PHYSIOLOGICAL AND AGRONOMIC RESPONSES OF UPLAND RICE (*Oryza sativa* L.) VARIETIES GROWN ORGANICALLY UNDER JASAAN SOIL SERIES

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ABSTRACT

Upland rice is mostly grown in extremely diverse marginal upland ecosystems with highly degraded, infertile and acidic soils. The responses of selected upland rice varieties (Dinorado, Speaker, Ma. Gakit, and Cabuyok) to vermicast, Bio-N, and its combination were evaluated under Jasaan soil series in Claveria, Misamis Oriental from September 2013 to January 2014. The study was laid out following a 3 x 4 factorial in split-plot design with three replications. The Bio-N, vermicast and its combination served as the main plot while the upland rice varieties as the subplot. No synthetic chemical fertilizers and pesticides were used. Served application of vermicast, Bio-N and its combination did not influence the relative chlorophyll content of the leaves and dry matter accumulation of upland rice varieties before heading. It also did not influence the number of spikelets per panicle, weight per panicle, 1000 seeds weight and grain yield of the selected upland rice varieties. However, the significant effect of vermicast and Bio-N applied in combination revealed only at approximately three weeks after heading. Among the upland rice varieties, the grain yield of Speaker variety tended to be higher compared with other varieties. Results suggest that the farmer could either use vermicast, Bio-N, or in combination depending on the availability of the materials, and opt to use Speaker upland rice variety for its yield advantage.

Keywords: upland; rice; Bio-N; vermicast; organic; fertilizer

1. INTRODUCTION

Traditional upland rice (*Oryza sativa* L.) is one of the main staple crops in upland production system in the Philippines and in Asia (Mercado et. al. 1993; George et. al. 2001; Atlin et. al. 2006). However, traditional upland rice is mostly grown in marginal upland areas with highly degraded, infertile and acidic soils. Traditional upland rice is usually aromatic, tall and late maturing, and is usually grown organically, with lesser cultural practices or management intervention. This practice resulted to its lower yield, thus, treated as subsistence crop (Atlin et. al. 2006).

Recent report showed an increasing trend in the per capita rice consumption (PCRC) in the Philippines, opposite to the decreasing trend in other ASEAN countries (Francisco et. al. 2013). Hence, the Philippine government is promoting upland rice farming in every region of the country to augment the total national rice production. This initiative of the Philippine government is in consonance with the development goal of the Brunei Darussalam-Indonesia-Malaysia-Philippines East ASEAN Growth Area (BIMP-EAGA) to address the socioeconomic development of less developed, marginalized, and far-flung areas (BEC 2015). Upland rice ecosystem, however, is threatened by continued climatic changes such as erratic rainfall and high temperature resulting to drought condition. Among these climatic changes, drought is the major abiotic stress affecting upland rice production. Upland rice has shallow root systems and usually grown in infertile soil, thus it is more susceptible to drought than other crops (Bernier et. al. 2008; Kumar et. al. 2008).

Upland rice varieties have different drought responses (Kumar et. al. 2008). Previously, it was demonstrated that traditional upland rice variety Speaker produced higher grain yield compared with improved upland rice variety IR 55419, outperforming the improved check variety UPL Ri-5 and two other local varieties, Dinorado and Cabuyok, respectively. The yield of traditional variety "Speaker" and improved upland rice variety IR 55419 were consistently higher even when subjected to drought induction. The amount of accumulated nitrogen decreases as the duration of drought induction increases. The traditional upland rice variety Speaker produced significantly higher dry matter before and after heading than other upland rice varieties. Speaker maintained significantly higher relative chlorophyll content in the leaves before and after heading (Taylaran et. al. 2011a & 2013). In this study, the physiological and agronomic responses of selected upland rice varieties to vermicast, Bio-N and its combinations were investigated.

2. MATERIALS AND METHODS

2.1 Plant materials and establishment of rice plants

The study was conducted in Claveria, Misamis Oriental from September 2013 to January 2014. The study used four upland rice varieties (Ma. Gakit, Denorado, Kabuyok, and Speaker) obtained from DA-CES, Lanise, Claveria, Misamis Oriental. Bio-N (*Azospirillium lipoferum*) and vermicast were likewise used. The study was laid out following a 3 x 4 factorial in Split-plot design and replicated three times. The Bio-N, vermicast and its combination, served as the main plot (Factor A), while the upland rice varieties served as the subplot (Factor B). Four to five pre-germinated seeds were sown directly at 60cm distance between furrows and 20cm between rows. Vermicast was applied at 3.1 kg per plot (2m x 5m) based on the result of soil analysis. Bio-N was applied at 6 packs per hectare. Thinning of unhealthy seedlings was done 10-14 days from seedling emergence. Only 1-2 seedlings were grown per hill.

2.2 Measurement of relative chlorophyll content

Used were the upper fully expanded leaf of three main stem plants per hill of ten randomly selected plants per treatment at one month after emergence and two months after emergence. Meanwhile, flag leaf and 3rd leaf were used for the measurement of relative chlorophyll value using SPAD chlorophyll meter (SPAD-502, Minolta, Japan) at booting stage, heading stage, one week after heading, two weeks after heading and at three weeks after heading. These were recorded as a mean of six measurements for each selected individual leaf between 9:00 am and 2:00 pm.

2.3 Measurements of dry weight

Five hills per variety were randomly selected at 30 days after emergence (DAE), 60 DAE at heading, 25 days after heading and at harvest. Plants were separated into leaves, leaf sheaths plus stems and panicles (after heading and harvest). Each group of plant parts was dried in a ventilated oven at 80^{o}C for four days or to constant weight.

2.4 Measurement of yield and yield parameters

The number of spikelets per panicle, weight per panicle, weight of 1000 seeds and plot yield were determined. The yield was adjusted to 14% moisture content and expressed in ton per hectare.

3. RESULTS AND DISCUSSION

3.1 Relative chlorophyll dynamics of selected upland rice

The relative chlorophyll content of the leaves of the selected upland rice varieties was determined using the chlorophyll meter or SPAD meter (SPAD-502, Minolta, Japan). This is a simple, portable diagnostic tool that measures the greenness or relative chlorophyll content of leaves (Peng et. al. 1996; Gholizadeh et. al. 2009). The relative chlorophyll content of the leaves of selected upland rice varieties was not significantly influenced by the application of vermicast and Bio-N and its combination before heading (Table 1).

Table 1: Relative chlorophyll content at 1 month and 2 months after emergence and booting stage of upland rice (*Oryza sativa* L.) varieties applied with Bio-N and vermicast and its combination.

TREATMENTS	1 month after Emergence	2 months after Emergence	Booting Stage
FACTOR A (Fertilizers)			
A_1 – Bio-N	30.10	40.91	48.25
A_2 – Vermicast	30.67	40.63	47.79
A_3– Bio N + Vermicast	29.79	40.92	48.21
FACTOR B (Varieties)			
B_1– Speaker	31.11	40.51	47.78
B_2 – Ma. Gakit	29.54	41.08	47.96
B_3 – Dinorado	30.17	41.45	48.22
B_4 – Kabuyok	29.91	40.22	48.35
(A)	*n.s.*	*n.s.*	*n.s.*
(B)	*n.s.*	*n.s.*	*n.s.*
(A x B)	*n.s.*	*n.s.*	*n.s.*
c.v. (%)	*5.49*	*4.77*	*4.51*

Moreover, there was no significant difference in the relative chlorophyll content among upland rice varieties used in this study. However, strong linear relationship between SPAD values and leaf nitrogen concentration (Gholizadeh et. al. 2009) and between leaf nitrogen and the rate of leaf photosynthesis (Hirasawa et. al. 2010; Taylaran et. al. 2011b) has been reported leading to higher dry matter production. After heading, the relative chlorophyll content of the leaves was significantly influenced by the application of vermicast plus Bio-N at approximately three weeks after heading. This result suggests that the combined effects of vermicast and Bio-N might delay the senescence of rice leaves. Among the varieties, Dinorado revealed significantly higher relative chlorophyll content at approximately three weeks after heading (Table 2).

Table 2: Relative chlorophyll content at 1st, 2nd and 3rd week at heading stage upland rice (*Oryza sativa* L.) varieties applied with Bio-N and vermicast and its combination.

TREATMENTS	1st week at heading stage	2nd week at heading stage	3rd week at heading stage
FACTOR A (Fertilizers)			
A_1 – Bio-N	50.49	50.73	52.79[b]
A_2 - Vermicast	50.72	49.06	53.36[b]
A_3 – Bio N + Vermicast	51.53	52.43	55.29[a]
FACTOR B (Varieties)			
B_1 – Speaker	51.11	48.02	53.02[b]
B_2 – Ma. Gakit	50.88	52.22	52.78[b]
B_3 – Dinorado	51.37	52.71	55.21[a]
B_4 – Kabuyok	50.28	50.03	54.24[ab]
(A)	*ns*	*ns*	**
(B)	*ns*	*ns*	*
(A x B)	*ns*	*ns*	*ns*
c.v. (%)	*4.42*	*10.68*	*2.87*

Means of same column followed by common letters are not significantly different at 5%, 1 % levels using Tukey's Test.

Table 3: Oven dry weight (g) at 30 and 60 days after emergence of upland rice (*Oryza sativa* L.) varieties applied with Bio-N and vermicast and its combination.

TREATMENTS	Oven Dry Weight 30 days after emergence	Oven Dry Weight 60 days after emergence
FACTOR A (Fertilizers)		
A_1 – Bio-N	0.21	2.72
A_2 - Vermicast	0.19	3.61
A_3 – Bio N + Vermicast	0.23	2.83
FACTOR B (Varieties)		
B_1 – Speaker	0.18	3.63
B_2 – Ma. Gakit	0.22	3.07
B_3 – Dinorado	0.22	2.87
B_4 – Kabuyok	0.24	2.62
(A)	*n.s*	*n.s*
(B)	*n.s*	*n.s*
(A x B)	*n.s*	*n.s*
c.v. (%)	*39.75*	*54.14*

3.2 Changes in dry matter accumulation

Dry matter accumulation is a function of fertilization and nitrogen accumulation (Taylaran et. al. 2009, 2010 & 2011b). The traditional upland rice variety Speaker accumulated significantly higher dry matter weight at harvest among the selected upland rice varieties (Taylaran et. al. 2011a & 2013). However, in the present study, the dry matter accumulation of selected upland rice varieties was not significantly affected by the application of vermicast and Bio-N and its combination before heading (Table 3). Previous report demonstrated that the traditional upland rice variety produced significantly higher dry matter after heading to harvest. The higher dry matter production might be attributed to the higher grain yield in traditional upland rice variety Speaker. However, harvest index was significantly highest in improved upland rice variety IR 55419 (Taylaran et. al. 2011a & 2013) which might be attributed to the comparably higher grain yield compared with traditional upland rice variety Speaker.

Table 4: Number of spikelets per panicle and weight per panicle (g) of upland rice (*Oryza sativa* L.) varieties applied with Bio-N and vermicast and its combination.

TREATMENTS	No. of Spikelets per Panicle	Weight per Panicle
FACTOR A (Fertilizers)		
A_1 – Bio-N	41.75	1.81
A_2 - Vermicast	37.42	1.49
A_3 – Bio N + Vermicast	46.25	1.96
FACTOR B (Varieties)		
B_1 – Speaker	44.33	1.82
B_2 – Ma. Gakit	40.33	1.72
B_3 – Dinorado	44.00	1.84
B_4 – Kabuyok	38.55	1.64
(A)	*ns*	*Ns*
(B)	*ns*	*n.s*
(A x B)	*n.s*	*n.s*
c.v. (%)	*7.42*	*10.47*

3.3 Yield and yield components

The number of spikelets per panicle, weight per panicle and 1000 seeds weight were not significantly influenced by the application of vermicast and Bio-N and its combination (Table 4 & 5). Among the varieties, Speaker tended to have higher number of spikelets per panicle and weight of 1000 seeds weight than the other varieties. Although the grain yield of upland rice applied with the combination of vermicast and Bio-N tended to be higher (Table 5), it was not significantly affected by the application of vermicast and Bio-N and its combination. These results suggest that the farmers can either use the vermicast and Bio-N applied singly or in combinations. Moreover, farmers can use any of the upland rice varieties but they may opt to use the Speaker variety owing to its relative advantage in grain yield.

Table 5: Weight of 1,000 seeds (g) and grain yield (t/ha) of upland rice (*Oryza sativa* L.) varieties applied with Bio-N and vermicast and its combination.

TREATMENTS	Weight of 1,000 seeds	Total Grain Yield
FACTOR A (Fertilizers)		
A_1 – Bio-N	24.39	2.43
A_2 - Vermicast	23.81	2.25
A_3 – Bio N + Vermicast	23.97	2.63
FACTOR B (Varieties)		
B_1 – Speaker	25.31	2.47
B_2 – Ma. Gakit	22.92	2.35
B_3 – Dinorado	24.55	2.45
B_4 – Kabuyok	23.45	2.45
(A)	*ns*	*ns*
(B)	*ns*	*ns*
(A x B)	*ns*	*ns*
c.v. (%)	*4.12*	*4.39*

4. CONCLUSION

The relative chlorophyll content of the selected upland rice varieties was not significantly influenced by the application of vermicast and Bio-N and its combination. Moreover, the dry matter accumulation before heading was not affected by vermicast and Bio-N applied singly or in combination. The yield components were unaffected by the above-mentioned treatments. These resulted to the unaffected yield of the selected upland rice by that fertilization. These suggest that farmers could use either vermicast or Bio-N applied singly or in combination. Moreover, farmers may also use either of the upland rice varieties but they may opt to use Speaker variety for its relative grain yield advantage.

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