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Response of Climate–Resilient Rice (*Oryza sativa* L.) Varieties to Plant Spacing and Water Management

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ABSTRACT

Cultivation of climate change-resilient rice varieties is an appropriate coping strategy to the negative effects of climate change. This study was conducted at the SeedNet area of the Visayas State University, Visca, Baybay City, Leyte to determine some physiological and agronomic responses of submergence and drought tolerant lowland rice varieties grown at different plant spacing and water management. A nested design was used in randomized complete blocks with three replications. Rice variety was designated as the main plot and plant spacing as the subplot nested within two (2) water regimes: continuous flooding (conventional) and no flooding. NSIC Rc194 (submergence tolerant) had a higher grain yield than NSIC Rc192 (drought tolerant) due to more productive tillers and heavier grains. The low yield of NSIC Rc192 could be attributed to lodging and attack of birds, such as maya. Water management and spacing did not affect the grain yield of both varieties. No flooding treatment resulted in reduction of water applied by 69% compared to the continuous flooding treatment. Under no flooding condition and wider spacing, NSIC Rc194 and NSIC Rc192 varieties had higher root pulling resistance implying that rice plants had higher root density under no flooding condition at 30 cm x 30 cm spacing. Plants at 30 cm × 30 cm spacing were significantly taller while those at 20 cm x 20 cm spacing had higher LAI, more plants and productive tillers per m^{-2}, and higher crop growth rate (CGR). Interaction among water management, variety, and spacing was noted in net assimilation rate (NAR). NSIC Rc194 (submergence tolerant) is a more productive, climate-change ready variety than NSIC Rc192 (drought tolerant) under VSU conditions.

Keywords: water stress, root pulling resistance, phyllochron, drought tolerance, submergence tolerance

INTRODUCTION

Rice is the staple food for the majority of the Filipinos hence, it is the most important commodity in the Philippines. It is unique among the major food crops in its ability to grow under wetland conditions (Bouman et al 2007). However, many

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lowland rice cultivars are still sensitive to complete submergence (Nishiuchi et al 2012). In addition, nutrient-use efficiencies in flooded rice are often low because of high losses, resulting in groundwater contamination and high fertilizer costs for farmers. Thus, new water management practices are required to increase water-use efficiency in rice production while maintaining productivity (Bouman et al 2002).

Rice depends largely on temperature, solar radiation, moisture, and soil fertility for their growth and nutritional requirements. Rice grown under closer spacing may have limitations in the maximum availability of the above mentioned factors. On the other hand, a wider planting distance would have lesser plants per unit area and utilization of these factors would be below optimum which would result in low yield. It is, therefore, necessary to determine the optimum density of plant population per unit area in obtaining maximum yields (Baloch et al 2002).

Varieties may differ in their response to varying plant densities and water management. It is important to test submergence and drought tolerant lowland rice varieties to assess their agronomic performance under different water management and spacing. Hence, this study.

MATERIALS AND METHODS

This study was conducted at the SeedNet area of the Visayas State University (VSU), Visca, Baybay City, Leyte from December 08, 2013 to April 06, 2014.The experimental area was flooded for one week to soften the soil. This was plowed and harrowed twice at weekly intervals for two (2) weeks using a hand tractor. After the last harrowing, the field was leveled and dikes were constructed. Irrigation canals and a drainage system were constructed around each plot. Soil analyses were done for soil pH, percent (%) organic matter, total nitrogen, extractable P, and exchangeable K contents. Analyses were done in the Central Analytical Services Laboratory, PhilRootcrops Complex, VSU, Visca, Baybay City, Leyte.

Experimental Design

The experimental area was laid out in a nested design with complete block in three replications with lowland rice varieties as the main plot and plant spacing as the subplot nested within two water regimes: continuous flooding and no flooding (keeping the soil saturated but not flooded). Replications and treatment plots were separated by 1.0 m and 0.5 m alleyways, respectively. Plot size was 5 m x 4 m (20 m^2) with 20 and 13 rows for 20 cm x 20 cm and 30 cm 30 cm, respectively. Treatments were as follows:

A. Water management
  WM_1 = Continuous flooding
  WM_2 = No flooding
B. Main plot (Lowland rice varieties)
  V_1 = NSIC Rc192 (drought tolerant)
  V_2 = NSIC Rc194 (submergence tolerant)
C. Sub plot (Plant spacing)
  S_1 = 20 cm x 20 cm
  S_2 = 30 cm x 30 cm

Seedbed and Seedling Preparation

Seedbeds with 1 m x 2.5 m dimensions were prepared for each variety. One (1) kilogram seeds of each variety were soaked in water for 24h and incubated for two (2) days before sowing. Pre-germinated seeds were sown thinly and uniformly in raised seedbeds. Ditches were constructed around the seedbed. The seedbeds were irrigated after three (3) days at a depth of 2-3 cm and maintained until the seedlings were ready for transplanting.

Fertilizer Application

The fertilizer rate used was 120-60-60 kg ha^{-1} N, P_2O_5 and K_2O. Nitrogen was applied in 3 splits. Whole amount of P_2O_5 and K_2O was applied together with the first N application by broadcasting and incorporating into the soil before transplanting. The second and third N application was top-dressed during mid tillering and panicle initiation stage.

Transplanting

Thirteen (13) day-old seedlings of NSIC Rc192 and NSIC Rc194 were transplanted at the rate of two (2) seedlings per hill at a planting distance specified in the treatments. Replanting of missing hills was done seven (7) days after transplanting.

Water Management

Water management was carried out as follows:

Conventional flooding (WM$_1$) **-** The rice field was flooded continuously with 2-3 cm water depth at the vegetative stage starting at 3 DAT until 55 DAT. During the reproductive stage, 3-5 cm water depth was maintained. The field was drained two (2) weeks before harvesting.

No flooding (WM$_2$) – The soil was kept saturated but not flooded. This was done by allowing the entry of water that was immediately drained to prevent flooding. This was repeated before the soil dried up or cracked. Water outlets were constructed to facilitate water movement especially during rainy periods.

Pest Management

Duck pasturing was done one (1) week prior to transplanting to control golden snails. Handpicking of adults and egg masses of golden snail was also done in the morning and afternoon. For weeds, rotary weeding was done 10 days after transplanting and the second rotary weeding was done 20 days after transplanting (DAT). Spot weeding was done thereafter. Leaf folder, green leaf hopper, and brown leaf hopper were controlled using Padan insecticide. A scarecrow was used to control birds.

Harvesting and Processing

Harvesting was done by using a sharp sickle when 85% of the grains had ripened and firmed. All the sample plants were cut at the base excluding two (2) border rows in each side and two (2) hills at both ends of each row. The samples were threshed, sun dried for three (3) days to attain a moisture content of about 14%, and winnowed before gathering all the necessary data.

Data Gathered

1. Plant height (cm) - This was recorded by measuring 10 sample hills from the ground level to the tip of the tallest part of the plant randomly selected in each treatment plot at maturity.

2. Phyllochron – The phyllochron (day leaf $^{-1}$) of each successive leaf on the main stem of each sample plant was determined by dividing the time interval between the two consecutive Haun leaf number measurements (Wilhelm and MacMaster 1995):

$$\text{Phyllochron} = \frac{\textit{Interval between appearance of 2 consecutive leaves (day)}}{\textit{Haun stage difference between 2 dates of consecutive appearance}}$$

3. Root pulling resistance (RPR) – This was measured using a 100 kg spring balance to determine the root strength (O' Toole and Soemartono, 1981). The plant was tied to abaca rope attached to a spring balance and pulled to obtain the RPR in kg. The measurement was done at flowering stage.

4. Leaf Area Index (LAI) - This was determined at heading stage by measuring the five (5) sample hills from each treatment plot. The number of tillers were counted. Leaf area index was computed using the formula below:

$$LAI = L \times W \times CF \times 0.75$$

Leaf area hill per hill = total area of middle tiller x total number of tillers

$$LAI = \frac{\textit{Sum of total leaf area hill per hill of 5 sample hills (cm}^2\textit{)}}{\textit{land area covered by 5 sample hills (cm}^2\textit{)}}$$

5. Net assimilation rate (NAR) – This was calculated on the basis of dry matter and leaf area taken over time. This was done biweekly from vegetative until reproductive stage. Net assimilation rate was determined using the formula:

$$NAR = \frac{W_2 - W_1 (\ln LA_2 - \ln LA_1)}{(LA_2 - LA_1)(T_2 - T_1)}$$

where:

In = Natural Logarithm

LA_1 = Leaf Area at time T_1

LA_2 = Leaf Area at time T_2

W_1 = Total plant dry weight at time T_1

W_2 = Total plant dry weight at time T_2

$T_1 - T_2$ = Time interval between the first and second measurement

7. Harvest Index (HI) – This was determined by harvesting five (5) random sample hills from each treatment plot. The samples were cut close to the ground and the grains and straw were oven dried at 70 ^{0}C for three (3) days or until the weights became constant. Harvest index was obtained using the formula:

$$\text{HI} = \frac{\textit{Economic yield (grain dry weight in kg)}}{\textit{Biological yield (grain and straw dry weight in kg)}}$$

8. Number of productive tillers hill^{-1} - This was determined by counting the number of tillers hill^{-1} that developed panicles from the five (5) sample hills in each treatment plot at maturity.

9. Number of productive tillers m^{-2}– The number of productive tillers hill^{-1} was converted to productive tillers per m^{-2} using the formula:

$$\text{Number of productive tillers m}^{-2} = \frac{\textit{Number of plants x Ave number of productive tillers}}{\textit{Harvestable area } (m^2)}$$

10. Number of filled and unfilled grains panicle^{-1} - This was determined by counting all filled and unfilled grains of 10 selected panicles from each treatment plot manually.

11. Grain weight panicle^{-1} - This was taken by weighing the panicles from 10 sample panicles used for filled and unfilled grains count.

12. Weight of 1000 grains (g) - This was determined by weighing 1,000 sample grains (14%) randomly taken from each treatment plot.

13. Grain yield (t ha^{-1}) - This was determined by weighing the total grains from the harvestable area in each treatment plot. The grains were cleaned, sun-dried, and weighed and was converted into tons per hectare using the formula:

$$\text{Grain yield (t ha}^{-1}) = \frac{\textit{Plot yield (kg)}}{\textit{Harvestable area } (m^2)} \text{ x } \frac{10{,}000\ m^2\ ha^{-1}}{1{,}000\ kg\ t^{-1}}$$

14. Volume of Water Applied

This was done following the procedure below:

a. Measurement of flow rate using bucket method – An inlet was created from the main canal going to each treatment plot. At the end of the inlet, a bucket was placed to collect the water from the inlet and the time to fill the bucket was recorded. Flow rate (Q) was calculated using the following formula:

$$Q = \frac{\textit{Volume of the container (v), li}}{\textit{Time (t), sec}}$$

$$Q_{ave} = \frac{\textit{Total Q}}{\textit{Number of trials}}$$

where:

Q = flow rate, li/sec
Q_{ave}= average flow rate, li/sec

b. Measurement of the total volume of water supplied (m^3 ha^{-1}) – This was calculated using the following formula:

$$V = A_{ave}\ (tf - to)$$

where:

V = total volume supplied, li
Q_{ave}= average flow rate, li/sec
t_f= final time upon irrigating, sec
t_0= initial time upon irrigating, sec

Statistical Analysis

The data were statistically analyzed using the computer software Statistical Analysis System (SAS version 6.12). The data were analyzed using combined analysis of variance. Tukey's test or HSD was used as basis for comparison among treatment means.

RESULTS AND DISCUSSION

Analysis showed that the soil had a pH of 6.23 with 5.74 % organic matter, 0.30 % N, 6.78 mg kg^{-1} P, and 33.30 mg kg^{-1} K. These results indicate that the soil pH was neutral, organic matter, potassium, and total nitrogen levels were average but phosphorus was low (Landon 1991).

The total volume of water supplied under continuous flooding treatment was 6,458.4 m^3 ha^{-1}. On the other hand, only 2,024.4 m^3 ha^{-1} of water was supplied under the no flooding treatment. No flooding treatment resulted in the reduction of the volume of irrigation water by 69% compared to the continuous flooding treatment. This result conforms to the findings of Escasinas and Zamora (2011) that keeping the soil moist but not flooded reduces water requirement by 52 – 53%.

Plant Height (cm)

NSIC Rc192 grew taller than NSIC Rc194 irrespective of water management (Fig.1). This might be due to inherent varietal differences, NSIC Rc 192 being a tall type variety. NSIC Rc192 is inherently taller than NSIC Rc194 (Fig. 1). When grown under a spacing of 30 cm x 30 cm, both varieties grew taller than at 20 cm x 20 cm spacing due to greater exposure and lesser competition for sunlight.

Phyllochron (day leaf^{-1})

The phyllochron was not affected by spacing in this study. However, phyllochron differed between the two varieties at 49 DAT (Table 1). It also differed between water management at 7 DAT. Plants under continuous flooding resulted in longer (>8) phyllochron compared to plants under no flooding condition (>7). At 49 DAT, NSIC Rc192 had shorter phyllochron than NSIC Rc194 possibly because NSIC Rc192 is an early maturing variety. Shorter phyllochron means that the time interval between appearances of successive leaves on the main culm is faster indicating faster leaf development and the production of more tillers (Escasinas 2009). As expected, phyllochron at early stage of growth is generally longer. As the plants grew older, phyllochron became shorter (Table 3). This is because of transplanting shock experienced by rice seedlings; hence, longer time and more energy were needed for leaf formation.

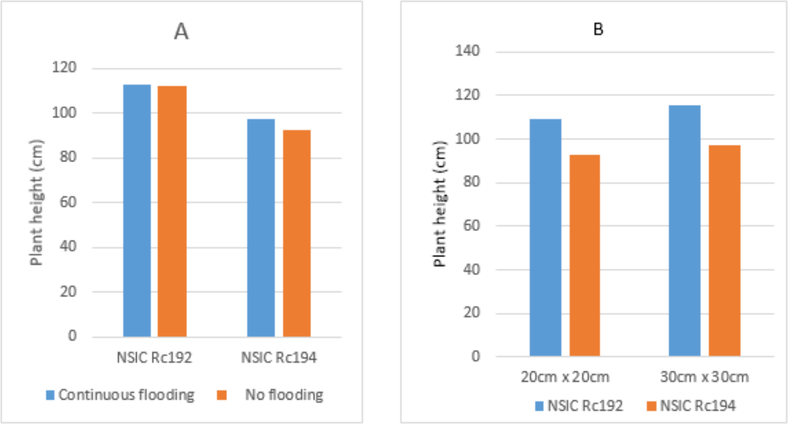

Figure 1. Plant height (cm) of lowland rice as influenced by water management (A) and spacing (B)

Table 1. Phyllochron of lowland rice as influenced by water management, variety, and spacing

Treatment	Phyllochron (day leaf^{-1})						
	7 DAT	14 DAT	21 DAT	28 DAT	35 DAT	42 DAT	49 DAT
Water Management							
Continuous flooding	8.91a	8.20a	6.15a	5.53a	5.53a	6.04a	3.95a
No flooding	7.75b	9.20a	6.53a	5.62a	5.34a	5.74a	4.08a
Variety							
NSIC Rc192	7.74a	8.47a	7.12a	5.60a	5.20a	5.78a	3.33b
NSIC Rc194	8.93a	8.93a	5.55a	5.64a	5.67a	6.01a	4.71a
Spacing							
20 cm x 20 cm	8.32a	8.66a	6.46a	5.70a	5.43a	5.87a	3.86a
30 cm x 30 cm	8.34a	8.74a	6.21a	5.33a	5.44a	5.92a	4.17a
C.V. (%)	24.47	21.04	29.53	28.85	24.54	29.99	17.32

Means within a column with the same letter(s) are not significantly different at 5% level, HSD.

Root Pulling Resistance (kg)

Rice grown under no flooding had higher root pulling resistance (RPR) than those in continuous flooding (Fig.2A). Under no flooding condition, rice plants produced denser roots so these could seek out water and other essential nutrients. Likewise, rice plants grown with wider spacing (30 cm and 30 cm) had higher RPR than those at 20cm x 20cm spacing (Fig. 2B).

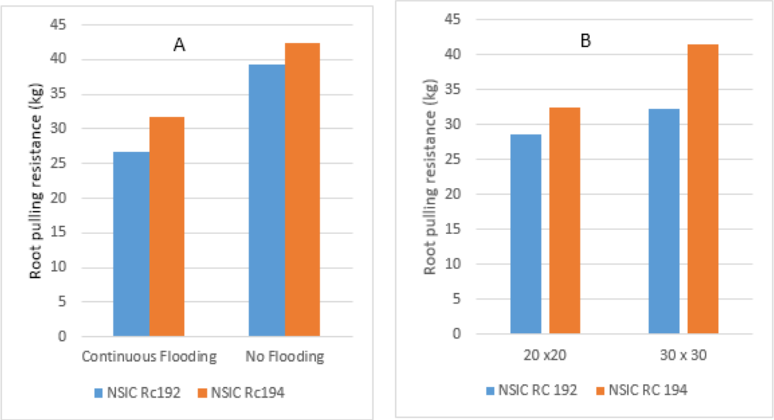

Figure 2. Root pulling resistance of lowland rice under different water management (A) and spacing (B)

More force was needed to pull the plants with wider spacing compared to plants with closer spacing. This is because of the greater lateral extension of roots at wider row spacing (Scheiner et al 2000). Thus, more roots were anchored in the soil indicating greater root growth in wider plant spacing resulting in high RPR.

NSIC Rc194 had higher RPR value compared to NSIC Rc192. This could be due to more tillers developed per hill resulting to greater root density anchored to the soil (Escasinas & Zamora 2011). Root pulling resistance is of functional significance as it determines the volume of contact with soil and thus the capability to absorb water and nutrients (Vasant 2012).

Leaf Area Index

NSIC Rc194 had higher LAI when grown under continuous flooding than when grown under no flooding condition (Fig. 3A). Higher LAI was recorded from plants with 20cm x 20cm spacing, while lower LAI was obtained from those with 30 cm x 30 cm spacing (Fig. 3B). Escasinas (2009) explained that higher LAI at closer spacing is generally due to higher plant population.

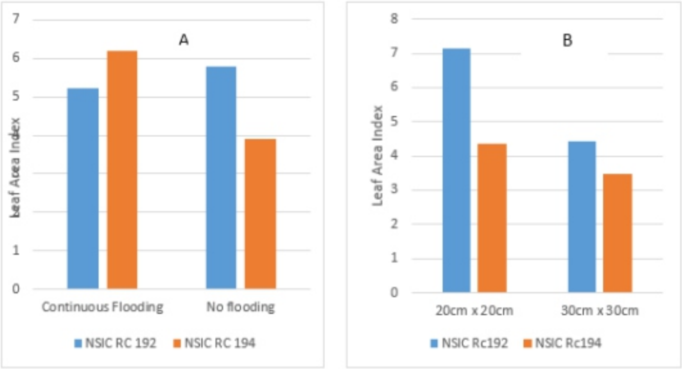

Figure 3. Leaf area index of lowland rice as influenced by water management (A) and spacing (B)

Crop Growth Rate (g m^{-2} d^{-1})

Crop growth rate was markedly affected by plant spacing. The highest crop growth rate (CGR) was attained at 20 cm x 20 cm spacing 7-14, 42-56, and 56-72 DAT while the lowest was at 30 cm x 30 cm (Table 2). The higher crop growth rate at closer spacing could be attributed to higher LAI value and to more plants and productive tillers per unit area. These findings conform with Escasinas (2009) that higher CGR value is attained at closer spacing than wider spacing. Moreover, CGR increased continuously until 56 DAT and declined towards maturity of the crop because some leaves senesce as the rice plant gets older. No interaction was observed among the treatments.

Table 2. Crop growth rate (CGR, g m^{-2} d^{-1}) and net assimilation rate (NAR, g m^{-2} d^{-1}) of lowland rice as influenced by water management, variety, and spacing

Treatments	CGR (g m^{-2} d^{-1})				NAR (g m^{-2} d^{-1})			
	14-28 DAT	28-42 DAT	42-56 DAT	56-70 DAT	14-28 DAT	28-42 DAT	42-56 DAT	56-70 DAT
Water management								
Continuous flooding	2.25a	15.15a	15.22a	40.11a	5.56a	14.67a	21.06a	7.13a
No flooding	3.58a	20.61a	33.15a	38.91a	2.99b	12.62a	18.45a	4.34b
Varieties								
NSIC Rc192	3.38a	19.79a	48.79a	37.07a	4.60a	13.33a	19.71a	6.12a
NSIC Rc194	2.45a	15.97a	39.58a	41.95a	3.95a	13.95a	19.80a	5.35a
Spacing								
20 cm x 20 cm	4.41a	21.56a	56.10a	54.61a	4.54a	13.65a	19.94a	5.62a
30 cm x 30 cm	1.42b	14.19a	32.27b	24.41b	4.01a	13.64a	19.57a	5.85a
C.V. (%)	46.68	18.88	38.46	16.30	20.11	15.06	8.38	23.20

Means within a column with the same letter(s) are not significantly different at 5% level, HSD

Net Assimilation Rate (g m^{-2} d^{-1})

The net assimilation rate was influenced significantly by the interaction of water management, variety, and plant spacing during 42-56 DAT (Table 3). NSIC Rc194, when grown under continuous flooding at 20 cm x 20 cm spacing, had higher NAR. Significant reduction in NAR was observed when NSICRc194 was grown under no flooding condition at 20cm x 20cm spacing. Likewise, a significant reduction in NAR (16.99 g m^{-2} d^{-1}) of NSIC Rc192 occurred when grown at 30 cm x 30 cm spacing under no flooding condition.

Table 3. Net assimilation rate (NAR) of lowland rice at 42-56 days after transplanting as influenced by water management x variety x spacing interaction

Treatments	NAR (g m^{-2} d^{-1})	
	NSIC Rc192	NSIC Rc194
Continuous flooding		
20 cm x 20 cm	20.36ab	22.80a
30 cm x 30 cm	21.63a	19.45ab
No flooding		
20 cm x 20 cm	19.86ab	16.73b
30 cm x 30 cm	16.99b	20.21ab

Means followed by a common letter(s) across water management, variety, and plant spacing are not significantly different at 5% level, HSD.

Harvest Index

Interaction among water management, variety, and plant spacing was observed in harvest index. Under continuous flooding, NSIC Rc192 produced higher harvest index when grown at 30 cm x 30 cm spacing but this drastically decreased when grown under no flooding of similar spacing (30 cm x 30 cm). NSIC Rc 192 also had lower HI when grown under continuous flooding with 20cm x 20cm spacing.

Table 4. Harvest index of lowland rice as influenced by the interaction among water management x variety x plant spacing

Treatments	Harvest Index	
	NSIC Rc192	NSIC Rc194
Continuous flooding		
20 cm x 20 cm	0.15b	0.24a
30 cm x 30 cm	0.24a	0.25a
No flooding		
20 cm x 20 cm	0.22ab	0.24a
30 cm x 30 cm	0.08b	0.23ab

Means followed by a common letter(s) across water management, variety, and plant spacing are not significantly different at 5% level, HSD

Number of productive tillers (m^2)

Regardless of water management, the NSIC Rc194 variety produced more productive tillers per square meter. NSIC Rc192 had less productive tillers in both conventional and no flooding water management (Fig. 4). Among the two varieties, NSIC Rc194 is the more efficient, climate-ready variety in terms of productive tiller formation.

Plants at 20 cm x 20 cm spacing had more productive tillers m^{-2} than those at 30 cm x 30 cm spacing (Fig. 5A). This may be due to more plants per unit area with closer spacing. This conformed to the findings of Escasinas and Zamora (2011) that there are more productive tillers m^{-2} at closer spacing. On the other hand, on per hill basis, lowland rice produced more productive tillers at wider spacing than at closer spacing (Fig. 5B).

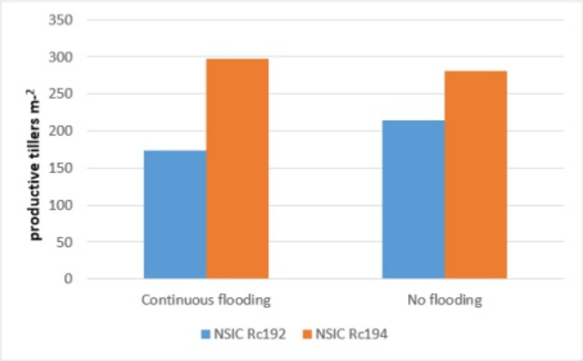

Figure 4. Number of productive tillers per square meter of lowland rice as affected by water management and variety

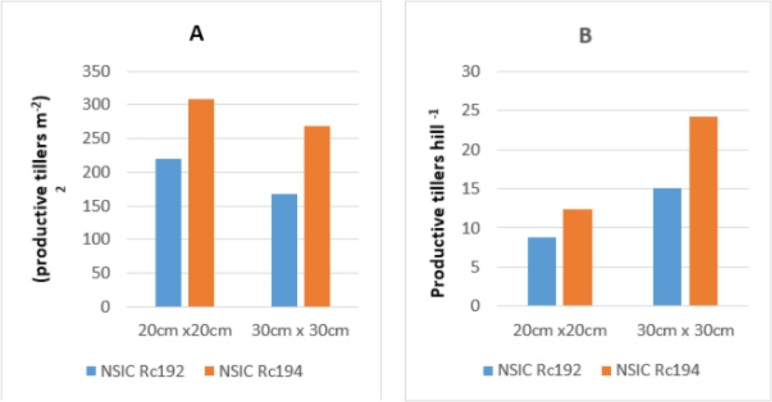

Figure 5. Number of productive tillers per square meter (A) and per hill basis (B) of lowland rice as affected by spacing

Number of filled and unfilled spikelets panicle^{-1}, and weight of grains per panicle^{-1} (g)

The number of filled and unfilled spikelets per panicle were not affected by water management, variety, and spacing. However, a significant difference in the weight of grains per panicle was observed between rice varieties (Table 5). Grains per panicle of NSIC Rc194 was heavier compared to NSIC Rc192 (Fig. 6A and Fig. 6B). NSIC Rc192 had lighter grains per panicle. This could be due to lesser weight per 1000 grains (Fig. 7A) and to more unfilled spikelets per panicle, although the difference was not high enough to cause significant differences among varieties.

Table 5. Grain yield and some yield components of lowland rice as influenced by water management, variety, and spacing

Treatments	No. of filled grains panicle $^{-1}$	No. of unfilled grains panicle $^{-1}$	Grain weight panicle $^{-1}$ (g)	Grain yield (t ha^{-1})
Water management				
Continuous flooding	71.97a	43.60a	2.14a	2.35a
No flooding	86.78a	32.87a	2.57a	2.70a
Varieties				
NSIC Rc192	79.52a	45.07a	2.05b	1.91b
NSIC Rc194	79.23a	31.40a	2.66a	3.13a
Spacing				
20 cm x 20 cm	73.45a	36.12a	2.13a	2.31a
30 cm x 30 cm	85.30a	40.35a	2.58a	2.74a
C.V. (%)	25.08	44.14	28.67	26.69

Means within a column with the same letter(s) are not significantly different at 5% level, HSD

Weight of 1,000 grains (g)

NSIC Rc194 had heavier grains when planted either at 20 cm x 20 cm and 30 cm x 30 cm spacing. On the other hand, NSIC Rc192 produced lighter grains when grown at 30 cm x 30 cm (Fig. 7A). Furthermore, there was an interaction between water management and plant spacing on the weight of 1,000 grains (Fig. 7B). Under no flooding condition, rice plants produced heavier grains when grown at 20 cm x 20 cm spacing. A reduction in the weight of grains resulted when grown at 30 cm x 30 cm spacing. The reverse was true when rice was grown under continuous flooding.

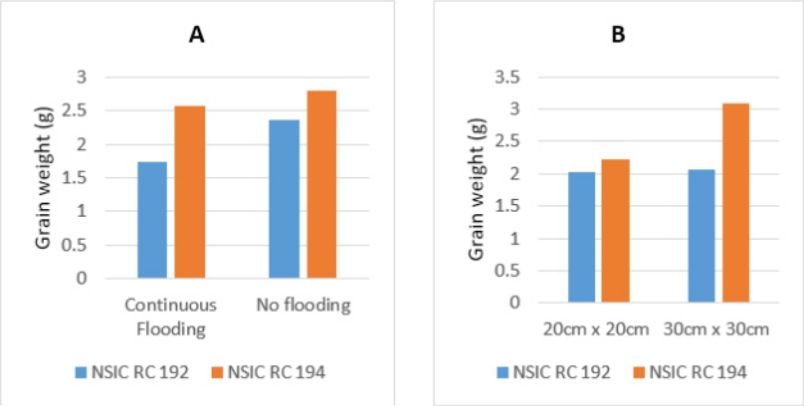

Figure 6. Grain weight per panicle (g) of lowland rice at different water management (A) and spacing (B)

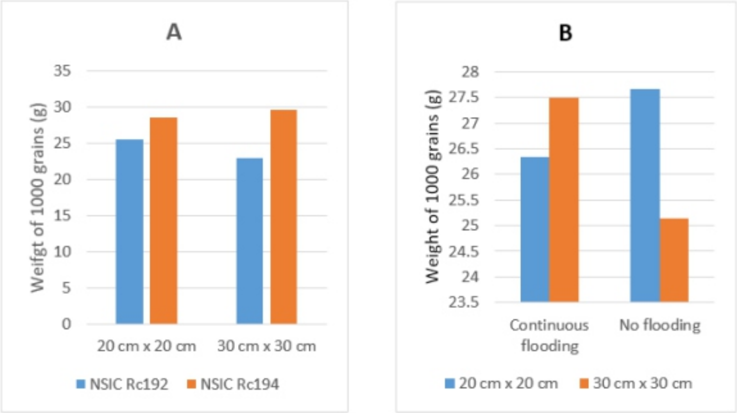

Figure 7. Weight of 1,000 grains of lowland rice as influenced by spacing (A) and interaction between water management and spacing (B)

Grain Yield (t ha^{-1})

Despite the occurrence of a typhoon during the plants' maturity, results showed that rice variety significantly influenced grain yield. However, the yield was not affected by water management and spacing used (Table 5). NSIC Rc194 significantly had a higher grain yield compared to NSIC Rc192 (Fig. 8). This could be due to more productive tillers and heavier grains. Furthermore, this variety was shorter, hence, not prone to lodging. NSIC Rc192, on the other hand, is a taller variety.

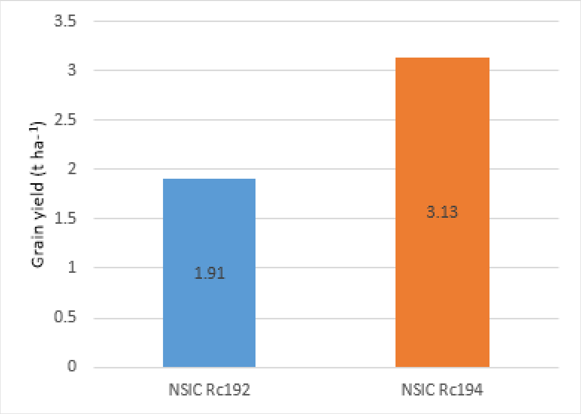

Figure 8. Grain yield (t ha^{-1}) of NSIC Rc192 and NSIC Rc194 lowland rice irrespective of plant spacing and water management

The yield of NSIC Rc192 was lower than the projected national average yield (3.7tha^{-1}) due to the occurrence of a typhoon at maturity that resulted to lodging, making it susceptible to bird infestation (*Passer domesticus*). Bullard (1988) reported that lodging makes crops more susceptible to bird damage. Moreover, NSIC Rc192 has wider angle between the flag leaf and its panicle making panicles more exposed to bird attack.

The grain yield of the two varieties was not influenced by water management implying that these varieties could be grown either under continuous flooding and no flooding under VSU conditions without affecting its yield. Similarly, plant spacing of 20cm x 20cm and 30cm x 30cm did not affect the yield of both varieties suggesting that spacing of 20cm x 20cm and 30cm x 30cm could be used in planting NSIC Rc192 (drought tolerant) and NSIC Rc194 (submergence tolerant) under flooding and no flooding conditions.

CONCLUSIONS

NSIC Rc194, a submergence tolerant variety, is a more productive climate-resilient rice than NSIC Rc192, a drought tolerant variety, under VSU conditions. This variety produced more productive tillers and heavier grains. This could be grown at either 20cm x 20cm and 30cm x 30cm spacing under continuous flooding and no flooding water management without reducing its yield. Root pulling resistance (RPR) of NSIC Rc194 and NSIC Rc192 is higher under no flooding and at 30cm x 30cm, while their phyllochron were not affected by spacing and water management.

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