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GROWTH, DEVELOPMENT, YIELD, AND QUALITY OF SOME NEW RICE VARIETIES IN QUANG BINH PROVINCE

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Abstract: This research was conducted to evaluate the growth, development, and yield of some new rice varieties in order to serve quality rice production in Quang Binh province. The nine rice varieties were designed in a randomized complete block with three replicates for each variety. The research showed that the growing time of nine varieties were 115 days to 125 days in the Winter-Spring season and 105 days to 113 days in the Summer-Autumn season, respectively under the local conditions. In general, the rice varieties were less susceptible to diseases. We selected two varieties, namely GM2-17 (normal rice) and LL.HH3 (hybrid rice). They had high yields in both Winter-Spring and the Summer-Autumn season at 6.233 tons/ha and 6.079 tons/ha for GM2-17 and 7.004 tons/ha and 6.648 tons/ha for LL.HH3, respectively. They also had a good quality and long grains and were suitable to the consumers' demand.

Keywords: crop season, growth, rice variety, quality, yield

1 Introduction

As a province in the North Central Coast of Viet Nam, Quang Binh has many favorable conditions to develop sustainable agriculture. In the past years of development and integration, Quang Binh province has focused on the vigorous renovation of crop structure, seed quality, rapid and effective production of new high-yield rice varieties, and sustainable agriculture [5].

To reach the goal of economic development orientation in the coming years, Quang Binh province has set the principle goals including developing comprehensive agriculture in both crop production and animal husbandry. Specifically, the province has paid much attention to producing diverse goods and products, attaching importance to economic value, and exploiting the potential of land, labor, capital, technology, and markets. It also strives to maintain food security, increase the value of income per hectare of the farming land, protect the ecological environment, and better apply new scientific and technological achievements in production. Conversion of crop structure to high-value crops were planted, 20 % of paddy land area to form seed and specialty rice areas to supply to domestic market and export [4]. In addition, the rice quality is of decisive importance for a modern, effective and sustainable rice production [1].

In recent years, thanks to the promotion of the application of scientific and technological advances to production, higher-yield rice varieties have been expanded, and they contribute to the province's rice output. However, the variety spectra are still limited, lacking high-quality

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varieties to meet the demand of domestic consumers and export. Besides, the new varieties also have to ensure shorter growing time and good insects and pests resistance. Therefore, the objective of this study is to evaluate the adaptability, growth, development, yield, and quality of some new rice varieties in Quang Binh province to overcome the shortcomings of the old ones.

2 Materials and methods

2.1 Materials

Nine quality rice varieties were used in the research, and they were divided into 2 groups. The first group was normal rice varieties that were collected from the Field Crops Research Institute, Hai Duong Province including GM1-68, GM1-9, GM2-16, GM2-17 and HT1 (control 1). The second group was hybrid rice varieties that were collected from China including LL.HH2, LL.HH3, ZZ1 and Nhi uu 838 (control 2).

2.2 Methods

The experiments were planned in a Randomized Complete Block design with 3 replications for each variety. Transplantation density was 50 plants/m^2. The area of each plot was 10 m^2. The experiments were conducted in two seasons: Winter-Spring 2014–2015 (WS) and the Summer-Autumn 2015 (SA) at the An Ninh Breeding Plant Station, Quang Ninh District, Quang Binh Province, Vietnam.

Fertilizer applications for 1 ha were 500kg CaO powder, 10 tons farm yard manure, 240 kg NPK (SV-L1 – Sao Viet fertilizer 1st time) for basal fertilizing. For top dressing had three times of fertilizer application, including 300 kg NPK (SV-L2 – Sao Viet fertilizer 2nd time) divided two small times, 3rd time applied 140 kg (SV-L3 – Sao Viet 3rd time) at 20–30 days before flowering stage (following to NPK Sao Viet for rice fertilizer protocol).

Data analysis: Data were analyzed with one-way ANOVA using Statistix 9.0 software. The comparison between experimental varieties means of plant height, panicle length, flag leaf area, number of spikelet/panicle, and theoretical yield and the actual yield was made using Least Significant Difference ($p \leq 0.05$).

3 Results and discussion

3.1 Agronomic characteristics of rice varieties

The growth time of the nine varietes in the Winter-Spring crop is longer than in the Summer-Autumn crop, ranging from 118–125 days in WS as opposed to 105–113 days in SA.

The ratio of effective tiller rate of varieties in 2 seasons was fairly good (> 70 %) in both normal and hybrid rice varieties (Table 1).

Table 1. Agronomy characteristics of rice varieties

Variety	Growth time (day)		Effective tillers rate (%)		Plant height (cm)		Panicle length (cm)		Flag leaf area (cm^2)	
	WS	SA	WS	SA	WS	SA	WS	SA	WS	SA
GM1-6	125	110	76.01	75.97	86.2^{f}	92.2^{f}	18.77^{b}	19.99^{a}	26.19^{d}	30.26^{b}
GM1-9	125	110	75.93	75.91	100.8^{c}	101.9^{c}	18.79^{b}	20.21^{a}	28.78^{c}	28.43^{d}
GM2-16	124	113	80.97	81.00	97.2^{d}	99.1^{d}	20.28^{a}	20.87^{a}	25.70^{d}	29.56^{bcd}
GM2-17	122	111	80.73	80.74	89.4^{e}	95.5^{e}	20.30^{a}	20.84^{a}	26.31^{d}	30.25^{b}
HT1 (control 1)	122	110	82.57	80.34	105.0^{b}	107.1^{b}	20.78^{a}	20.88^{a}	29.63^{bc}	28.46^{cd}
LL.HH2	118	109	73.34	74.27	96.4^{d}	99.3^{d}	21.02^{a}	21.12^{a}	30.65^{ab}	29.26^{bcd}
LL.HH3	115	105	73.31	74.39	111.8^{a}	113.4^{a}	21.01^{a}	21.30^{a}	30.98^{ab}	29.54^{bcd}
ZZ1	124	112	72.88	71.90	105.4^{b}	108.7^{b}	19.94^{ab}	20.18^{a}	29.78^{bc}	29.83^{bc}
Nhi uu 838 (control 2)	118	108	76.53	71.89	97.4^{d}	100.8^{cd}	20.96^{a}	21.13^{a}	31.28^{a}	33.01^{a}
$LSD_{0.05}$	–	–	–	–	2.60	1.94	1.46	1.46	1.41	1.38

Note: Values in the same column with the same letter indicate no significant difference at $\alpha = 0.05$

All varieties had a low plant height, and there was a significant difference of this characteristic of the varieties in two seasons. The lowest plant height was found in GM1-6 at 86.2 cm and 92.2 cm in WS and SA, respectively. The highest plant height was found in LL.HH3 at 111.8 cm and 113.4 cm in WS and SA, respectively. The values were higher than those of the control (97.4 cm and 100.8 cm).

The panicle length of the varieties varied from 18.77 cm to 21.30 cm in both seasons. In the hybrid rice group, the variety with the largest flag leaf area was Nhi uu 838 (31.28 cm^2), and the lowest flag leaf area was found in ZZ1 (29.78 cm^2). In the normal rice varieties group, the flag leaf area of all varieties was lower than that of the control (29.63 cm^2).

3.2 Morphological characteristics of rice varieties

All rice varieties had an erect plant shape. Culm strength of rice varieties had vertical stems, hard plants, good fall resistance (score 1) in both WS and SA. Experimental varieties had moderate leaf senescence (score 5), as shown in Table 2.

The length of the flowering stage was calculated from the date when flowering was at 10 % till to the full 80 %. This is affected by weather conditions and hereditary factors of the varieties. The varieties had a medium flowering duration (score 5, 4–7 days of flowering).

Panicle threshability is important in determining the actual yield, harvesting time and harvesting practices. In both crops, most of the varieties were hard to be threshable (score 1), except GM1-6, LL.HH3 and ZZ1, which had an average seed loss (score 5).

Table 2. Morphological characteristics of rice varieties (score)

Variety	Plant shape	Culm strength		Leaf senescence		Length of flowering stage		Panicle threshability		Panicle exsertion	
		WS	SA	WS	SA	WS	SA	WS	SA	WS	SA
GM1-6	Erect	1	1	5	5	5	5	5	5	1	1
GM1-9	Erect	1	1	5	5	5	5	1	1	1	1
GM2-16	Erect	1	1	5	5	5	5	1	1	1	1
GM2-17	Erect	1	1	5	5	5	5	1	1	1	1
HT1 (control 1)	Erect	1	1	5	5	5	5	1	1	1	1
LL.HH2	Erect	1	1	5	5	5	5	1	1	1	1
LL.HH3	Erect	1	1	5	5	5	5	5	5	1	1
ZZ1	Erect	1	1	5	5	5	5	5	1	1	1
Nhi uu 838 (control 2)	Erect	1	1	5	5	5	5	1	1	1	1

3.3 Insects damage and diseases infection

Seven common diseases on rice such as stem borer, leaf folder, sheath blight, panicle blast and leaf blast recorded in the Winter-Spring season 2014–2015 and the Summer-Autumn season 2015 are shown in Table 3.

Most of the rice varieties in production now are affected by sheath blight (*Rhizoctonia solani* Kuhn), and the disease is most severe between pre-flowering and harvesting. In the experimental rice varieties, the sheath blight was only detected in the Summer-Autumn season 2015. Truong The Viet et al. [6] investigated the situation of the sheath blight disease in Binh Dinh province and found that in the Winter-Spring crop, such disease often caused mild damage and it developed strongly in the Summer-Autumn crop. Regarding rice blast, the varieties were slightly affected in both seasons except for GM1-6, and three hybrid rice varieties (LL.HH2, LL.HH3, and ZZ1) were infected with neck panicle blast at score 3.

Table 3. Insects damage and diseases infection on rice varieties (score)

Variety	Stem borer		Leaf folder		Sheath blight		Panicle blast		Leaf blast	
	WS	SA	WS	SA	WS	SA	WS	SA	WS	SA
GM1-6	1	0	1	1	0	1	3	1	1	1
GM1-9	0	0	1	1	0	1	1	1	1	1
GM2-16	0	0	1	3	0	3	1	1	1	1
GM2-17	0	0	1	3	0	3	1	1	1	1
HT1 (control 1)	1	0	1	1	0	1	1	1	1	1
LL.HH2	0	0	1	3	0	1	3	1	1	1
LL.HH3	0	0	1	3	0	1	3	1	1	1
ZZ1	1	0	1	3	0	3	3	1	3	1
N.uu 838 (control 2)	1	0	1	1	0	1	1	1	1	1

3.4 Yield components and yield of rice varieties

Yield, the basic factor of a variety, is the final result of the growth and development of that variety. Nowadays, in the breeding selection, besides choosing high yield, we also pay attention to quality rice varieties.

Table 4. Yield components of rice varieties

Variety	No. Panicle/ m^2		No. Spikelet/ panicle		No. Filled spikelet/ panicle		Unfilled spikelet ratio (%)		1000-grain weight (g)	
	WS	SA	WS	SA	WS	SA	WS	SA	WS	SA
GM1-6	318	310	122.43^{de}	125.65^{cd}	98.20^{bc}	98.06^{d}	24.01	15.65	24.1	23.6
GM1-9	316	309	123.34^{cd}	125.74^{c}	99.36^{b}	99.52^{c}	14.14	16.52	23.8	23.5
GM2-16	322	324	123.04^{cd}	126.34^{bc}	98.56^{b}	99.85^{c}	12.16	24.15	25.2	24.6
GM2-17	321	323	124.21^{c}	127.45^{b}	99.21^{b}	100.16^{bc}	17.15	20.42	24.5	24.4
HT1 (control 1)	316	318	121.32^{e}	124.31^{d}	97.05^{c}	99.54^{c}	12.64	16.26	23.6	23.3
LL.HH2	324	332	126.76^{b}	130.52^{a}	102.66^{a}	103.25^{a}	14.46	22.61	28.1	28.2
LL.HH3	325	330	128.17^{a}	131.08^{a}	103.50^{a}	103.98^{a}	8.65	22.56	31.0	30.1
ZZ1	318	312	118.65^{f}	122.09^{e}	95.63^{d}	96.34^{e}	10.14	24.41	34.6	33.7
Nhi uu 838 (control 2)	323	330	127.91^{ab}	130.78^{a}	102.56^{a}	101.31^{b}	11.24	21.46	30.0	30.0
$LSD_{0.05}$	–	–	1.24	1.39	1.42	1.37	–		–	

Note: Values in the same column with the same letter indicate no significant difference at α = 0.05

The number of panicles per a metre squared is a very important component of rice yield. This component, apart from hereditary factors, also depends greatly on external factors as well as cultivation techniques. In the Winter-Spring crop season 2014–2015, the number of panicles/m^2 of varieties ranged from 316 to 325. Variety LL.HH3 in the hybrid group had the highest rate, which was higher than that of Nhi uu 838 (control variety), while variety GM1-9 had the lowest number of panicles/m^2, which was equal to that of HT1 in the normal rice variety group. In the Summer-Autumn crop season 2015, the lowest panicle rate was found in variety GM1-9 (309 panicles/m^2), much lower than that of the control (318 panicles/m^2) in the normal rice varieties group. The highest rate was found in LL.HH2 (332 panicles/m^2), higher than that of the control (330 panicles/m^2) in the hybrid rice variety group (Table 4).

The number of filled spikelets depends on the external conditions of the flowering period, the ability of panicle exertion, and the insect resistance. In the normal rice varieties group in the Winter-Spring crop season 2014–2015, all the varieties had a higher number of filled spikelets/panicle than that of the HT1 control variety (97.05 spikelets), ranging from 98.20–99.36 spikelets. In the hybrid rice varieties, ZZ1 had the lowest number of filled spikelets/panicle at 95.63, lower than that of the Nhi uu 838 control variety (102.56 spikelets). In the Summer-Autumn crop season 2015, normal rice and hybrid rice varieties did not differ significantly regarding the number of filled spikelets, ranging from 96.34 to 103.98 spikelets/panicle.

There is a large variation in the unfilled spikelet ratio among the varieties. The unfilled spikelet ratio in the Winter-Spring crop 2014–2015 ranged from 8.65 % for LL.HH3 to 24.01 % for GM1–6. In the Summer-Autumn crop, it was between 15.65 % for GM1-6 and 24.41 % for ZZ1. Thus, the unfilled spikelet ratio in the Winter-Spring crop is generally higher than that of the Summer-Autumn crop. This is also consistent with the results found in the IRRI rice area. If the night/day temperature is around 20/30 °C between flowering and harvesting, the rice will reach 80 % of the filled spikelets [1]. The weather of the Winter-Spring crop has a wider day/night temperature range than that of the Summer-Autumn crop.

The weight of 1000 grains, the most stable component of the yield of a variety, is a highly hereditary element. It is also affected by external conditions, especially those after the flowering stage. The weight of 1000 grains of varieties of the Winter-Spring crop 2014 – 2015 ranged from 23.6 grams for HT1 to 34.6 grams for ZZ1. In the Summer-Autumn 2015, the weight of 1000 grains of varieties ranged from 23.3 grams to 33.7 grams.

Table 5. Theoretical yield and actual yield of rice varieties (tons/ha)

Variety	Winter-Spring crop 2014–2015		Summer-Autumn 2015	
	Theoretical yield	Actual yield	Theoretical yield	Actual yield
GM1-6	7.544^{e}	5.200^{f}	7.183^{f}	5.038^{f}
GM1-9	7.497^{e}	6.030^{d}	7.242^{ef}	5.665^{e}
GM2-16	7.997^{d}	5.730^{e}	7.958^{d}	5.587^{e}
GM2-17	7.815^{d}	6.233^{c}	7.910^{d}	6.079^{c}
HT1 (control 1)	7.247^{f}	6.020^{d}	7.391^{e}	5.823^{d}
LL.HH2	9.366^{c}	6.242^{c}	9.687^{c}	6.019^{c}
LL.HH3	10448^{a}	7.004^{a}	10.349^{a}	6.648^{a}
ZZ1	10537^{a}	6.623^{b}	10.154^{b}	6.469^{b}
Nhi uu 838 (control 2)	9.965^{b}	6.277^{c}	10.043^{b}	6.032^{c}
$LSD_{0,05}$	2.43	1.69	1.63	1.17

Note: Values in the same column with the same letter indicate no significant difference at α = 0.05

The theoretical yield is formed from the components of yield such as the number of panicles/m^2, number of filled spikelets/panicle, and the weight of 1000 grains. Experimental varieties had high theoretical yield from 7.247 tons/ha for HT1 to 10.537 tons/ha for ZZ1 in the Winter-Spring crop season 2014–2015 and 7.183 tons/ha for GM1-6 to 10.349 tons/ha for LL.HH3 in the Summer-Autumn crop season 2015. The hybrid rice varieties group had a very high yield potential (> 10 tons/ha). In the normal rice variety group, most varieties had the theoretical yield higher than that of the HT1 control variety. In the hybrid rice variety group, the variety that had a theoretical yield lower than that of the control variety Nhi uu 838 was LL.HH2 (Table 5).

Data from Table 5 showed that the hybrid rice varieties were more productive than the normal rice varieties. In the normal rice varieties, the actual yield of GM2-17 was the highest at

6.233 tons/ha in the Winter-Spring 2014–2015 crop season and 6.079 tons/ha in the Summer-Autumn crop season 2015. In the hybrid rice varieties, the highest actual yield was for LL.HH3 at 7.004 tons/ha in the Winter-Spring 2014–2015 and 6.648 tons/ha in the Summer-Autumn crop season 2015.

3.5 Commercial quality traits of rice varieties

The rate of husked rice and white milled rice among the varieties had a little difference. The white rice grains of the varieties reached greater than 60 % in both seasons, only ZZ1 variety ranged from 39.3 to 42.3 % (Table 6).

Table 6. Commercial quality traits of rice varieties

Variety	Brown rice rate (%)		Milled rice rate (%)		Head rice rate (%)		Grain shape	White kernel (score)
	WS	SA	WS	SA	WS	SA		
GM1-6	79.6	78.5	69.5	69.2	82.6	80.7	Slender	1
GM1-9	80.9	80.3	70.4	69.6	89.7	87.2	Slender	1
GM2-16	79.9	79.2	69.7	68.7	86.4	84.7	Slender	0
GM2-17	81.0	80.9	70.6	70.2	89.8	88.6	Slender	0
HT1 (control 1)	79.3	79.2	69.2	69.4	85.6	86.3	Slender	0
LL.HH2	80.7	80.0	70.0	70.1	87.2	87.3	Slender	1
LL.HH3	81.2	81.0	70.8	70.4	87.9	87.5	Bold	1
ZZ1	79.4	78.8	68.7	68.2	86.2	85.4	Bold	5
Nhi uu 838 (control 2)	80.8	80.2	70.4	70.3	86.3	85.6	Bold	1

The head rice (whole-grain rate) varies with crops, cultivation techniques, postharvest preservation, and processing technology. Rice seeds are classified as high grade with high whole-grain rate (over 90 %) [3]. The experimental rice varieties with head rice rate of nearly 90 % were GM1-9, GM2-17, and LL.HH3.

The commercial quality of a variety is related to the grain length, which is the most stable trait, less affected by the environment. The taste of consumers about grain shape varied greatly, with a preference for round/bold grain, or medium-length grain, but the slender grain is most widely consumed in the international market [1]. The majority of experimental varieties were of a slender grain shape, with a grain length of 6–7 mm, and the LL.HH3, ZZ1 and Nhi uu 838 varieties were of bold grains (length/wide rate less than 2.1 mm).

The white kernel is an important indicator that greatly affects the quality of the variety. The rice that does not have a white kernel is always higher in value in the market, though white kernel of rice does not affect the quality of cooked rice but only reduces the quality of rice husks and the appearance of rice. In the experimental varieties, the ZZ1 variety and the Nhi uu 838 had a higher white kernel (score 5), while the other varieties have a lower white kernel (score 1), which were promising to be accepted in the market.

4 Conclusion

From our results, we selected two varieties that had a high actual yield in the Winter-Spring crop season 2014–2015 and the Summer-Autumn crop season 2015, namely GM2-17 (6.233 and 6.079 tons/ha, respectively) and LL.HH3 (7.004 and 6.648 tons/ha, respectively). These varieties had a short duration at 122 and 115 days in WS; 111 and 105 days in SA, well growth, rather high insects, and disease resistance. Their commercial quality suits the demand of consumers and adapts with local conditions.

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