Identification of the Best Seed Sowing Rates for Optimizing Grain Yield of At-362 Rice Variety

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Abstract

Rice (Oryza sativa L.) is a staple food for a substantial portion of the global population and it is cultivation all over the world. Seed rate has a significant impact on plant population, crop quality and overall yield in paddy cultivation. Hence, this study was conducted to identify the best seed sowing rates for optimized growth and yield potentials of the At362 rice variety in Ampara District, Sri Lanka. Six different seed rates viz; 2 Bu/ac, 2.5 Bu/ac (Control), 3 Bu/ac, 3.5 Bu/ac, 4 Bu/ac and 4.5 Bu/ac were selected for this experiment. The treatments were arranged in Randomized Complete Block Design (RCBD) with three replications. Data on growth and yield related parameters were collected at different time periods and analyzed using SPSS software. The results revealed that most of the tested parameters were significantly ($p<0.05$) affected by different seed rates. Lower seeds rate (2 Bu/ac, 2.5 Bu/ac and 3 Bu/ac) resulted in increased mean values for growth parameters including plant height, number of leaves produced in the main culm, flag leaf length and width, culm length and root length compared to higher seed rates. Similarly, panicle length and number of filled per panicle were higher at 2.0 and 2.5 Bu/ac respectively. However, the number of panicles/m^2 was significantly higher in 4 Bu/ac and 4.5 Bu/ac while the filled panicle and the grain weight were increased in the lower seed rates suggesting that the increasing seed rates marginally increased the panicle production in cv. At362 rice variety.

Keywords: ***At362, flag leaf, Oryza sativa L., Panicle, Seed rates***

I. INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important staple crops in the world, providing a foundational source of nutrition for many different civilizations around the world while sustaining the livelihoods of billions (Sandeep *et al*., 2018). With Asia in the forefront of rice cultivation, countries like China, India, Indonesia, and Bangladesh emerge as key contributors to global rice production (Singh *et al*., 2021). In the Sri Lankan context, rice is incredibly significant both culturally and economically. The various agro-climatic conditions of Sri Lanka enable the cultivation of a wide range of rice varieties, from high-yielding modern varieties to traditional selections with significant cultural and historical significance (Irangani and Prasanna, 2017).

The goal of sustainable and effective crop production has taken center stage in contemporary agricultural practices to solve the problem of global food security. In this regard, the appropriate seed sowing rate is one of the most important variables affecting the yield of crops (Tadesse and Tadesse, 2019). The choice of an ideal seed sowing rate may considerably impact the final grain yield of a specific crop variety (Abuzar *et al*., 2011). Higher plant densities increase the yield up to a limit and thereafter a decline in yield is observed (Dongarwar *et al*., 2018). Increased competition for nutrition, air and light among the plants are the causes for the yield reduction (Tadesse and Tadesse, 2019). Moreover, high seeding rates result in unproductive tillers, increased disease pressure, and lodging susceptibility (Garba *et al*, 2013). In contrast, weeds can take advantage of gaps in the field created by sparse plant populations caused by a reduced seed rate (Nie and Peng, 2017). Low plant density may also lead to insufficient use of the available resources, which could restrict production potential (Ali and Talukder, 2008). A controlled reduced seed rate, however, can occasionally be advantageous, especially in regions with scarce water supplies or with certain rice types that have active tillering traits (Pathak *et al*., 2011).

The ideal seed rate achieves a delicate balance between increasing potential production and guaranteeing that each plant has sufficient access to vital elements (Mohaddesi *et al.*, 2011). This method encourages strong growth, healthy tillering, and effective nutrient usage. It lowers the likelihood of disease outbreaks and improves the crop's ability to endure environmental shocks. The ideal seed rate varies depending on the type of soil, climatic conditions, and variety of rice (Tadesse *et al*., 2019). Precision in selecting this rate can result in uniform plant stands, improved grain filling, and ultimately, enhanced yield and grain quality. Hence, this study evaluated the impact of different seed rates on the crop performance of the At362 rice variety. Ampara district is a prominent rice growing region in Sri Lanka, and a total of 136,036 hectares of paddy was planted largely using the At-362 and Bg-94-1 owing to its superior agronomic and yield features (Mubarak *et al*., 2022; Sewwandi *et al*., 2023). The results of this study can help farmers in Ampara district of Sri Lanka to make well-informed decisions about seed allocation that increase agricultural productivity while avoiding resource waste.

II. MATERIALS AND METHODS

A. Description of the Study Area

A field experiment was carried out at Rice Research Station, Sammanthurai which is located in Ampara District (7°21'18.4"N; 81°46'38.2"E) from May to August during the *Yala* season of 2022. The mean annual temperature of this area is 27 °C to 30 °C and annual precipitation is between 1500 mm to 2225 mm. The soil type is non-calcic brown which contains sand with slightly acidic soil.

B. Planting Materials

The rice variety At362 was selected to conduct the trial since it is the most popular and high yielding rice variety in Ampara district. Initially, the land was prepared and paddy seeds were sown in six different seed sowing rates (2.0 Bu/ac, 2.5 Bu/ac (Control), 3.0 Bu/ac, 3.5 Bu/ac, 4.0 Bu/ac and 4.5 Bu/ac). The experiment was arranged in a Randomized Complete Block Design (RCBD) with 3 replicates and the plot size was 2 m x 3 m. fertilizing and irrigation were done at regular recommended intervals. Weeds were removed manually at regular intervals. Pest and disease management were performed with cultural techniques whenever required.

C. Data Collection

Plant height (cm) was obtained by measuring the main stem length from ground level to the tip of leaves using (Sivaneson and Vijayakumari, 2019) during the 4^{th}, 6^{th}, 8^{th} and 10^{th} weeks after seed sowing (WAS). The number of plants/m^2 and tillers/m^2 were taken by placing a quadrate of 0.5 × 0.5 m size on the field at 6 WAS. The number of leaves produced on the main culm per plant was counted during 6, 8 and 10 WAS. Flag leaf length (cm) and width (cm), root length (cm) and culm height (cm) were taken at 10 WAS. At harvest, panicle length (cm) was measured from the base to the tip of the panicle (Himasha *et al*., 2022). The number of panicles, total number of spikelets, and filled and unfilled grains per panicle were also counted separately. Dry weights were determined by placing the plant samples inside an oven at 80°C for 72 hours until a constant weight was observed. All the above data were collected from 10 randomly selected plants in each plot.

D. Data Analysis

Statistical analysis of the collected data was performed using SPSS software (version 25). The statistical evaluation of the treatments was conducted using the analysis of variance (ANOVA). To determine whether there was a significant difference between the treatment means at 0.05 probability levels, Tukey's post-hoc test was used.

III. RESULTS AND DISCUSSION

A. Effect of Different Seed Rates on Plant Height

Plant height is an important parameter that helps determine the growth attained during a period of time (Pachuri *et al*., 2017). Our results indicated that different seeding rates had significant ($p<0.05$) effects on the rice plant height at 6, 8 and 10 WAS while no significant ($p>0.05$) effect was observed during 4 WAS. The seed rates 2 Bu/ac, 2.5 Bu/ac and 3 Bu/ac resulted in significantly higher plant heights compared to other treatments while the plants grown at 4.5 Bu/ac had the lowest plant heights (Table 01).

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Table 01: Mean Plant Height (cm) of cv. At362 Rice Variety

Treatment	4WAS	6WAS	8WAS	10WAS
2.0 Bu/ac	38.66±1.16^{a}	49.0±1.08^{b}	72.08±0.73^{bc}	79.5±1.43^{b}
3.0 Bu/ac	38.88±0. 87^{a}	51.83±0.75^{b}	73.10±1.38^{c}	80.26±1.04^{b}
3.5 Bu/ac	36.66±0.66^{a}	45.16±1.08^{a}	72.26±0.95^{bc}	76.70±1.07^{ab}
4.0 Bu/ac	37.88±1.18^{a}	43.36±0. 85^{a}	68.13±1.41^{ab}	77.43±1.07^{ab}
4.5 Bu/ac	38.33±1.20^{a}	43.86±0. 68^{a}	65.7±0.87^{a}	73.80±1.16^{a}
2.5 Bu/ac (Control)	37.77±0.75^{a}	50.33±0.59^{b}	73.06±1.00^{c}	80.16±1.13^{b}
CV	7.73%	11.95%	9.23%	8.58%
P	0.636	0.001	0.001	0.001

Values shown are mean ± S.E. Means with different letters represent significant differences at Tukey's $p<0.05$.

B. Effect of Seed Rates on Number of Tillers

Number of tillers/m^2 were not significantly ($p>0.05$) affected by different seed rates (Table 02).

C. Effect of Seed Rates on Number of Leaves

A significant difference ($p<0.05$) in the number of leaves produced on the main culm per plant was observed in different seed treatments during 6, 8 and 10 WAS. The highest number of leaves were produced by 2.5 Bu/ac (6.03) and 2 Bu/ac (6.43) during 6 WAS and 8 WAS respectively. During 10 WAS, both 2.0 Bu/ac and 2.5 Bu/ac resulted in the highest number of leaves (7.3 and 7.26 respectively). The lower number of leaves was recorded by 4.0 Bu/ac (Table 03).

Table 02: Mean Number of Tillers/m^2 of cv. At-362 Rice Variety at 6WAS

Treatment	No. of tillers/m^2
2.0 Bu/ac	360.89±65.15^{a}
3.0 Bu/ac	442.22±55.11^{a}
3.5 Bu/ac	513.77±55.68^{a}
4.0 Bu/ac	477.78±37.00^{a}
4.5 Bu/ac	507.11±51.06^{a}
2.5 Bu/ac (control)	446.66±21.31^{a}
C.V	35%
P	0.077

Values shown are mean ± S.E. Means with different letters represent significant differences at Tukey's $p<0.05$.

Table 03: Number of leaves produced on the main culm of cv. AT362 rice plants

Treatment	6WAS	8WAS	10WAS
2.0 Bu/ac	5.60±0.12^{ab}	6.43±0.10^{b}	7.30±0.17^{b}
3.0 Bu/ac	5.60±0.16^{ab}	6.36±0.10^{ab}	7.10±0.15^{ab}
3.5 Bu/ac	5.66±0.13^{ab}	6.13±0.11^{ab}	7.03±0.17^{ab}
4.0 Bu/ac	5.26±0.09^{a}	5.93±0.10^{a}	6.46±0.16^{a}
4.5 Bu/ac	5.56±0.12^{ab}	6.03±0.14^{ab}	6.43±0.16^{a}
2.5 Bu/ac (Control)	6.03±0.19^{b}	6.10±0.14^{ab}	7.26±0.20^{b}
CV	14.49%	11.03%	14.43%
P	0.05	0.03	0.01

Values shown are mean ± S.E. Means with different letters represent significant differences at Tukey's $p<0.05$.

D. Effect of Seed Rates on Flag Leaf Length and Width and Culm Length

Different seed rates significantly ($p<0.05$) affected the flag leaf length and width and culm length. The highest flag leaf length (29.9 cm) at 10 WAS recorded at 3.0 Bu/ac while the lowest was at 4.5 Bu/ac (24.50 ± 0.62^{a}). Meanwhile, the highest flag leaf width (0.9 cm) was recorded in three treatments including the control (2.0 Bu/ac, 3.0 Bu/ac and 2.5 Bu/ac) conversely, the rest of the treatment had lower values. The control treatment (2.5 Bu/ac) resulted in the highest culm length (65.3 cm) while the 4.0 Bu/ac (60.3 cm) and 3.5 Bu/ac (58.5 cm) treatments had the lowest (Table 04).

E. Effect of Seed Rates on Root Length

Figure 01 shows the root length of the At362 rice variety at 6, 8 and 10 WAS which was significantly ($p<0.05$) affected by different seed rates. A lengthier root system contributes to the rice plant in obtaining water and nutrients from deeper soil layers (Himasha *et al*., 2021). At 6 WAS, the highest root length was recorded in 2 Bu/ac (12.4 cm) and 3 Bu/ac (11.7 cm) compared to the control. However, at 8 (14.6 cm) and 10 (16.1 cm) WAS, 4 Bu/ac resulted in the highest root length (Figure 01).

Table 04: Mean Culm Height, Flag Leaf Length and Width (cm) at Flowering Stage of cv. AT362 Rice Plants

Treatment	Flag Leaf length(cm)	Flag Leaf width(cm)	Culm height (cm)
2.0 Bu/ac	28.17 ± 0.78^{ab}	0.87 ± 0.03^{b}	63.11 ± 1.07^{ab}
3.0 Bu/ac	29.86 ± 0.50^{b}	0.87 ± 0.03^{b}	63.11 ± 0.77^{ab}
3.5 Bu/ac	26.16 ± 1.03^{ab}	0.71 ± 0.04^{a}	58.55 ± 1.47^{a}
4.0 Bu/ac	29.10 ± 2.68^{ab}	0.69 ± 0.04^{a}	60.33 ± 0.57^{a}
4.5 Bu/ac	24.50 ± 0.62^{a}	0.71 ± 0.03^{a}	62.77 ± 1.68^{ab}
2.5 Bu/ac (Control)	27.93 ± 0.70^{ab}	0.87 ± 0.02^{b}	65.33 ± 1.15^{b}
CV	26.06%	26.92%	6.42%
P	0.044	0.001	0.004

Values shown are mean ± S.E. Means with different letters represent significant differences at Tukey's $p<0.05$.

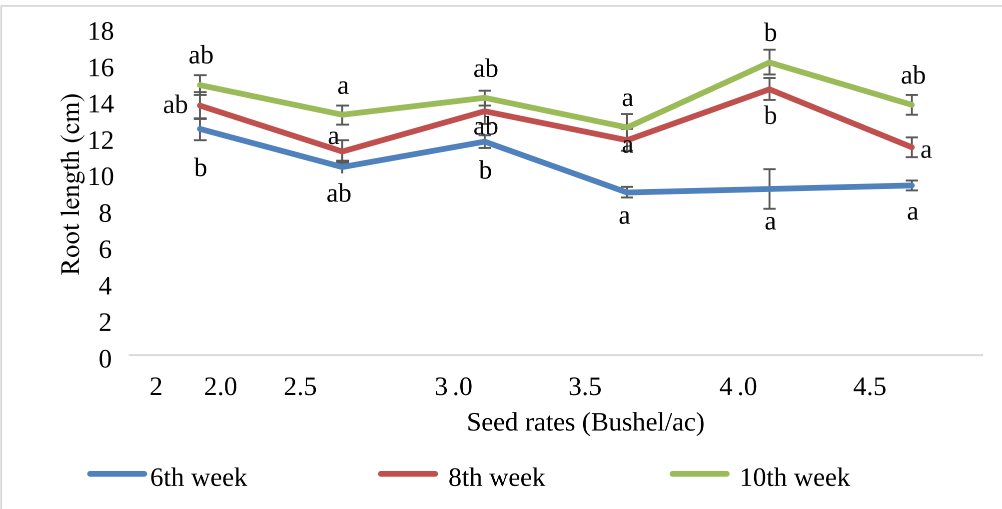

Figure 01. Effects of Seed Sowing Rates on the Root Length of cv.At-362 Rice Variety

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F. Effect of Different Seed Rates on Panicle Characteristics

According to the findings, panicle characteristics showed significantly differences ($p<0.05$) in our study. Seed rates 4 Bu/ac (386.2) and 4.5 Bu/ac (380.9) gave the highest number of panicles/m^2, while 2.0 Bu/ac had the lowest count (272.9). However, the highest panicle length (23.3 cm), number of grains per panicle (120.6), and number of filled grains per panicle (89.6) were recorded in 2.0 Bu/ac followed by 2.5 Bu/ac (70.0) and 4.0 Bu/ac (65.5) while the lowest values were recorded in 3.5 Bu/ac (Table 05).

G. Effects of seed rates on biomass characteristics and yield

Grain yield is a complex character which depends on several factors (Begum *et al*., 2018). According to our findings, the control treatment (2.5 bushel/ac) produced the highest grain yield (2.74 kg/12m^2) compared to the other treatments. A declining trend in grain yield was seen with the increasing seed rates. Treatment 4.5 bushel/ac has the lowest grain yield (1.95 kg/12m^2) of the other treatments (Table 06).

Table 05: Panicle Characteristics of cv.At-362 Rice Variety at Harvesting Stage

Treatment	**Number of panicles /m^2**	**Panicle length (cm)**	**Number of spikelets /panicle**	**Number of filled grains /panicle**	**Number of unfilled grains / panicle**
2.0 Bu/ac	272.88±10.45^a	23.26±0.3^d	120.63±4.73^c	89.63±4.08^c	30.60±2.23^c
3.0 Bu/ac	327.11±15.48^{ab}	21.43±0.39^{bc}	86.90±4.93^b	59.73±3.94^{ab}	27.40±1.98^{bc}
3.5 Bu/ac	340.00±15.57^{ab}	19.61±0.31^a	66.30±4.04^a	46.20±3.00^a	20.23±1.41^{ab}
4.0 Bu/ac	386.22±19.59^b	20.88±0.34^{ab}	91.43±5.63^{ab}	65.56±4.73^b	25.93±1.82^{abc}
4.5 Bu/ac	380.88±39.94^b	21.10±0.38^{bc}	83.46±4.5^b	62.90±4.00^{ab}	19.90±1.14^a
2.5 Bu/ac	310.66±27.59^{ab}	22.35±0.36^{cd}	96.46±5.31^b	70.46±4.61^b	26.83±1.84^{abc}
CV	22.6%	10.4%	34.16%	31.13%	41.15%
P	0.01	0.01	0.001	0.001	0.001

Values shown are mean ± S.E. Means with different letters represent significant differences at Tukey's $p<0.05$.

Table 06: Mean Dry Weight of cv. AT362 Rice Plants

Treatment	**Panicle weight (g/10panicle)**	**Straw weight(g/10 culms)**	**Above ground weight (g/10 culms)**	**Total grain yield/12m^2 (kg)**
2.0 Bu/ac	17.81±1.29^a	6.73±0.98^a	24.54±1.85^a	2.45±0.43^a
3.0 Bu/ac	12.68±2.04^a	5.81±0.84^a	18.48±2.82^a	2.38±011^a
3.5 Bu/ac	10.02±1.35^a	5.52±1.17^a	15.55±2.5^a	1.87±0.23^{ab}
4.0 Bu/ac	13.67±1.59^a	5.50±0.17^a	19.17±1.76^a	2.22±0.23^a
4.5 Bu/ac	14.17±2.2^a	5.58±0.64^a	19.783±2.4^a	1.95±0.16^{ab}
2.5 Bu/ac (Control)	15.51±2.77^a	6.61±0.40^a	22.12±3.03^a	2.74±0.27^a
CV	26.84%	20.97%	23.01%	20.79%
P	0.19	0.78	0.23	0.751

Values shown are mean ± S.E. Means with different letters represent significant differences at Tukey's $p<0.05$.

Gunawardana *et al*. (2013) conducted a field experiment in rice var. Bg300, under aerobic circumstances examined with three seed paddy rates (100, 150, and 200 kg/ha). According to their findings, larger seed paddy rates (150 and 200 kg/ha) resulted in lower grain production (0.49 and 0.33 t/ha, respectively) than the acceptable seed rate (100 kg/ha) (150kg/ha). Furthermore, the rate of seed paddy used had no effect on the number of seeds per panicle of rice plants ($p>0.05$). Field experiments sown with 100 kg/ha and 200 kg/ha produced statistically identical results, however plots sown with 150 kg/ha produced considerably lower full grain% than the other seed rates.

These findings are aligned with the current findings as the lower seed rates (2.0, 2.5 & and 3.0 bu/ac) produced an increased number of leaves, and larger flag leaves (length & and width). This may result in increase in leaf area index (LAI) and enable rice plants to synthesis large amounts of photosynthates during the day times (Mubarak *et al*., 2022). On the contrary, the increased seed rates tend to decline the plant leaf area in the rice canopy, as such the amount of photosynthates translocated into rice panicles is lower, causes large depletion in the rice grain yield. According to Anwar *et al*. (2011), the maximum number of panicles/m2 was associated with the lowest number of filled grains/panicle and 1000 grain weight, resulting in a low grain yield. However, according to Baloch *et al*. (2002), greater plant density causes intra-specific competition for light and nutrients, resulting in a decrease in grain output.

IV. CONCLUSION

According to the results of the present study, there were significant variations in plant height, flag leaf, root, and panicle and grain characteristics of the At362 rice variety. Notably, lower seed rates outperformed than the higher seed rates in terms of plant growth indices such as plant height, leaf traits, flag leaf features and panicle characteristic, as such the number of grains and fill percentages were positively influenced by decreasing seed rates. The lower seed rates (2.5 bushel/ac) produced the increased grain yield among the treatments. Hence, the present seed rates practiced by the DOA seem sufficient to maintain the rice production. However, additional field trials with economic analysis needed to confirm the financial benefits to the farmer who wanted to increase their rice yield as well as profit margins generated through their paddy cultivation.

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