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Effect of Organic Nitrogen on Yield and Yield Components of Rice (*Oryza Sativa* L.)

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Abstract

Nitrogen (N) is the most important nutrient to produce more dry matter through photosynthesis process. The objectives of this study were to investigate photosynthesis activity, yield and yield components as affected by different N levels and to increase farmers' awareness of improving rice yield potential with photosynthesis efficiency. Experiments were conducted in plastic house with complete randomized design. Four different types of organic fertilizer (i.e., O1: Cattle pig dropping; O2: Poultry manure-II; O3: Sugarcane bagasse; O4: Cattle manure) were used in combination with one control (without any organic fertilizer or amendment) and three different N levels (50, 100, and 150 kg N per hectare). The result of small pot experiment indicated that photosynthetic oxygen evolution rate of N treated plants was increased by an average of 51% as compared to control. A significantly higher leaf photosynthetic rate was observed in O1 organic fertilizer compared to that of the other treatments. Total N content of pot soil after rice harvested on 57 DAT showed the order of N uptake by rice plant was O1 > O2 > O3 > O4. Plant height, tiller number, SPAD reading and biomass accumulation were significantly influenced as N supply increased which might be due to increased photosynthesis rate and Rubisco activity. Responses of agronomic characteristics were associated with nutrient concentrations and its availability in different organic fertilizers.

Keywords: rice, nitrogen, SPAD, photosynthesis, yield

Introduction

Rice (*Oryza sativa* L.) is a staple food for almost 50 percent of the world population, and is contributing more than 40 percent of the calories consumption in Asia. World population is increasing with alarming rate and about 40 percent more rice will be required by 2030 than it was produced in 2005 to fulfill the demand of the growing population. Globally, rice yields have risen by less than 1 percent per year in recent years-slower than population growth and down from well over 2 percent during the Green Revolution period of 1970-90 (IRRI, 2008).

Nitrogen (N) is the most essential nutrient for rice grain filling through the enhancement of photosynthetic capacity (Mae, 1997) and comparatively large amounts are required among the three macronutrients by rice crop (Wang *et al.,* 2004). However, at the same time, under-fertilization or over-fertilization of N causes several physiological changes in plant growth and development, which in turn, results low rice yield (Heenan, 1982). Rice is more sensitive to overdoses of nitrogen than to excess levels of potassium and adversely affect the quality of the grain. Increase in rice grain yield is accompanied to increase nitrogen rate and attains plateau at 180 kg N per hectare (ha) and becomes less at higher rates (Zhang *et al.*, 2009). The mechanism for differences in grain yield with different nitrogen rates are due to the difference in partitioning of dry matter between grain and straw. Nearly half of the total dry matter in modern varieties was partitioned to the grain (Bufogle *et al.*, 1997). Thus, productivity of rice varieties depends on their responsiveness of supplied N to soil. Therefore, we must avoid applying too much nitrogen in rice field for economic yield.

In context of Nepal, rice is the most important food crop for economics and social values which is grown from tropical plains up to high elevation of the world at 3050 meter above sea level (Chhumchure, Jumla). Rice covers about 46 percent of total cultivated area which provides more than 50 per cent of the total calories requirement of the Nepalese people. It contributes about 21 percent to the agriculture gross domestic production (Dahal, 2010). In the developing and land locked countries, cost and availability of chemical fertilizer is a serious problem. Increasing N use efficiency is a major challenge for rice researchers and farmers for low production cost of rice. For the sustainable agriculture system, maintaining of soil fertility has prime importance. Organic fertilizer can play an important role in this regards through slow and continuous release of ions, soil water retention during drought and increase drainage in wet weather. In Nepal, general recommended dose of organic manure for rice cultivation is 6 t ha^{-1}. When extension workers advise farmers on the amount of fertilizer for practical rice cultivation, both the quantity and quality is important because of varied amount of nutrients content of different organic fertilizers. Hsieh and Hsieh (1993) reported that organic matter is often used as an index of soil fertility because it generally influences soil physical, chemical and biological properties.

In this study, we will discuss about the usage of different sources of organic fertilizer with special focus on N levels for improving leaf photosynthesis in connection with maximum yield and yield components of indica rice (*Oryza sativa* L. var. Taichung Sen No. 10).

Materials and methods

Climatic condition

The experiments for organic fertilizer application with special focus on different levels of N nutrient in relation to photosynthesis and yield components of paddy rice were conducted from 2009 to 2010 at the National Pingtung University of Science and Technology (NPUST), located at 22˚39'N, and 120˚36'E with an elevation of 71 meters. Average light intensity of photosynthetically active radiation (PAR), i.e., solar radiation from 400 to 700 nanometers, inside P-house at 9:00 am and 12:00 pm was 755 and 1010 µmol m^{-2} s^{-1} in sunny day on November 14, 2009 during small pot experiment. The site has a mean annual temperature of 25˚C.

Small pot plastic house experiment design

The small pot experiment was conducted at National Pingtung University of Science and Technology (NPUST) from October 10, 2009 to December 12, 2009 to examine photosynthesis rate and agronomic characteristics of rice plants in relation to quality and quantity of different organic fertilizers. Paddy rice (*O. sativa* var. Taichung Sen No. 10*)* was grown with four types of organic fertilizers with four levels of each, which includes one control (C) and three N levels (50, 100 and 150 kg N ha^{-1}). The control (C) treatments doesn't have any organic fertilizer or amendment; low level (L) which received 50 kg ha^{-1} of nitrogen; medium level (M) which received 100 kg ha^{-1} of nitrogen; high level (H) which received 150 kg ha^{-1} of organic nitrogen. Four organic fertilizers were: 1) cattle pig dropping (O1); 2) poultry manure-II (O2); 3) sugarcane bagasse (O3); and 4) cattle manure (O4). Out of four types of organic fertilizers: O1, O2, O3 were branded and O4 was locally produced. The bio-chemical characteristics of different organic fertilizers used for experiments were given in Table 1. Experimental design was a complete randomized design (CRD) with 12 replications of each treatment (combination of four organic fertilizers × four levels = 16 treatments).

A total 192 small pots (diameter 20 cm, height 13 cm, area 0.0314 m^2) were used to grow rice plant and each pot represented one experimental unit. Soil for the pot was collected near the site of field experiment, which was supposed to have consistent characteristics with field experiment. Soil surface was cleaned up to eliminate previous crop roots, residues and then collected and dried under open shed. Soil was thoroughly mixed. Pots were filled with soil-organic fertilizer mixture prepared by mixing the calculated amounts of soil and organic fertilizers as shown in Table 2. All fertilizer was thoroughly mixed with soil before filling the pot. Due to limited amount of nutrients applied per pot was 2 times greater than of the recommended rate of application. Due to limited pot size, plants need more fertilizer to fulfill nutrient requirement for whole life time. Another reason behind increasing amount is that only 40-50% nutrients get available to plants due to mineralization process.

Rice seeds were soaked for 48 hours to increase the seed water content and then were exposed to a temperature about 30˚C to promote germination. Seeds were sown in plastic seeding-box (60 cm × 30 cm × 3 cm) with 200 gram seed per box on in early October (October 10, 2009). Rice seedlings of 2.5-3.5 leaf stage (age) were transplanted on October 28, with 3-4 plants per pot. Water level was maintained at 4-6 cm deep (above soil) in each pot during the experiment. Required data were collected and analyzed using following methods.

Table 1. Bio-chemical characteristics of organic fertilizers used for P-house and field experiment

Name	pH[1]	EC[1] (d S m^{-1})	OC %	Total N[2]	Total P[3]	C:P	Total Ca	Total Mg	Total K	Total Na	Fe	Mn	Cu	Zn	Ni
				-----%-----			-------------%------------				----------mg per kg[4]----------				
Cattle pig dropping (O1)	6.61	22.0	41.9	4.6	1.37	31	9.4	0.9	0.6	0.3	3280	9	38	168	15
Poultry manure–II (O2)	7.0	5.91	34.7	1.4	0.71	49	6.3	0.7	0.1	0.2	1747	263	24	181	16
Sugarcane bagasse (O3)	7.14	16.8	34.7	2.5	0.59	59	0.6	0.9	0.5	0.4	3047	63	40	101	17
Cattle manure (O4)	6.73	3.15	18.1	1.3	0.71	25	8.7	0.7	0.5	0.2	14147	1050	49	327	23

[1]1:5 Compost: water Source: Jobe and Tsai (2006) [2]Micro-Kjeldahl determination

[3]H_2O_2/H_2SO_4 digests

[4]Maximum Allowable level (mg per kg) of Ni = 25 and Cu = 100 (150)

Table 2. Relative amount of soil (kg pot^{-1}) and organic fertilizers (kg pot^{-1}) required for each small pot in P-house experiment[1]

Treatments	N content (%)	Treatments						
		C	L		M		H	
		Soil	Soil	OF	Soil	OF	Soil	OF
O1	4.6	4.19	4.18	0.01	4.17	0.03	4.15	0.04
O2	1.4	4.19	4.15	0.05	4.10	0.10	4.06	0.14
O3	2.5	4.19	4.17	0.03	4.14	0.05	4.12	0.08
O4	1.3	4.19	4.15	0.05	4.10	0.10	4.05	0.15

[1]Control (C): no any OF; low level (L): 50 kg N ha^{-1}; medium level (M): 100 kg N ha^{-1}; high level (H): 150 kg N ha^{-1}; O1: Cattle pig dropping; O2: Poultry manure-II; O3: Sugarcane baggase ; O4: Cattle manure, OF: organic fertilizer.

Photosynthesis measurement

For the measurement of photosynthetic rate, the oxygen evolution was determined at active tillering stage i.e., 40 days after transplanting (DAT) of rice leaves with a digital "The Rank Brothers Oxygen Electrode system" (Rank Brothers Ltd., Model 10, England) from December 4, 2010 to December 7, 2010. Five pots (samples) from each treatment were randomly selected and tagged for photosynthetic analysis. Fully expanded rice leaf (Y-leaf), closer to flag leaf of main culm, was collected and used to quantify photosynthetic oxygen evolution. Ice-box was used to bring the leaf from field to laboratory which inhibited leaf senescence.

Thirty leaf disks each of 0.1237 cm^2 of fresh leaf was cut with disk punch and put into incubation chamber. The carbon dioxide was supplied during the measurement by adding 3 milliliter (mL) buffer solution, prepared at pH 7.22 with mixing 2.5 mL of 1/100 M $NaHCO_3$, 0.10 mL of 1/100 M Na_2CO_3 and 0.40 mL of 1/15 M KH_2PO_4. Then, one drop of Triton X-100 (detergent) was added to enable leaf disks to go inside the buffer solution. In order to activate the photosynthesis of leaf disks, a projector lamp emitted (artificial illumination) 1300 µmol m^{-2} s^{-1} was used and kept 30 cm distance from the reaction chamber at the equal height. Light intensity of lamp was measured using LI-COR (Quantum) meter. The temperature of reaction chamber was maintained at 30 ± 1˚C, using a water bath. The rate of photosynthesis was calculated from the rate of increase of dissolved oxygen in buffer. Data was recorded at the Plant Physiology Laboratory, NPUST using computer software.

Data was recorded in every 0.0533 minute which was continued for ten minutes. Therefore, for every leaf sample, there were 188 recorded photosynthesis values. Using this whole set of data, slopes were calculated. Then, O_2 evolution in each sample was calculated using solubility of O_2 in water at 30˚C (237 nmoles O_2/mL H_2O) × volume of buffer solution × slope for linear straight line (reading per minute) divided by leaf area (3.711 cm^2). General Linear Model (GLM) procedure of SAS 9.1 system (English) was used to determine whether significant difference existed among treatments. Duncan's Multiple Range Test (DMRT) at $p < 0.05$ was done for assuming the validity of the analysis. Sigma-plot was used to draw graphs.

Agronomic traits measurement

Five randomly selected pots from each treatment were tagged and agronomic characteristics of plant height, tiller number per pot, leaf number, chlorophyll reading, fresh and dry biomass were investigated at 45 DAT and 57 DAT. Plant height was measured from the base of plant to the top leaf using a 1.30 meter ruler at 45 DAT and 57 DAT. Tiller number and leaf number were determined by counting tiller number manually in each pot. While counting tillers, main culms were ignored. A chlorophyll meter (SPAD-502, Minolta Camera Co. Ltd., Japan) was used to record the chlorophyll readings (values). Fully expanded leaf (Y-leaf), next to the flag-leaf was used to measure chlorophyll content because it plays active role for photosynthesis activity. Nitrogen translocate from old to young leaves when the plant is nitrogen deficient (Wang *et al.*, 2006). Since the SPAD readings at different measuring positions of individual leaf are varied, average SPAD readings of three points, i.e., two-third down from the tip, mid-point and one-third away down the tip of each leaf blade were recorded. The aerial parts of plants were harvested from the base to observe fresh and dry biomass (leaf and column weight) accumulation at 57 DAT. First, fresh weight of the above ground plant were taken and then put in a paper bag for drying. Whole plants were oven-dried at 80˚C for 72 hours and dried samples were weighed again when cooled down. Based on fresh and dry weight, water content of leaves among different treatments was computed.

Analysis of total nitrogen in soil

After harvesting of plant on 57 DAT, soil samples were again taken from small pot of each treatment to highlight the possible changes in total nitrogen. The air-dried soil samples were grinded and passed through 2 mm sieves and stored in plastic jar (container) with label for test. The total nitrogen in soil was determined by the Kjeldahl method using Hoskins steam distillation apparatus. Air-dried soil sample of 0.2-0.5 g (containing about 1 mg of N) were taken in a micro-Kjeldahl flask, 1 mL $KMnO_4$ solution (5%) added and swirled to mix thoroughly for sometimes. The flasks were held at 45˚ angle, and 2 mL of dilute H_2SO_4 was added down the neck and swirled. The flasks were allowed to stand for 5 minutes, and 1 drop of octyl alcohol added. Reduced

Fe (0.50 ± 0.01 g) was added down into the bulb of the Kjeldahl flasks and swirled and allowed to stand for 15 minutes. The flasks were heated gently on the digestion stand for 45 minutes, and allowed to cool. Then, 1.1 g of K_2SO_4 catalyst mixture (100:10:1) was added. After the catalyst, 3 mL of conc. H_2SO_4 was added and heated the flask continuously on the digestion stand. When the water was removed and frothing has ceased, the heat was increased until the mixture assumed a yellowish green color and the digestion completed by boiling the mixture gently for 5-6 hours. After completion of digestion, the Kjeldahl flasks were allowed to cool and about 15 mL of water was added slowly before shaking, then the diluted digest was transferred to the distillation chamber of the Hoskins apparatus. Five mL of H_3BO_3 solution (2%) with 2 drops indicator was taken in 50-mL Erlenmeyer flasks and placed the flask under the condenser of the distillation apparatus so that the end of the condenser was contacted with the H_3BO_3. Twenty mL of 10N NaOH was added to the funnel of apparatus and run the alkali slowly into the distillation chamber by opening the funnel stopcock. When about 1 mL of alkali remain in funnel, rinsed the funnel rapidly with about 15 mL of water. The funnel stopcock was closed, and immediately distillation commenced by closing the steam bypass tube at the base of the steam jacket of the distillation chamber. When the distillate reached 35-mL marks of the receiver flask, the distillation was stopped by opening the steam bypass tube, then rinsed the end of the condenser and determined NH_4^+-N in the distillate by titration with 0.01*N* HCl using a 10-mL burette graduated at 0.01-mL intervals (1 mL of 0.01*N* HCl = 0.14 mg of NH_4^+-N). The color changed from green to pink at the endpoint.

Results and discussion

Photosynthesis activity and total N of small pot plastic house experiment

In Figure 2, it showed significant differences in photosynthetic oxygen evolution rates of rice leaves among different treatments on 40 DAT (active tillering stage). Many papers reported that photosynthesis potential increased under high oxygen evolution rates. Therefore, photosynhtetic activity increased linearly up to 150 kg N ha^{-1}. High N level treatmenent had greater evolution rate (528 nmol $O_2/cm^2/min$) followed by medium (453 nmol $O_2/cm^2/min$), low (444 nmol $O_2/cm^2/min$) and control (315 nmol $O_2/cm^2/min$) treatments. These might be due to incresed level of leaf N content with increasing N application rates. These data revealed that as the N level decreased, photosynthetic rate also declined and similar results were observed by Dordas and Sioulas (2008) in safflower and Zhao et al. (2005) in sorghum plant. Peng et al. (1995) reported a close relationship between photosynhtetic rate and leaf nitrogen content for both green house- and field-grown rice plant. Weerakoon et al. (1999) observed that CO_2 assimilation increased significantly in rice seedlings under green house conditions as nitrogen level increased between 373 to 545 µmol mol^{-1} CO_2, and no further increases in assimilation with higher atmospheric CO_2 concentration.

Oxygen evolution rate of O1 treatment was maximum followed by O3, O2 & O4 treatments (Figure 3). Total N content in the pot soil after harvested of the rice plant on 57 DAT have shown that total N was maximum in O4 treatment followed by O3, O2 and O1 treatments (Table 3). This might be due to low N uptake by plant during the growth from O4 treatment. Iron (Fe) and Zinc (Zn) content of O4 is much higher i.e., 14147 and 327 mg kg^{-1}. High Iron cause manganese deficiency. Maximum allowable level of Zn is 100 mg per kg of soil. In such condition, plant may not uptake the available nutrients due to soil toxicity. Heavy metal such as Cadmium (Cd) stress in soil is closely related to the performance of N fertilizer which inhibited growth, flag leaf area, photosynthesis and yield of rice (Alpha *et al.*, 2009). The mean photosynthetic oxygen evolution rate followed the sequence of O1 (497 nmol $O_2/cm^2/min$) > O3 (463 nmol $O_2/cm^2/min$) > O2 (430 nmol $O_2/cm^2/min$) > O4 (299 nmol $O_2/cm^2/min$). Thus, appropriate amount and available forms of nutrients are important for uptake by plant.

Soil N availability was greater in O1 treatment comparaed to others. Yang et al. (2007) observed rice plant have greater N uptake tendency under high N application than under a low N application and shoot N utilization under free-air CO_2 enrichment (FACE) was enhanced by 46% and 38% during transplanting to early-tillering and early-tillering to mid-tillering stage showing progressive decrease with time. Jiang et al. (1994) reported that the depression of photosynthesis in the low-root activity rice plant introduced by soluble starch application was due to lower stomatal conductance in the treated plants and not due to the lower internal CO_2 assimilation capacity. Delieu and Walker (1981) reported that the leaf-disks apparatus used in the measurement of the oxygen evolution is suitable for measurement of photosytnhesis capacity, i.e. the flux through the photosynthesis pathway when light, CO_2 and water are nonlimiting. That's why, we concluded that quality as well as nutrients content are prime important while selecting different brands of organic fertilizer on the market to minimize environmental pollution and maximize agriculutre output.

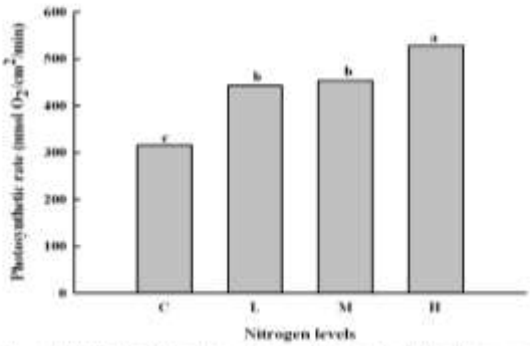

Figure 2. Effect of N levels on photosynthetic rate of rice leaves grown under small pot P-house experiment. Each vertical bar represents mean photosynthetic rate of 3 replications. Value marked by same letter are not significantly different at *p < 0.05* probablity level according to DMRT.

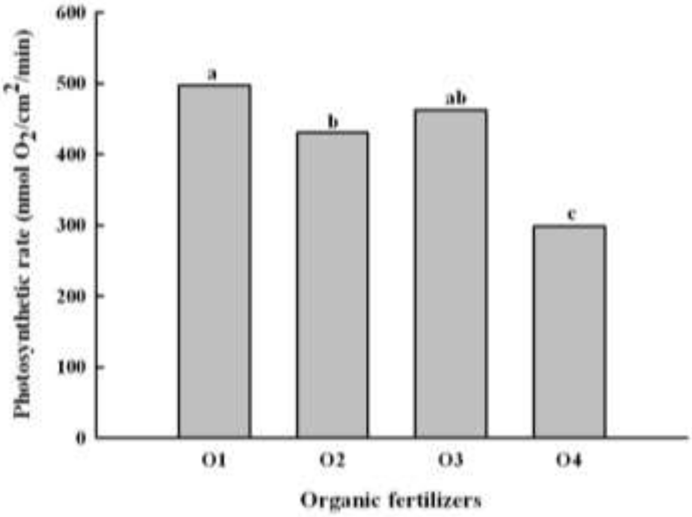

Figure 3. Effect of organic fertilizers on photosynthetic rate of rice leaves grown under small pot P-house experiment. Each vertical bar represents mean photosynthetic rate of three replications. Values marked by the same letters are not significantly different at $p < 0.05$ probability level according to DMRT.

Table 3. Total N content in soil after harvested of rice plants on 57 DAT. Four treatments were used with one control & three N levels using different organic fertilizers in small pot P-house experiment[1]

Treatments	Soil total N (%)
Organic Fertilizers	
O1	0.080c
O2	0.089b
O3	0.093a
O4	0.095a
Nitrgen levels	
C	0.068d
L	0.076c
M	0.089b
H	0.107a

[1]In a column, means followed by different letters are significantly different at $p < 0.05$ probability level according to Duncan's Multiple Range Test (DMRT). O1: cattle pig dropping; O2: poultry manure-II; O3: sugarcane bagasse; O4: cattle manure; control (C): no any OF; low level (L): 2.17 t ha^{-1}; medium level (M): 4.35 t ha^{-1}; high level (H): 6.52 t ha^{-1} organic fertilizers; DAT: day after transplanting (rice).

Effect of nitrogen level on agronomic characteristics, yield & yield components of rice plant

Plant height and tiller number as affected by organic-N

Plant height was significantly different between N treated and control treatments (Table 4). At 45 DAT, plant height was not significantly different among different nitrogen levels, however, it showed significant differences at 57 DAT. Highest plant height was attained by medium level treatment (64.67), followed by high level treatment (61.47), low level treatment (59.92) and then control treatment (45.67). Tillering behavior of plant showed significant differences between N levels and control treatments at both dates (Table 4). The highest number of tillers was achieved in medium level treatment (8.20), followed by high level treatment (7.37), low level treatment (6.54) and control treatment (1.42) at 57 DAT. The low temperature during the early tillering stage might reduce tiller number. Low temperature reduces number of tillers and the growth speed of tillers in rice (Kashiwagi *et al.*, 2010). The slow growth performance of the plants was also associated with slow and continuous released of N ions from organic fertilizer through mineralization. For higher growth rate and faster development, green plants must produce greater amount of photosynthates. Plant height, and tiller number increased with increasing nitrogen supply at different stages indicating that organic fertilizer slowly release ions by the mineralization process. Nutrients from organic matter become available gradually to the plant and could have a long lasting effect on growth and development (Khunthasuvon *et al.*, 1998).

Table 4. Effect of organic-N levels on plant height and tiller number at different growth stages of rice plants in small pot P-house experiment[1]

Treatments	45 DAT		57 DAT	
	Plant Height (cm)	Tiller number (no./plant)	Plant Height (cm)	Tiller number (no./plant)
C	43.05b	1.33c	45.67c	1.42d
L	45.80a	2.80b	59.92b	6.54c
M	47.10a	3.33a	64.67a	8.20a
H	48.13a	3.43a	61.47ab	7.374b

[1]In a column, means followed by different letters are significantly different at $p < 0.05$ probability level according to Duncan's Multiple Range Test (DMRT). Control (C): no any OF; low level (L): 2.17 t ha^{-1}; medium level (M): 4.35 t ha^{-1}; high level (H): 6.52 t ha^{-1} organic fertilizer; DAT: day after transplanting.

Effect of types of organic fertilizers on plant height and tiller number

Significant differences in plant height and tiller numbers were observed among different organic fertilizers (Table 5). Plant height was greater with O1 treatment, followed by O3 treatment, O2 treatment and O4 treatment. Similarly, number of tillers was also the greatest in O1 treatment, followed by O3, O2 and O4 treatments on both 45 and 57 DAT. Differences in the plant growth performance probably due to slow nutrients availability by mineralization process. Mineralization of organic fertilizer is a gradual and long lasting process and depends on moisture and temperature around the root system. Farmyard manure was as effective as chemical fertilizer, provided the manure contained high nutrient content (Khunthasuvon *et al.,* 1998). Mae (1997) observed close correlation between the number of tillers and amount of N absorbed during this period. Therefore, nutrients content and their availability should be considered while selecting organic fertilizer for better growth and development of plant.

Table 5. Effect of different types of organic fertilizers on plant height and tiller number at different growth stages of rice plants in small pot P-house experiment[1]

Treatments	45 DAT		57 DAT	
	Plant height (cm)	Tiller number (no. $plant^{-1}$)	Plant height (cm)	Tiller number (no. $plant^{-1}$)
O1	58.20a	5.89a	72.49a	12.05a
O2	48.50b	2.29b	51.53c	2.12c
O3	47.70b	2.23b	59.58b	5.33b
O4	29.69c	0.50c	39.11d	1.33d

[1]In a column, means followed by different letters are significantly different at $p < 0.05$ probability level according to Duncan's Multiple Range Test (DMRT). O1: cattle pig dropping; O2: poultry manure-II; O3: sugarcane bagasse; O4: cattle manure, DAT: day after transplanting.

Effect of organic-N levels on biomass accumulation

In Figure 3, it showed significantly differences in wet and dry biomass production among the treatments in small pot rice experiment. While compared with control treatment, fresh and dry biomass accumulation showed significant increase with increasing amount of N application rates. Water content was found to be 80% in N applied treatment while it was 72% in control (Table 6). Medium level treated plants had maximum dry matter accumulation followed by high and low treatments which is consistent with earlier finding which stipulated that upland rice has the capacity to accumulate biomass and nutrients in response to fertilization (George *et al.,* 2001). Dry matter production was 246%, 454% and 351% higher in low, medium and high level treatment, respectively, when compare to control plants. A significantly higher leaf net photosynthetic rate was observed in the plants under high level nitrogen treatment than others (Figure 2). Wang et al. (2004) noted that high photosynthesis of rice was achieved as level of N supply increased up to certain limit (100 kg/ha), and it could be due to increased Rubisco activity, resulting higher biomass production. Table 9 showed different levels of performance under different organic fertilizers treatments and O1 had better biomass accumulation compare to other treatments. Similarly, SPAD readings also significantly differ among control and N treated plants as well as among different organic fertilizers (Table 6). Differences in performance may be due to nutrients content and its availability for growth and development of plants. Thus, we can conclude that per unit biomass production of different treatments were highly affected by level of nitrogen and its availability (uptake) by the plants.

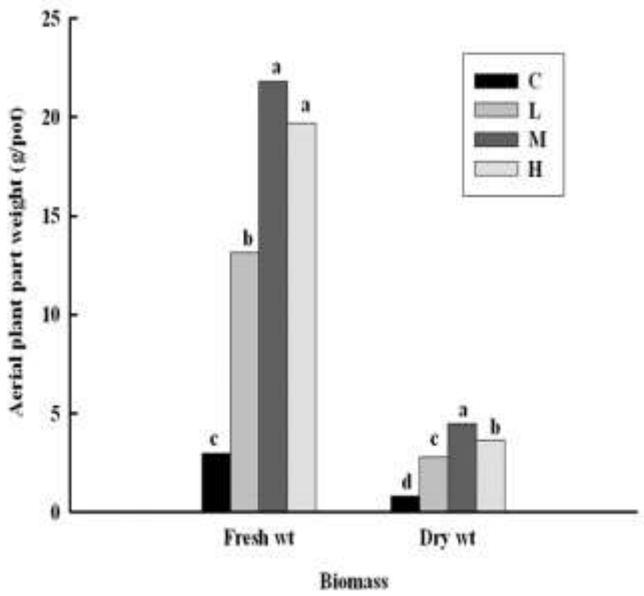

Figure 3. Effect of nitrogen level on relative fresh and dry weight of rice plants on 57 DAT in small pot house experiment

Table 6. Effect of organic-N levels and types of fertilizers on biomass accumulation (g pot^{-1}) and SPAD reading on 57 DAT of small pot P-house experiment[1]

Treatments	Fresh weight	Dry Weight	SPAD 57 DAT
Organic-N levels			
C	2.97c	0.81d	28.55c
L	13.13b	2.80c	33.16b
M	21.81a	4.49a	33.01b
H	19.69a	3.65b	36.51a
Organic fertilizers			
O1	42.55a	8.29a	40.33a
O2	6.01c	1.41c	29.51c
O3	13.20b	2.67b	34.57b
O4	1.95d	0.49d	23.44d

[1]In a column, means followed by different letter are significantly different at $p < 0.05$ probability level according to Duncan's Multiple Range Test (DMRT). Control (C): no any OF; low level (L): 2.17 t ha^{-1}; mid level (M): 4.35 t ha^{-1}; high level (H): 6.52 t ha^{-1} organic fertilizer; O1: Cattle pig dropping; O2: Poultry manure-II; O3: Sugarcane bagasse; O4: Cattle manure; DAT: day after transplanting.

Conclusion

Nitrogen is one of the most important essential nutrients for growth and development of rice plants. In this study, we studied whether the organic-N levels can affect photosynthetic oxygen rate, SPAD reading, total N content, productive tillers and yield components of rice. The cumulative evidences from this study have shown potential for effective use of organic fertilizer to improve photosynthesis and eventually yield components, and sustain environmentally healthy soil and crop system as well. In small pot plastic house experiment, photosynthetic oxygen evolution rate of rice leaf declined with decreasing N application rate on 40 DAT. Photosynthetic oxygen evolution rate was maximum (497 nmol $O_2/cm^2/min$) under O1 organic fertilizer treatment. Then following the maximum rate, there was a steady decrease in photosynthetic rates in order of 463 (O3) > 430 (O2) > 299 nmol $O_2/cm^2/min$ (O4). Photosynthesis activity was significantly different among organic fertilizers due to different level of N uptake by rice plant. Uptake and utilization of N depend on quality of organic fertilizer as well as its available form of nutrients content. Plant height, number of tiller, and biomass accumulation were found to be significantly promoted or reduced by different treatments under small pot P-house condition. SPAD readings also showed significantly differences among control and N treated plants as well as among different organic fertilizers. Biomass accumulation was significantly increased with increasing amount of N levels. Plants under O1 treatment produced higher biomass than all the other treatments and the lowest value was recorded in O4 treatment. Organic fertilizers had varied performances in dry matter production which is associated with concentration of nutrients and its availability during growth and development of plants. Therefore, selection of good quality organic fertilizer is the prime importance for success of an organic farming system.

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