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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).

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**

## **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

Rice plant

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

## **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).

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

## **2.4 Direct seeding of Rice**

## **2.5 Transplanting of Rice**

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

### **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**

### **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

#### **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

#### **2.532 Problems with Mechanical Transplanting in Sri Lanka**

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

**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

## **2.7 Seedling Vigor**

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

## **2.8 Growth parameters of seedlings**

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

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