



**GROWTH AND YIELD OF OM4218 RICE CULTIVARSOWED ON DIFFERENT DENSITY IN SUMMER-AUTUMN CROPPING IN KIEN GIANG PROVINCE, VIETNAM**

by

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**ABSTRACT**

Density is one of the technical factors to increase rice yield, to achieve high yield, it is necessary to increase the number of cotton to the required limit. Density determines the number of cotton per unit area and this is the most important factor determining 74% of rice yield. A study investigating the growth and yield of OM4218 rice at different sowing densities in the summer-autumn crop 2020 in Kien Giang province, Vietnam was conducted. The experiment was arranged to Randomized Complete Block Design included 4 treatments with 3 replications, treatment 1(NT1-broadcast 80 kg/ha), NT2 (100 kg/ha), NT3 (150 kg/ha) and NT4 (200 kg/ha). The results showed that different sowing weight significant effect on all the studied growth and yield characters. The results showed treatment 2 produce the highest grain yield compared to later ones with 6.99 (tons/ha). Although, the increasing sowing weight that from 150 to 200 (kg/ha), also decreased the grain yield from 6.16 and 5.65 (tons/ha), respectively, by the decrease of grain weight, number of filled grains/panicle. And the treatment 2 have had effective positive limited damage of brown planhopper, blast disease, rats, anti fall for rice and significantly reduce investment costs.

**Key words:** broadcast, brown planhopper, grain yield, OM4218 rice variety, rats, shoots, sowing density

## 1.1 INTRODUCTION

Rice is a staple food in many countries around the world, Vietnam is the 6<sup>th</sup> largest rice-growing country in the world with an area of over 7.4 million hectares, and the 2<sup>nd</sup> largest rice exporter with more than 6 million tons per year (General Statistic Office, 2019). Among the technical factors for increasing crop productivity, apart from fertilizer and fertilizer application, population density greatly affects plant growth. Population competition also affects the development of rice, when rice plants must live in cramped conditions, lack of light, making rice weak and vulnerable to attacks and diseases (Nguyen Kim Chung and Nguyen Ngoc De, 2005). The traditional practice of spreading sowing with farmers with a high density of about 200 kg/ha or more, fertilizing with nitrogen will create favorable conditions for pests and diseases to develop and reduce yields from 38.2 to 64.6 %, reducing the proportion of head rice from 3.1-11.3% and reducing weight of 1,000 grains from 3.7-5.1% (Le Huu Hai *et al.*, 2006). Because people have the traditional practice of sowing at high densities of about 200 kg/ha, but in reality rice is a plant that can adjust itself in the population, if sowing with too high density rice will branch little or no tillering, a high incidence of ineffective shoots, and even plants dying from competition for survival, along with a high nitrogen fertilizer, leading to a strong development of pests and diseases. For a unit of area, the higher the density, the higher the number of panicle, within a certain limit, increasing the number of panicle does not reduce the number of seeds/panicle and the weight of thousands of seeds but if it exceeds a certain limit, the number of seeds/panicle will gradually decrease and the weight of thousands of seeds will be reduced due to competition for nutrition and light, so when sowing too thick, the productivity will be seriously reduced. However, if transplanting is too sparse for varieties with short growing periods, it is difficult to achieve the optimal number of spiked shoots. Therefore, selecting the appropriate density is the most optimal method to achieve the maximum number of seeds per unit of cultivated area, minimizing the damage of pests and thereby reducing investment costs.

**Study Area:** Kien Giang is a coastal province in the Mekong Delta region in the south of Vietnam. This is the province with the largest area in the Southwest region and the second largest in the South. As a province located in the key economic region of the Mekong River Delta, the monthly average temperature ranges from 27.50C. The rainy season starts from April to November, the dry season from December to March next year. The average annual rainfall is about 1,600-2,000 mm. Kien Giang climate has very few natural disasters, not cold, no direct storms, abundant light and heat, so it is very favorable for many crops and animals to grow. Agricultural land, accounting for 64.2% of the natural area, Kien Giang's agriculture is wet rice cultivation with more than 300,000 hectares (Wikipedia).

## 1.2 MATERIALS AND METHODS

Rice variety: OM4218, growing time 90-95 days, long, clear, soft rice, light alum. Plant height 90-95 cm. Tools: target frame of 0.25m<sup>2</sup> (0.5m x 0.5m), grain moisture meter, analytical balance, measuring tape, rice sample bag. Fertilizers: Urea (46% N), DAP (18-46-0), KCL (60% K<sub>2</sub>O). The experiment was conducted in the Summer-Autumn crop of 2020 in Kien Giang province on high-yielding rice variety OM4218 with a growth period of 90-95 days.

The experiment was arranged in a randomised completeblock design (RCBD) with four treatments (Table 1.1) in three replications. The area of each plot was arranged to be 81 m<sup>2</sup> and the fertilizer

formula used was 70 N - 60 P<sub>2</sub>O<sub>5</sub> - 30 K<sub>2</sub>O for treatment 1; 80 N - 60 P<sub>2</sub>O<sub>5</sub> - 30 K<sub>2</sub>O for treatment 2; 90 N - 60 P<sub>2</sub>O<sub>5</sub> - 30 K<sub>2</sub>O for treatment 3; 100 N - 60 P<sub>2</sub>O<sub>5</sub> - 30 K<sub>2</sub>O for treatment 4.

**Table 1.1: Experiments of seeding density**

No.	Treatment	Seeding density (kg ha <sup>-1</sup> )
1	NT1	80
2	NT2	100
3	NT3	150
4	NT4	200

The targets of plant height and number of shoots were recorded every 10 days. The first time at 10 days after sowing (DAS) and end at 90 DAS. Each experimental plot chooses 5 fixed points, each frame has a fixed frame size of 50 x 50 cm. Each frame selects 10 fixed random trees to collect targets. Plant height (cm): measured from the ground to the highest tip. Number of shoots per m<sup>2</sup>: count the number of shoots at the rice stage of 10, 20, 30, 40, 50, 60, 70, 80 and 90 days of age and harvest at all target frames and determine the number of shoots per m<sup>2</sup>. Panicle length: in each frame with an area of 0.25m<sup>2</sup>, measure the panicle length of 10 rice plants and calculate the average length. Productivity composition: Number of panicle/m<sup>2</sup>, number of firm seeds/panicle, firm seed rate and 1,000 grain weight. Theoretical yield based on data on yield components by the formula: Theoretical yield = Number of panicle/m<sup>2</sup> x Number of firm seeds/panicle x 1,000 grain weight x 10<sup>-5</sup> (tons/ha). Actual yield of rice is calculated from the amount of rice harvested from 5 m<sup>2</sup>, threshing, drying, jute, weighing and converting to 14% moisture, symbolized as W<sub>14%</sub> (kg): Actual yield (tons/ha) = W<sub>14%</sub> x 2. Evaluate the ability to react to some pests and diseases such as brown backed planthopper, rice blast disease and rats according to IRRI rating scale (IRRI, 2013). Use EXCEL software to calculate data. SPSS 23.0 software is used for variance analysis (ANOVA) and compared the difference between treatments by Duncan test at 5% significance level.

### 1.3 RESULTS AND DISCUSSION

#### 1.3a. Overall evaluation

Brown plant hopper density was recorded in treatments 1, 2 and 3 with mild infection at level 1, but in treatment 4, brown plant hopper density was higher at level 3. Blast disease appeared from 30 DAS to maturity with level 1 in 3 treatments (1, 2 and 3) and at level 3 in rice blast disease. treatment 4. No mice were found to be harmful in all four treatments. Rice fell when entering the firm stage 15-25 days after flowering and appeared only in treatments 3 and 4 with levels of 5% and 10%, respectively, there was no fall in the other treatments (Table 1.2). This result is consistent with the research of Tran Thi Hoang Dong *et al.*, (2017) showing that if sowing at a low density of 60-100 kg/ ha rice will produce to grow, develop and tolerate pests and diseases better than sowing at high densities (120-140 kg/ ha).

**Table 1.2: Recording overview of OM4218 rice seed with sowing at different densities in the Summer-Autumn season of 2020 in Kien Giang province**

Treatment	Blast disease (level)	Brown plant hopper(level)	Rat harm (%)	Fallen (%)
NT1	1.0	1.0	0.0	0,0
NT2	1.0	1.0	0.0	0,0

NT3	3.0	1.0	0.0	5.0
NT4	3.0	3.0	0.0	10.0

### 1.3b. The plant height

The results in Table 3 show that the height of rice in the 10, 20 and 30 DAS were not significant differences between four treatments used, the height of rice in these stages was from 13.7 to 36.7 cm. However, there were significant differences between treatments in the 40 to 80 DAS. The maximum height of rice in the treatments ranged from 91.7 to 96.3 cm. The highest height of rice was in NT4 (96.3 cm), significantly different from the other treatments and the lowest was in treatment 1 (91.7 cm) (Table 1.3). The height of rice is an important indicator to evaluate the impact of technical measures and external conditions on the plant growth. The height of rice is a genetic feature that is typical of each variety and has little variation. However, the height of rice can also be subject to fluctuations when affected by external factors, nutrients, plant height changes most clearly when the insufficient nutrition is too abundant or too insufficient (Nguyen Ngoc De, 2009). This shows that, in the 10, 20, 30 DAS, young rice plants do not have competition among the plants in the population, so the plant height at these stages is not significant difference. However, from the 40 DAS, the rice plants will switch to breeding stage, so there will be fierce competition between the plants/ buds in the population for light, nutrition, water and space differences in plant height between different planting densities, particularly in the seeding density (200 kg/ ha) had the highest height due to the positive outreach to compete for light, but the rice body will be weak, poorly grow, easily fall due to unbalanced development (only grow and develop height). In the thin seeding treatments (80, 100 kg/ ha), the plants grow well, so the height of seedlings is smaller than that of thick seeding, but the trees will be healthy and sturdy.

**Table 1.3: The influence of sowing density on the height of trees of OM4218 rice in the Summer-Autumn season of 2020 in Kien Giang province**

Treatment	Days after sowing(DAS)							
	10	20	30	40	50	60	70	80
NT1	13.7	21.3	36.3	50.3 <sup>b</sup>	63.7 <sup>c</sup>	75.7 <sup>b</sup>	84.3 <sup>d</sup>	91.7 <sup>c</sup>
NT2	13.7	21.3	36.0	50.3 <sup>b</sup>	64.3 <sup>c</sup>	76.0 <sup>b</sup>	86.0 <sup>c</sup>	92.7 <sup>c</sup>
NT3	13.7	20.7	36.7	52.7 <sup>a</sup>	66.0 <sup>b</sup>	76.3 <sup>b</sup>	87.0 <sup>b</sup>	94.7 <sup>b</sup>
NT4	13.7	21.0	36.7	53.7 <sup>a</sup>	68.3 <sup>a</sup>	79.0 <sup>a</sup>	88.7 <sup>a</sup>	96.3 <sup>a</sup>
F	<i>ns</i>	<i>ns</i>	<i>ns</i>	**	**	**	**	**
CV (%)	4,22	3,37	1,37	1,12	1,08	0,84	0,47	0,62

Note: Values are the mean of three replicates. Means within each column having different letters, are significantly different according to Duncan at *ns*: no significant differences, 1% (\*\*) level. NT1: broadcast 80 kg ha<sup>-1</sup>, NT2: broadcast 100 kg ha<sup>-1</sup>, NT3: broadcast 150 kg ha<sup>-1</sup>, NT4: broadcast 200 kg ha<sup>-1</sup>.

### 1.3c. The number of shoots per unit area

The number of shoots per m<sup>2</sup> at from 10-90 DAS were significant difference among treatments, the highest shoot was treatment 1, followed by treatment 2, treatment 3, and the treatment 4 had the lowest shoots. The 40 days after sowing was the period when rice plants had the highest number of shoots (maximum shoots), treatments were statistically different and ranged from 892 -1,343 shoots/ m<sup>2</sup>, treatment 4 was the highest (1,343 shoots/ m<sup>2</sup>); treatment 1 was lowest (892 shoots/ m<sup>2</sup>). Starting from the 50-day period after sowing (after reaching the maximum number of shoots) the

number of shoots in the treatments began to decrease gradually until the 90-day period after sowing. After 90 days of shoots  $\text{perm}^2$ , there was a statistically significant difference in the number of shoots  $\text{perm}^2$  compared to the period of maximum shoots (Table 1.4). Tillering is a biological characteristic of rice, the number of tillers is closely related to the process of formation of effective panicle and yield later. The tillering capacity of rice depends on many factors such as weather conditions, nutrition, density, light, water sources as well as technical conditions of cultivation (Nguyen Van Hoan, 2009). Light and nutrition were the main factors influencing the maximum number of shoots in different treatments of seeding density. Sowing sparsely, rice plants receive a lot of light, so they shoot more buds and vice versa, rice seedlings receive less light, so shoots are poor, the maximum number of buds is mainly from the main stem of rice (Nguyen Truong Giang, 2011). This study is also consistent with the experimental results in the 20 days after sowing and 40 days after sowing at 200 kg/ ha sowing, the maximum number of shoots was mainly from the main stem of rice. The number of shoots  $\text{perm}^2$  is an important indicator that is closely related to the number of shoots  $\text{perm}^2$  closely related to the density of seedlings, thick seedlings with no tillering or poor, poorly grown trees, but good seeding and sowing seedlings ensure sufficient number of shoots  $\text{perm}^2$  for optimum yield. In the thicker treatments, the number of shoots was always higher than the thin-growing treatments, but these were ineffective shoots that did not give panicle but also competed to grow, making plants weak, grow poorly and easily infection with pests, falling.

**Table 1.4: The influence of sowing density on the number of buds of OM4218 rice in the Summer-Autumn season of 2020 in Kien Giang province**

Treatment	Days after sowing (DAS)								
	10	20	30	40	50	60	70	80	90
NT1	391.0 <sup>d</sup>	414.0 <sup>d</sup>	671.0 <sup>d</sup>	892.0 <sup>d</sup>	781.0 <sup>c</sup>	690.0 <sup>d</sup>	626.0 <sup>d</sup>	560.0 <sup>d</sup>	494.0 <sup>d</sup>
NT2	402.0 <sup>c</sup>	432.0 <sup>c</sup>	681.0 <sup>c</sup>	902.0 <sup>c</sup>	790.0 <sup>c</sup>	701.0 <sup>c</sup>	642.0 <sup>c</sup>	571.0 <sup>c</sup>	512.0 <sup>c</sup>
NT3	512.0 <sup>b</sup>	622.0 <sup>b</sup>	702.0 <sup>b</sup>	1000.0 <sup>b</sup>	892.0 <sup>b</sup>	721.0 <sup>b</sup>	652.0 <sup>b</sup>	582.0 <sup>b</sup>	522.0 <sup>b</sup>
NT4	690.0 <sup>a</sup>	781.0 <sup>a</sup>	801.0 <sup>a</sup>	1343.0 <sup>a</sup>	1063.0 <sup>a</sup>	897.0 <sup>a</sup>	724.0 <sup>a</sup>	608.0 <sup>a</sup>	540.0 <sup>a</sup>
F	**	**	**	**	**	**	**	**	**
CV (%)	0,32	0,53	0,19	0,31	3,13	0,44	0,61	0,92	1,12

Note: Values are the mean of three replicates. Means within each column having different letters, are significantly different according to Duncan at 1% (\*\*) level. NT1: broadcast 80 kg ha<sup>-1</sup>, NT2: broadcast 100 kg ha<sup>-1</sup>, NT3: broadcast 150 kg ha<sup>-1</sup>, NT4: broadcast 200 kg ha<sup>-1</sup>.

### 1.3d. The panicle length, total number of seeds/panicle, the percent of filled grains and the percent of unfilled grains

**Panicle length and total number of seeds/panicle:** The results in Table 1.5 show that among the treatments of sowing density were statistically significant at the 1% significance level of panicle length and the total number of seeds/panicle, the highest was in treatment 1 (19.7 cm, 118 seeds, respectively) and the lowest were in treatment 4 (17.5 cm, 97 seeds, respectively). The length and the total number of seeds on the rice paddy vary depending on the variety and conditions of the crop: seeding density, nutrition, etc., and contribute to an increase in yield. This result shows that, in the sowing field, the density of rice will be lack of nutrition, light, ... so the panicle has a short length, and the total number of seeds on the panicle is also less. On the other hand, thin sowing will help the rice plant to grow well, producing panicle with a longer length and total number of seeds per flower than sowing thick seeding, contributing to the increase of rice yield. The number of

seeds/panicle is also an important factor in the yield, the number of seeds/panicle is decided from the neck of the flower to 5 days before flowering, at this stage the number of seeds/panicle has a positive influence on rice yield. By affecting the number of differentiated flowers, the number of seeds/panicle contributes to increasing productivity (Nguyen Ngoc De, 2009).

**The percent of filled grains and unfilled grains:** The percent of filled grains and the percent of unfilled grains in the treatments had a statistically significant difference, the highest was in treatment 1 (86.2%), followed by treatment 2 (85.8%) and the lowest was in treatments 4 (78.8%). On the contrary, the percentage of grains lost in treatment 4 was highest (21.2%) and lowest was in treatment 1 (13.8%) (Table 1.5). The percent of filled grains is determined from the beginning of the rice initiation period until the rice is firm but most importantly, the periods of mitosis, flowering, drying, pollination, fertilization and solidification. The percent of filled grains depends on the number of flowers on the flower, the physiological characteristics of the rice plant and the influence of external conditions, often the number of flowers on the flower is too high which will lead to a low the percent of filled grains. To have high yield, the percent of filled grains must be over 80% (Nguyen Ngoc De, 2009). Experimental results showed that percent of filled grains was inversely proportional to the seeding density and the percent of unfilled grains was proportional to the seeding density. The percent of filled grains will be high if the seedlings are thin at the density and vice versa, the percent of filled grains will be low if the seedlings are densely packed. At the density of thick seeded rice, there is a higher the percent of unfilled grains due to competition in nutrition, light and pests. Thus, the application of techniques to reduce seeding density for high seed percentage and low seed rate should be able to produce high yields.

**Table 1.5: Influence of sowing density on panicle length, total number of seeds/panicle, the percent of filled grains and unfilled grains of OM4218 rice in Summer-Autumn crop 2020 in Kien Giang province**

Treatment	Panicle length	Total number of seeds/panicle	The percent of filled grains	The percent of unfilled grains
NT1	19.7 <sup>a</sup>	118.0 <sup>a</sup>	86.2 <sup>a</sup>	13.8 <sup>b</sup>
NT2	19.4 <sup>b</sup>	115.0 <sup>b</sup>	85.8 <sup>a</sup>	14.2 <sup>b</sup>
NT3	18.1 <sup>c</sup>	111.0 <sup>c</sup>	80.6 <sup>b</sup>	19.4 <sup>a</sup>
NT4	17.5 <sup>d</sup>	97.0 <sup>d</sup>	78.8 <sup>b</sup>	21.2 <sup>a</sup>
F	**	**	**	**
CV (%)	0,9	1,14	2,23	10,79

Note: Values are the mean of three replicates. Means within each column having different letters, are significantly different according to Duncan at 1% (\*\*) level. NT1: broadcast 80 kg ha<sup>-1</sup>, NT2: broadcast 100 kg ha<sup>-1</sup>, NT3: broadcast 150 kg ha<sup>-1</sup>, NT4: broadcast 200 kg ha<sup>-1</sup>.

### 1.3e. Components of yield and yield

**Number of panicle per m<sup>2</sup>:** Results in Table 1.6 show that, among treatments, was a difference in statistical analysis at the 1% significance level of the number of panicle perm<sup>2</sup> of the treatments ranging from 494.0-540.0 panicle, the lowest was at Treatment 1 (494.0 panicle) and the highest was in treatment 4 (540.0 panicle) (Table 1.6). The number of panicle per m<sup>2</sup> is one of the four factors that make up the rice yield. According to Yoshida (1981), the number of shoots per m<sup>2</sup> of rice field is highly dependent on budding and is determined largely at 10 days after the maximum number of shoots. The number of sprouts/ m<sup>2</sup> depends on the density of sowing and the ability of

rice to dust; The seeding density and the ability of rice to hatch dust vary depending on the rice variety, fertilizer amount and water regime, the number of panicle per  $m^2$  is proportional to the yield (Nguyen Ngoc De, 2009). The effective time for rice to shoot is an important time affecting the formation of panicle per  $m^2$ . This time ends about 10 days before the rice plant reaches the maximum number of shoots. Shoots formed during this period are capable of forming panicle. For seeding treatments with a density of 80 and 100 kg/ ha, the number of panicles was formed on both the main stem and shoots formed during the effective shoot jumping period, for the sowing trial with a density of 200 kg/ ha, the number of spikelets formed only on the main stem due to limitations in the effective shoot period. Thus, the density of sowing greatly affects the effective scion and the number of sprouts per unit area, the thicker the density, the more effective the sowing will prevent the effective scion and lead to the effect panicle number per unit area, in contrast to sowing will be good for efficient bud jumping and forming number of panicle per area unit.

**Table 1.6 Influence of sowing density on components of yield and yield of OM4218 rice in the Summer-Autumn crop of 2020 in Kien Giang province**

Treatment	Number of panicle/ $m^2$	Number of filled grains	Weight of 1,000 seeds (g)	Theoretical yield (tons/ha)	Actual yield (tons/ha)
NT1	494.0 <sup>c</sup>	102.0 <sup>a</sup>	21.2 <sup>a</sup>	10.70 <sup>a</sup>	6.92 <sup>b</sup>
NT2	512.0 <sup>b</sup>	99.0 <sup>b</sup>	21.1 <sup>a</sup>	10.70 <sup>a</sup>	6.99 <sup>a</sup>
NT3	522.0 <sup>b</sup>	89.7 <sup>c</sup>	20.1 <sup>c</sup>	9.40 <sup>b</sup>	6.16 <sup>c</sup>
NT4	540.0 <sup>a</sup>	76.7 <sup>d</sup>	20.7 <sup>b</sup>	8.60 <sup>c</sup>	5.65 <sup>d</sup>
F	**	**	**	**	**
CV (%)	1,12	1,41	0,46	1,98	0,02

Note: Values are the mean of three replicates. Means within each column having different letters, are significantly different according to Duncan at 1% (\*\*) level. NT1: broadcast 80 kg  $ha^{-1}$ , NT2: broadcast 100 kg  $ha^{-1}$ , NT3: broadcast 150 kg  $ha^{-1}$ , NT4: broadcast 200 kg  $ha^{-1}$ .

**Number of filled grains:** The number of filled grains/ panicle in the treatments was significantly different at the 1% level, treatment 1 had the largest number of filled grains/ panicle (102.0 seeds) and the fourth treatment had the number of filled grains/ panicle. smallest (76.7 grains) (Table 1.6). It is one of the four components that make up yield. In general, for rice varieties with large flowers, good cultivation techniques, adequate fertilization, proper care, favorable weather, the more flowers diverge, the smaller the number of degraded flowers, the more grains more panicle can lead to more beads/ panicle. In improved rice varieties, the number of filled grains/ panicle from 80-110 seeds for sowing rice is good in the Mekong Delta conditions (Nguyen Thanh Hoi, 2003). Thus, in a certain range, the number of filled grains/ panicle is inversely proportional to the seeding density, the lower the seed density is the number of filled grains/ panicle will be high. The seeding with 80 and 100 kg/ ha was shown to be better than the remaining seeding with an increase of filled grains/ panicle.

**Weight of 1,000 seeds (g):** The results in Table 1.6 show that, between treatments with significant differences in 1,000 grain weight, treatments 1 and 2 were the highest (21.2 and 21.1 g, respectively) and the difference was not significant; The lowest was in treatment 3 with 1,000 grain weight of 20.1 g and treatment 4 was 20.7 g (Table 1.6). The 1,000 grain weight is also one of the factors that make up the rice yield but it is less volatile which is mainly due to the genetic characteristics of the seed. In most rice varieties, the 1,000 grain weight usually varies between 20-

30 g (Nguyen Ngoc De, 2009). Grain weight is also a factor that significantly affects productivity. This result shows that 1,000 grain weight is also affected by seeding density. If seeded with a dense density (200 kg/ ha), the weight of 1,000 seeds will be low because the supply of nutrients and photosynthetic products into the seeds is adversely affected, so the seeds are not fully filled with seeds, so the weight will be reduced. Thus, the technical measure of finding suitable density (reduced density) also contributes to an increase in weight of 1,000 seeds and can reach the maximum weight of 1,000 seeds of the variety.

**Theoretical yield (tons/ha):** The statistical results in Table 1.6 show that between the treatments with significant theoretical yield, the theoretical yield ranged from 8.6-10.7 tons/ ha, in which the sowing treatment 80 and 100 kg/ ha had the highest and equal theoretical yield (10.7 tons/ ha) and the 200 kg/ ha seeding treatment had the lowest theoretical yield (8.6 tons/ ha) (Table 1.6). Theoretical yield reflects the yield potential of rice and depends on the number of sprouts/ m<sup>2</sup>, the number of firm grains/ panicle and the weight of 1,000 seeds. The higher these indicators, the higher the theoretical productivity. The more components of the theoretical yield increase, the higher the rice yield, until these components reach an optimal equilibrium, the maximum rice yield. If one of these components changes, it will affect the remaining components and reduce productivity (Nguyen Thanh Hoi, 2003). Therefore, the increase in the number of panicle per m<sup>2</sup> will affect the reduction of the percentage of firm grains and the weight of 1,000 seeds, which reduces the theoretical yield of 200 kg/ ha seed treatment. However, according to the results of this experiment, it is shown that the number of firm grains/ panicle, the percentage of firm grains and the weight of 1,000 seeds are the main factors that make the difference in theoretical yield among treatments despite the number of panicle per m<sup>2</sup> was the opposite.

**Actual yield (tons/ha):** Actual yield of the different treatments was statistically significant at the 1% significance level, yield ranged from 5.65 to 6.99 tons/ ha. In particular, the treatment of 100 kg/ ha sowing was the highest (6.99 tons/ ha), followed by the treatment of 80 kg/ ha (6.92 tons/ ha) and the lowest was the treatment of 200 kg/ ha (5.65 tons/ ha) (Table 1.6). Productivity is an aggregate indicator of all components of productivity. In fact, the components of productivity are very closely related to each other, increasing the productivity of rice must not only affect each factor individually but also the aggregate effect. Actual yield (ton/ ha) is the most important indicator to assess the impact of technical measures on rice productivity (Nguyen Thanh Hoi, 2003). Actual yield is the final factor for classifying and evaluating high or low yield varieties. Rice productivity is regulated by four closely related yield components, if one of these four components fluctuates excessively, it will affect the rest and make the actual yield increase or decrease (Nguyen Van Hoan, 2009). In fact, the actual yield is much lower than the theoretical productivity due to biological constraints such as the adaptation of varieties to soil, water, nutrition, pests, weeds. In particular, farmers' knowledge and farming practices are very important, costs and profits are also basic factors affecting investment and thus affecting rice productivity (Nguyen Ngoc De and Pham Thi Phan, 2004). The results showed that the increase in seeding density increased the number of sprouts per m<sup>2</sup> and reduced the percentage of firm seeds and the weight of seeds. Therefore, the actual yield was reduced when sowing at high density in the 200 kg sowing trial/ ha. However, the rationality of the yield components in the 80 and 100 kg/ ha seed treatments resulted in higher actual yields. Thus, if applied technical measures to reduce the density of sowing and sowing at 80 or 100 kg/ ha, the actual yield will be higher than sowing at the density of 200 kg/ ha (an increase of 19.1%) and while reducing a significant amount of seed.

### 1.3f. Investment costs

In each rice crop, farmers need to invest a lot of expenses such as seeds, fertilizers, plant protection chemicals, etc. In this experiment, due to the use of low density, the investment costs are reduced varieties, fertilizers, and plantprotection chemicals. Thus, if seeding at a density of 100 kg/ ha will save 100 kg of seeds/ ha with the current price of OM4218 rice variety at 14,000 VND/ kg, the farmer will save 1.4 million VND in initial cost seeding per hectare compared to seeding at a density of 200 kg/ ha, while saving on fertilizer and plant protection chemicals costs with a total cost saving of 4.0 million VND per ha means farming farmers will have an additional profit of 4.0 million VND/ ha if applied with a density of 100 kg/ ha (Table 1.7).

**Table 1.7: Some major investment costs in the experiment**

*Unit: thousand VND/ha*

Treatment	Rice seeds	Fertilizer	Plantprotection chemicals	Total	Difference
NT1	1,120	2,000	1,200	4,320	5,080
NT2	1,400	2,200	1,800	5,400	4,000
NT3	2,100	2,800	3,000	7,900	1,500
NT4	2,800	3,200	3,400	9,400	-

### 1.4 CONCLUSIONS

The rice plants had better growth at 80 and 100 kg/ ha treatment through the criteria of plant height, number of shoots, the degree of pest and fall infection. The sowing trial at the density of 100 kg/ ha had a higher number of filled grains/ panicle (99.0 seeds), the percent of filled grains (85.8%), and a weight of 1,000 seeds (21.1 g) was lower than the cultivated one at the density of 80 kg/ ha but higher than that the other two treatments. The practice of sowing at a seeding density of 100 kg/ ha is the optimal seeding density compared to the others, which is the one with the highest actual yield (6.99 tons/ ha) and an increase 19.1% compared to seeding density of 200 kg/ ha. Sowing 80 and 100 kg/ ha to reduce investment costs including seeds, fertilizers, plant protection chemicals and increase profits, investment costs are different from the 200 kg/ ha sowing treatment 5.08 million VND and 4.0 million VND, respectively.

Sowing sowing at a density of 100 kg/ha in the summer-autumn season in Kien Giang province will yield the best yield and profit among the other seeded densities in this study. The application of seed density reduction helps reduce the use of chemical fertilizers and plant protection chemicals that will contribute to reducing environmental pollution.

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