Agronomic Performance of Lowland Rice (*Oryza Sativa* L.) Psb Rc82 Under Different Nursery Management and Seedling Age at Transplanting

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Abstract

Nursery management and age of seedlings at transplanting affects growth and yield of lowland rice. A field experiment was conducted at the experimental area of the Department of Agronomy, Visayas State University, Baybay, Leyte to: (1) evaluate effects of nursery management and seedling age on the growth and yield of lowland rice PSB Rc82; (2) determine the appropriate nursery management and seedling age for optimum yield; and (3) evaluate the profitability of PSB Rc82 production under different nursery management and seedling age. Different nursery management were designated as the mainplot and age of seedlings as the subplot. Wetbed method of nursery management, irrespective of seedling age resulted in earlier heading and maturity, higher crop growth rate at 21-42 DAT, more filled spikelets and consequently higher grain yield (2.18 t ha^{-1}). Using 25 -day old seedlings at transplanting resulted in earlier heading and maturity, higher harvest index and net assimilation rate at 21-42 DAT. Older seedlings gave more filled grains per panicle resulting in higher grain yield than younger seedlings. Thus, this study recommends 25-day old seedlings at transplanting under wetbed method for PSB Rc82 lowland rice production.

Keywords: crop growth rate, dapog method, harvest index, net assimilation rate, wetbed method

Research article

INTRODUCTION

As a cereal grain, rice (*Oryza sativa* L.) is the most widely consumed staple food for a large part of the world's human population, especially in Asia. It is the agricultural commodity with the third highest worldwide production of 741.5 million tons in 2014, after sugarcane and maize of 1.9 and 1.0 billion tons, respectively (FAOSTAT, 2017). Out of 3.3 M ha total rice production area in the country, about 1.4 M ha are irrigated lowland rice (Bureau of Agricultural Statistics, 2015). The country's palay yield obtained from April - June 2017 increased by 11.72% from 3.73 million MT in 2016 to 4.15 million MT (www.psa.gov.ph). This increase is attributed to adequate water and available seeds of high yielding varieties (HYV) and fertilizer support from Department of Agriculture and Local Government Units during the cropping period. To markedly sustain the said level of production, management even at the initial stages of growth or in the nursery is needed.

Two of the various management practices being adopted by farmers in the country are appropriate seedling age and proper nursery establishment. One of the considerations in aiming high yield is the use of healthy seedlings which can be attained by proper nursery management. considerations in aiming high yield is the use of healthy seedlings which can be attained by proper nursery management.

Rice seedlings can be raised in nurseries through dapog and wetbed method. Dapog method is preferable in areas where water management is not a problem. The dapog seedbed can be watered with a sprinkler or wet broom sticks to lessen displacement of seeds in the seedbed. This method reduced the duration of seedling in the seedbed, reduced seedbed area, have more choices for seedbed location but with less root or stem injury and labor cost in pulling the seedlings.

On the other hand, wetbed method is preferable in areas where water control is applicable. Wetbed raised seedlings has uniform size, free from diseases, insect pests and damage. Moreover, only fewer seeds are required per unit area and seedlings are easy to transplant (http://rice-production.blogspot.com).

In rice, distance of planting varies with variety and seedling age. Transplanting shock is a setback to growth due to injury or damage in uprooting the seedling. It increases as the seedling becomes older. In general, yield of rice increases with younger age of seedling at transplanting. Seedling age also varies with environmental conditions and the type of nursery management. Enzyme activity, photosynthesis and respiration set a minimum and maximum age for a particular nursery by considering its dependency on its growth. When a plant established its root system and its leaves are large enough to begin making its own food continued processes for development happened. Studies claimed that transplanted rice raised by dapog and wetbed method is resistant to lodging due to healthy and vigorous seedling growth, established tillers and more vigorous and fibrous root system (https://www.dawn.com/news/). However, researches on seedling age and nursery management in lowland rice is still limited, hence, this study.

MATERIAL and METHOD

An experimental area was flooded for seven days at a depth of 5-6 cm. The field was puddled using hand tractor on a biweekly interval to remove weeds and provide desirable tilth and texture of the soil. Canals were constructed to facilitate water management. Final puddling was done a week before planting leaving 2.5 cm of standing water. For the initial soil analysis, ten soil samples were collected randomly from the experimental field at depths 0-20 cm. These were composited, airdried, pulverized, sieved using 2mm wire mesh and analyzed at the Central Analytical Services Laboratory for soil pH, organic matter content, total nitrogen, extractable phosphorus and exchangeable K. For the final soil analysis, three samples were collected from each treatment plot right after harvest. These were processed and analyzed for the same soil parameters mentioned above.

This study was conducted at the SeedNet area of the Department of Agronomy, VSU, Baybay City, Leyte from February 3, 2018 to May 11, 2018.

The experiment was laid out in split plot arranged in randomized complete block design in three replications with nursery management as the mainplot (M_1 – Wetbed and M_2 – Dapog) and age of seedlings (T_1 =10-day old seedlings, T_2 =15-day old seedlings, T_3 =20-day old seedlings, T_4 =25-day old seedlings) as the subplot.

Lowland rice PSB Rc82 variety was used in the study. In wetbed method, the seeding rate was 40 kg ha^{-1}. The seeds were soaked in tap water for 24h and then incubated for 48h. A 1 m x 1 m bed was prepared per age of seedling treatment. Pre-germinated seeds were sown thinly and uniformly on raised seedbeds. Complete fertilizer at 1 tablespoon per square meter or approximately 15 grams per square meter was applied. Drainage canals were constructed around each seedbed to remove excess water. Four (4) days after, the seedbed was irrigated about 2- 3 cm deep and gradually increasing the water level to 5 cm to control weeds and to make pulling of seedlings easier.

For dapog method, the same seeding rate was used. The seeds were soaked in tap water for 24h and then incubated for 48h. A bed of 0.40 m x 1.80 m (0.72 square meter) per seedling age treatment was constructed beside the wetbed seedbed. The surface of the raised soil bed was covered with polyethylene sheets. Compost of 1 cm thick was placed on the sheet as medium for pre- germinated seeds and served as seedbed. To prevent the soil and seeds from washing away, sticks were placed to fence or protect the bed. This was pressed with a wooden flat board right after seeding and was sprinkled with water when needed.

The water level in the field was maintained at 2-3 cm. The fertilizer rate used was 120-60-60 kg N, P_2O_5 and K_2O per hectare. Nitrogen was applied in 3 splits. The 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 carried out during mid-tillering (20 DAT) and panicle initiation stages by topdressing. Panicle initiation was determined by dissecting and visually observing the furry tip of panicle at the center of the stem.

Before transplanting, ducks were pastured for several weeks. Handpicking of adults and egg masses of golden snail was done a day before transplanting. Excess water in the field was drained prior to transplanting. Seedlings were transplanted at the age specified in the treatments at a distance of 20 cm x 20 cm between rows and hills. There were 15 rows per plot and 25 hills per row. Replacement of missing hills was done 3-7 days after transplanting.

Depth of water was maintained at 2-3 cm. Rotary weeding was done in all treatment plots at ten (10) days after transplanting including the alleyways and borders. The area was irrigated the day after weeding to prevent buried and uprooted weeds from recovering. Thereafter, spot handweeding was done to control weeds.

Three days after transplanting, the area was irrigated gradually at a depth of 2.5 cm and gradually increased as the plants grew. During panicle initiation, water was increased to a depth of 3 cm to 5 cm and was drained during fertilizer application and two weeks before harvest to facilitate harvesting operation and data gathering. Irrigation was resumed 3-5 days after application.

Golden apple snail **(***Pomacea canaliculata* L.) was controlled by handpicking the adult snails and egg clusters before and after transplanting the seedlings. During heading and milking stages, botanical pesticides were applied to minimize the attack of insect pests. The experimental area was kept clean to keep rats from inhabiting them. Guarding of birds as well as the use of scarecrow were employed.

Harvesting was done when approximately 85% of the grains in the panicle in each treatment plot was ripened. At this stage, grains were considered ripe and are ready for harvest when they turn yellow and the grains at the base of the panicle are at hard dough stage.

All the plants within the harvestable area of 4.20 m x 2.20 m (9.24 square meter) with 11 rows and 21 hills row^{-1} were cut at the base using a sharp sickle. Two end rows in each side and two end hills (both ends) in each row served as borders. The panicles were threshed and cleaned by winnowing before the necessary data were gathered.

Data Gathered

Agronomic characteristics of lowland rice were evaluated based on the days from sowing to heading, days from sowing to maturity, plant height (cm) and fresh straw yield (t ha^{-1}) using the following formula:

$$\text{Fresh straw yield (t ha}^{-1}\text{)} = \frac{\text{Straw yield (kg)}}{\text{Harvestable area (9.24m}^2\text{)}} \text{ x } \frac{10000\text{m}^2\text{ha}^{-1}}{1000\text{ kg t}^{-1}}$$

Yield and yield components were determined on the number of productive tillers per hill, number of filled grains per panicle, percentage of filled spikelets per panicle, weight of 1,000 grains (g) and grain yield (t ha^{-1}) using the formula:

$$\text{Grain yield (t ha}^{-1}\text{)} = \frac{\text{Plot yield (kg) at 14\% MC}}{\text{Harvestable area (9.24 m}^2\text{)}} \text{ x } \frac{10000\text{ m}^2\text{ha}^{-1}}{1000\text{ kg t}^{-1}}$$

Physiological parameters were evaluated on Leaf Area Index (LAI), Net Assimilation Rate (NAR)**, C**rop Growth Rate (CGR) and Harvest Index (HI).

For profitability analysis, the production cost was determined by recording all the expenses incurred throughout the conduct of the study from land preparation up to harvesting. These include cost of chemical, materials and labor used in the field. The gross income was determined by multiplying the yield of each treatment plot by the current price of palay per kilo.

The net return was determined by subtracting the total expenses from the gross income for each treatment. The gross income, net return and benefit cost ratio was determined using the following formula:

Gross income = Yield (kg ha^{-1}) x current price kg^{-1}
Net return = Gross return – Total cost
Benefit cost ratio = Net income (PhP ha^{-1}) / Total cost (PhP ha^{-1})

All data collected were analyzed using Statistical Analysis Software (SAS) Version 9.2. and treatment means for significant parameters were compared using Tukey's Studentized Range (HSD) test.

RESULTS and DISCUSSIONS

Soil Analysis

The soil used in this experiment was very strongly acidic at 4.88. It has low in organic matter (2.24%), low in available phosphorus (5.66 mg/kg), medium total N (0.21%) and exchangeable potassium (0.33 me/100 g soil) (Landon, 1991).

Agronomic Characteristics of Lowland Rice

Table 1 shows the agronomic characteristics of lowland rice under different nursery management and seedling age at transplanting. Statistical analysis revealed that the number of days from sowing to heading and maturity were significantly affected by the treatments used. Plant height was affected by age of seedlings but not by nursery management. No significant difference was observed in straw yield for nursery management and age of seedlings used.

Lowland rice under dapog method delayed its heading and maturity. This could be due to the high seeding rate of dapog which resulted in closer spacing in the seedbed and leads to slow growth of seedlings. Furthermore, dapog - grown seedlings only relied on the endosperm to permit seedlings to grow at their early days without receiving any outside nutrients except air, water and sunlight. Once the food material contained in the endosperm have been exhausted, the seedlings quickly begin to die off (https://nature-and-farming.blogspot.com). Since nutrients are limiting on dapog seedlings, growth and development were affected leading to longer maturity periods.

Twenty-five-day old seedlings resulted in longer days to heading and maturity comparable to 10 and 20- day old seedlings. Nahar et al (2009) and Shah (2001) explained that older seedlings had delayed heading and maturity due to low solar radiation intercepted during vegetative stage of the crop due to its planophile - like canopy structure. Menete et al (2008) pointed out that plants from younger seedlings (10–20 days old) completed their vegetative growth earlier (5–9 d) thus matured earlier than plants from older seedlings (30 days old). However, this response is variety-dependent, due to inherent genetic differences in the duration of the crop’s life cycle. Lampayan et al (2015) found that seedling competition in the seedbed extends maturity in late transplanted seedlings.

They further stated that 10 days delay in transplanting resulted in an additional 5–6 days in the field both in high and low seeding rates.

In terms of plant height, using 25 -day old seedlings at transplanting produced taller plants than 10 -day old seedlings (Table 1). This is because during transplanting, plants in 25 -day old seedlings were already taller and bigger compared to 10 -day old seedlings.

Table 1. Agronomic characteristics of lowland rice as influenced by nursery management and seedling age at transplanting

Treatments	Number of days from sowing to		Plant height (cm)	Fresh straw yield (t ha^{-1})
	heading	maturity		
Nursery Management				
M_1 = Wetbed	86.50b	116.50b	97.35	24.46
M_2 = Dapog	91.25a	121.25a	94.78	25.08
Age of Seedlings				
T_1 =10 -day old seedlings	89.33ab	119.33ab	91.98b	25.37
T_2=15 -day old seedlings	86.67b	116.67b	96.63ab	23.77
T_3 =20 -day old seedlings	88.83ab	118.83ab	5.48ab	24.35
T_4 =25 -day old seedlings	90.67a	120.67a	100.18a	25.59
C.V. (a) %	0.69	0.52	5.53	16.03
C.V. (b) %	2.23	1.67	4.35	12.67

Means within column followed by the same letter are not significantly different at 5% level, HSD.

Physiological Parameters

Statistical analysis revealed that leaf area index and net assimilation rate from 42 to 84 days after transplanting were not significantly affected by nursery management and seedling age. However, harvest index and net assimilation rate from 21 to 42 days after transplanting were significantly influenced by the age of seedlings particularly the older seedlings (Table 2).

Higher harvest index was observed in rice when 25 -day old seedlings were used at transplanting. However, it was comparable to 15 and 20 -day old seedlings. Harvest index is a variable factor in crop production that indicates plants efficiency to convert the absorb nutrients and products of photosynthesis into grains in proportion to straw yield (Yang and Zhang, 2010). Plants at 25-day old seedlings resulted in higher NAR than younger seedlings (10-day old) at early vegetative stage. Murty et. al (1986) stated that net assimilation rate of crop plants obtained at early growth stages without mutual competition is the manifestation of photosynthetic capacity of a specific variety in a given climatic conditions.

Table 2. Physiological characteristics of lowland rice as influenced by nursery management and seedling age at transplanting

Treatments	Leaf Area Index	Harvest Index	Net Assimilation Rate (g m^{-2} d^{-1})			
			21-42 DAT	42-56 DAT	56-70 DAT	70-84 DAT
Nursery Management						
M_1 = Wetbed	8.12	0.39	11.48	2.82	6.44	4.97
M_2 = Dapog	8.37	0.36	11.11	3.14	6.36	4.53
Age of Seedlings						
T_1=10-day old seedlings	8.80	0.35b	7.12b	3.09	6.23	4.44
T_2=15-day old seedlings	8.27	0.36ab	10.36ab	3.25	6.33	4.48
T_3=20-day old seedlings	8.26	0.38ab	2.39ab	2.82	6.59	5.15
T_4=25-day old seedlings	7.66	0.41a	15.31a	2.76	6.47	4.94
C.V. (a) %	22.33	18.78	30.57	30.75	19.86	30.48
C.V. (b) %	11.01	8.86	39.34	15.34	35.89	39.49

Means within column followed by the same letter are not significantly different at 5% level, HSD.

Crop growth rate (CGR) is significantly affected by nursery management and age of seedlings at early growth stage of lowland rice (Table 3). Higher crop growth rate was attained with wetbed method. Crop growth rate is a measure of crop productivity. It is the rate of dry matter accumulation per unit area per unit time. This suggests that wetbed method is more productive in terms of dry matter accumulation than dapog method. An interaction between nursery management and age of seedlings on crop growth rate at 21-42 DAT was likewise observed (Table 4). Under wetbed method, transplanting of 20-25 -day old seedlings resulted in higher crop growth rate, however, using younger seedlings reduced the crop growth rate either in wetbed or dapog method. It was observed that there was a continuous increase on growth rate of rice until 70 DAT and declined towards maturity of the crop because some leaves senesced as the rice plant gets matured.

Table 3. Crop growth rate of lowland rice at different growth stages as influenced by nursery management and seedling age at transplanting

Treatments	Crop Growth Rate (g m^{-2} d^{-1})			
	21-42 DAT	42-56 DAT	56-70 DAT	70-84 DAT
Nursery Management				
M_1 = Wetbed	16.69a	33.86	52.49	42.66
M_2 = Dapog	6.07b	26.95	45.45	38.56
Age of Seedlings				
T_1 =10 -day old seedlings	6.20c	28.27	44.32	36.78
T_2 =15 -day old seedlings	7.54bc	32.82	52.27	44.16
T_3 =20 -day old seedlings	13.86ab	29.81	49.71	41.87
T_4 =25 -day old seedlings	17.91a	30.71	49.58	39.64
C.V. (a) %	25.18	21.10	34.64	32.39
C.V. (b) %	36.91	22.83	30.75	39.45

Means within column followed by the same letter are not significantly different at 5% level, HSD.

Table 4. Interaction effects between nursery management and age of seedlings on crop growth rate at week 1 (21-42 DAT) of lowland rice

Age of seedlings	Nursery Management	
	M_1 = Wetbed	M_2 = Dapog
T_1 - 10 -day old seedlings	6.13b	6.27b
T_2 - 15 -day old seedlings	8.65b	6.43b
T_3 - 20 -day old seedlings	22.26a	5.46b
T_4 - 25 -day old seedlings	29.70a	6.11b

Means within column followed by the same letter are not significantly different at 5% level, HSD.

Yield and Yield Components

The yield and yield components of rice as influenced by nursery management and age of seedlings are shown in Table 5. Statistical analysis revealed that among the parameters studied only the percentage filled spikelets panicle^{-1} and grain yield (t ha^{-1}) were significantly affected by the nursery management and age of seedlings at transplanting. The number of productive tillers hill^{-1}, number of filled grains panicle^{-1} and weight of 1000 grains were not affected by the treatments.

Moreover, interactions between nursery management and age of seedlings on number of filled grains panicle^{-1}, percentage of filled spikelets panicle^{-1} and grain yield (t ha^{-1}) were observed (Tables 6-8). Wetbed method of crop establishment produced higher number of filled grains panicle^{-1} regardless of age of seedlings. However, in dapog method using 25 -day old seedlings for transplanting reduced the number of filled grains panicle^{-1}. Similar trend was observed on the percentage filled grains panicle^{-1} (Tables 6 and 7).

The grain yield of PSB Rc82 was affected by the interactions between nursery management and age of seedlings (Table 8). Transplanting older seedlings (25 -day old seedlings) under wetbed method gave higher yield than using younger seedlings (10 -day old seedlings). However, 25 -day old seedlings gave comparable yield with 15- and 20-day old seedlings. Generally, dapog method gave lower yield than wetbed method which is comparable when younger seedlings were used under wetbed method. Using older seedlings (25 -day old seedlings) gave higher yield than younger seedlings (10 -day old seedlings) under wetbed method probably because older seedlings had good head start over younger seedlings especially under biotic stress.

Table 5. Yield and yield components of lowland rice as influenced by nursery management and seedling age at transplanting

Treatments	Number of		Percent filled spikelets panicle^{-1}	Weight of 1000 grains (g)	Grain yield (t ha^{-1})
	productive tillers hill^{-1}	filled grains panicle^{-1}			
Nursery Management					
M_1 = Wetbed	14.27	55.77	43.04a	26.43	2.18a
M_2 = Dapog	16.59	42.58	34.33b	30.81	1.57b
Age of Seedlings					
T_1=10 -day old seedlings	15.12	44.25	37.69ab	22.22	1.32b
T_2=15 -day old seedlings	16.37	57.10	43.31a	25.14	1.89ab
T_3=20 -day old seedlings	13.75	51.38	40.74ab	28.20	1.89ab
T_4=25 -day old seedlings	16.48	43.93	32.99b	38.93	2.40a
C.V. (a) %	11.73	25.31	9.81	20.80	12.19
C.V. (b) %	18.48	19.61	15.21	37.12	26.37

Means within column followed by the same letter are not significantly different at 5% level, HSD.

Table 6. Interaction effects between nursery management and age of seedlings on number of filled grains $panicle^{-1}$ of lowland rice

Age of seedlings	Nursery Management	
	M_1 = Wetbed	M_2 = Dapog
T_1- 10 -day old seedlings	40.73ab	47.76a
T_2- 15 -day old seedlings	55.13a	59.06a
T_3- 20 -day old seedlings	60.46a	42.30ab
T_4- 25 -day old seedlings	66.73a	21.13b

Means followed by the same letter are not significantly different at 5% level, HSD.

Table 7. Interaction effects between nursery management and age of seedlings on percentage of filled spikelets $panicle^{-1}$ of lowland rice

Age of seedlings	Nursery Management	
	M_1 = Wetbed	M_2 = Dapog
T_1 - 10 -day old seedlings	31.99ab	43.38a
T_2 - 15 -day old seedlings	44.73a	41.88a
T_3 - 20 -day old seedlings	47.61a	33.88ab
T_4 - 25 -day old seedlings	47.82a	18.16b

Means followed by the same letter are not significantly different at 5% level, HSD.

Older seedlings may have more assimilates stored in the stalks, thus could remobilize these assimilates for the repair of tissues damaged by pests.

Table 8. Interaction effects between nursery management and age of seedlings on grain yield ($t\ ha^{-1}$) of lowland rice

Age of seedlings	Nursery Management	
	M_1 = Wetbed	M_2 = Dapog
T_1 - 10 -day old seedlings	1.28b	1.37b
T_2 - 15 -day old seedlings	1.93ab	1.85b
T_3 - 20 -day old seedlings	2.29ab	1.49b
T_4 - 25 -day old seedlings	3.22a	1.59b

Means followed by the same letter are not significantly different at 5% level, HSD

This result conforms to the observations of most Leyte conventional farmers who found out that older seedlings performs better than younger seedlings. However, results of this study are in contrast with the Systems of Rice Intensification (SRI) where younger seedlings (10 -day old) produced more yield than older seedlings (25 -day old). SRI proponents stated that rice seedlings transplanted before commencing the fourth phyllochron retained their higher tillering potential than those of more than 14 days old.

Cost and Return Analysis

The cost and return analysis of PSB Rc82 under different nursery management and seedling age at transplanting are presented in Table 9. The variations in the net income of lowland rice could be attributed to the difference in the production cost and yield. Wetbed method and 25 -day old seedlings, obtained the highest net income of Php 2,531.00 and Php 6,651.00, respectively. The rest of the treatments resulted in net loss due to lower yield. Rice tungro virus and rice bug contributed to lower yield of PSB Rc82.

Table 9. Cost and return analysis of lowland rice production as influenced by nursery management and seedling age at transplanting

Treatments	Grain yield ($t\ ha^{-1}$)	Gross Income ($PhP\ ha^{-1}$)	Production Cost ($PhP\ ha^{-1}$)	Net Income ($PhP\ ha^{-1}$)
Nursery Management				
M_1 = Wetbed Method	2.18	41,420.00	38,889.00	2,531.00
M_2 = Dapog Method	1.57	29,830.00	40,449.00	-10,619.00
Age of seedlings				
T_1 = 10 -day old seedlings	1.32	25,080.00	40,389.00	-15,309.00
T_2 = 15 -day old seedlings	1.89	35,910.00	39,909.00	-3999.00
T_3 = 20 -day old seedlings	1.89	35,910.00	39,429.00	-3519.00
T_4 = 25 -day old seedlings	2.40	45,600.00	38,949.00	6, 651.00

Current price of palay= PhP 19.00 kg^{-1}

CONCLUSIONS

Based on the results obtained, the following conclusions can be drawn:

1. Wetbed method resulted in early heading, maturity and higher crop growth rate at 21-42 DAT. Twenty-five-day old seedlings gave higher harvest index, net assimilation rate and crop growth rate at 21-42 DAT. Using older seedlings gave higher yield under wetbed method.
2. Wetbed method and 25-day old seedlings were the appropriate nursery management and age of seedlings for PSB Rc82 under stress condition.
3. Transplanting 25-day old seedling gave higher income of Php 6, 651.00 while wetbed method of transplanting seedlings gave a net income of Php 2, 531.00.

RECOMMENDATIONS

1. It is recommended to use 25 -day old seedlings at transplanting under wetbed method of nursery management for PSB Rc82 lowland rice production under VSU conditions.

2. Follow- up study using PSB Rc82 as test crop at different planting seasons under similar agroclimatic conditions is recommended to validate the results of the study.

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