ISSN 1533-9211

DOI 10.5281/zenodo.6911950

EFFECTS OF DIFFERENT SOWING DENSITY ON THE GROWTH AND YIELD OF RICE OM 18

NGUYEN VAN CHUONG

Department of Crop Science, Agricultural Faculty of An Giang University - Vietnam National University, Ho Chi Minh City, Vietnam, 18 Ung Van Khiem St., Long Xuyen city, An Giang province.

ABSTRACT

Sowing density that is an important role to raise the rice yield components and yield to the required limit. Number of cottons per crop area, which has significanty determined by sowing density is the most important factor determining 74% of rice yield. The field study determined effects of different sowing density on the growth and yield of rice OM 18 rice in the summer-autumn crop of 2022in An Giang province, Vietnam. The field experiment was arranged to Randomized Complete Block Design included 4 treatments with four replications. Four treatment included: R1 (broadcast 70 kg/ha), R2 (90 kg/ha), R3 (110 kg/ha) and R4 (130 kg/ha). The results showed that different sowing weights significant affected on the growth and yield properties. The results showed the highest grain yield (6.99 t/ha) obtained at R2 and lowest value of treatment R4 (5.95 t/ha). When the hihger increase of sowing rice weight from 110 to 130 (kg/ha) lessened significanty the rice yield from 6.56 (R3: 110 kg/ ha) to 5.95 tons/ha (R4: 130 kg/ha), respectively. The yield component and yield of rice OM 18 had the maximum values of treatment R2 (90 kg/ha) compaired to others. Furthermore, the treatment R2 (90 kg/ha) was effectiveness of lowest limited damage of brown planhopper, blast disease, rats, anti-fall for rice OM18 and significantly reduce investment costs.

Key words: effect, growth, OM 18, rice, sowing density, yield,

A. INTRODUCTION

Rice is a staple food in many countries around the world, Vietnam is the 6th largest rice-growing country in the world with an area of over 7.4 million hectares, and the 2nd 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 (Akita, 1982). 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 (Baloch et al., 2002). 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 acertain limit (Tari, et al., 2007). 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 (Bozorgi et al., 2011). 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:

An Giang which is a province in the Mekong Delta region is the main rice storehouse in southern of Vietnam. The An Giang province is the largest rice area in the Southwest region. As a province located in the key economic region of the Mekong River Delta, the monthly average temperature ranges from 27.5^{0}C. 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. Local 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 landsoil, accounting for 64.2% of the natural area, agriculture is wet rice cultivation with more than 300,000 hectares.

B. MATERIALS AND METHODS

Rice variety: OM18, growing time 90-95 days, long, clear, soft rice, light alum. Plant height 90- 95 cm. Tools: target frame of 0.25m^2 (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_2O). 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 randomized complete block design (RCBD) with four treatments (Table 1.1) in three replications. The area of each plot was arranged to be 81 m^2 and the fertilizer formula used was 70 N - 60 P_2O_5 - 30 K_2O for treatment 1; 80 N - 60 P_2O_5 - 30 K_2O for treatment2; 90 N - 60 P_2O_5 - 30 K_2O for treatment 3; 100 N - 60 P_2O_5 - 30 K_2O for treatment 4.

The Seybold REPORT

ISSN 1533-9211

DOI 10.5281/zenodo.6911950

Table 1: Experiments of seeding density

Treatment	Sowing density (kg /ha)
R1	70
R2	90
R3	110
R4	130

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^2: 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^2. Panicle length: in each framewith an area of $0.25m^2$, measure the panicle length of 10 rice plants and calculate the average length. Productivity composition: Number of panicle/m^2, 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^2 x Number of firm seeds/panicle x 1,000 grain weight x 10^{-5} (tons/ha). Actual yield of rice is calculated from the amount of rice harvested from 5 m^2, threshing, drying, jute, weighing and converting to 14% moisture, symbolized as $W_{14\%}$ (kg): Actual yield (tons/ha) = $W_{14\%}$ x 2. Evaluate the ability to react to some pests and diseases such as brown backed plant hopper, 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.

C. RESULTS AND DISCUSSION

1. Overview

Table 2 Recording overview of rice OM18 with sowing at different densities

Treatment	Blast disease(level)	Brown plant hopper (level)	Rat harm (%)	Fallen (%)
R1	1.0	1.0	0.0	0,0
R2	1.0	1.0	0.0	0,0
R3	3.0	1.0	0.0	5.0
R4	3.0	3.0	0.0	10.0

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

The Seybold REPORT
ISSN 1533-9211
DOI 10.5281/zenodo.6911950

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. Rats did not 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 Chandrankar & Khan, (1981) showed 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 (110-130 kg/ ha).

2. Plant heights

The results in Table 3 showed that the height of rice in the 10, 20 and 30 DAS were insignificant differences between four treatments, 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 R4 (96.3 cm), significantly different from the other treatments and the lowest was in treatment 1 (91.7 cm) (Table 3). The height of rice is an important indicator to evaluate the impactof 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, nutritions, plant height changes most clearly when the insufficient nutrition is too abundant or too insufficient (Nguyen Ngoc De, 2009). This results showed that, in the 10, 20, 30 DAS, young rice plants did 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 may switch to breeding stage, so there could 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 (130 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 (70, 90 kg/ ha), the plants growed well, so the height of seedlings was smaller than that of thick seeding, but the trees could be healthy and sturdy.

Table 3: The influence of sowing density on the height of rice OM 18

Treatment	Days after sowing(DAS)							
	10	20	30	40	50	60	70	80
R1	13.7	21.3	36.3	50.3^{b}	63.7^{c}	75.7^{b}	84.3^{d}	91.7^{c}
R2	13.7	21.3	36.0	50.3^{b}	64.3^{c}	76.0^{b}	86.0^{c}	92.7^{c}
R3	13.7	20.7	36.7	52.7^{a}	66.0^{b}	76.3^{b}	87.0^{b}	94.7^{b}
R4	13.7	21.0	36.7	53.7^{a}	68.3^{a}	79.0^{a}	88.7^{a}	96.3^{a}
F	ns	ns	ns	**	**	**	**	**
CV (%)	4,22	3,37	1,37	1,12	1,08	0,84	0,47	0,62

The Seybold REPORT
ISSN 1533-9211
DOI 10.5281/zenodo.6911950

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.R1: broadcast70 kg ha^{-1}, R2: broadcast 90 kg ha^{-1}, R3: broadcast 110 kg ha^{-1}R4: broadcast 130 kg ha^{-1}.

3. number of shoots

Number of shoots per m^2 from 10 to 90 DAS were significant differences among treatments, the highest shoot was treatment R1, followed by treatment R2, treatment R3, and the treatment R4 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^2, treatment 4 was the highest (1,343 shoots/ m^2); treatment 1 was lowest (892 shoots/ m^2).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 perm^2, there was a statistically significant difference in the number of shoots perm^2 compared to the period of maximum shoots (Table 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; Sheieh, 1977). 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 perm^2 is an important indicator that is closely related to the number of shoots 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 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 alsocompeted to grow, making plants weak, grow poorly and easily infection with pests, falling.

The Seybold REPORT

ISSN 1533-9211

DOI 10.5281/zenodo.6911950

Table 4: The influences of sowing density on the number of buds of Rice OM 18

Treatment	Days after sowing (DAS)								
	10	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**
R1	391[d]	414[d]	671[d]	892[d]	781[c]	690[d]	626[d]	560[d]	494[d]
R2	402[c]	432[c]	681[c]	902[c]	790[c]	701[c]	642[c]	571[c]	512[c]
R3	512[b]	622[b]	702[b]	1,000[b]	892[b]	721[b]	652[b]	582[b]	522[b]
R4	690[a]	781[a]	801[a]	1,343[a]	1,063[a]	897[a]	724[a]	608[a]	540[a]
F	**	**	**	**	**	**	**	**	**
CV (%)	0.32	0.53	0.19	0.31	3.13	0.44	0.61	0.92	1.12

Note: (**) significantly differences 1%.

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

a. Panicle length and total number of seeds/panicle: The results in Table 5 showed that among the treatments of sowing density were statistically significant at the 1%. Panicle length and the total number of seeds/panicle, the highest were in treatment R1 (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, inthe 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 fromthe 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 (Uddin et al., 2010).

b. 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 5). The percent of filled grains was 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 percentage of filled grains dependson 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. Having the 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

The Seybold Report
ISSN 1533-9211
DOI 10.5281/zenodo.6911950

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 seedpercentage and low seed rate should be able to produce high yields.

Table 5: Influence of sowing density on panicle length, total number of seeds/panicle, the percent of filled grains and unfilled grains of rice OM18

Treatment	Panicle length	Total number of seeds/panicle	The percent of filled grains	The percent of unfilled grains
R1	19.7[a]	118[a]	86.2[a]	13.8[b]
R2	19.4[b]	115[b]	85.8[a]	14.2[b]
R3	18.1[c]	111[c]	80.6[b]	19.4[a]
R4	17.5[d]	97.0[d]	78.8[b]	21.2[a]
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 ns: no significant differences, 1% (**) level.R1: broadcast70 kg ha^{-1}, R2: broadcast 90 kg ha^{-1}, R3: broadcast 110 kg ha^{-}R4: broadcast 130 kg ha^{-1}.

C. Yield components and yield

Number of panicle per m^2: Results in Table 6 show that, among treatments, was a difference in statistical analysis at the 1% significance level of the number of panicle per m^2 of the treatments ranging from 494-540 panicle, the lowest was at Treatment R1 (494 panicle) and the highestwas in treatment 4 (540 panicle) (Table 6). The number of panicle per m^2 is one of the four factors that make up the rice yield. According to Uddin et al., (2011), the number of shoots per m^2 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^2 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 themaximum number of shoots. Shoots formed during this period are capable of forming panicle. For seeding treatments with a density of 70 and 90 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 trialwith a density of 130 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 Seybold REPORT
ISSN 1533-9211
DOI 10.5281/zenodo.6911950

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 6 Influence of sowing density on yield components and yield of rice OM18

Treatment	Number of panicle/m^2	Number of filled grains	Weight of 1,000 seeds (g)	Theoretical yield (t/ha)	dry yield (t/ha)
R1	494.0^c	102.0^a	21.2^a	10.70^a	6.52^b
R2	512.0^b	99.0^b	21.1^a	10.70^a	6.99^a
R3	522.0^b	89.7^c	20.1^c	9.40^b	6.56^c
R4	540.0^a	76.7^d	20.7^b	8.60^c	5.95^d
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 ns: no significant differences, 1% (**) level.R1: broadcast 70 kg ha-1, R2: broadcast 90 kg ha-1, R3: broadcast 110 kg ha-1R4: broadcast 130 kg ha-1.

d. 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 flowersdiverge, 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 seedsfor 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 70 and 90 kg/ ha was shown to be better than the remaining seeding with an increase of filled grains/ panicle.

e. Weight of 1,000 seeds (g): The results in Table 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 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

ISSN 1533-9211

DOI 10.5281/zenodo.6911950

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 themaximum weight of 1,000 seeds of the variety.

f. 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 70 and 90 kg/ ha had the highest and equal theoretical yield (10.7 tons/ ha) and the 130 kg/ ha seeding treatment had the lowest theoretical yield (8.6 tons/ ha) (Table 6).Theoretical yield reflects the yield potential of rice and depends on the number of sprouts/ m^2, 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^2will affect the reduction of the percentage of firm grains and the weight of 1,000 seeds, which reduces the theoretical yield of 130 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^2 was the opposite.

g. Actual yield (tons/ha): Actual yield of the different treatments was statistically significant at the 1% significance level, yield ranged from 5.95 to 6.99 tons/ ha. In particular, the treatment of 90 kg/ ha sowing was the highest (6.99 tons/ ha), followed by the treatment of 70 kg/ ha (6.92 tons/ ha)and the lowest was the treatment of 130 kg/ ha (5.95 tons/ ha) (Table 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 eachfactor individually but also the aggregate effect. Actual yield (t/ 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, and 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^2 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 130 kg sowing trial/ ha. However, the rationality of the yield components in the 70 and 90 kg/ ha seed treatments resulted in higher actual yields. Thus, if applied technical measures to reduce the density of sowing and sowing at 70 or 90 kg/ ha, the

ISSN 1533-9211
DOI 10.5281/zenodo.6911950

actual yield will be higher than sowing at the density of 130 kg/ ha (an increase of19.1%) and while reducing a significant amount of seed.

5. 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 plant protection chemicals. Thus, if seeding at a density of 90 kg/ ha will save 40 kg of seeds/ ha with the current price of OM18 rice variety at 14,000 VND/ kg, the farmer will save 560,000 VND/ ha in initial cost seeding per hectare compared to seeding at a density of 130 kg/ ha, while saving on fertilizer and plant protection chemicals costs with a totalcost 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 90 kg/ ha (Table 7).

Table 7: Some major investment costs in the experiment *Unit: thousand VND/ha*

Treatment	Rice seeds	Fertilizer	chemicals	Total	Difference
R1	1,120	2,000	1,200	4,320	5,080
R2	1,400	2,200	1,800	5,400	4,000
R3	2,100	2,800	3,000	7,900	1,500
R4	2,800	3,200	3,400	9,400	-

D. CONCLUSIONS

The rice plants had better growth at 70 and 90 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 90 kg/ ha had a higher number of filled grains/ panicle (99.0 seeds), the percent of filled grains (85.8%), and aweight of 1,000 seeds (21.1 g) was lower than the cultivated one at the density of 70 kg/ ha but higher than that the other two treatments. The practice of sowing at a seeding density of 90 kg/ hais the optimal seeding density compared to the others, which is the one with the highest actual yield (6.99 tons/ ha) and an increase 14.9% compared to seeding density of 130 kg/ ha. Sowing 70 and900 kg/ ha to reduce investment costs including seeds, fertilizers, plant protection chemicals and increase profits.

REFERENCE

Akita, K., (1982). Studies on compensation of crop plants: XI. Effects of planting density on the yield component in rice plant. Sci. Rep. Fac. Agric. Kobe Univ., 15: 17-21.

Baloch, A.W., Soomro, A.M. Javed, M.A. Ahmed, M. Bughio, H.R. Bughio M.S. & Mastoi, N.N. (2002). Optimum plant density for high yield in rice (Oryza sativa L.). Asian J. Plant Sci., 1: 25-27

Bozorgi HR, Faraji A, Danesh RK, Keshavarz A, Azarpour E.& Tarighi F (2011). Effect of Plant Density on Yield and Yield Components of Rice. World Appl. Sci. J. 12(11):2053-2057.

Chandrankar, B.L. & Khan, R.A. (1981). Optimum Spacing for early medium and late duration tall indica rice cultivars. Oryza 18(2):108-109.

ISSN 1533-9211

DOI 10.5281/zenodo.6911950

General Statistical Office (2019). Statistical Yearbook of Viet Nam, 2018. Statistical Publishing House, pp.1024.

International Rice Research Institute (IRRI). (2013). SES Standard evaluation system for Rice. 56 page.

Le Huu Hai, Pham Van Kim, Pham Van Du, Tran Thi Thu Thuy & Duong Ngoc Thanh (2006). Influence of blast on rice yield and milling quality at two densities of sowing and nitrogen fertilizers. Collection of scientific research works Department of Agriculture and Applied Biology 2006, Volume 2: Plant Protection - Plant Science - Agricultural Genetics. Can Tho University, p. 77-82.

Mobasser, H.R., Delarestaghi, M.M., Khorgami, A., Tari, B.D. & Pourkalhor, H. (2007). Effect of planting density on agronomical characteristics of rice (Oryza sativa L.) varieties in North of Iran. Pak. J. Biol. Sci. 10(18):3205-3209.

Nguyen Kim Chung and Nguyen Ngoc De (2005). Effect of sowing method and nitrogen levels on growth and short-term rice yield. Can Tho University Journal of Science, 5(B): 161-187.

Nguyen Ngoc De (2009). Rice crop syllabus. Ho Chi Minh City National University Publishing House. 338 pages.

Nguyen Ngoc De and Pham Thi Phan (2004). Research to develop integrated intensive farming processes for fragrant rice exports in high coastal areas in the Mekong Delta (2002-2004). Research and Development Institute of Mekong Delta Farming System - Can Tho University.

Nguyen Thanh Hoi (2003). Summer-autumn rice yield and the issue of organic poisoning. Summary of the workshop "Measures to improve summer-autumn rice productivity in the Mekong Delta" on January 10, 2003 at the Department of Agriculture-Can Tho University, pages 26-35.

Nguyen Truong Giang (2011). Influence of seeding density on rice yield in the Summer-Autumn crop in 2010 in Phung Hiep district, Hau Giang province. Can Tho University Journal of Science, 18(B): 248-253.

Nguyen Van Hoan (2009). Technique of intensive rice farming in farmer households. 4th Edition.

Sheieh YJ (1977). Effect of planting density on community photosynthesis and on yielding components of rice plants. Bot. Bull. Acad. Sin. 18:153- 168.

Uddin J, Ahmed S, Harun OR, Hasan M & Asaduzzaman (2011). Effect of spacing on the yield and yield attributes of transplanted aman rice cultivars in medium lowland ecosystem of Bangladesh. J. Agric. Res. 49(4):465-476.

Uddin J, Hasan M, Ahmed S, Hasan M (2010). Effect of spacing on morphology and yield response of different aman rice cultivars under costal high land ecosystem. Indian J. Agric. Res. 44(4):251-258.