

**Effect of different planting methods on growth and yield of paddy variety Bg 360****R. Subaraj, L. Pradheeban and K. Thanusan\****Department of Agronomy, Faculty of Agriculture, University of Jaffna, Sri Lanka***Abstract**

Rice is the staple food in Sri Lanka. Bg 360 is currently considered the best improved paddy variety cultivated by farmers in Mannar. In the Mannar district, farmers practice different planting methods, and the number of effective tillers obtained varies, which causes yield variation and different production costs in paddy cultivation. To identify the best-suited planting method for the rice variety Bg 360, an experiment was carried out in a randomized complete block design with three replications by adopting five different methods of planting as treatments, namely broadcasting ( $T_1$ ), drum row seeding ( $T_2$ ), SRI method of planting ( $T_3$ ), manual transplanting ( $T_4$ ), and machine transplanting ( $T_5$ ). The parameters such as plant height, leaf area index, tillers, number of grains, panicle numbers and yield per plot were measured. Data were analyzed in the SAS 9.4 version, and mean separation was performed in DMRT to identify the best treatment. The experiment results showed that the planting methods significantly affect the plant height, effective tillers and grain yield. A high number of effective tillers (between 6 – 20 per plant) and yield (number of grains per panicle, 1000 grain weight and number of panicles per plant) were observed in the SRI method, and low value was received from the broadcasting method. The planting methods also significantly affected the time of crop maturity (by two weeks). Direct-seeded rice matured early (110 days), while transplanting took 120 days. Further, transplanted rice, especially in the SRI method, showed low seed requirement, low weeds, pest disease and incidence and low cost of production. Farmers generally do not adopt the SRI method for cultivation because of high time consumption and labour requirements. Based on the study, it can be concluded that transplanted rice, especially the SRI method, is more beneficial than other planting methods to cultivate the Bg 360 paddy variety.


**Keywords:** *Planting methods, rice, SRI method, treatment, tillers, yield***Introduction**

Rice (*Oryza sativa*) is a leading crop, along with wheat and corn, constituting a major food staple for half of the world's population. It is an annual cereal in the Poaceae family. The majority of people on earth eat rice as a basic diet, and 75% of all rice consumed comes from irrigated rice (Evangelista *et al.*, 2014). Because of the high demand and selling price, the Bg 360 cultivar is one of the major popular and favorable short grain samba varieties among farmers (Department of Census and Statistics, 2021).

There is a need to increase paddy productivity due to the increasing population and limited land availability. Every year, 51 million more people consume rice in the Asia-Pacific Region, home to more than 56 per cent of the world's population. As a result, the tiny margin of rice self-sufficiency that many nations have is rapidly eroding. A significant challenge is how the current yearly production of 524 million tons of rice will expand to 700 million tons by the year 2025 while using less land, less labour, less water, and fewer pesticides. The irrigated rice land currently makes up roughly 56 per cent of the total area and

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contributes to 76 % of the overall production. The salinity of the soil, the high expense of construction, the shortage of water, the competing demands for water, and environmental issues make it difficult to expand the land area to increase productivity. Therefore, yield should be increased by adopting new technology in crop management practices. Utilizing new planting technology will have the most significant impact on ecosystems in terms of enhanced production on a time scale (Zhu, 2000).

Numerous problems, including a lack of water, high input costs, a labour shortage, inadequate plant nutrition and population, weed and pest infestation, and a lack of competent personnel, have all impacted rice output. In general, rice farmers struggle with a lack of skilled labour during transplanting and a low rice yield. It is essential to reduce the impact by using the proper planting methods for the production of rice in order to regulate competitive pricing in local and worldwide markets. In various regions of the world, research and development initiatives on innovative rice establishment technologies, such as transplanting, direct sowing, and aerobic rice cultivation, were started to overcome this issue (Baloch *et al.*, 2012). When developing sustainable rice production techniques, crop establishment, one of the key processes that frequently receive insufficient attention, should be taken into account. Currently, the most widely utilized techniques in irrigated rice cultivation are direct seeding (DSR), which includes drum-seeding and broadcasting and manual and machine transplanting (Nguyen *et al.*, 2022).

Around 40 % of daily caloric requirements are from rice, Sri Lanka's most significant staple crop. With few trade activities, Sri Lanka is basically self-sufficient in rice. Over 90 % of the domestic rice supply is used for meals. By boosting and stabilizing rice output, government initiatives seek to

achieve food security (Wang *et al.*, 2017). There are two rice-growing seasons in Sri Lanka each year. The *Maha* season, which makes up around two-thirds of rice production, is the primary rice-growing period. Inter monsoon rain and the northwest monsoon, which are evenly dispersed across the island, are received during the *Maha* season. Rainfall occurs primarily in the southwest of the nation during the *Yala* season. Less rice is planted during the *Yala* season than during the *Maha* season (Wang *et al.*, 2017).

Significant paddy-growing regions in Sri Lanka include Kurunegala, Ampara, Polonnaruwa, Anuradhapura, Hambanthota, and Trincomalee. The national average paddy yield is 4307 kg per hectare (Paddy Statistical Report, 2021). In Sri Lanka, 2,088,202 metric tons of paddy were projected to be produced during the 2021 *Yala* season. With a net area of 681,521 hectares and a total production of 3,061,394 mt in *Maha* 2020/21, the average yield was 4307 kg (DCS, 2021). In addition to fisheries, forestry, and livestock, which contribute 1% and 0.7% of the country's GDP, agriculture makes up 6.9 per cent of the total. Over 30 % of Sri Lanka's workforce works in the agricultural industry ( National Output, Expenditure, 2021). The average paddy yield in the country is lower than that of industrialized nations like Australia, the United States, Japan, Spain, Korea, and China, with 8.3, 6.8, 6.2, 6.1, and 5.9 tons per hectare, respectively (Herdt, 2009).

The main climatic conditions affecting rice productivity are soil moisture availability and temperature, which are quite harmful. However, other biotic and abiotic elements, which directly or indirectly affect the crop's growth and development, such as soil fertility, planting techniques, and other biotic and abiotic factors, also have a role in determining the crop's production and productivity. Weeds, pests, disease problems, and the high cost of production

in broadcasting methods lead to lower yields than transplanting. The planting techniques used in rice crop production affect growth and yield in addition to labour costs and crop costs. Increasing tillering capability increases crop yield and decreases seeding rates, reducing seed costs. Plant vigour can be increased with effective tillers through transplanting, providing the highest possible output. Rice needs a lot of water from emergence to maturity compared to other cereal crops, but its water use efficiency is very low. Transplanting crops reduces competition for growth resources like sunlight, moisture, and nutrients. It also makes it easier to manage crops by weeding, and applying herbicides, and pesticides. Transplanted rice is produced in puddling fields to reduce percolation losses and control weeds (Virk *et al.*, 2018).

While transplantation creates consistent plant stands and increases crop production, transplanting is more expensive than broadcasting. Planting methods influence crop output and yield components in addition to profitability because of increasing production costs. Accordingly, there is a possibility to boost rice crop output, productivity, and profitability by utilizing an appropriate planting technique. Consequently, subsistence farmers can achieve food security and self-sufficiency. According to the available data, island-wide, short-grain samba varieties were cultivated in 106,989 ha and 21.3% extent in *Yala* 2021 (Paddy Statistical Report, 2021). In northern Sri Lanka, short grain samba varieties were cultivated as 10,699ha in *Yala* in 2021. The Bg 360 cultivar is one of the popular and favourable short grain samba varieties among farmers because of the high demand and selling price (DCS, 2021).

There are two fundamental planting procedures: direct seeding, which comprises broadcast sowing (BS) and sowing in line (SL), and transplanting of

seedlings, which have proliferated due to technological advancements throughout the world (Yield *et al.*, 2021). Farmers in Sri Lanka use different planting techniques, including transplanting and direct sowing, resulting in most districts obtaining a lower and inconsistent yield (RRDI, Batalagoda, 2015). The most common sowing technique used for direct seeding is broadcasting, which made up 95.3% of the total area seeded. Growing requires less work and is simple (Paddy Statistical Report, 2021). Many environmental factors, including nutrient availability, soil water status, weed competition, and disease, have a substantial impact on growth and output; also, the transplanting methods practised at a lower level than broadcasting in the formation of rice grain production is significantly influenced by the number of productive tillers per plant. There are significantly fewer productive tillers than those that have formed at this stage of the crop because young tillers die off earlier than they should for various reasons. Environmental factors that affect the tillering rate include nutrient availability, soil water status, competition with weeds and diseases, and weed and disease competition (Prakash and Kumari, 2021). Compared to direct sown rice, transplanted crops often yield more tillers. Under optimal growing circumstances, modern rice types yield 20–25 tillers, including primary, secondary, and tertiary. Around 20–25 tillers become unproductive, and only 14–15 yield panicles. Furthermore, studies have demonstrated that optimal tillering promotes synchronized flowering, maturity, and uniform panicle size.

In 2006, a study was conducted by HARTI regarding the SRI planting method. Farmers are not adopting this technology due to the higher cost of planting, but this method has several advantages, such as low seed requirement, low weed and pest disease incidence, and low cost of production. In India and the International Rice Research Institute, the final yield and

profit were proved higher in SRI and transplanting methods than in broadcasting methods. Based on these contexts, a research study was conducted to identify the best planting method for paddy cultivation in Mannar to obtain higher productivity among the methods used by farmers.

## Materials and Methods

### Location of the study

Mannar District is located northwest of Sri Lanka in the Northern Province. It has an area of 1,996 square kilometres. The experiment was conducted at the GSPF, Murunken, during March to June 2022 (*Yala* season). This place is situated in *Northern Sri Lanka*, and its geographical coordinates are 8° 50' 0" North, 80° 2' 0" East in Mannar district.

### Selection of Variety

Currently, rice varieties Bg 358, Bg 360, Bg 406, At 308 and At 353 are cultivated to a large extent compared to other varieties in Mannar District. According to the data collected from the Department of Agriculture Mannar, most farmers prefer to cultivate variety Bg 360 due to higher consumer preference and higher yield. Therefore, Bg 360 was selected for the experiment, and registered seeds were collected from the government seed production farm, Vavuniya. The Bg 360 variety is a white grain "samba" (smallest thin grain) variety that is resistant to gall midge, rice blast, and bacterial leaf blight.

### Field Layout

<b>T1R1</b>	<b>T2R1</b>	<b>T3R1</b>	<b>T4R1</b>	<b>T5R1</b>
<b>T2R2</b>	<b>T3R2</b>	<b>T4R2</b>	<b>T5R2</b>	<b>T1R2</b>
<b>T3R3</b>	<b>T4R3</b>	<b>T5R3</b>	<b>T1R3</b>	<b>T2R3</b>

**Figure 1:** Field layout of the experiment

## Experimental design and treatments

The experiment was carried out in a randomized complete block design with three replicates.

### Treatments

Different methods of planting were considered as treatments.

T<sub>1</sub>- Broadcasting - The 807gram and 315gram pre-germinated seeds were directly sown in the randomized plots by broadcasting.

T<sub>2</sub>- Row seeding - The 315 grams of pre-germinated seeds were directly sown as row seeding in the randomized plots by a manual drum seeder in three plots. In each hill placed five seeds.

T<sub>3</sub>- SRI Method - Thirteen days old seedlings were transplanted maintaining 25 x 25 cm plant-to-plant and row-to-row distance as called SRI method, and in each planting hill one seedling was planted.

T<sub>4</sub>- Manual transplanting - Twenty-one days old seedlings were planted manually and in each planting hill, three seedlings were planted.

T<sub>5</sub>- Machine transplanting - Twenty-one days old seedlings were planted by using a transplanter in each planting hill three seedlings were planted.

In each method of planting, the recommended seed rate was used for this study.

### **Data collection**

Growth parameters like plant height (Measuring tape), number of tillers, leaf area index (Length and width method) and effective tillers and yield parameters such as number of panicles per plant, panicle length (measuring tape), number of grains per plant and 1000 grain weight (weighing scale) were collected by using appropriate methods.

### **Statistical analysis**

ANOVA was performed by using the SAS 9.1 computer software package, and mean separation was performed by using Duncan's Multiple Range to select the best treatments at  $p < 0.05$ .

### **Results and Discussion**

The results obtained from the research study of different planting methods with their recommended seed rate influencing growth and yield performance in rice variety of Bg 360 were discussed in this chapter.

#### **Plant Height**

A significant difference was observed after nine weeks between direct and transplanting methods, but after that, no significant difference was found in the same planting methods (Table I). The highest value was observed in the SRI (System of Rice Intensification) method and the lowest in direct seeding methods. Plant height is an important agronomic trait of rice that directly affects the yield of this crop. The dwarf phenotype is beneficial for rice lodging, but if the plants are too short, it will lead to insufficient growth and ultimately affect the yield potential of rice. Therefore, in the absence of lodging, it is essential to increase plant height to increase yield (Wicramasinghe, 2017). The highest plant height was recorded in seedling line transplantation, followed by conventional transplanting. The minimum plant height was recorded in pre-germinated seed broadcast treatment (Ali and Akhlaq, 2013).

#### **Total Number of Tillers per Plant**

The difference in the number of tillers/plants in different methods of planting at every three-week interval is shown in Table I. There was a significant difference observed within different methods of planting. The highest number of tillers/plants was observed in the SRI method of planting, and the lowest number of tillers/plant was in the broadcasting method. Tillering in rice (*Oryza sativa*) is important because of its ability to generate secondary tillers from vegetative tillers. It helps to increase the number of panicles and the seed set and to improve grain yield. Therefore, tillering is a critical agronomic trait in rice. "Tillering" refers to the production of side shoots and is a property possessed by many species in the family Poaceae. This enables them to produce multiple stems (tillers) starting from the initial single seedling (Prakash and Kumari, 2021). Also, in 2013, Ali and Akhlaq reported that the number of productive tillers was influenced significantly by different planting treatments. Line transplantation produced the highest number of productive tillers. While pre-germinated seed broadcast produced a minimum number of productive tillers

#### **Leaf Area Index**

The difference in leaf area index of Bg 360 paddy variety under different methods of planting is shown in Table II. There was a significant difference found between different methods of planting. The machine transplanting cultivation method showed the highest (5.9) leaf area index value, and the row seeding method showed the lowest LAI value (2). Leaf area index (LAI) is important in explaining the ability of crops to intercept solar energy for biomass production, amount of plant transpiration, and understanding the impact of crop management practices on crop growth. The leaf area index value is directly proportional to the yield of the crop. The different planting methods influence the leaf area index of the crop. The planting

method affects the vegetative growth and leaf length, width, and number of leaves, as it is frequently related to crop yield (Dennis *et al.*, 1991).

### Number of Effective tillers

The difference in number of effective tillers/plants in different planting methods is shown in Table II. There was a significant difference found in the number of effective tillers with different methods of planting. The highest (20) number of effective tillers/plant was shown in the SRI method of planting, and the broadcasting method showed the lowest (6) number of effective tillers/plants. The importance of effective tillers in rice is the ability to produce panicles by filling beneficial grains on plants. Each effective tiller increases the number of panicles and grains, finally

enhancing the yield per plant. Generating a secondary tiller or producing a tertiary tiller is the difference between the number of tillers and the number of primary tillers. This ensures the formation of dense tufts and multiple seed heads. Tillering rates are highly influenced by many environmental factors such as nutrient availability, soil water status, competition with weeds and diseases. The planting methods influenced these environmental factors and changed the production of effective tillers from each plant (Prakash and Kumari, 2021). Rowland and Whiteman, Naklunge *et al.*, and Oyewole, Attah (2007) also indicated that broadcasting generally depresses seed germination and thereby affects crop establishment due to less root-soil contact to exploit the soil resources fully.

**Table II:** Effect of different planting methods on growth parameters of paddy

Treatment	Leaf area index	Effective tillers
<b><u>Planting methods</u></b>		
Broadcasting(T <sub>1</sub> )	2.9 <sup>c</sup>	6 <sup>d</sup>
Row seeding(T <sub>2</sub> )	2 <sup>d</sup>	7.1 <sup>c</sup>
SRI method(T <sub>3</sub> )	4.1 <sup>b</sup>	19.8 <sup>a</sup>
Manual transplanting(T <sub>4</sub> )	2.9 <sup>c</sup>	8.8 <sup>b</sup>
Machine transplanting (T <sub>5</sub> )	5.9 <sup>a</sup>	7.34 <sup>c</sup>

Means with the same letter within a given treatment are not significantly different at P= 0.05

### Number of Panicles per Plant

The difference in the number of panicles/plants under different planting methods was shown in Table III. There was a significant difference found among different methods of planting. The SRI planting method showed the highest (20) number of panicles/plants, and the broadcasting method produced the lowest (6) number of panicles/plants. The terminal component of the rice tiller is an inflorescence called a panicle. The inflorescence or panicle is born on the uppermost internode of the Culm. The panicle bears rice spikelets, which develop into grain. These findings are in agreement

with those obtained by Aslam *et al.* (2014), and Parsad (2001), who reported that transplantation of rice increased all the growth and yield attributes of rice over direct growth.

### Length of Panicle

A significant difference was found between different planting methods and lengths of panicles (Table III). The manual transplanting method showed the highest (24 cm) length of panicle, and the row seeding method showed the lowest (21 cm) length. Rice panicle length, defined as the length from the panicle neck to the apex, is generally measured at maturity. The panicle

neck, which has a cyclic structure, is treated as a dividing point between the stem and the panicle.

### **Number of Grains per Panicle**

The difference in the number of grain/panicles of different planting methods is shown in (Table III). There was a significant difference found among different planting methods. The broadcasting planting method showed the highest number of grains/panicles, and the SRI (System of Rice Intensification) had the lowest number of grains/panicles. The ovule, after fertilization, develops into the seed with its coats completely fused with the developing ovary wall or pericarp. The number of grains per panicle is determined by the different planting methods, stand density and spacing within plants.

### **Thousand (1000) grains weight (g)**

The number of grains per panicle and 1000 grains per panicle is defended by the availability of nutrients, water, sunlight, number of tillers, root depth, and pest attacks on the grain formation period. The difference in weight of 1000 grains of different planting methods is shown in Table III. There were significant differences found within different planting methods. The manual transplanting method showed the highest (271) weight of 1000 grains, and the broadcasting method showed the lowest (250) weight of 1000 grains.

### **Yield (ton/ha)**

The difference in yield of different planting methods is shown in Table III. There was a significant difference found between the different planting methods. The SRI planting method showed the highest yield, and the broadcasting planting method showed the lowest yield. High significance was found between the two planting methods. The low paddy yields recorded in pre-germinated seed methods than in the seedling transplanting method. This has been due to seeds' exposure to pest

destruction and weed competition in broadcast conditions. The results align with Thakur, Mahajin *et al.*, and Maqsood (2007), who achieved higher grain yield in the transplanted technique compared to direct sowing.

### **Conclusion**

A significant difference was found among different planting methods on growth and yield parameters of Bg 360 paddy variety. Direct seeding and transplanting establishment methods showed significant differences in growth and yield parameters. In direct seeding, the broadcasting method produced low numbers of tillers, effective tillers, lower plant height and low yield. In the transplanting method, the highest growth (plant height, effective tillers) and final yield was observed in the SRI method performed well than other planting methods. Both drum seeding and broadcasting showed comparable same performance. Based on five planting methods, the highest yield was 5.82 tons/ha received from the SRI method, and the lowest was 4.02 tons/ha from the broadcasting method. It can be concluded that the SRI method of planting is the most suitable among the other methods of planting for paddy variety Bg 360 to obtain good yield under limited land availability.

### **Recommendations**

Future work-study should be continued with different soils to ensure the same results and experiment should be conducted with multi-locations of each district. The study will be continued in the *Yala* and *Maha* seasons to find the consistency of the result. The same seed rate should be used in different methods of planting. Research could be expanded to different varieties to find the results.

**Table I:** Effect of different planting methods on plant height and number of tillers per plant

Treatment	Plant height					Total number of tillers per plant				
	3 WAP	6 WAP	9 WAP	12 WAP	15 WAP	3 WAP	6 WAP	9 WAP	12 WAP	15 WAP
<b><u>Planting methods</u></b>										
Broadcasting(T <sub>1</sub> )	15.67 <sup>a</sup>	40.9 <sup>aa</sup>	70 <sup>a'</sup>	91.67 <sup>c''</sup>	91.67 <sup>c''</sup>	1 <sup>a</sup>	5 <sup>aa</sup>	7 <sup>c'</sup>	9 <sup>s</sup>	9 <sup>s</sup>
Row seeding(T <sub>2</sub> )	14.93 <sup>b</sup>	39.2 <sup>bb</sup>	67.67 <sup>b'</sup>	91.33 <sup>c''</sup>	91.33 <sup>c''</sup>	1 <sup>a</sup>	5 <sup>aa</sup>	7.97 <sup>b'</sup>	10 <sup>rs</sup>	10 <sup>rs</sup>
SRI method(T <sub>3</sub> )	10.93 <sup>d</sup>	31.23 <sup>cc</sup>	64.53 <sup>c'</sup>	94.67 <sup>aa''</sup>	94.67 <sup>a''</sup>	0 <sup>b</sup>	4 <sup>bb</sup>	28.1 <sup>a'</sup>	30 <sup>p</sup>	30 <sup>p</sup>
Manual transplanting(T <sub>4</sub> )	12 <sup>c</sup>	23.97 <sup>dd</sup>	64.47 <sup>c'</sup>	93.67 <sup>b''</sup>	93.67 <sup>b''</sup>	0 <sup>b</sup>	2 <sup>cc</sup>	8 <sup>b'</sup>	12 <sup>q</sup>	12 <sup>q</sup>
Machine transplanting (T <sub>5</sub> )	11 <sup>d</sup>	23.03 <sup>ee</sup>	62.37 <sup>d'</sup>	93.33 <sup>b''</sup>	93.33 <sup>b''</sup>	0 <sup>b</sup>	2 <sup>dd</sup>	7.3 <sup>b'c'</sup>	11 <sup>qr</sup>	11 <sup>qr</sup>
Interaction effect (N × A)	S	S	S	NS	NS	S	S	S	S	S

Means with the same letter within a given treatment are not significantly different at P= 0.05

WAP, S and NS indicate the Week after Planting, Significance and non-significance, respectively.

**Table III:** Effect of different planting methods on yield parameters of paddy

Treatment	Panicle per plant	Length of panicle	Grains per panicle	1000 grains weight(g)	Yield (ton/ha)
<b><u>Planting methods</u></b>					
Broadcasting(T <sub>1</sub> )	6 <sup>d</sup>	22.5 <sup>b</sup>	270.67 <sup>a</sup>	11.5 <sup>ab</sup>	4 <sup>c</sup>
Row seeding(T <sub>2</sub> )	7.1 <sup>c</sup>	21.53 <sup>c</sup>	258 <sup>b</sup>	11.83 <sup>ab</sup>	4.2 <sup>c</sup>
SRI method(T <sub>3</sub> )	19.8 <sup>a</sup>	22.7 <sup>b</sup>	250.47 <sup>c</sup>	12.5 <sup>ab</sup>	5.8 <sup>a</sup>
Manual transplanting(T <sub>4</sub> )	8.8 <sup>b</sup>	24.1 <sup>a</sup>	261.2 <sup>b</sup>	12.67 <sup>ab</sup>	4.9 <sup>b</sup>
Machine transplanting (T <sub>5</sub> )	7.33 <sup>c</sup>	23.83 <sup>a</sup>	257.1 <sup>b</sup>	11.5 <sup>ab</sup>	4.7 <sup>b</sup>

Means with the same letter within a given treatment are not significantly different at P= 0.05



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