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Influence of Organic and Inorganic Nitrogen on Grain Yield and Yield Components of Hybrid Rice in Northwestern Pakistan

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Abstract: Field experiments were conducted to assess the impact of various organic sources, inorganic nitrogen (N) and the different combinations of inorganic N (urea) + organic source on the yield components (YC) and grain yield (GY) of hybrid rice (*Oryza sativa* L., Pukhraj) under rice-wheat system. The experiments were conducted at Batkhela (Malakand), Northwestern Pakistan, in 2011 and 2012. Our results revealed that YC and GY ranked first for the hybrid rice when applied with sole inorganic N (urea), followed by the application of N in mixture (urea + organic sources), while the control plots (no N applied) ranked in the bottom. Among the six organic sources (three animal manures: poultry, sheep and cattle; three crop residues: onion, berseem and wheat), application of N in the form of poultry manure was superior in terms of higher YC and GY. When applying 120 kg/hm^2 N source, 75% N from urea + 25% N from organic source resulted in higher YC and GY in 2011, while applying 50% N from urea + 50% N from organic sources caused higher YC and GY in 2012. Therefore, the combined application of N sources in the form of urea + organic source can produce good performances in terms of higher YC and GY of rice under rice-wheat cropping system.

Key words: rice; organic source; urea; nitrogen; yield component; grain yield

Nitrogen (N) is the most limiting nutrient of rice-wheat cropping system in Pakistan. Rice-wheat rotation is the most important cropping system in Pakistan (Amanullah and Inamullah, 2016a, b). Although considered as the backbone of food self-sufficiency in many parts of the world, the rice-wheat cropping system is facing a sustainability problem due to the extension of modern crop production system with the indiscriminate use of chemical fertilizers and pesticides (Prasad, 2005; Hidayatullah and Amanullah, 2015). It causes some serious concerns, such as declined factor productivity (Biswas and Sharma, 2008; Patil, 2008; Yadav, 2008), depletions of soil organic carbon and mineral nutrient contents (Prakash et al, 2008), etc.

Continuous use of chemical fertilizers without organic sources (OSs) will lead to gradual decline of organic matter content and change of native N status in the soils, which results in lower productivity in the rice-wheat system (Fu et al, 2014; Pei et al, 2015). Rice provides 35%–60% of the dietary calories for more than three billion people in the world (Fageria, 2003). According to FAO (2001), the worldwide demand for milled rice is about 5.33×10^8 t. Although rice is a heavy N consumer, the N fertilizer utilization efficiency in rice is very low under tropical conditions where it rarely exceeds 50% and usually ranges from 15% to 35% (de Dutta, 1986). N use efficiency is important for the economic sustainability of cropping systems (Fageria and Baligar, 2005; Amanullah et al, 2010). Adequate N sources and rates are very important, which can not only increase yield but also reduce the cost of production and environmental pollution (Fageria et al, 2011). In the cropping system based on modern rice (*Oryza sativa* L.), low productivity (Biswas and Sharma, 2008; Patil, 2008; Yadav, 2008) and low soil fertility are the consequences of unbalanced use of N-fertilizers.

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Pakistan is known as the 5th largest rice exporter, 10th biggest rice cultivator area and 14th leading rice producer in the world (Anonymous, 2014). Rice is one of the most important cereal crops in Northwestern Pakistan but its yield is very low there (from 1 633 kg/hm^2 in Lower Dir to 2 323 kg/hm^2 in Swat) (Amanullah, 2011). The growers in this area only apply urea to rice crop at a very low rate (50–60 kg/hm^2) rather than the recommended rate of 120 kg/hm^2.

Organic manures are considered to produce higher crop productivity for sustainable agriculture (Suzuki, 1997; Myint et al, 2010). Judicious use of chemical and organic fertilizers can improve rice plant growth, and increase rice yield and quality (Place et al, 1970; Fageria et al, 2006; Ahmad et al, 2008; Masarirambi et al, 2012). According to Gately and Kelly (1987), the type of N fertilizer may affect the growth, yield and grain quality of rice. Nutrient-rich organic manures can be served as an effective substitute to reduce the costs of chemical fertilizers (Kumar and Mathew, 1994; Masarirambi et al, 2012). In addition, soil organic manures can not only provide nutrients to the soil but also improve water holding capacity and assist the soil to maintain better aeration for seed germination and plant root development (Zia et al, 1998). The objective of this study was to investigate the impacts of different organic sources (animal manures vs. crop residues) in various combinations with inorganic nitrogen (urea) on grain yield and yield components of hybrid rice (Pukhraj) under rice-wheat cropping system in northwest Pakistan.

MATERIALS AND METHODS

Field experiments were conducted to investigate the impacts of organic N sources (animal manures and crop residues) and inorganic N source (urea) on the yield components (YC) of hybrid rice Pukhraj including the number of panicles per plant, filled grains per panicle, 1000-grain weight and grain yield (GY). The experiments were carried out on farmer's field at Batkhela (34°37′ N and 71°58′17″ E), Malakand Division, Pakistan, in 2011 and 2012. The soil was clay loam, slightly alkaline (pH = 7.3), non-saline (ECe = 1.02 dS/m), moderately calcareous in nature ($CaCO_3$ = 7.18%), low in soil fertility [containing less organic matter (0.71%), total N (0.51%), extractable P (5.24 mg/kg) and Zn (0.93 mg/kg)]. The details of 26 treatments are listed in Table 1. Organic sources were applied 30 d before transplanting while urea was applied in two equal splits, 50% at transplanting and 50% at 30 d after transplanting. A uniform basal dose of 60 kg/hm^2 P_2O_5 (as triple super phosphate) and 60 kg/hm^2 K_2O (as sulphate of potash) were applied uniformly to all plants. N sources were not applied to the control plots

Table 1. Treatments used in this study.

Treatment	Nitrogen from urea (%)	Nitrogen from organic sources (%)						Total nitrogen applied (kg/hm^2)
		Cattle	Poultry	Sheep	Onion	Wheat	Berseem	
T_1	0	0	0	0	0	0	0	0
T_2	100	0	0	0	0	0	0	120
T_3	75	25	0	0	0	0	0	120
T_4	75	0	25	0	0	0	0	120
T_5	75	0	0	25	0	0	0	120
T_6	75	0	0	0	25	0	0	120
T_7	75	0	0	0	0	25	0	120
T_8	75	0	0	0	0	0	25	120
T_9	50	50	0	0	0	0	0	120
T_{10}	50	0	50	0	0	0	0	120
T_{11}	50	0	0	50	0	0	0	120
T_{12}	50	0	0	0	50	0	0	120
T_{13}	50	0	0	0	0	50	0	120
T_{14}	50	0	0	0	0	0	50	120
T_{15}	25	75	0	0	0	0	0	120
T_{16}	25	0	75	0	0	0	0	120
T_{17}	25	0	0	75	0	0	0	120
T_{18}	25	0	0	0	75	0	0	120
T_{19}	25	0	0	0	0	75	0	120
T_{20}	25	0	0	0	0	0	75	120
T_{21}	0	100	0	0	0	0	0	120
T_{22}	0	0	100	0	0	0	0	120
T_{23}	0	0	0	100	0	0	0	120
T_{24}	0	0	0	0	100	0	0	120
T_{25}	0	0	0	0	0	100	0	120
T_{26}	0	0	0	0	0	0	100	120

Table 2. Analysis of variance and significance level for each parameter of Pukhraj as affected by organic and inorganic N management.

Source of variance	*df*	No. of panicles per plant	No. of filled grains per panicle	1000-grain weight	Grain yield
Year	1	**	***	***	***
Block	6	–	–	–	–
Treatment	25	***	***	***	***
Control vs Rest	(1)	***	***	***	***
Urea vs Pure organic source	(1)	ns	***	***	***
Among all organic source	(23)	***	***	***	***
Pure organic source vs Mixture	[1]	***	***	***	***
Pure organic source	[5]	ns	***	***	***
Animal manure vs Crop residue	{1}	**	***	***	***
Mixture	[17]	**	***	***	***
Ratio	{2}	*	**	***	*
Organic source	{5}	***	***	***	***
Ratio × Organic source	{10}	ns	ns	ns	ns
Year × Treatment	25	ns	***	***	***
Year × Control vs rest	(1)	**	***	**	***
Year × Urea vs Pure organic source	(1)	ns	*	ns	***
Year × Among all organic source	(23)	ns	***	**	***
Year × Pure organic source vs Mixture	[1]	ns	***	ns	*
Year × Pure organic source	[5]	ns	ns	ns	ns
Year × Animal manure vs Crop residue	{1}	ns	ns	*	ns
Year × Mixture	[17]	ns	ns	*	***
Year × Ratio	{2}	**	***	***	***
Year × Organic sources in mixture	{5}	ns	ns	ns	*
Year × Ratio × Organic source	{10}	ns	ns	ns	ns
Error	150	–	–	–	–
Total	207	–	–	–	–
Coefficient of variation (%)	–	7.4	3.9	3.2	8.5

*, ** and *** indicate that data are significant at the 5%, 1% and 0.1% levels, respectively; ns stands for the non-significant data at the 5% level.

in both years. After the harvest of rice crop in October, wheat variety Siren-2010 was grown in November in both years as a subsequent crop.

The experiments were carried out in a simple randomized complete block design with four replications. The plot size was 12 m^2 (3 m × 4 m) with 300 plants per plot, and the plant to plant distance was 20 cm. All plots were separated by 30 cm ridges to stop the movement of water/nutrient. The number of panicles was counted using the average value of 10 plants (hills) per treatment. The number of filled grains was counted using the average value of 10 panicles selected from five different plants. One thousand grains were randomly selected for each treatment and weighed with three replications. After maturity, 2 m^2 of rice plants for each treatment were harvested, dried and weighed to calculate grain yield (kg/hm^2).

Data were subjected to analysis of variance (ANOVA) according to the methods described for simple randomized complete block design combined over the years (Steel et al, 1996), and the means in different treatments were compared using the least significant difference (LSD) test ($P \le 0.05$). The Statistix 8.1 (Analytical Software, Tallahassee, USA) was used for the statistical analysis.

RESULTS

The detailed analysis of variance used along with significance level for each parameter is shown in Table 2.

Number of panicles per plant

Organic sources had no significant impact on number of panicles per plant (Table 3). The means of two-year data showed that the application of animal manures produced higher number of panicles per plant than crop residues. Year × organic source interaction had no significant impact on number of panicles per plant. N source ratios and the interaction of year and ratio had significant impacts on number of panicles per plant (Table 2). The planned mean comparison showed that the rest plots (N-treated plots) produced larger number of panicles per plant than control plots. Application of sole urea produced the maximum number of panicles per plant compared with N mixtures. Application of N mixtures produced more number of panicles per plant than pure organic sources. Number of panicles per plant was similar in both

Table 3. Number of panicles per plant as affected by organic and inorganic N management.

Treatment	2011	2012	Mean
Cattle manure	12	14	13
Poultry manure	12	14	13
Sheep manure	12	13	13
Onion leaves	12	13	12
Wheat straw	11	12	12
Berseem straw	12	13	12
Level of significance	ns	ns	ns
Ratio			
75% urea and 25% organic source	13	13	13
50% urea and 50% organic source	13	14	14
25% urea and 75% organic source	12	14	13
Level of significance	*	**	*
Mixture			
Urea + Cattle manure	13	14	14
Urea + Poultry manure	13	14	14
Urea + Sheep manure	13	14	13
Urea + Onion leaves	13	14	13
Urea + Wheat straw	12	13	12
Urea + Berseem straw	13	14	13
Level of significance	***	ns	**
Planned mean comparison			
Control	11	10	10 b
Rest	13	14	13 a
Urea	14	14	14 a
Mixture	13	14	13 b
Pure organic source	12	13	12 b
Mixture	13	14	13 a
Urea	14	14	14 a
Pure organic source	12	13	12 a
Animal manure	13	14	13 a
Crop residue	12	13	13 b
Urea	14	14	14 a
Pure organic source + Mixture	13	14	13 b

*, ** and *** indicate that data are significant at the 5%, 1% and 0.1% levels, respectively; ns stands for the non-significant data at the 5% level. Means followed by different letters in the same category are significantly different at the 5% level.

Table 4. Number of filled grains per panicle as affected by organic and inorganic N management.

Treatment	2011	2012	Mean
Cattle manure	186	216	201
Poultry manure	189	225	207
Sheep manure	187	219	203
Onion leaves	180	209	194
Wheat straw	160	191	175
Berseem straw	181	216	198
Level of significance	***	***	***
Ratio			
75% urea and 25% organic source	230	225	227
50% urea and 50% organic source	229	237	233
25% urea and 75% organic source	225	232	228
Level of significance	ns	***	**
Mixture			
Urea + Cattle manure	231	234	232
Urea + Poultry manure	234	236	235
Urea + Sheep manure	230	234	232
Urea + Onion leaves	227	229	228
Urea + Wheat straw	217	220	219
Urea + Berseem straw	229	231	230
Level of significance	**	***	***
Planned mean comparison			
Control	143	126	135 b
Rest	220	228	224 a
Urea	242	240	241 a
Mixture	228	231	229 b
Pure organic source	180	213	196 b
Mixture	228	231	229 a
Urea	242	240	241 a
Pure organic source	180	213	196 b
Animal manure	220	231	226 a
Crop residue	212	222	217 b
Urea	242	240	241 a
Pure organic source + Mixture	216	226	221 a

*, ** and *** indicate that data are significant at the 5%, 1% and 0.1% levels, respectively; ns stands for the non-significant data at the 5% level. Means followed by different letters in the same category are significantly different at the 5% level.

animal manures and crop residues.

Number of filled grains per panicle

Organic sources but not year × organic source interaction had significant impacts on rice filled grains per panicle (Table 4). The use of poultry manure produced the highest number of filled grains per panicle, followed by using sheep manure while the lowest number of filled grains per panicle was obtained with the application of wheat straw. Although number of filled grains per panicle showed no significant response to year and organic source interaction, it was generally higher in 2012 than in 2011. The average number of filled grains per panicle of the two years varied from 219 to 235 after applying different N mixtures. The number of filled grains per panicle in 2012 was higher than those in 2011 when using different N mixtures. In both years, number of filled grains per panicle was higher when using the mixtures of urea and poultry manure while it was lower when using the mixtures of urea and wheat straw. The planned mean comparison showed that the rest plots (N-treated plots) produced higher number of filled grains per panicle than control plots. The application of N mixtures produced higher filled grains per panicle than pure organic sources. Number of filled grains per panicle significantly increased in 2012 compared with that in 2011 when using pure organic sources. But after applying sole urea, the difference in number of filled grains per panicle in two years was not significant. There was no significant difference in number of filled grains per panicle between applying animal manures and crop residues. The application of sole urea produced more filled grains per panicle than applying pure organic sources or the mixtures.

1000-grain weight

Organic sources but not year × organic source interaction had significant impacts on 1000-grain weight (Table 5). Among the organic sources, poultry manure produced the highest 1000-grain weight (35.25 g), while the lowest 1000-grain weight (31.06 g) was obtained after the application of wheat straw. Rice produced higher 1000-grain weight in 2012 than that in 2011. In 2011, 1000-grain weight ranged between 29.70 g (wheat straws) and 34.48 g (poultry manure), while it ranged between 32.42 g (wheat straws) and 36.01 g (poultry manure) in 2012. The larger increase in 1000-grain weight in 2012 was obtained after the application of crop residues rather than animal manures. In both years, 1000-grain weight was higher when using the mixtures of urea and poultry manure, and was lower when using urea and wheat straw. The planned mean comparison showed that the rest plots (N-treated plots) produced higher 1000-grain weight than control plots. The application of sole urea produced the highest 1000-grain weight (36.83 g). And 1000-grain weight increased after applying N mixtures in 2012 compared with 2011 while it decreased after applying sole urea in 2012 compared with 2011. The application of N mixtures produced higher 1000-grain weight (34.47 g) than applying pure organic source (33.28 g). Moreover, 1000-grain weight was higher after the application of animal manures compared with applying crop residues.

Table 5. 1000-grain weight as affected by organic and inorganic N management. g

Treatment	2011	2012	Mean
Cattle manure	33.74	33.86	33.80
Poultry manure	34.48	36.01	35.25
Sheep manure	33.59	34.36	33.97
Onion leaves	32.27	33.31	32.79
Wheat straw	29.70	32.42	31.06
Berseem straw	31.53	34.10	32.82
Level of significance	***	**	***
Ratio			
75% urea and 25% organic source	34.69	34.29	34.49
50% urea and 50% organic source	33.95	35.91	34.93
25% urea and 75% organic source	33.35	34.61	33.98
Level of significance	***	***	***
Mixture			
Urea + Cattle manure	34.89	35.81	35.35
Urea + Poultry manure	35.54	36.21	35.88
Urea + Sheep manure	34.74	35.56	35.15
Urea + Onion leaves	33.48	34.49	33.98
Urea + Wheat straw	31.59	32.72	32.16
Urea + Berseem straw	33.76	34.81	34.28
Level of significance	***	***	***
Planned mean comparison			
Control	29.19	27.74	28.47 b
Rest	34.13	34.97	34.55 a
Urea	37.06	36.60	36.83 a
Mixture	34.00	34.93	34.47 b
Pure organic source	32.55	34.01	33.28 b
Mixture	34.00	34.93	34.47 a
Urea	37.06	36.60	36.83 a
Pure organic source	32.55	34.01	33.28 b
Animal manure	34.78	35.58	35.18 a
Crop residue	32.50	33.82	33.16 b
Urea	37.06	36.60	36.83 a
Pure organic source + Mixture	33.64	34.70	34.17 b

*, ** and *** indicate that data are significant at the 5%, 1% and 0.1% levels, respectively; ns stands for the non-significant data at the 5% level. Means followed by different letters in the same category are significantly different at the 5% level.

Grain yield

Among the six organic sources including three animal manures and three crop residues, poultry manure produced the highest grain yield (8 459 kg/hm^2), followed by cattle manure (7 711 kg/hm^2) and sheep manure (7 579 kg/hm^2) (Table 6). The lowest grain yield (6 200 kg/hm^2) was obtained with the application of wheat straw. In both years, the grain yield was higher when using the mixtures of urea and animal manures compared with using urea and crop residues. Rice produced higher grain yield in 2012 than in 2011 when using different N source ratios. Among the three ratios of urea and organic sources, 50% urea and 50% organic sources resulted in the highest grain yield (9 417 kg/hm^2), followed by 75% urea and 25% organic sources (9 096 kg/hm^2), and 25% urea and 75% organic sources (9 014 kg/hm^2). The planned mean comparison showed that the rest plots (N-treated plots) produced higher grain yield (8 904 kg/hm^2) than control plots (4 169 kg/hm^2). On average, application of N mixtures produced higher grain yield (9 176 kg/hm^2) than applying pure organic source. There was no significant difference in grain yield with the application of animal manure and crop residue. On average, application of sole urea produced higher grain yield than applying pure organic source or the mixtures of urea and organic sources.

DISCUSSION

The increases in YC and GY after the application of poultry manure were attributed to its low C/N ratio (12:1). The less YC and GY after the application of wheat straw may be due to its higher C/N ratio (116:1). Suzuki (1997) stated that the organic materials with

Table 6. Grain yield as affected by organic and inorganic N management. kg/hm^2

Treatment	2011	2012	Mean
Cattle manure	7 203	8 219	7 711
Poultry manure	7 617	9 302	8 459
Sheep manure	7 045	8 112	7 579
Onion leaves	6 422	7 528	6 975
Wheat straw	5 887	6 514	6 200
Berseem straw	6 491	7 614	7 052
Level of significance	*	***	***
Ratio			
75% urea and 25% organic source	8 804	9 388	9 096
50% urea and 50% organic source	8 350	10 484	9 417
25% urea and 75% organic source	7 882	10 146	9 014
Level of significance	***	***	*
Mixture			
Urea + Cattle manure	8 722	10 639	9 681
Urea + Poultry manure	8 971	11 236	10 104
Urea + Sheep manure	8 629	10 718	9 674
Urea + Onion leaves	8 013	9 469	8 741
Urea + Wheat straw	7 662	8 669	8 165
Urea + Berseem straw	8 076	9 304	8 690
Level of significance	***	***	***
Planned mean comparison			
Control	4 378	3 961	4 169 b
Rest	8 290	9 517	8 904 a
Urea	10 311	9 772	10 041 a
Mixture	8 345	10 006	9 176 a
Pure organic source	6 778	7 881	7 329 b
Mixture	8 345	10 006	9 176 a
Urea	10 311	9 772	10 041a
Pure organic source	6 778	7 881	7 329 b
Animal manure	8 403	10 284	9 344 a
Crop residue	7 504	8 665	8 085 b
Urea	10 311	9 772	10 041 a
Pure organic source + Mixture	7 953	10 339	9 146 b

*, ** and *** indicate that data are significant at the 5%, 1% and 0.1% levels, respectively; ns stands for the non-significant data at the 5% level. Means followed by different letters in the same category are significantly different at the 5% level.

high C/N ratios are likely to compete for N, which may lead to N deficiency in extreme cases. In addition, the organic sources with higher C/N ratios may probably undergo less decomposition under waterlogged condition. Previously, Sahrawat (2006) has discovered that the soil organic matter accumulated in submerged soils had inefficient decomposition. Based on this study, we propose that lowering the C/N ratio of wheat straw by composting will improve crop productivity under rice-based system. These results agree with the results of Ebaid and El-Refaee (2007), El-Refaee et al (2006) and Hossaen et al (2011). They reported that the increase in rice yield is associated with the increase in yield attributes. The increase in 1000-grain weight after the application of organic sources may be due to better nutrient availability and uptake by plants (Singh and Agarwal, 2001; Iqbal et al, 2002). Our study further confirms that combined application of organic and inorganic N is better than sole organic source on increasing rice YC and GY (Fan et al, 2005; Yaduvanshi and Swarap, 2005; Shah et al, 2010). The difference in nutrient absorption from different N source combinations greatly influences rice growth and yield potential (Ahmad et al, 2008).

In 2011, a greater amount of N from urea (75% N from urea and 25% N from organic sources) resulted in higher YC and GY. However, the better decomposition of organic source in 2012 required less inorganic N, and therefore, applying 50% N from urea and 50% N from organic sources had positive impacts on YC and GY. We propose that with the passage of time the mixtures having higher organic N over inorganic N (25% N from urea and 75% N from organic sources) could increase YC and GY of hybrid rice. Our results have further confirmed that YC and GY were significantly increased ($P \leq 0.05$) by applying urea + poultry manure and were reduced after applying urea + wheat straw. According to Hassanuzazzaman et al (2010), a large amount of plant nutrients are supplied by poultry manure and can contribute to improving crop growth and yield. The improvement in YC and GY in our experiment after the integrated use of urea and poultry manure may also be attributed to the lower C/N ratio: poultry manure (12:1) < berseem manure (14:1) < sheep manure (15:1) < onion leaves (17:1) < cattle manure (18:1) < wheat straw (116:1). According to Garrity and Flinn (1987), application of poultry manure and N-P-K fertilizer (half) can improve nutrient availability and soil condition for proper plant growth by reducing the loss of nutrients so that the maximum yield can be achieved.

Sole urea was better than mixture in terms of YC and GY in 2011, while N applied in mixture performed better than sole urea in 2012. However, sole organic source produced less YC and GY than mixtures in both years. Myint et al (2010) reported that mineral fertilization can produce the highest plant growth and nutrient uptake in one-season of cultivation compared with organic source. The maximum GY and YC with sole urea and mixture were due to the better growth of rice (Swarup and Yaduvanshi, 2000; Rahman et al, 2007; Yadana et al, 2009). These results are also supported by the studies of Singh and Agarwal (2001), Iqbal et al (2002) and Shah et al (2010) who have reported a marked increase in YC and GY after applying organic source + mineral N-fertilizer. This may be due to the facts that N is easily available from mineral fertilizer at the early rice growth stage, and organic manures are mineralized at the later rice growth stages normally subject to N stress. The combined use of organic-N and inorganic-N is better than sole urea for grain, straw and biological yields, because organic manures can reduce N loss (Yaduvanshi and Swarap, 2005) and maintain the supply of N to rice plants for longer time (Fan et al, 2005; Shah et al, 2010). According to Khan et al (2004), Salem (2006), and Antil and Singh (2007), combined application of organic and inorganic N-fertilizers can increases the number of panicles per square meter, panicle length, panicle weight, number of filled grains per panicle, 1000-grain weight and grain yield of rice. Recently, the combination of organic sources with mineral N fertilizer has attracted much attention from many rice-growing areas of Asia (Myint et al, 2010).

YC and GY significantly increased ($P \leq 0.05$) in the N treated plots (the rest) over control plots (no N applied). Mineral N fertilizer and the mineralization of organic source throughout the growing period could save the rice plants from nutrient stress at any stage, which resulted in maximum YC and GY compared with those in control. Khan et al (2004) and Antil and Singh (2007) reported that organic + inorganic N application is highly beneficial for wetland rice cultivation. The higher rice yield after the integrated N management might be due to the increase in number of filled grains per panicle, the number of panicles per plant and 1000-grain weight (Myint et al, 2010). The difference in nutrient absorption from different N source combinations significantly influences growth and yield potential (Ahmad et al, 2008). Myint et al (2010) reported that organic sources can increase yield through the improvement of soil water holding capacity, physical and chemical conditions, the reduction of volatilization of nitrogenous fertilizers to NH_3 gas and the greater availability of plant nutrients for a longer time.

CONCLUSIONS

Grain yield and yield components of hybrid rice decreased tremendously when N was not applied. Among the six organic sources used, poultry manure was found more beneficial in terms of higher YC and GY. On the contrary, wheat residue had more negative impacts on YC and GY of rice. Among the three crop residues used, berseem and onion were more beneficial for increasing rice productivity. Applying the required N (120 kg/hm^2) in the ratio of 75% N from urea and 25% N from organic source had better performance in 2011, while applying 50% N from urea and 50% N from organic source had better performance in 2012. The performance of applying onion residue was far better than wheat straw, and onion residue was found almost comparable to berseem (legume crop) residue.

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