; Tekrony and Egli, 1991).

Following proper nursery management practices is very important factor which affects on the seedling vigor and early plant growth of rice after field establishment in all the transplanting methods. Studies on the optimum seed rate for the nursery trays of Mechanicaly transplanted rice on seedling vigor and the early plant growth of rice have not been yet investigated properly in Sri Lanka. The main intention of this study is to identify the optimum seeding rate for the nursery trays use for mechanical transplanting and compare the seedling vigor and early plant growth with direct seedling, wet bed nurseries used for random transplanting and with parachute method of transplanting.

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## **1.1 Objectives**

### **1.1.1 General**

To identify the optimum seeding rate in nursery trays for Machine transplanting and comparison of seedling vigor and early plant growth with other nursery methods

### **1.1.2 Specific**

To find out the effect of seeding rate on different growth parameters of the seedlings in modified dapog nursery trays.

To identify the effect of different nursery methods on the vigor of the seedlings and early plant growth.

# **Chapter 02**

# **Literature Review**

## **2.1 Rice plant**

**Rice cultivation in the world**

The task of producing the additional rice to meet the expected demands of the year 2025 poses a major challenge. The danger is that stability in rice production is linked to social and political stability of the countries in the Asia-Pacific Region (Hossain, 1996). The scope of area expansion in some countries is offset by the reduction in rice lands in major rice producing countries. So

The question turns more problematic when we think that production increases have to be realized annually using less land, less people, less water and less pesticides. T

The research scientists should understand well the farmers’ constraints to high rice productivity and provide them with appropriate technological packages for specific locations to bridge the gap under participatory approaches (IRRI, 1998; Price and Balasubramanian, 1998). The extension service should ensure that farmers use correctly and systematically recommended technological packages (ICMPs) in the rice fields, through effective training and demonstrations. For

Bridging the rice yield gap in the Asia-Pacific Region

Crops can be established using dry seed, pre‐germinated seed and seedlings. The most suitable planting technique depends on locality, soil type, and crop ecosystem. Crops can be direct seeded by hand broadcast, dibbling, line sowing or drilled using a machine in both wet and dry soil. Transplanted crops can be established manually, either in rows or randomly, or by machine. Direct seeded crops tend to mature faster than transplanted crops but often face more competition from weeds.

Rice Production Manual

The important reasons for low rice yield include water shortage, weed infestation, prevalence of insect pests and diseases and inappropriate sowing method leading to low plant population. Low plant population can be optimized using a proper sowing method.COMPARISON OF DIFFERENT PLANTING METHODS FOR OPTIMIZATION OF PLANT POPULATION OF FINE RICE ( Oryza sativa L .) IN PUNJAB ( PAKISTAN )

## **2.2** **Rice cultivation in Sri Lanka**

Agriculture can be named as the backbone of Sri Lankan economy on which one third of the rural population depends on (Dushani and Sandika, 2009). Among the agricultural crops rice, is the main contributor for the rural economy which occupies more than 72% contribution on livelihood of them (Henegedara GM, 2002).

Rice is the principle con- tributor of the rural economy as the majority (72%) of rural households is engaged in production of rice as their main and supplementary source of live- hood (Henegedara 2002). Rice is the main crop cul- tivated by the majority of farmers in rural areas and it is the staple food of the 18.6 million inhabitants of Sri Lanka. Further, it is the livelihood of more than 1.8 million farmers. Rice contributes 1.8 % of country’s GDP (Central Bank 2008). Rice is culti- vated in almost all parts of the country, except at very high altitudes, as a wetland crop (Henegedara 2002). The annual per capita consumption of rice was

around 92 kg in 1998 and it was dependent on the paddy production in the country and the price of imported wheat flour.

The main difference between the two methods are direct seedling method, the seeds are sown directly in wet or dry field, whereas in transplanting method, seedling are first raised in seedbed in the nursery and uprooted for transplanting manually or mechanically. Development and performance

Over 75% of the world supply is consumed by people in Asian countries and thus rice is of immense importance to food security of Asia. The demand for rice is expected to increase further in view of expected increase in the population.

Biology of Rice.Pdf

Rice plant

The Rice (*Oryza sativa* L.) is among the world wide cultivated cereal crops in the world which is next to the wheat

Oryza sativa was first cultivated in south-east Asia, India and China between 8 000 and 15 000 years ago (OECD 1999; Normile 2004).

Rice is also grown from sea level to 3 000 m and in both temperate and tropical climates. A variety of water regimes are used, including unsubmerged upland rice (10% of total cultivation), moderately submerged lowland rice (irrigated, 45%, or rain-fed, 30%), and submerged rice (up to six m of water, 11%, or floating, 4%). Rice can grow in a wide range of soil types as well, including saline, alkaline and acid-sulfur soils (Takahashi 1984b; Oka 1988; Ahn et al. 1992; OECD 1999

The genus Oryza belongs to the tribe Oryzeae of the family Poaceae (http://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi). There are 12 genera within the Oryzeae tribe (Vaughan 1994). The genus Oryza contains approximately 22 species of which 20 are wild species and two, O. sativa and O. glaberrima, are cultivated (Vaughan 1994).

O. sativa is the most widely grown of the two cultivated species. It is grown worldwide, including in Asian, North and South American, European Union, Middle Eastern and African countries. O. glaberrima however, is grown solely in West African countries. O. sativa and glaberrima-sativa hybrids are replacing O. glaberrima in many parts of Africa due to higher yields (Linares 2002)

The Biology and Ecology of Rice ( Oryza sativa L .) in Australia

Rice (Oryza sativa L.) is grown successfully in regions having the necessary warmth and abundant moisture favourable to its growth, be it under lowland or upland condition. It is one of the most important and indispensable caloric cereal food crop in Ghana. Beyond providing sustenance through growing, earning income and consuming, rice plays an integral, but important cultural role in many rural communities of Ghana

“ DIGANG ” RICE ( Oryza sativa L .) UNDER UPLAND CONDITION OF BAWKU , UPPER EAST REGION , GHANA

## **2.4 Constrains with Rice Cultivation in Sri Lanka**

low yield of transplanted rice, poor nursery management seems to be a major cause due to which seedlings cannot perform well after transplanting in the main fiel

Influence of Nursery Management and Seedling Age on Growth and Economic Performance of Fine Rice

rice cultivation is a labor-intensive task that could not be accomplished easily. Land preparation, transplanting and harvesting are the expensive and time- consuming operations for successful rice cultivation. Tray soil

Labor cost accounts the biggest input cost for rice production (Clayton, 2010).

There is a need to explore establishment methods (EM) that require less labour but still allow the crop to be transplanted on time since labour scarcity has emerged as a serious problem in rice cultivation in Sri Lanka. Direct seeding (DS) is practiced as a solution but, apart from irregular stand establishment, the most disastrous constraint in DS is the invasion of weeds and weedy rice (Marambe 2009; Gunawardana et al., 2013). Use of herbicide in controlling weeds in DS is effective but excessive use is costly and causes problems such as ground water contamination, development of herbicide- resistant weed populations. Optimizing plant density and timeliness of operation is considered essential for optimizing yield in rice cultivation (Chaudhary et al., 2005). Hence, mechanical transplanting (MT) is one of the feasible alternatives in eliminating weed problem in DS and huge labour use in transplanting while facilitating the timeliness crop establishment.

Impact of varieties, spacing and seedling management on growth and yield of mechanicaly transplanted rice

Industrialization, migration of agricultural labor to other job and high labor wage are the threat for sustainable rice production as well as food security. Labor crisis and high wage is particularly critical during peak labor-need periods, which typically occur during rice transplanting and harvesting. Tray soil

To overcome these, farm mechanization has been considered as an important remedial measure. In recent time, transplanting and harvesting machinery are considered top priority for sustainable rice production.

Agricultural machines have replaced human force in many rice cultivation practices such as land preparation, transplanting, harvest, and post-harvest process in many developed countries. Though land is Prepared mechanically but seedling raising and transplanting is still done traditionally in Bangladesh. About 156 man-days per hectare are required for producing rice. Forty five man-days are consumed for seedling raising and transplanting which is about 29% of the total labor requirement. Tray soil

Mechanisation of small holding will play an important role in increasing rice production.status and prostpectus

Manual paddy transplanting is the tedious, laborious and time consuming operations requiring about 250-300 man h ha-1 which is roughly 25% of total labor requirement of rice production [11]. Mufti AI, Khan AS. 1995. Performance evaluation of Yanmar paddy transplanter in Pakistan. Agricultural mechanization in Asia, Africa and Latin America. 26 (1): 31-36. status and prostpectus

At transplanting time, there is acute shortage of labour. This results in increased labour wages and a delayed transplanting operation. In some cases, a proper crop stand is not maintained by the hired labour. Hence there is an urgent need to have mechanization in rice production which will result in reducing the labour work and time consumed. Mechanical transplanting to release the work force and to reduce the cost of paddy production. Farmers are aware of the advantages associated with transplanting of paddy over the broadcasting. But they are unable to practice it for high scarcity of labor. The transplanting machines available in the country are imported. They are costly and unable to meet the plant geometry.

development and performance evaluation

Proper seed rate is not maintained and non uniform seed delivery observed many times. This leads to uneven plant stand.development and performance evaluation

basis. Manual transplanting takes longer period to complete transplanting operation. Therefore, major constraints are the high cost of manual transplanting and uneven plant population. Singh et al. (1985)studied the response of rice to different planting methods. development and performance evaluation

Timeliness of transplanting is essential for optimizing the yield and this can only be achieved through mechanical transplanting. A delay in transplanting reduces the yield. development and performance evaluation

t was reported that a delay in transplanting by one month reduces the yield by 25% and a delay of two month reduced the yield by 70% (Rao and Pradhan, 1973). There Techno-economic performance of 4-row self-propelled mechanical rice transplanter at farmers field in Bangladesh

crisis of labour

Crisis of labor has created an unusual situation. The farm owners have to find the labors going door to door or they have to wait for the labors to finish the work in the nearby fields. Sometimes, they have to hire labor offering extra wages with additional facilities. As a result, the scheduled time of transplanting paddy expires in many places. Under such circumstances a less expensive and labor saving method of rice transplanting without yield loss is the urgent need of the hour (Tripathi et.al., 2004). Techno-economic performance of 4-row self-propelled mechanical rice transplanter at farmers field in Bangladesh

Because of the good off-farm employment opportunities available in the area and the prevailing hot season, the persons already engaged in non-farm jobs are generally reluctant to perform rice transplantation.Therefore, frequent shortage of labour always has been reported during the season. The other common problems associated with the rice transplantation by hired labour are lower plant population per unit area, improper fixation of nursery plants in the soil, a higher percentage of missing plantation and un-even transplantation in paddy fields, i.e. dense and thin planted patches in the field. Diffusion Possibilities of Mechanical Rice Transplanters

The important reasons for low rice yield include water shortage, weed infestation, prevalence of insect pests and diseases and inappropriate sowing method leading to low plant population. Low plant population can be optimized using a proper sowing method.

Direct seeded rice: purely a site specific technology

Though a contract system for undertaking transplanting evolved during this period, the careless attitude of contract labourers (aggressive pulling of seedlings from the nursery, clipping seedlings and transplanting at more depth with insufficient plant density, etc) to complete the work in the shortest possible time has been affecting the productivity of rice in Bangladesh. Though the work standards have been declining, these contract labourers have started demanding higher wages every year.

Transplanting Rice Seedling Using Machine Transplanter : a Potential Step

The shifting agronomy to direct-seeded rice, necessitated by the

unavailability of labour for transplanting, has exacerbated weed problems such as Echinochloa spp. (Marambe and Amarasinghe, 2002), the sedges (Marambe, 2006) and weedy rice (Marambe and Amarasinghe, 2000; Marambe, 2005). In

WEEDY RICE: EVOLUTION, THREATS, AND MANAGEMENT B. Marambe Department of Crop Science, Faculty of Agriculture, University of Peradeniya, Sri Lanka.

In rice, the planting methods have an impact on

the growth and yield besides cultivation cost and labour requirements

(Sanjitha

Rani and Jayakiran, 2010). “ DIGANG ” RICE ( Oryza sativa L .) UNDER UPLAND CONDITION OF BAWKU , UPPER EAST REGION , GHANA

## **2.4 Direct seeding of Rice**

At present, rice cultivation is as direct seeded in America, Western Europe such as Italy and French, Russia, Japan, Cuba, India, Korea, and the Philippines and in some parts of Iran, due to high technology, high labor cost and shortage of skilled labor (Akhgari,2004).

Direct seeded rice: purely a site specific technology

The area under direct-seeded rice has been increasing as farmers in Asia seek higher productivity and profitability to offset increasing costs and scarcity of farm labor.

Rice is direct-seeded by essentially two methods (dry and wet seeding) based on the physical condition of the seedbed and seed (pregerminated or dry). Dry seeding is practiced in rainfed lowland, upland, and flood-prone areas. Wet seeding is a common practice in irrigated areas, and it is further subdivided into aerobic wet seeding, anaerobic wet seeding, and water seeding, based on the level of oxygen in the vicinity of the germinating seed or the depth of flood- water at seeding. Seeds

Direct seeding offers such advantages as faster and easier plant- ing, reduced labor and less drudgery, earlier crop maturity by 7–10 d, more efficient water use and higher tolerance of water deficit, less methane emission, and often higher profit in areas with an assured water supply. Although labor and its associated costs may be re- duced for crop establishment, other technologies are essential to overcome constraints imposed by direct seeding. For example, we should enhance the interaction of crop stand establishment, water management, and weed control in relation to crop lodging in both dry- and wet-seeded rice. Technology for land preparation, precision leveling, and prevention of crop lodging must be improved in wet direct-seeded rice. Similarly, management practices and control strat- egies are currently lacking for several pests (rats, snails, birds, etc.) that damage surface-sown seeds and for problem weeds that com- pete with rice seedlings

Direct seeding is becoming an attractive alternative to transplanting (TPR) of rice. Asian rice farmers are shifting to direct seeding to reduce labor input, drudgery, and cultivation cost (De Datta 1986, De Datta and Flinn 1986). The increased availability of short-duration rice varieties and cost-efficient selective herbicides has encouraged farmers to try this new method of establishing rice

Dry seeding

The broadcast sowing/row seeding/drilling/dibbling of dry rice seeds on dry (or moist) soil is called dry seeding.

Water seeding

Pregerminated seeds are sown directly into water depths of 20–40 cm

Weed pressure is often two to three times higher in D-DSR than in transplanted crops.

Compared with TPR, the outbreak of insect pests and diseases is more severe in W- DSR because of high plant density and the consequent cooler, more humid, and shadier microenvironment inside the canopy

Direct seeding:research issues and opportunities

Traditionally, rice is transplanted, but consistent increase in labour cost

in recent

times, calls for other planting

methods. As a result of increased labour cost, planting systems is gradually being replaced by direct sowing in many developing countries (Dawe, 2003; Naklang, et al., 1996).

The comparatively low paddy yields recorded especially in pre-germinated seed broadcasting methods than seedling transplanting method could have been due to exposure of seeds to pest destruction and weed competition in broadcast conditions. It could be some of these problems of rice broadcasting that Damkheong, et al., (1980) indicated,

“ DIGANG ” RICE ( Oryza sativa L .) UNDER UPLAND CONDITION OF BAWKU , UPPER EAST REGION , GHANA

Broadcasting Sprouted Seeds in Puddled Land This method is adopted in an area where agricultural labourers are not easily available for

transplanting or some time labourers are very expensive. In this method field is prepared and puddled just like in the case of transplanting. About

(Oryza sativa

Direct

seeding is not feasible due to decreasing water availability for agriculture

Availability of nutrients and moisture in direct seeding has been low due to the presence of more number of weeds and shallow plant root growth (Craigimiles et al. 1968; Ramamoor thy et al. 1974) FP

per panicle was produced by the DSBSW treatment. Less number of grains per panicle in direct seeding might again be explained in terms of low availability of moisture and nutrients at grain formation stage. The availability of moisture and nutrients was low due to the fact that there were more number of weeds in direct seeding and also roots of plant could not penetrate deep enough to exploit the soil resources fully (Jana et al. 1981; Singh et al. 1981).

COMPARISON OF DIFFERENT PLANTING METHODS FOR OPTIMIZATION OF PLANT POPULATION OF FINE RICE ( Oryza sativa L .) IN PUNJAB ( PAKISTAN )

## **2.5 Transplanting of Rice**

Transplanted crops will mature faster in the production field, however they will take 5‐10% longer after establishing the nursery to harvest. Rice Production Manual

Transplanting is widely practiced in most of the Asian

Direct seeded rice: purely a site specific technology

Int. J. Adv. Res. Biol. Sci. (2017). 4(1): 53-57 countries (Mabbayad and Obordo, 1971)

Transplanting using rice transplanter is a cost effective technology. It is a promising technology in due to labor shortage during peak period of rice transplanting Tray soil management

Due to severe weed problem and grazing in lean season the farmers prefer transplanting than direct sowing of seeds. It is a labour intensive operation which requires 200-250 man-h/ha. During peak season labourers are not available. Status and prospectus

The transplanting has number of advantage over direct sowing, as listed below:

1) The time that a crop occupies the land is reduced by 3-4 weeks.

2) Helps the plant a better start over the weeds.

3) Permits optimum plant spacing, which is critical for higher yield.

4) Ensures uniform maturity of the crop.

5) Less seed requirement.

6) Facilitate better weeding and intercultural operations. Development and performance

Appropriate nutrient management, proper seed rate at nursery bed and

then transplanting at suitable age are the key factors to get vigorous stand in main field (Lal and Roy, 1996, Himeda, 1994).

Influence of Nursery Management and Seedling Age on Growth and Economic Performance of Fine Rice

Transplanting produced significantly more number of productive tillers per hill, more number of spikelets per panicle than direct sowing but planting method had no effect on lOOO-grainweight.

Identification of quantitative trait loci for yield and yield components in an advanced backcross population derived from the Oryza sativa variety IR64 and the wild relative O-rufipogon

Although transplanting is the common method of rice production but it is more laborious, cumbersome, time consuming and entails a lot of expenditure on raising nursery, its uprooting, transporting etc., whereas for direct seeding only two man hours are required for the same area (Hashimoto et al., 1976). Careless transplanting by hired labour results in low planting densities in the farmer's field. The scarcity and high cost of farm labour invariably delay transplanting and often lead to the use of aged seedlings (Santhi et' al., 1998).

transplanting gave significantly higher paddy yield (2.77 t ha") than direct seeding (2.30

Transplanting produced significantly more productive tillers hiU-1

(14.51) than direct seeding (8.30).

Number of Spikelets Per Panicle: The number of spikelets panicle'l was significantly affected by the planting method. Transplanting significantly increased the number of spikelets per panicle over the direct seeding method. The maximum number of spiekelets panicle" obtained using transplanting could be due to sufficient amounts of moisture and nutrients available to the plants due to deep penetration and wide spread of roots at the panicle initiation and flowering stages, which eventually resulted in more panicle bearing and more number of spikelets panicle,l. The plants in direct sowing method were at disadvantage due to being shallow-rooted and high infestation of weeds which further reduced the availability of moisture and nutrient to the plants.

Identification of quantitative trait loci for yield and yield components in an advanced backcross population derived from the Oryza sativa variety IR64 and the wild relative O-rufipogon

Maximum number of productive tillersm-2 was recorded in direct seeded rice (3.25.89); (365.67); (380.97) followed by transplanted rice (319.27);

Transplanting of rice required maximum labor resulting in maximum cost of production however planting was delayed due to labor scarcity. Low plant population is the major cause for

low rice (Oryza sativa L.) yields in Pakistan which can be optimized using a proper sowing method. It would be advantageous, if transplanting could be substituted by direct seeding of rice which could result in proper plant population. Direct seeded rice is an alternate option to cope with the problems of water and labor scarcity associated with conventional method (Weerakoon et al., 2011).

A lot of expenditure is required on raising nursery, its uprooting and transporting. Whereas for direct seeding, only two man hours are required to sow the same area.

Direct seeded rice: purely a site specific technology

Paddy transplanting by labour results in low and non-uniform plant population due to which crop yields are reduced

(Mahajan et al., 2009).

Direct seeded rice: purely a site specific technology

For successful rice production, suitable transplanting densi- ties for optimum tillering and essential for improving the growth variables re- sponsible for high yield (Ghosh and Singh, 1998). rowth and yield of rice as affected by transplanting dates and seedlings per hill under high temperature of Dera Ismail Khan, Pakistan.

Transplanting method recorded the highest average yield because the planting distance ensure air circulation, water and light which are basic factors necessary for photosynthesis (Baloch et al., 2002). This is in agreement with reports by IRRI (1984) that transplanting enables optimal spacing, and proper spacing can increase tiller and paddy yield. The

in areas where labour is found, transplanted rice will produce gross economic return than other methods under upland conditions; and even where labour is scarce and costly, transplanting through seedling throwing will give higher yield and income than other methods (Manjappa and Kataraki, 2002; Sanjitha Rani and Jayakiran, 2010).

“ DIGANG ” RICE ( Oryza sativa L .) UNDER UPLAND CONDITION OF BAWKU , UPPER EAST REGION , GHANA

Manual transplanting of rice seedlings into puddled fields is still widely practiced. Transplanted crops require less seed, are better able to compete against weeds but require much more labor to establish. In areas where labor is becoming a problem, mechanical

transplanters are starting to become popular. The total crop duration for transplanted crops will be 5‐10% longer than a direct seeded crop, although the actual time in the production field is be less. The soil type often determines how soon the seedlings need to be transplanted after final working. In many sandy soils, transplanting has to be undertaken within hours of fina

Pulling and transplanting of seedlings is very labor intensive. Depending on soil type, one hectare of rice requires 30 to 40 person days to establish. Seedlings are normally hand transplanted 20 ‐25 cm apart, but this distance may be increased or decreased depending on soil fertility and water supply. The range is normally 15 to 30 cm with 2‐3 seedlings placed in each hill.

Mechanical

Rice Production Manual

can be optimized using a proper sowing method. Transplanting is widely practiced in most of the Asian countries (Mabbayad and Obordo,

1971)

However, an efficient weed management in transplanted rice gave higher economic yields than direct seeding method (Hossain et al. 2002). But transplanting method is more laborious, time consuming and expensive than direct seeding (Hashi-moto et al. 1976). A lot of expenditure is required on raising nursery, its uprooting and transporting. Where as for direct seeding, only two man hours are required to sow the same area

COMPARISON OF DIFFERENT PLANTING METHODS FOR OPTIMIZATION OF PLANT POPULATION OF FINE RICE ( Oryza sativa L .) IN PUNJAB ( PAKISTAN )

No of seedlings per hill, depth, height of plants

Transplanting two to three seedlings per hill under normal conditions is enough. The use of more seedlings per hill, besides not being any additional advantage, involves an extra expense on seedlings. In case of transplanting with old seedlings, the number of seedlings per hill can be increased

The tiller buds formed at the basal node are not suppressed in case of shallow plantings . Therefore, the seedlings should be transplanted at 2 to 3 cm depth. Shallow planting gives better yields. The deeper planting results in an increased height of the plants besides delays and inhibits tillering. The

(Oryza sativa

Number of seedlings transplanted per hill

varies from country to country. While in

Burma, one to four seedlings are transplanted

per hill, in Sri Lanka only one seedling is

used. Usually, 5 to 7 seedlings are

transplanted in Philippines. Results in India

indicated that the number of fertile tillers

were greater with 3-4 seedlings

(Hedayetullaha, 1977).

Planting of different number of seedlings per

hill produced significant influence on rice

growth parameters. Planting of 3-4 seedlings

per hill recorded significantly higher plant

height

Maiti and Bhattacharya

(2011) and Rasool et al., (2013) who reported

that planting of fewer numbers of seedlings

enabled the plant to produce healthy

hill-1

leaves and tillers which had undergone

normal physiological growth and field

duration, resulting in more healthy leaf area

Growth and Yield of Machine Transplanted Rice ( Oryza sativa L .) as Influenced by Age and Number of Seedlings

water height. Seedling tray requirement depended on the space setting adjustment and seedlings dispensed per hill in the field. The tray requirement was reduced with higher space setting. Irrespective of space settings in the transplanter, mechanically transplanted rice produced the higher grain yield than the hand

adjustment and seedlings dispensed per hill in the field. The tray requirement was reduced with higher space setting. Irrespective of space settings in the transplanter, mechanically transplanted rice produced the higher grain yield than the hand transplanted rice. These findings revealed that wider spacing of mechanical transplanter (30 cm) along with tender seedlings

Irrespective of space settings in the transplanter, mechanically transplanted rice produced the higher grain yield than the hand transplanted rice. These findings revealed that wider spacing of mechanical transplanter (30 cm) along with tender seedlings helped to increase the grain yield.

transplanted rice. These findings revealed that wider spacing of mechanical transplanter (30 cm) along with tender seedlings helped to increase the grain yield. Keywords: Tender seedlings, plant

Seedlings dispensed in each stroke: The varietal difference caused variation of the seedlings density in tray which consequently affected the rate of seedlings dispensed per stroke indicated the increase in seedling tray requirement (Fig. 4). Islam (2016) stated that the main objectives

The varietal difference caused variation of the seedlings density in tray which consequently affected the rate of seedlings dispensed per stroke indicated the increase in seedling tray requirement (Fig. 4). Islam (2016) stated that the main objectives of mechanical transplanting are to faster in operation and avoid missing hill. Therefore, seedlings density setting should be

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of mechanical transplanting are to faster in operation and avoid missing hill. Therefore, seedlings density setting should be adjusted to avoid the missing hill.

Plant to plant spacing: Plant spacing is the major

Plant to plant spacing: Plant spacing is the major driving factors affecting productivity. The distribution of plant to plant spacing in mechanically transplanted plot is presented in Fig. 5. Transplanter was operated in three space setting (18.5, 20.0 and 21.5 cm). In actual

Plant spacing is the major driving factors affecting productivity. The distribution of plant to plant spacing in mechanically transplanted plot is presented in Fig. 5. Transplanter was operated in three space setting (18.5, 20.0 and 21.5 cm). In actual field condition, plant spacing was not confined on the setting value due to slippage and skidding of the transplanter. Soil

transplanted plot is presented in Fig. 5. Transplanter was operated in three space setting (18.5, 20.0 and 21.5 cm). In actual field condition, plant spacing was not confined on the setting value due to slippage and skidding of the transplanter. Soil settlement in puddled soils also influenced the plant to plant spacing. The distance between plants determined the tray

field condition, plant spacing was not confined on the setting value due to slippage and skidding of the transplanter. Soil settlement in puddled soils also influenced the plant to plant spacing. The distance between plants determined the tray requirement in a transplanting operation and controlled by the space setting options depending on the seedlings density in

settlement in puddled soils also influenced the plant to plant spacing. The distance between plants determined the tray requirement in a transplanting operation and controlled by the space setting options depending on the seedlings density in trays. In mechanically transplanted plots, plant to plant spacing was obtained between 17-20 cm which was depended mostly

requirement in a transplanting operation and controlled by the space setting options depending on the seedlings density in trays. In mechanically transplanted plots, plant to plant spacing was obtained between 17-20 cm which was depended mostly on soil type, soil settling time, water height and depth of puddling. In manually transplanted plots, plant spacing varied from

trays. In mechanically transplanted plots, plant to plant spacing was obtained between 17-20 cm which was depended mostly on soil type, soil settling time, water height and depth of puddling. In manually transplanted plots, plant spacing varied from 27 × 25 cm.

on soil type, soil settling time, water height and depth of puddling. In manually transplanted plots, plant spacing varied from 27 × 25 cm.

Grain yield influenced by rice transplanter: Effect of plant spacing on grain yield: Grain yield is a function of inter play

Effect of plant spacing on grain yield: Grain yield is a function of inter play of various yield components such as number of productive tillers, spikelets panicle-1 and 1000 grain weight (Partha and Haque, 2011). The line to line spacing was fixed to 30 cm and plant to plant spacing can

Grain yield is a function of inter play of various yield components such as number of productive tillers, spikelets panicle-1 and 1000 grain weight (Partha and Haque, 2011). The line to line spacing was fixed to 30 cm and plant to plant spacing can be varied in mechanical transplanter. During transplanting, three seedlings interval setting (18.5×30, 20×30 and 21.5×30 cm)

and 1000 grain weight (Partha and Haque, 2011). The line to line spacing was fixed to 30 cm and plant to plant spacing can be varied in mechanical transplanter. During transplanting, three seedlings interval setting (18.5×30, 20×30 and 21.5×30 cm) was applied from space setting panel of the transplanter. Yield data of those plots in respect to space setting were compared

be varied in mechanical transplanter. During transplanting, three seedlings interval setting (18.5×30, 20×30 and 21.5×30 cm) was applied from space setting panel of the transplanter. Yield data of those plots in respect to space setting were compared with manually transplanted rice. It was observed that yield was slightly increased with the increase in plant to plant space

was applied from space setting panel of the transplanter. Yield data of those plots in respect to space setting were compared with manually transplanted rice. It was observed that yield was slightly increased with the increase in plant to plant space setting (Fig. 8). El-Kassa by et al. (2012) conducted field experiment on plant density and seedlings age on two cultivars in

with manually transplanted rice. It was observed that yield was slightly increased with the increase in plant to plant space setting (Fig. 8). El-Kassa by et al. (2012) conducted field experiment on plant density and seedlings age on two cultivars in Egypt

transplanted rice for both the variety due to use of tender aged seedlings (Fig. 10). This result is in accordance with the findings of Islam (2016) and Islam et al. (2016b). Makarim et al. (2002) stated that the performance of tender aged seedlings showed better than older seedlings. Tillering influenced the panicle intensity as well as grain yield of rice (Quyen et al.,

findings of Islam (2016) and Islam et al. (2016b). Makarim et al. (2002) stated that the performance of tender aged seedlings showed better than older seedlings. Tillering influenced the panicle intensity as well as grain yield of rice (Quyen et al., 2004). McHugh et al. (2002) and Thiyagarajan et al. (2002) observed that 8-15 day and 10-day old seedlings transplanted at

showed better than older seedlings. Tillering influenced the panicle intensity as well as grain yield of rice (Quyen et al., 2004). McHugh et al. (2002) and Thiyagarajan et al. (2002) observed that 8-15 day and 10-day old seedlings transplanted at 25 hills m−2 showed the highest grain yield in Madagascar and Sumatra. Krishna and Biradarpatil (2009) observed high grain

2004). McHugh et al. (2002) and Thiyagarajan et al. (2002) observed that 8-15 day and 10-day old seedlings transplanted at 25 hills m−2 showed the highest grain yield in Madagascar and Sumatra. Krishna and Biradarpatil (2009) observed high grain yields of 3.25 t ha-1 with 12-day old seedlings than 8-, 16- and 25-day old seedlings and the yield decline of seedlings of latter

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yields of 3.25 t ha-1 with 12-day old seedlings than 8-, 16- and 25-day old seedlings and the yield decline of seedlings of latter three ages was primarily attributed to the reduction in the number of tillers. Younger seedlings could relieve the transplanting stress in a shorter period of time compared to that of older seedlings due to the higher nitrogen content in the former

three ages was primarily attributed to the reduction in the number of tillers. Younger seedlings could relieve the transplanting stress in a shorter period of time compared to that of older seedlings due to the higher nitrogen content in the former (Yamamoto et al., 1998), and the plants’ ability to faster resumption of the rate of phyllochron development (Anonymous,

stress in a shorter period of time compared to that of older seedlings due to the higher nitrogen content in the former (Yamamoto et al., 1998), and the plants’ ability to faster resumption of the rate of phyllochron development (Anonymous, 2004).

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Effect of row spacing of Rice transplanter on seedling requirement and grain yield

### **2.51Wet bed for Random transplanting**

Wet-bed nursery The wet-bed nursery is mainly used in areas where there is enough water. Pre-

germinated seeds are broadcasted on a soil that is thoroughly puddled and leveled. Drainage canals for proper removal of water must be constructed. Addition of organic manure (decomposed) and small amounts of inorganic fertilizer as basal dressing will increase easiness of uprooting of seedlings and seedling vigor. Total seed bed area is about 1/10 of the area to be transplanted and requires about 100 kg of seed paddy per ha. Development and performance of

### **2.52 Parachute method**

A recently developed method for rice transplantation “parachute method” however, over-comes some of these problems in the two traditional methods. It requires less labour, less time and is more efficient. Other

advantages are good and quick stand

establishment, higher tillering and thus higher paddy yield. However, parachute method of rice transplanting requires more skilled labour for nursery raising and transplanting. This study reports a comparison and an

COMPARISON OF DIFFERENT PLANTING METHODS FOR OPTIMIZATION OF PLANT POPULATION OF FINE RICE ( Oryza sativa L .) IN PUNJAB ( PAKISTAN )

### **2.53 Mechanical transplanting**

Farmers could use soil alone as a media for raising seedling for rice transplanter with sprouted or dry seeds. tray soil

Dapog method required area is much smaller than conventional nurseries. Leveled seed bed should be made and center of the bed should be slightly higher than the edge to permit water to drain off the surface development and performance evaluation

cost of transplanting was Rs. 1152/ha and energy requirement was 230 MJ/ha. The maximum grain yield was observed in mechanical transplanting followed by manual transplanting, direct dry sowing and direct sprouted sowing. Mechanical transplanting

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significantly increased grain yield by 23%, 37% and 63%; straw yield by 17%, 14% and 22%; and biological yield by 20%, 24% and 39% over manual transplanting, direct dry sowing and direct sowing of sprouted rice in puddled conditions, respectively.

Singh R., A. Kumar and S.S. Singh. 2005. Response of rice cv Pusa Basmati 1 to different planting methods, IRRN, 30

development and performance evaluation

Haytham et al. (2010) studied the preparation of mat – type seedlings for

mechanical paddy transplanter. A plastic box (58 cm × 28 cm × 3 cm) called a nursery box, was used for raising rice seedlings. This conventional soil seedbed system had 47

been a major problem viz., a nursery box filled with soil weighs about 6 kg, high cost of the nursery boxes and heavy and hard work. The seedling mat (120 cm × 28 cm × 3 cm) was established in a layer of treated rice straw arranged on a firm surface and has been developed in the Rice Research and Training Center, Egypt, to save the operation cost. This study showed the potential of SM technology to stimulate agriculture in the region and consequently led to increased productivity.

development and performance evaluation

Mechanical transplanting systems increased yield, improved labor efficiency, ensured timeliness in operation and faster transplanting.

Mechanical rice transplanting method generates employment and alternate sources of income for rural youth through custom services on nursery raising and transplanting. The mechanical transplanting of rice has been considered the most promising option, as it saves labor, ensures timely transplanting and attains optimum plant density that contributes to high productivity.

Mechanical transplanting facilitate for optimum plant spacing Optimum plant spacing ensures the plants to grow properly with their aerial and underground parts utilizing more solar radiation and nutrients.

Mechanical transplanter has high field capacity and farmers can transplant rice seedlings within very short time by using mechanical transplanter. Recently, mechanical transplanter is introduced in our country. As a new technology, this machine needs to be evaluated in different agro- ecological zone and in different rice season.

Techno-economic performance of 4-row self-propelled mechanical rice transplanter at farmers field in Bangladesh

Rice researchers regarded lower plant population as one of the major constraints in enhancing rice production in the area. In order to solve this problem and increasing plant population in rice fields, the Agricultural Department of the Punjab and Farm Machinery Institute of Pakistan Agricultural Research Council are trying to popularising the use of mechanical rice transplanters in this zone. Presently,

the main advantage of the mechanical transplanting reported the farmers was that the nursery plants are firmly pegged into the soil, provided that the field is precisely or laser levelled. In case of poor levelling, uniform transplantation is not possible. So, good transplantation requires;

very precisely levelled paddy

fields, 8-9 inches long nursery plants or at least 25 days old nursery, roots of the nursery plants should be free from pebbles and also not very bushy, and the paddy field should not be too much puddled and it should not be heavily irrigated on transplanting day

Diffusion Possibilities of Mechanical Rice Transplanters

Mechanical transplanting (MT) of rice is considered as a feasible option tominimize huge labour use with timeliness cultivation in rice.

MT of rice is the process of transplanting young seedlings, which have

been grown in a mat nursery using a rice transplanter (Joseph et al., 2015). In conventional manual transplanting (CT), 20-30 people are required to transplant 1 ha/day, but 3 people can transplant approximately 2 ha/day using the rice transplanter. The other advantages of MT include uniform spacing, optimum plant density, less transplanting shock and better employment opportunities for rural youth through the development of custom service business. It is also capable of adjusting desired within row space (WRS), per hill seedling number (PHSN) and planting depth (PD0 according to the seedling age (SA), soil type and the level of puddling done in the field.

Presently,

Impact of varieties, spacing and seedling management on growth and yield of mechanicaly transplanted rice

In Asia, a number of different transplanters are now being used to establish rice crops. Machines are manufactured in China, Japan, Korea and Taiwan with varying levels of complexity. Machines range in size from a two‐row, walk‐behind models to eight‐row, ride‐on models. Land must be well prepared for machine transplanting. The soil needs to be level and have sufficient bearing strength to carry the machine and support the planted seedlings. Fields may need to be drained one or two days longer than they are for hand transplanting to stop seedlings floating. Most mechanical transplanters place seedlings in rows either 20‐30 cm apart with in‐row spacing determined by ground speed or head speed of the tra

Rice Production Manual

Mechanical transplanting in rice involves transplanting specifically raised younger seedling of rice as a mat (mat type nursery) using a self-propelled mechanical rice transplanter at pre- determined and desired spacing. Machine transplanter was first developed in Japan in 1960s, whereas the earliest attempt to mechanize rice transplanting dates back to late 19th century. In Japan, development and spread of rice transplanters progressed rapidly during 1970s and 1980s. They also developed new technologies of seedling raising for rice transplanter (Tasaka et al., 1996). In

disseminate this technology, with the following objectives: ? Ensure quality seedlings in proper time by raising seedlings in the tray under plastic shade

? Ensure uniform spacing and planting depth of transplanted rice

? Save time and cost during periods

Seedling establishment in tray: needed for mechanical

of peak-labour demand

transplanting of rice

? Create new forms of employment through creation of seedling nursery entrepreneurs and transplanting service providers ? Improve farmers socio-economic conditions

2

machine transplantation resulted in earlier maturity of the crop (by 15 days) and 9% increased production compared to manual transplantation. Besides higher yield, 25-30% production cost was reduced by using machine transplanter.

The

Transplanting Rice Seedling Using Machine Transplanter : a Potential Step

Firstly it was seen that the area required to establish a paddy nursery is very small. Secondly the Kubota/ Hayleys demonstrations clearly showed that with proper nursery management and mechanized transplanting it will bring about as much as a 50% saving on seed paddy(compared to the broadcasting method). Furthermore, currently the formal seed paddy sector is only able to supply 30% of the seed paddy requirement to farmers. Therefore farmers are compelled to “grow” their own seed paddy which may be of poor quality and bring about a reduced yield at the time of the harvest. This saving will greatly contribute to the Agriculture Department’s endeavours to ensure that farmers have adequate supply of high quality seed paddy in the future. The

Without any doubt, the main reason that guarantees and proves a greater return on investment in the case of Kubota rice transplanter is the increase yield. Hayleys Agriculture has conducted many trials island wide including the Rice Research Institute at Bathalagoda and Samanthurai. These trials have proved that yield could be increased as much as 10-20% due to higher tillering per hill (20-25) when compared to the traditional broadcasting method.

Due to the benefits mentioned above, the government should encourage the adoptation of this technology by the farming community and perhaps provide loans/leasing facilities at concessionary interest rates through the financial institutions to the farmers

Hayleys Agriculture plants seeds of greater productivity through mechanized Rice Transplanter Saves on seed paddy, reduce weedicide usage and guarantees a greater yield

Mechanical transplanting improves labor efficiency, ensures timeliness in operation, faster transplanting and attains optimum plant density that contributes to high productivity (Islam et al., 2016 and Manjunatha et al., 2009). Seedlings raising is a

Mechanical transplanting improves labor efficiency, ensures timeliness in operation, faster transplanting and attains optimum plant density that contributes to high productivity (Islam et al., 2016 and Manjunatha et al., 2009). Seedlings raising is a crucial part of mechanical transplanter. Farmers do not know how to raise seedlings suitable for mechanical

Effect of row spacing of Rice transplanter on seedling requirement and grain yield

#### **2.531 Transplanters**

Mechanisation is needed to raise productivity in rainfed upland and rainfed lowland and to increase cropping intensity in irrigated farms

The manual and self propelled transplanter reduces cost of transplanting by 45-50% and labour requirement by 75-80%.

status and prospectus of

Mechanization decreases

cost of production by reducing labour needed for

particular operation and economy of power and other

inputs (Das, 2012) Study of Adoption of Mechanical Rice Transplanters through Custom Hiring in Tamil Nadu-

a Case Study

Paddy Transplanter Machine transplanting using rice transplanters requires considerably less time

and labor than manual transplanting. It increases the approximate area that a person can plant from 0.7 to 1ha/day. Transplanting of paddy seedlings can be categorized into three groups as follows: 1. By hand (manual) 2. Manually operated machines (work by man power) 3. Mechanically operated machines (work by engine power) development and performance evaluation

Mohanty et al. (2010) reported that the inadequate number of hills per hectare

transplanted by manual labour and the delay in transplanting due to labour shortage during peak transplanting season pushed the demand for a mechanical transplanting. development and performance evaluation

Rice transplanting was mechanized by 1970s and 1980s in Japan and Korea, respectively (Haytham et al., 2010). They also developed new technologies of seedling raising for rice transplanter (Tasaka et al., 1996). Now more than 99% of paddy fields are cultivated by mechanized transplanting in both countries. Mechanical rice transplanting is being introduced in Bangladesh and gaining popularity through the different intervention of some governmental and non-governmental organizations. Usually, a plastic tray called a nursery box (58 × 28 × 2.5cm) is used for raising rice seedlings. Soil is packed into it, and seeds are sown. Nursery boxes are then arranged plain land and the seedlings are raised. When the seedlings are sufficiently grown, the nursery boxes are put on a van and taken to the paddy fields. The seedlings are then transplanted by a transplanter (Haytham et al., 2010). But many technical issues must be considered for successful operation of rice transplanter. For example, in machine transplanting, seedling should be raised with special care in tray. Raising seedling for transplanting requires suitable seedling age, materials and advanced practices including tray and nursery bed soil, seed

preparation for pre-germination and disease disinfection. About 3 leaf stage and 12 to 15cm height seedlings are required for machine transplanting (Kitagawa et al., 2004). **Tray soil**

Transplanters types -status and prostpectus of mechanization of rice

Techno-Economic Performance of a Self-Propelled Rice Transplanter and Comparison with Hand Transplanting for Hybrid Rice Variety

Paddy transplanter Transplanter is a machine used to transplant matured (15-21days) paddy

seedlings at proper place, at right time into the puddled field. A common paddy transplanter comprises; a seedling tray on which mat type rice nursery is kept; a seedling tray shifter that shifts the seedling tray and pickup forks with needles that pick up a seedling from mat type nursery on the seedling tray and put the seedling into the puddled soil. The float of the transplanter served as a base and also helps in movement of the machine over excess water in the field. It creates 2-3 cm raised bed for placement of seedlings at 4-5 cm depth. It also serves as a platform for placement of nursery during transplanting operation. Eight row as well as four row commercially available self propelled transplanter

development and performance

About the transplanter we used

Within row space (WRS) 12 cm, 14 cm, 16 cm, 18 cm, 21 cm

per hill number of seedlings

Planting depths (PD) 1.5 cm , 2 cm, 2.3 cm, 2.7 cm, 3 cm, 3.7 cm

Use of higher WRS (18 cm or 21 cm) or lower number of PHSN (4) did not affect the yield. This study also proves the feasibility of using a wider range of pds (1.5-3.7 cm) in MT

Impact of varieties, spacing and seedling management on growth and yield of mechanicaly transplanted rice

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#### **2.532 Problems with Mechanical Transplanting**

However, rice transplanters are considerably expensive for almost all Asian small-hold farmers. It is popular in industrialized countries where labor cost is high, for

The farmer of Bangladesh does not give attention to the age of seedlings at transplanting and use 30 or more day’s age of seedling. For optimum yield, age

Techno-economic performance of 4-row self-propelled mechanical rice transplanter at farmers field in Bangladesh

The rice mechanization can be

further increased by following the steps are listed below

a)

Subsidized transplanting machinery

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b)

Subsidized

nursery sowing machine and nursery

centers.

c)

Providing

incentive to farmer for mechanized

transplanting.

d)

T

raining women SHGs to use transplanting machinery

in order to ensure alternative employment.

e)

Setting

up separate training center to train operators or

initiating apprentice training under government subsidy.

f)

Ensuring only proven machinery

that are reliable,

serviceable and having adequate service facility.

**Earlier problems in india**

**1 For instance, from researchers' point of view, poor anchoring of**

**seedlings in the soil, uprooting of seedlings by the wave action produced due to the movement of the machine, poor metering of seedlings ranging from 3 to 11 seedlings per hole, 35-55% missing plantation were the major problems diagnosed. From farmers' perspectives, it was difficult for them to maintain 2-4 inches water depth in the field, farmers' fields are also not precisely leveled and they do not like seedling preparation operation as it was time consuming and laborious (IRRI-PAK Agricultural Machinery Program, 1978; Khan et al., 1979).** Diffusion Possibilities of Mechanical Rice Transplanters

**the main advantage of the mechanical transplanting reported the farmers was that the nursery plants are firmly pegged into the soil, provided that the field is precisely or laser levelled. In case of poor levelling, uniform transplantation is not possible.**

**Cutting nursery according to the size of feeding trays and its transportation is a tough job, 3. Raising nursery for a very large paddy area is very costly, 4.**

**The presence of pebbles in the roots of the nursery often damages the plants and breaks the pegging needles of the machine**

**the innovator farmers reported that mechanically transplanted fields yielded 200-240 kg acre-1 higher as compared with the manually transplanted fields at similar inputs use level. But the problem is the price of the transplnter is high and the farmers has to spend more money on the rental of the transplnter but even though the can gain more harvest than the manual transplanting of rice.** **This implies that a significant increase in paddy production can take place by wide spread adoption of mechanical transplanters in the area. And also supplying transplnters by the governemt free of charge**

**It is also needed to search for alterations in the machine to deal with the problem of pebbles in the soil.**

Diffusion Possibilities of Mechanical Rice Transplanters

**Adoption to MT is still low due to socio-economic reasons and lack of technical information available.**

Impact of varieties, spacing and seedling management on growth and yield of mechanicaly transplanted rice

**Presently, MT is promoted in Yaya 2 program which is implemented**

**by the Department of Agriculture (DOA), Sri Lanka. Further, the Food Production National Programme implemented by the Ministry of Agriculture is aiming to enhance the productivity of rice up to 5 t/ha in year 2018 where MT is identified as one of the main area to be exploited. Despite with many advantages, farmers are still reluctant to adopt MT because of some socio- economic reasons and lack of technical specifications available related to agronomic management options of the transplanter. Problems in nursery preparation, selecting suitable varieties and appropriate planting spaces have been reported and a trend in giving up the use of mechanical transplanter in rice cultivation has been observed. Studies on efficient use of mechanical transplanter to optimize the growth and yield of rice have not yet been properly investigated in Sri Lanka.**

Impact of varieties, spacing and seedling management on growth and yield of mechanicaly transplanted

**Though the farmers were experienced in rice cultivation, they mostly lacked knowledge on farm mechanization.**

Transplanting Rice Seedling Using Machine Transplanter : a Potential Step

**Rice transplanting using machine transplanter is technologically viable and economically feasible. But the cost of 4 rows machine transplanter is high (approximately 200000 BDT or 2500 US$) and this constrain smallholder farmers from adopting this technology. However some of the following measures can enhance adoption. Government may enhance the subsidy component for promoting this technology from 50 to 75 per cent so that every farmer could afford a machine transplanter and can do timely operations**

**? A healthy agricultural mechanization policy must be formulated immediately including machine development and manufacturing, quality protection by standardization of machines, skill development of researchers, farmers, mechanics and machine operators and marketing system improvement**

**? Funds for relevant machinery research, development and extension are to be provided to the capable institutions including selected Agricultural Research Institutes and Universities on competitive basis. This stimulates quality research to produce new machines within possible shortest time. Also it enhances farm activities and agricultural machinery industries.**

**Before distributing these implements to farmers, efforts should be made to build the knowledge and skills of extension functionaries on use of these implements**

Transplanting Rice Seedling Using Machine Transplanter : a Potential Step

**2.6 Seeding rate**

**The amount of seed was 130g (dry) and 150g (sprouted) per tray. Tray soil**

**The number of seedlings per hill in rice transplanter increased from 1.7 to 2.8 as the seeding rate increased from 60 to 100 g per tray. The missing hills decreased from 13.32 to 7.65 % with increasing seeding rate from 60 to 100 g per tray**

**total cost of transplanting in the treatments of T2, T3 and T4 was decreased by 19.20, 22.44 and 25.70%, respectively as compared to hand transplanting** Techno-Economic Performance of a Self-Propelled Rice Transplanter and Comparison with Hand Transplanting for Hybrid Rice Variety

**60, 80 and 100 g per tray.** Techno-Economic Performance of a Self-Propelled Rice Transplanter and Comparison with Hand Transplanting for Hybrid Rice Variety

**number of seedlings per hill in rice transplanter increased from 1.7 to 2.8 as the seeding rate increased from 60 to 100 g per tray. The average number of seedlings per hill in rice transplanter was obtained to be 2.2 compared to 1.1 in hand transplanting.**

Techno-Economic Performance of a Self-Propelled Rice Transplanter and Comparison with Hand Transplanting for Hybrid Rice Variety**60**

**The seed rate per tray for mechanical transplanting was 130-140 gm dry seed.** Techno-economic performance of 4-row self-propelled mechanical rice transplanter at farmers field in Bangladesh

**Rice plants significantly reduce the yield after transplanting seedlings grown at higher seed rate as compared to seedlings grown with low seeding density (Singh et al., 1987).**

**Mostly farmers use high seed rates in the nursery to avoid weed competition and to uproot seedlings easily, but they don’t realize its effect after transplanting in main field**

**Transplanting shock was also higher in older seedlings grown with high seed rate due the more root damage during up- rooting, as separation of seedlings caused maximum root damage during uprooting and at the time of transplanting in main field. Our results are in line with the explanations of some previous studies (Singh et al., 2005; Lal and Roy, 1996; Panda et al., 1991) who reported that seedlings grown with low seed rate and with fertilizer application increased vigor, showing a better stand in main field after transplanting and ultimately effected growth and yield of rice crop**

Influence of Nursery Management and Seedling Age on Growth and Economic Performance of Fine Rice

**seeds or 4 seed /m2. When farmers direct seed their crops, only 10‐20% of the seeds sown will actually established. In a nursery, this may increase to 40‐50%.**

Rice Production Manual

**The seed rate naturally influences the growth of the seedlings. Thin sowing gives strong and tillered seedlings, whereas thick sowing provides thin and tall seedlings without tillers. Thin sowing in nurseries is always better and it will produce strong and sturdy seedlings, which can withstand adverse climatic conditions better and produce better yields. Therefore,**

(Oryza sativa

**and BRRI dhan48 were transplanted in the farmer’s field by mechanical rice transplanter and compared with hand transplanting. Seedlings density was reduced at the seed rate higher than 145 gm tray-1 indicating higher seed rate increased the seedlings mortality. Seedlings mat prepared**

**in the farmer’s field by mechanical rice transplanter and compared with hand transplanting. Seedlings density was reduced at the seed rate higher than 145 gm tray-1 indicating higher seed rate increased the seedlings mortality. Seedlings mat prepared by the farmers were varied in seedling height, density and color due to management skill of the**

Effect of row spacing of Rice transplanter on seedling requirement and grain yield

**Seedlings density depended on the seeding rate, germination and uniform placement of seed during tray preparation. Seedlings density followed increasing trend with**

**Seed rate applied by the respective farmers was ranged from 125 to 150 gm tray-1. Seedlings density depended on the seeding rate, germination and uniform placement of seed during tray preparation. Seedlings density followed increasing trend with the increase in seed rate up to 145 gm tray-1 (Fig. 1). Seedlings mortality increased in higher seed rate and reduced the**

**rate, germination and uniform placement of seed during tray preparation. Seedlings density followed increasing trend with the increase in seed rate up to 145 gm tray-1 (Fig. 1). Seedlings mortality increased in higher seed rate and reduced the seedling density in seedling tray (Hossen, 2016). The amount of seed used in tray preparation varied depending on the variety**

**the increase in seed rate up to 145 gm tray-1 (Fig. 1). Seedlings mortality increased in higher seed rate and reduced the seedling density in seedling tray (Hossen, 2016). The amount of seed used in tray preparation varied depending on the variety and germination rate. Seed rate was also varied from one farmer to another due to farmer’s perception. Amount of seed used**

**seedling density in seedling tray (Hossen, 2016). The amount of seed used in tray preparation varied depending on the variety and germination rate. Seed rate was also varied from one farmer to another due to farmer’s perception. Amount of seed used per tray by different farmers had direct influence on the seedlings density obtained per tray and consequently tray**

**and germination rate. Seed rate was also varied from one farmer to another due to farmer’s perception. Amount of seed used per tray by different farmers had direct influence on the seedlings density obtained per tray and consequently tray requirement in the field. Islam et al. (2015) mentioned that tray requirement, number of seedlings dispensed per stroke and**

**per tray by different farmers had direct influence on the seedlings density obtained per tray and consequently tray requirement in the field. Islam et al. (2015) mentioned that tray requirement, number of seedlings dispensed per stroke and missing hill during transplanting operation were subjected to the seed rate and uniformity of seedlings establishment.**

**requirement in the field. Islam et al. (2015) mentioned that tray requirement, number of seedlings dispensed per stroke and missing hill during transplanting operation were subjected to the seed rate and uniformity of seedlings establishment.**

Effect of row spacing of Rice transplanter on seedling requirement and grain yield

## **2.7 Seedling Vigor**

Seedling vigor is defined as the plant’s ability to emerge rapidly from soil or

water and cover the ground fast (Fukai, 2002).

Seedling vigor is the basic component of the transplanted rice, which depends on its growing environment and proper age. Influence of Nursery Management and Seedling Age on Growth and Economic Performance of Fine Rice

Success of transplanted rice directly correlate with the nursery seedlings as it plays major role for establishment in the main field (Padalia, 1980).

Transplanting of healthy seedlings grown at proper nitrogen application at nurserybedshowed better paddy yield (Panda et al., 1991 and TeKrony and Egli, 1991).

Healthy and vigorous seedlings from nursery-bed will give good results after transplanting in the main fiel

Increase in growth rate might be due to the better seedling vigor. Seedlings grown with high seeding density and without fertilizer appli- cation decreased vigor due to high seedling competition, which ultimately gave a weaker start to crop.

Influence of Nursery Management and Seedling Age on Growth and Economic Performance of Fine Rice

The optimum SA was identified as 12 days, but seedlings from 9 to 15 days can be also used without any yield decline

Impact of varieties, spacing and seedling management on growth and yield of mechanicaly transplanted rice

Early vigor is associated with rapid crop establishment which is important in increasing the ability of rice to compete against weeds. Rice competitiveness with weeds, as either the ability to suppress weeds or the ability to avoid being suppressed by weeds (Goldberg and Landa, 1991; Namuco, et al.,

3

2009), o Early Vigor Traits in Selected Upland and Rainfed Lowland Rice ( Oryza sativa L .) Genotypes

Thus, dry weight could be used as a basis in defining early vigor

Good seedling vigor is also another trait that could increase yield of upland rice.

Early Vigor Traits in Selected Upland and Rainfed Lowland Rice ( Oryza sativa L .) Genotypes

## **2.8 Growth parameters of seedlings**

Dry weight is associated with the accumulation of food reserves during early crop

establishment. Several studies suggested that dry weight is a useful tool in defining early vigor.

Early Vigor Traits in Selected Upland and Rainfed Lowland Rice ( Oryza sativa L .) Genotypes

## **2.9 Early Growth parameters of rice plants**

MT produced a comparatively lower ground cover %, but had higher tiller and panicle densities with 9-22 % yield advance compared to CT. Heading and maturity was delayed by 3-5 days in MT compared to the CT

Ground cover increased above 50 % at the 4th week after planting (WAP) in both establishment methods, but was always higher in CT compared to MT (Figures 1A, 1B, 1C and 1D). It reached above 80 % at the end of vegetative stage in CT. It was also observed that a higher ground cover % was achieved by 4-4½ months age varieties compared with 3-3½ months age varieties since the former have longer vegetative periods. Thus, MT may be more adaptable for rice varieties having longer vegetative period.

Tiller density (expressed as number/m2) under MT was significantly

higher than in CT

Irrespective with the lesser number of hills/m2 established in MT than that of in CT, high densities of tillers and panicles of MT were attributed by the production of higher number of tillers and panicles/hill compared to CT. MT produced an average of 18 tillers/hill compared to 13 The production of higher tiller and panicle/hill in MT may be due to the maintenance of uniform planting density during the establishment compared with irregular random planting in CT.

Table

Impact of varieties, spacing and seedling management on growth and yield of mechanicaly transplanted rice

The number of active tillers and panicles produced will be the major determinate of crop yield. Therefore the number of seedlings established must be sufficient to produce the desired number of tillers and panicles.

Each seedling will develop 3‐10 tillers depending the nutrient status, variety and planting rate and spacing. Higher seeding rates normally give fewer tillers per plant. Transplanted crops generally produce more tillers than direct seeded crops, and dry season crops often produce more tillers than wet season crops.

Three seedlings per hill is normal in most countries.

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Plant height was affected significantly by different sowing methods.

Number of panicle bearing tillers was influenced significantly by various sowing methods

Less number of panicle bearing tillers in direct seeding may again be explained in terms of availability of moisture and nutrients to the crop plants at the panicle initiation stage. The availability of moisture and nutrients was low due to lack of proper distance and more number of weeds in direct sowing. Moreover roots of plant could not penetrate deep enough to exploit the soil resources fully, giving a fair chance to the weeds to compete with the crop plant. Similar results were reported by Naklange et al. (1996).

The higher number of tillers in parachute compared to the other methods of direct seeding might be attributed to the availability of sufficient amount of nutrients and moisture at tillering initiation stage due to the deep placement of seedling and better establishment of roots. Secondly, this method had no transplanting shock as it had a mud ball along its roots, hence started growth one week earlier. Availability

COMPARISON OF DIFFERENT PLANTING METHODS FOR OPTIMIZATION OF PLANT POPULATION OF FINE RICE ( Oryza sativa L .) IN PUNJAB ( PAKISTAN )

% ground covers by beaded string method

? % ground covers by beaded string method at weekly interval till varieties reach 100% ground cover. First reading can be started at 12-15 DAS. For this, you have to make 20 knots at equal distance (10-cm apart). So the string will be 2-m long with 20 knots at 10-cm apart. Hold the string diagonally at two locations in a plot and see how many knots (if looking perpendicularly from top) are directly hitting the crop canopy (See figure below). Multiply no. of knots hitting canopy by 5 to estimate % ground cover. For example, if 5 knots hits canopy, then % ground cover would be 25%.

% ground covers by beaded string method

These experiments were conducted at the Rice Research and Development Institute, Batalagoda situated in LCIZ (IL3) during 2018/19 Maha seasons.

These experiments were conducted at the Rice Research and

Development Institute, Batalagoda situated in LCIZ (IL3) during 2016 Yala and 2016/17 Maha seasons. Three experiments were designed (i) to identify varieties suitable for MT compared with CT, (ii) to find out optimum WRS and PHSN and (iii) to identify optimum PD and SA to obtain a vigorous growth and maximum yield in mechanically transplanted rice using Kubota walk-behind type (Model NSP-4W) rice transplanter. The machine has the adjustment for changing WRS, PHSN and the PD. However, row width (between rows) of the transplanter is fixed as 30 cm since it was originated in Japan and was worked out for Japonica varieties having around 90 days of vegetative period during the growing season

Wet broadcast seeding In many irrigated and more reliable rainfed areas, pre‐germinated seed is broadcast into 2‐5cm of standing water. Seeding rates vary from 80‐120kg/ha and 1 person can plant 1 ha/day. Standing water levels are normally allowed to recede after seeding and water not added until the seedlings are 1‐2 leaf stage. If the soil surface dries to quickly then flash flooding of the fields may be needed. For this system to work effectively, fields must be level and have good drainage system. Seedling rearrangement will be required within 15‐20days after establishment. Weeds will need to be controlled with 21 days after establishment especially if a pre‐emergent herbicide has not been applied. This can be a very effective system for crop establishment, if there is a shortage of labor at planting, weeds can be managed and water

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