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EFFECTS OF NITRIFICATION INHIBITOR WITH ORGANIC MANURE AND UREA-N ON NUTRIENT ACCUMULATION AND YIELD OF MR219 RICE IN ACID SULPHATE SOIL

SM Shamsuzzaman[1], Masuda Begum[1], MM Hanafi[2*], AW Samsuri[2], H Mohd Saud[3] and Nur Maisarah Jantan[4]

Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia

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Abstract

The effects of nitrification inhibitor (Dicyandiamide; DCD) and source of nitrogen (N) on nutrient accumulation and yield of rice cultivar MR219 were studied in acid sulphate soil. The treatments of the experiment included the combination of various N sources (organic and inorganic) and two levels of DCD. The relative leaf chlorophyll content, amounts of nutrient accumulation and yield showed to increase with the application of DCD + organic manure and urea-N compare to urea alone. At heading stage, DCD with urea + oil palm compost (OPC) gave the highest SPAD value (12.25%) over urea alone. The highest N, P, K and S accumulation (50.87, 61.23, 45.58 and 61.48%, respectively) and grain (22.0%) and straw (13.9%) yield increase were obtained due to the application of DCD with urea + OPC. Therefore, 75% N as urea + 25% N as oil palm compost + DCD (15% N) may be a good practice for rice production in acid sulphate soil of Malaysia.

Application of organic manure combined with chemical fertilizer is profitious to the increase of soil fertility and improved soil physical and chemical properties. Thus it could increase crop production. Studies showed that increase of organic substance in soil changes the metabolism characteristics and the diversity of soil microbes (Gu *et al.* 2009), strengthens the metabolism of soil microbes, provides more metabolic products, and thus improves soil enzymes activity and soil fertility, and finally is helpful to nutrient uptake of crops and crop yield increment.

Cereals including rice accounted for approximately 50% of the worldwide N fertilizer utilized (IFA 2009), but N recovery efficiency (REN) in rice plant is low. Based on a worldwide evaluation, REN has been observed to be around 30% in rice (Krupnik *et al.* 2004). This low REN is associated with large loss of N fertilizer from the soil plant system (Houshmandfar *et al.* 2008). Significant N losses can occur through NO_3^- leaching, NH_4^+ runoff and gaseous emissions of NH_3 and N_2O. A possible option to reduce the leaching of NO_3 is the use of nitrification inhibitors along with the urea fertilizer. Dicyandiamide (DCD) is a nitrification inhibitor, slow the activity of nitrifying bacteria responsible for the oxidation of NH_4^+ to NO_2^- and can thereby reduce NO_3^- leaching (Di *et al.* 2007). Several studies evaluated ^{15}N uptake with and without DCD and in some cases DCD increased N uptake efficiency (Wilson *et al.* 1990). However, the combined effect of nitrification inhibitor with organic manure and urea on the nutrition accumulation of rice in acid sulphate soil is not clear. Therefore, DCD, OM and urea were selected to study the effects on N, P, K and S accumulation and yield of MR219 rice.

*Author for correspondence: <mmhanafi@agri.upm.edu.my> [1]Soil Resource Development Institute, Krishi Khamar Sarak, Dhaka-1215, Bangladesh. [2]Department of Land Management, Faculty of Agriculture, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia. [3]Department of Agriculture Technology, Faculty of Agriculture, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia. [4]Biological Research Division, Malaysian Palm Oil Board, 43000 Kajang, Selangor, Malaysia.

The experiment was conducted at experimental farm of Universiti Putra Malaysia, Serdang, Selangor (3.30^0N latitude and 101.50^0E longitudes) Malaysia. Rice (*Oryza sativa* L.) variety used in the trial was MR 219. Treatments comprised of four nitrogen source: 100% N (urea) of recommended dose from urea, 75% N (urea) +25% N (RS), 75% N (urea) + 25% N (PD) and 75% N (urea) + 25% N (OPC), and two levels of nitrification inhibitor: without inhibitor (NoNI) and with inhibitor (NI). A 20 litre plastic bucket was filled with 14 kg air-dry soil. Each treatment supplied with P (30 kg/ha) from triple super phosphate (TSP) and K (60 kg/ha) from muriate of potash (MOP) before one day of rice transplanting. Organic manures were applied as per treatments one week before final land preparation. Nitrogen from urea was top dressed in three equal splits at the time of TSP and MOP application, maximum tillering stage and at panicle initiation stage of crop growth. Nitrification inhibitor was applied at the rate of 15% of N with urea. The 15 days old seedlings were transplanted into bucket with two hills in each bucket and three seedlings per hill. The bucket was flooded at two days before rice transplanting, and rice management was similar as that in the paddy field. Different intercultural operations and plant protection measures were conducted following standard practices (MARDI 2002).

Relative leaf chlorophyll content or greenness of leaves was measured in terms of silicon photon activated diode value using a portable SPAD meter (MINOLTA^{TM} SPAD-502, Minolta camera Co., Osaka, Japan). All the panicles of sample hills were hand-threshed; filled grains were separated from unfilled grain. Grain and straw were adjusted to 14% moisture content and the yield was expressed as g/hill. Grain and straw sample were dried in an oven at 65^0C for 48 hrs and then ground by a grinding machine to pass through a 20 mesh sieve. Major nutrient content was determined by H_2O_2-H_2SO_4 digestion (Ohyama *et al.* 1991) using a Kel Plus auto N analyzer for N and P spectrophotometer for K, and S were measured with an ICP-MS (Agilent 7500a). Nutrient accumulation by grain and straw were calculated by multiplying the yield (oven dry basis) with the corresponding nutrient content (Liza *et al.* 2014). Nutrient accumulation (mg/hill) = $(Gy \times N_{Gr})/100 + (Sy \times N_{St})/100$. Where, Gy = Grain yield (g/hill), Sy = Straw yield (g/hill), N_{Gr} = Nutrient content in grain (%), and N_{St} = Nutrient content in straw (%).

All data were subjected to a two-way analysis of variance (ANOVA) (nitrogen source and nitrification inhibitor) using the PROC GLM function of the SAS statistical programme (SAS Institute, 1996). When there was a significant treatment effect, means were compared using DMRT. Treatment comparisons were deemed significant at $p < 0.05$.

Relative leaf chlorophyll content i.e. SPAD value of MR219 rice varied among different N sources, DCD and their interaction (Fig. 1). The leaves SPAD value was observed higher in the presence of DCD, than the absence of DCD. In both condition of DCD, SPAD values were recorded higher (42.30 - 47.48) at heading stage than that of tillering (38.36 - 41.87) and panicle initiation stage (40.36 - 44.00). At heading stage, highest SPAD value was recorded from OPC + urea with DCD (47.48 ± 1.16) identical followed by PD + urea with DCD (47.20 ±1.30) and OPC + urea (46.67 ± 1.58) or PM + urea (46.10 ± 1.03).

Urea alone resulted in lowest SPAD value (42.30 ± 1.21). The present findings confirm the observation of other researchers that the SPAD value of flag leaf during the flowering period in pot experiment increased with different levels and kinds of manure and fertilizer application using Manawthuka variety (Myint *et al.* 2009). This findings was consistence with Myint *et al.* (2010) who reported that urea with PM showed higher RLCC due to higher decomposable nutrient content and urea with RS lower SPAD value and tiller number due to N immobilization.

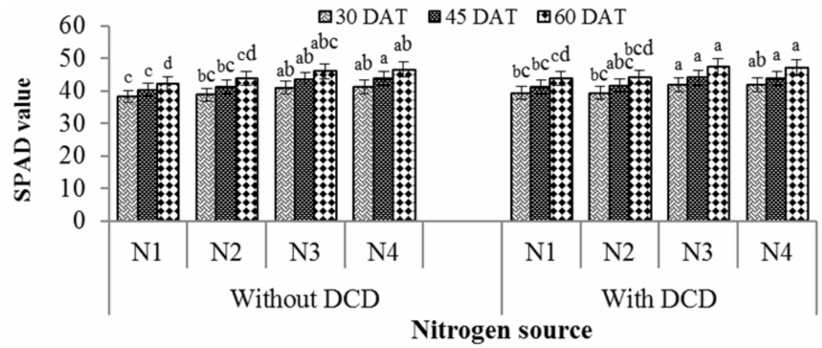

Fig. 1. Relative leaf chlorophyll content of rice variety MR219 as influenced by DCD with organic manure and urea-N. Vertical bars represent ± standard error of mean.

Table 1. Nitrogen accumulation in grain and straw of rice variety MR219 as influenced by DCD with organic manure and urea-N.

N source	Grain		Straw	
	Without DCD (mg/hill)	With DCD (mg/hill)	Without DCD (mg/hill)	With DCD (mg/hill)
N_1	238.54 ± 6.98d	257.16 ± 9.56c	215.76 ± 10.38d	232.80 ± 8.40cd
N_2	258.14 ± 10.14c	287.75 ± 11.68b	228.40 ± 12.30cd	246.27 ± 4.826bc
N_3	297.55 ± 5.96b	340.26 ± 9.83a	241.88 ± 11.28bc	278.97 ± 7.24a
N_4	294.30 ± 7.92b	340.88 ± 11.44a	252.54 ± 10.36b	291.38 ± 11.29a
CV (%)	3.11		3.97	

Means followed by the same letter within the same column are not significantly different (p > 0.05) using DMRT.

Table 2. Phosphorus accumulation in grain and straw of rice variety MR219 as influenced by DCD with organic manure and urea-N.

N source	Grain		Straw	
	Without DCD (mg/hill)	With DCD (mg/hill)	Without DCD (mg/hill)	With DCD (mg/hill)
N_1	76.19 ± 3.05e	88.96 ± 6.67d	69.43 ± 3.34e	75.63 ± 5.98de
N_2	88.94 ± 3.49d	97.73 ± 8.44c	82.20 ± 4.41d	91.32 ± 1.79c
N_3	107.45 ± 2.15b	121.10 ± 3.50a	96.32 ± 4.10bc	104.47 ± 3.29ab
N_4	109.33 ± 2.94b	124.06 ± 4.17a	99.01 ± 4.93bc	110.72 ± 6.24a
CV (%)	4.64		5.02	

Means followed by the same letter within the same column are not significantly different (p > 0.05) using DMRT.

The nutrient accumulation in rice varied significantly with N source, DCD and the interaction of N source and DCD. The highest amount of N, P, K and S accumulation in grain (340.88 ± 11.44, 124.06 ± 4.17, 103.08 ± 3.47 and 33.58 ± 1.13 mg/hill, respectively) and straw (291.38 ± 11.29, 110.72 ± 6.24, 551.26 ± 21.06 and 54.38 ± 2.03 mg/hill. respectively) were recorded for the application of DCD with OPC and urea and the lowest amount of these element in grain (238.54 ± 6.98, 76.19 ± 3.05, 64.44 ± 2.28 and 18.92 ± 1.08 mg/hill, respectively) and straw (215.76 ± 10.38, 69.43 ± 3.34, 403.96 ± 19.45, and 36.07±1.74 mg/hill, respectively) were recorded for the application of urea alone (Tables 1-4). Nitrogen (238.54 ± 6.98 - 340.88 ± 11.44 mg/hill) and P (76.19 ± 3.05 - 124.06 ± 4.17 mg/hill) uptakes were higher but K (64.44 ± 2.28 - 103.08 ± 3.47 mg/hill) and S (18.92 ± 1.08 - 33.58 ± 1.13 mg/hill) uptake were lower in grain than that of straw

Table 3. Potassium accumulation in grain and straw of rice variety MR219 as influenced by DCD with organic manure and urea-N.

N source	Grain		Straw	
	Without DCD (mg/hill)	With DCD (mg/hill)	Without DCD (mg/hill)	With DCD (mg/hill)
N_1	64.44 ± 2.28d	68.59 ± 3.58de	403.96 ± 19.45e	426.22 ± 20.83e
N_2	73.39 ± 2.88cd	80.85 ± 5.41c	434.94 ± 23.43de	473.78 ± 9.270cd
N_3	88.03 ± 1.77b	98.47 ± 4.70a	474.76 ± 22.13cd	520.15 ± 13.50ab
N_4	89.20 ± 2.40b	103.08 ± 3.47a	506.20 ± 20.75bc	551.26 ± 21.06a
CV (%)	4.34		4.99	

Means followed by the same letter within the same column are not significantly different ($p > 0.05$) using DMRT.

Table 4. Sulphur accumulation in grain and straw of rice variety MR219 as influenced by DCD with organic manure and urea-N.

N source	Grain		Straw	
	Without DCD (mg/hill)	With DCD (mg/hill)	Without DCD (mg/hill)	With DCD (mg/hill)
N_1	18.92 ± 1.08d	20.93 ± 1.57d	36.07 ± 1.74d	40.58 ± 2.20c
N_2	25.39 ± 1.00c	27.84 ± 2.40b	42.95 ± 2.31c	49.38 ± 0.97b
N_3	28.78 ± 0.57b	31.71 ± 0.91a	46.54 ± 2.17b	54.25 ± 1.41a
N_4	29.24 ± 0.79b	33.58 ± 1.13a	47.43 ± 1.96b	54.38 ± 2.03a
CV (%)	4.59		4.21	

Means followed by the same letter within the same column are not significantly different ($p > 0.05$) using DMRT.

(215.76 ± 10.38 - 291.38 ± 11.29, 69.43 ± 3.34 - 110.72 ± 6.24, 403.96 ± 19.45 - 551.26 ± 21.06 and 36.07 ± 1.74 - 54.38 ± 2.03 mg/hill, respectively). Dicyandiamide with urea + OPC also gave the highest total N (631.64±19.82 mg/hill), P (234.79 ± 7.83 mg/hill), K (651.01 ± 16.56) and S (87.85 ± 2.85 mg/hill) uptake which were statistically identical with urea + PD and DCD. Urea alone showed the lowest uptake of total N, P, K and S with the value of 454.30 ± 10.12, 145.62 ± 6.21, 468.40 ± 19.80 and 54.99 ± 1.72 mg/hill, respectively.

Myint *et al.* (2010) observed that use of PM as organic fertilizer provided the optimal nutrient accumulation, but use of cow manure and rice straw + urea provided comparatively low nutrient accumulation, because mix-application of rice straw + urea showed N immobilization and led to the poor N availability although urea was used as split application. Eventually, N content of straw and grain had little variation and there was very little increase in N uptake on application of DCD (Ghosh *et al.* 2003).

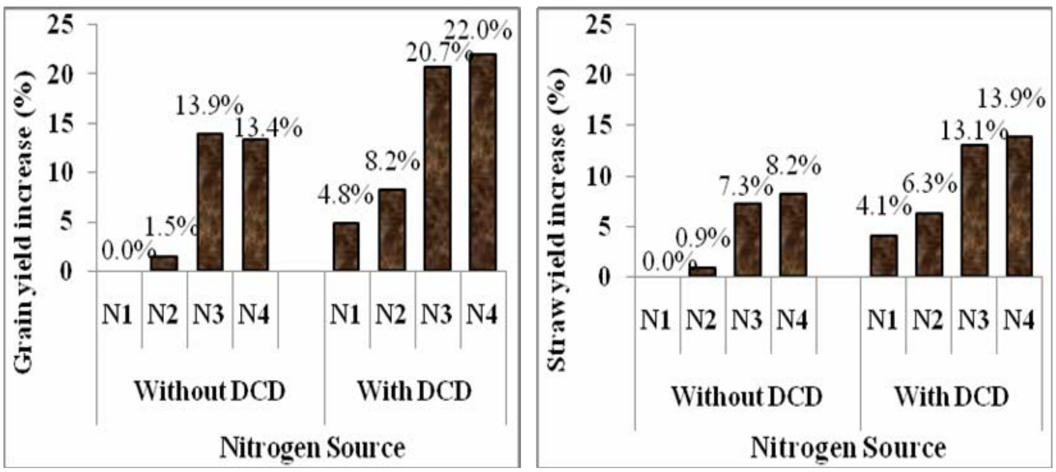

Fig. 2. Grain and straw yield increase of rice variety MR219 over control as influenced by DCD with organic manure and urea-N.

Grain and straw yield increased over control differed for N source and DCD. Nitrogen source with DCD resulted 4.8 - 22.0% gain yield and 4.1 - 13.9% straw yield increase over control; without DCD N source increased 13.4% grain yield and 8.2% straw yield over control. The highest increase 22.0 and 13.9% of grain and straw yield over control was found from urea + OPC with DCD ((Fig. 2). This result was in agreement with the findings of Ghosh *et al.* (2003) who found that addition of DCD with urea and ammonium sulphate resulted in significantly higher grain yield than without DCD.

Application of DCD combined with urea + OPC was profitious to increase relative leaf chlorophyll content, nutrient accumulation as well as yield of MR219 rice. Hence, combined use of 13.5 kg DCD along with 90 kg urea-N and 1.75 ton/ha OPC might be an efficient agricultural strategy for higher nutrient accumulation with higher yield.

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