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EFFECTS OF LIME, COW MANURE AND IRRIGATION METHODS ON SOIL PROPERTIES, YIELD AND CADMIUM ACCUMULATION OF RICE JASMINE 85

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Abstract

Agricultural soils could enhance oxic conditions and lessen roving ability of Cadmium (Cd) and uptake into rice grains when utilizing Alternate wetting and drying irrigation (AWDI). However However, scant study is available uptake of Cd speciation and uptake at the experimental sites for AWD with different soil polluting diffences. It is hypothesised that as the soil drying increases, rice uptake and following accumulation of Cd in the grain will reduce. In this field research, soil properties, yield and Cd uptake of rice Jasmine were determined at the prior stage of experiment and harvest, under two continuously flooded (CF) and AWDI methods. The studied results presented that all nutrients properties of AWDI increased remarkably at harvest compared to CF. Cadmium contents of rice stems and grains in the cow manure (CM) amendment were lower than that of rice stems (10.6%) and grains (55.5%) in non CM application. Cadmium contents of rice stems and grains in AWDI were lower than that of rice stems (45.7%) and grains (38.2%) in CF. Similarly, Cd contents of rice stems and grains differed from three liming rates. without liming, the average Cd content of stems and grains obtained the maximum value (159 and 76.4 µg/kg, respectively), which were significantly higher 3.5 (stems) and 3.7 times (grains) than those of the 2.0 tCaCO3/ha. Three stems and grain Cd contents of 0.0, 1.5 and 2.0 tCaCO3/ha were 159, 74, 8, 45,1 µg/kg in stems and 76.4, 37,4 and 20.5 µg/kg in grains , respectively. The average rice yield of non-cow manure addition (5.67 t/ha) were lower 1.26 times than that of 10.0 t CM/ ha application (7.14 t/ha). However, the rice yield of the CF and AWDI treatments that was insignificantly different at 5% was 6.45 and 6.46 t/ha, respectively. Furthermore, There were sufficient differences in the rice yield among lime addition treatments of three rates (0.0, 1.5 and 2.0 tCaCO3/ha). Specifically, in the 2.0 $tCaCO_3$ treatments, the average rice yield was 7.03 t/ha and higher than 1.22 times compared to non-lime amendment treatments (5.77 tons/ha). The following hight yield of 1.5 tCaCO3/ha was 6.65 t/ha. Therefore, application of Urea, P_2O_5, K_2O (84.0, 51.0, 30 kg/ha) fertilizers and 2.0 $tCaCO_3$, 10tCM per ha combined with AWDI needs to be introduced to tillers.

Keywords: Cadmium, AWDI, CF, lime, rice Jasmine 85

1. INTRODUCTION

Rice is the main foods, which are a popular nutrient to used for a whole world. Rice has been planting in Asian countries and its nutrient resource are an important role for human heath (Khan et al., 2018). Cadmium, which is a toxicology and exists in polluted soils is a dangerous problem to be a negative effect for environment and human health through agricultural foods. Rice could absorb a Cd toxicology from polluted soils and take plant parts (Chuong & Cuong, 2021). Cadmium uptake of rice from soil is according to the physical - chemical properties of soils and characteristics of each plant (Gall et al., 2015). Fertilizers, which have low quality and widely apply to the rice

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cultivation are main resource of the Cd contribution to agricultural soils and crops. This is the main reason to led to the high Cd content of the rice more and more increase in asian (Shi et al., 2020). According to prior study of Chuong & Cuong, 2021 showed that Cd concentration of An Phu soil valued from 37.1 to 380 µg/kg. The Cd contents of plant were mainly collected from the stems and grains. Cadmium uptake of plants reduce when the soil pH significantly increases (Almeida et al., 2012). When lime amendment for Cd contaminated soils could reduce the Cd uptake of plants from 40 to 70% (Rongbo et al., 2017). The Cd toxicology can be precipitated by lime in the pollution soils. Furthermore, application of lime combined with organic manures reduced the Cd content of rice grains up 48.3% compared to without lime addition (Chuong et al., 2019). The co-application of lime, organic manure combined with CaMgP fertilizers reduced the Cd store of the rice grains from 37.5% to 52.8% compared to without lime amendment (Lei et al., 2019). The prior research of Chuong, (2022) proved that Cd content of rice grains reduced with AWDI, although the water depth was lower than 13 cm from the soil surface (0 cm) compared to CF method. The development and productivity of rice remarkably reduced when planting on Cd pollution soils. Application of lime combined with cow manure reduced the Cd content of rice grains and increased rice yield (Yang et al., 2020). Furthermore, lime and cow manure addition combined with AWDI is the key method to reduce the Cd accumulation and raise yield of rice (Chuong, 2022). The main goal of this research is to assesse impacts of lime, CM combined with AWDI on yield and Cd uptake of rice in field experiment.

2. MATERIALS AND METHODS

The field experiment was designed on the local farm during the winter -Sping season of 2022 in Long Binh town, An Phu, An Giang, Vietnam (Table 1). The experimental soil was soil outside the dike, which was watered by river water. The experiment was carried out in the form of 3 factors: 02 cow manure (CM) rates x 2 irrigation methods x 3 lime rates. The whole treatments were 06 and 04 replicates. The total number of pots were 24. Rates of fertilizers and irrigation methods were shown in Table. Six treatments, which were designed from Jas.1 to Jas.6, consisted of two Irrigation method (CF and AWDI). Three CF treatments were Jas.1- control (NPK: 84.0kg urea + 51.0kg P_2O_5+30kg K_2O per ha); Jas.2 (NKP + 10.0 tCM/ha +1.5 $tCaCO_3$) Jas.3 (NKP + 10.0 tCM/ha +2.0 $tCaCO_3$). Three AWDI treatments were Jas.4- control (NPK: 84.0kg urea + 51.0kg P_2O_5+30kg K_2O per ha); Jas.5 (NKP + 10.0 tCM/ha +1.5 $tCaCO_3$) Jas.6 (NKP + 10.0 tCM/ha +2.0 $tCaCO_3$). The same level of urea, P_2O_5 and K_2O fertilizers was applied for all six treatments. The areas were 600 m^2 (5 m in width x 5 m in length x 6 treatment x 4 repeats). The CF method kept the water above 5 cm from the soil surface during crop. The AWDI kept the moisture of soil at four steps, which consisted of (i) 10 days after sowing (DAS), (ii) 30-40 DAS, (iii) 55-60 DAS and (iv) 80-100 DAS. At four steps, rice plant was not watered when the moisture of soil below 13 cm in rooting depth before being rewatered. When water tubes obtained 13 cm under the soil surface. Data were shown by the soil moisture tube (Avil Kumar and Rajitha, 2019; Joel et al. 2013).

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Table 1: Treatments of NPK, CM and lime application

Treatment	Cow Manure (t/ha)	Irrigation	Lime (t/ha)	Chemical fertilizer (kg/ha)
Jas.1	0	CF	0.00	Urea: P_2O_5: K_2O (84.0:51:30)
Jas.2	10		1.50	
Jas.3	10		2.00	
Jas.4	0	AWDI	0.00	
Jas.5	10		1.50	
Jas.6	10		2.00	

2.2 Sample collection

Soil samples: were collected from 0 to 20 cm in depth inside and outside the dyke in three comummunes of Long Binh, Khanh an and Khanh Binh (An Phu district, An Giang province). There were 10 samples, which were collected in each commune (05 soil samples inside the dyke for deep well water irrigation and 05 soil samples outside the dyke for river water irrigation), were collected in 5 points per sample. There were 30 soil samples in 03 communes. All collected Samples were stored in plastic bags and transported to the central laboratory. Samples were left to dry at room temperature, then ground and passed through a 0.5 mm mesh sieve. Soil samples were analyzed at the central laboratory of the An Giang University.

Water samples: were taken according to the vietnamese standard TCVN 6000-1995. The deep well water samples were taken in the form of pump up about 10 minutes to remove the sediment on the deep well and the old water. Water samples contained into plastic bottles labeled with full details of the collected side, date and time. The water Sample, which contained each bottle (01 liter), fixed with 3 ml HNO_3 65% (MERK). There were 30 water samples at 30 deep wells (10 wells per commune) in 03 communes of Long Binh, Khanh an and Khanh Binh (A Phu district, A Giang province). One water sample was repeated 03 times (05 minutes apart from pumping for 01 replicate). All water samples were analyzed at the center laboratory of the An Giang University

Stems and grains: Grain rice Jasmine 85 that was taken from Loc Troi Company used during the experimental time. Lime ($CaCO_3$) was collected from local lime company. Cow manure that bought from local farmers was composted by *Trichoderma*. All cow manure and lime were significantly applied by ten days before sowing. The chemical fertilizer was applied at stages 10, 20, 40, 50 days after sowing (according to local tillers). Rice Jasmin 85 had the mature time (90-95 days) and height (90- 95 cm). The seed density of rice Jasmine 85 was 90 kg/ha during the experimental crop (Ngyen Van Chuong, 2022). The weight of lime, cow manure, NPK fertilizer and irrigation method was shown in Table 2. Five appropriate locations per the treament had the frame size of 0.5 x 0.5 m, which counted number of panicle/m^2, number of fill grains per panicle and 1,000 grain weight. Theoretical yield was counted by the formula (number of panicle/m^2 x number of fill grains/panicle x weight of 1.000 grains x10^{-5}(tons/ha). All fresh grains of 5.0 m^2 were dried to 14% moisture. The actual yield of rice Jasmine 85 (t/ha) = W14% x

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2 (De, 2009). Sixty samples of deep well water, rice soil (30 sample per type) were taken two weeks before the experiment in An Phu district. All experiment and collected samples of soil and water, which were taken before the experiment. The soil, stem and grain samples were collected at the harvest. Samples of water, soil, stem and grain were analysed for total Cd by ICP-MS*.* pH meter was used to measure for Soil and water. Physical – chemical properties of soil were determined by Piper, (1950); Page et al. (1982).

Table 2: Characteristics of soil and water before the field experiment (n=5)

Composition	Parameters	Results	Composition	Parameters	Results
Texture (%)	Sand	60.9	Nutrient	Total nitrogen (%)	0.136
	Silt	35.6		Available P (mg/kg)	2.43
	Clay	3.50		Exchangeable K (mg/kg)	79.0
Chemical	pH_{soil}	4.80		Organic matter (%)	1.34
	$pH_{irrigation\ water}$	6.71	Cd (µg/kg)	Irrigation water	undetective
	CEC (cmol/kg)	2.52		Experimental soil	92.0

The soil texture of the experimental area is sandy loam with relatively light texture (Sand >50%), low acidity (pH < 5.0) (Blair et al., 2011). Organic matter (< 2.0%) is very low (Melson, 1961); total N content is low (<0.2%) (Brady, 1988); The available phosphorus is very low < 20 mg/kg (Bray II); The exchangeable K is low (Kuyma, 1976). From the above soil properties, this soil needs to improve its fertility. Moreover, the Cd content of the soil is not higher than the vietnamese standard (< 1,500 µg/kg). The cation adsorption capacity (CEC) is very low (<5.0) (Brady, 1988).

Data Analysis: Statgraphics XVI software was analysed for variance (ANOVA) and compared by Multiple range test of duncan at 5% level of probability. Figures were designed by Microsoft Excel software.

3. RESULTS AND DISCUSSION

Cadmium concentration of agricultural soils inside and outside the dike

Cadmium concentration of soil in three sites

The results in Fig. 1 showed that average Cd concentration of agricultural soils at 03 communes (Long Binh, Khanh Binh, Khanh An) ranged from 145 to 511 µg/kg on agricultural soils inside the dike. Futhermore, Cd contents of Soils outside the dike valued from 145 to 212 µg/kg and lower than those of soils inside the dike. The maximum Cd concentration of soild inside and outside the dike (511 and 212 mg/kg, respectively) was in Khanh An commune and the minimum Cd level of soil inside and outside the dike was (382 and 145 µg/kg, respectively) in Khanh Binh (Fig. 1).

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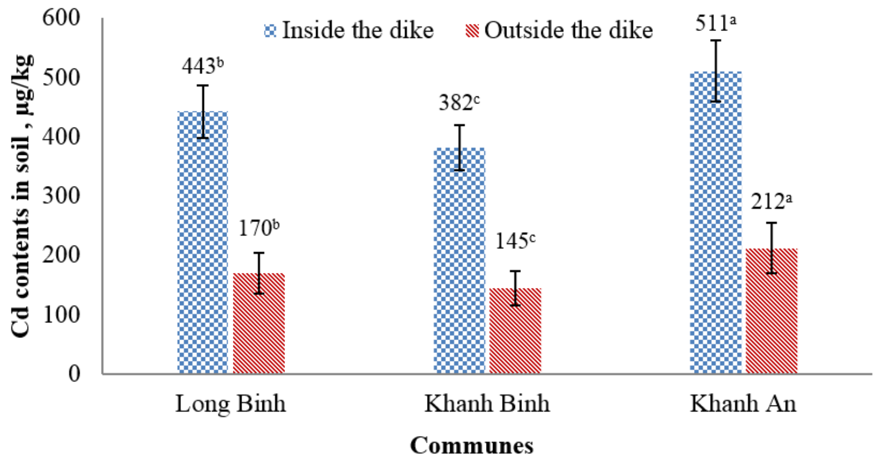

Fig. 1: Cadmium concentration of soil in three communes

Table 3: Cd Contents of rice soil inside and outside the dike in Long Binh, Khanh Binh and Khanh An

Soils	Locations	Cd contents of agricultural soil (µg/kg)				n
		Maximum	Average	Median	Minimum	
Inside the dyke	Long Binh	572	443[b]	431	379	5
	Khanh Binh	422	382[ab]	370	346	5
	Khanh An	570	511[a]	506	441	5
CV(%) = 17,1						
outside the dyke	Long Binh	184	170[b]	174	156	5
	Khanh Binh	162	145[b]	148	120	5
	Khanh An	262	212[a]	196	184	5
CV(%) = 19,9						

However, Cd concentration of soil in three communes did not exceed the permitted standards for agricultural soil in Vietnam and the European community (1,500 µg/kg g/kg). Results in Table 3 presented the Cd contents in crop soils inside the dike were 2-3 times higher than outside the dike. In Long Binh, the Cd concentration of soil inside the dyke (443 µg/kg) and outside the dyke (170 µg/kg) were lower than Khanh an and higher than Khanh Binh. The prior studie of Chuong and Cuong, (2021) revealed that Cd content of crop soils inside the dyke was significantly higher than that of soil outside the dyke.

Chemical properties of soil

The results in Table 4 showed that soil pH value between CF and AWD had significantly different at level 5%. pH value ranged from 4.8 to 5.6 for CF and AWDI method. The treatments of inorganic fertilizer combined with cow manure and lime achieved the highest average level of 5.60. On the contrary, the lowest pH observed at two control treatments (4.8 and 4.78 for CF and AWDI, respectively). Similarly, the maximum contents of organic matter were 2.52% (CF) and 5.60% (AWDI), which revealed in

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treatment Jas 3 & 6 (NPK+2.0 t $CaCO_3$/ha +10 tCM/ha) was significantly different at level 1%. Cation Exchange Capacity (CEC) of rice soil in CF and AWDI valued from 4.05 to 6.97 $cmol^+$/ kg and 2.44 to 4.48 $cmol^+$/ kg, respectively. The highest CEC contents were shown in added treatments of NPK+2.0 t $CaCO_3$/ha +10 tCM/ha (Jas 3 & 6), which obtained 6.97 $cmol^+$/ kg (CF) and 4.48 $cmol^+$/ kg (AWDI). Contrariwise, control treatments (Jas 1 & 4) that had the minimum CEC value were 4.05 (CF) and 2.44 $cmol^+$/ kg (AWDI). In generally, pH, OM and CEC had to raise at amended treatments of lime, CM compared to control (NPK only). There was significantly different among CF and AWD at level 1%. The prior study of Nguyen Van Chuong (2019) presented that co-application of CM, lime with NPK raiseed remarkably soil chemical properties such as pH, OM and CEC.

Table 4: Chemical properties of soil at harvest

Treatments	**pH**	**OM (%)**	**CEC ($cmol^+$/ kg)**
CF (A)			
Jas1(NPK:84.0 kg urea + 51.0kg P_2O_5+30kg K_2O/ ha)	4.80^b	2.28^c	4.05^c
Jas 2 (NPK+1.5 t $CaCO_3$/ha +10 tCM/ha)	5.30^a	2.42^b	5.97^b
Jas 3 (NPK+2.0 t $CaCO_3$/ha +10 tCM/ha)	5.60^a	2.52^a	6.97^a
AWDI (B)			
Jas 4 (NPK:84.0 kg urea + 51.0kg P_2O_5+30kg K_2O/ ha)	4.78^b	2.20^b	2.44^c
Jas 5 (NPK+1.5 t $CaCO_3$/ha +10 tCM/ha)	5.30^a	2.28^{ab}	3.40^b
Jas 6 (NPK+2.0 t $CaCO_3$/ha +10 tCM/ha)	5.60^a	2.42^a	4.48^a
F (A)	*	**	**
F (B)	*	*	**
F (A*B)	*	**	**
CV (%)	5.62	4.62	9.61

Note: * significant difference ($p \leq 0.05$). ** Significant difference ($p \leq 0.01$).

Table 5: Nutrien properties of soil at harvest

Treatments	**Total N (%)**	**Available P (mg/kg)**	**Exchangeable K (meq/100 g)**
CF (A)			
Jas.1(NPK:84.0 kg urea + 51.0kg P_2O_5+30kg K_2O/ ha)	0.177^c	200^a	150^b
Jas 2 (NPK+1.5 t $CaCO_3$/ha +10 tCM/ha)	0.210^b	155^b	132^c
Jas 3 (NPK+2.0 t $CaCO_3$/ha +10 tCM/ha)	0.258^a	208^a	167^a
AWDI (B)			
Jas.4 (NPK:84.0 kg urea + 51.0kg P_2O_5+30kg K_2O/ ha)	0.123^c	55.6^b	82.9^b
Jas 5 (NPK+1.5 t $CaCO_3$/ha +10 tCM/ha)	0.134^b	53.8^c	78.0^c
Jas 6 (NPK+2.0 t $CaCO_3$/ha +10 tCM/ha)	0.187^a	67.4^a	98.3^a
F (A)	**	**	**
F (B)	**	**	**
F (A*B)	**	**	**
CV (%)	25.7	25.3	25.4

Note:** significant difference at level 1% ($P_{value} \leq 0.01$).

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The results of Table 5 showed that the total nitrogen of the soil in all treatments, which ranged from 0.177 to 0.258% (CF) and 0.123 to 0.187% (AWDI) and statistically significant differences at level 1%. The highest total N contents were presented in added treatments of NPK+2.0 t $CaCO_3$/ha +10 tCM/ha (Jas 3 & 6), which raised 0.258% (CF) and 0.187% (AWDI). Contrariwise, control treatments (Jas 1 & 4) that had the lowest total N content were 0.177 % (CF) and 0.123% (AWDI). %. Available P valued from 155 to 208 (mg/kg) for CF and 53.8 to 67.4 (mg/kg) for AWD irrigation. The treatments of inorganic fertilizer combined with cow manure and lime achieved the highest Available P concentration of 208 mg/kg (CF) and 67.4 mg/kg (AWDI). On the contrary, the lowest Available P concentration observed at two treatments of Jas 2 and 5 (NPK+1.5 t $CaCO_3$/ha +10 tCM/ha) for CF and AWDI. Similarly, the maximum contents of exchangeable K were 167 meq/100 g (CF) and 98.3 meq/100 g (AWDI) that revealed in treatment Jas 3 & 6 (NPK+2.0 t $CaCO_3$/ha +10 tCM/ha) had significant differences at level 1%. In generally, the concentration of total N, Available P and exchangeable K raised at addition treatments of lime, CM and NPK compared to control (NPK only). There was significantly different among CF and AWD at level 1%. Co-application of CM, lime with NPK raiseed remarkably soil nutrient properties such as total N, Available P and exchangeable K (Belder et al., 2005, Nguyen Van Chuong, 2019)

Cadmium contents of stems, grains and yield of rice Jasmines 85

Table 6:The effect of irrigation method, lime and CM on Cd content of rice stems and grains

Factor	**Cd content of plant (μg/kg)**	
	stems	**grains**
Cow manure (A)		
0.0 t CM/ha	104^a	25.9^a
10.0 t CM/ha	93.0^b	12.3^b
Irrigation method (B)		
CF	113^a	87.0^a
AWDI	61.3^b	53.8^b
Lime (C)		
0.0 t $CaCO_3$/ha	159^a	76.4^a
1.5 t $CaCO_3$/ha	74.8^b	37.4^b
2.0 t $CaCO_3$/ha	45.1^c	$20,5^b$
F (A)	**	**
F (B)	**	**
F ©	**	**
F (A x B)	**	**
F (A x C)	*	**
F (B x C)	**	**
F (A x B x C)	**	**
CV (%)	7.16	8.70

(*) and (**): significant difference at level 5% and 1% (P_{value} ≤ 0.05 and ≤ 0.01).

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The results in Table 6 showed that the Cd content in stems among no CM addition treatments reached an average concentration of 104 µg Cd/kg, and higher than CM addition treatments, which reached an average content of 93.0 µg Cd/kg. The Cd concentration of stems (113 µg/kg) in CF method was significantly higher than that of the AWD treatments with the stem Cd content of 61.3 µg/kg. There was significantly statistical differences at 1% among the treatments of three lime rates. Cadmium contents of rice stems in three different lime ratios ranged from 45.1 to 159 µg/kg. The stem Cd accumulation of none lime addition treatments was the maximum value (159 µg/kg), on contrary, the minimum Cd content obtained at the treatments of 2.0 t $CaCO_3$/ha.

Similarly, the Cd content of rice grains in non CM amendment treatments, which was 25.9 µg/kg, was higher than 2 times that of 10 tCM/ha application (12.3 µg/kg) and significant differences at the 1% level. Similarly, the accumulated Cd content of CF in rice grains was significantly higher than that of AWD with an average content of 87.0 µg/kg and 53.8 µg/kg, respectively. This results proved that rice plants in CF condition accumulated more Cd in rice grains than AWDI condition. The Cd contents in rice grains also differed among three liming rates. Specifically, without liming treatments, the average Cd content in grains obtained the maximum value (76.4 µg/kg), which was significantly higher 3.5 times than that of the 2.0 t$CaCO_3$/ha application (20.5 µg/kg). Three grain Cd concentration of 0.0, 1.5 and 2.0 tCaCO3/ha were 76.4, 37, 4 and 20.5 µg/kg, respectively (Table 6). The results showed that the effectiveness of lime application on Cd-contaminated soil is likely to help reduce Cd accumulation in rice grains in the experiment. From results of Table 6, treatments of the lime, CM application and AWDI method reduce the Cd accumulation in the grain compared to CF and without lime. Thereby, liming has the ability to help reduce Cd accumulation in rice seeds. Continuous rice cultivation has required a large supply of phosphate fertilizers. However, the main sources of raw materials for the production of phosphate fertilizers contain a lot of Cd. The use of Cd-contaminated phosphate fertilizers in agriculture over a long period of time is the main cause of the increase in Cd content in agricultural soils (Bernhoft, 2013). Under the conditions of rice cultivation on Cd-contaminated soil could increase the ability to Cd uptake into parts of the plant, if the Cd accumulation of rice grains excceds the allowable concentration, it will be a high risk of Cd infection to humans through food chain (Doabi et al., 2018). The study used AWDI, CM and lime compared with CF reduce the Cd uptake of grains and stems and yield increase of rice (Oliver et al., 2019).

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Table 7:The effect of irrigation method, lime and CM on biomass and yield of rice

Factor	**Biomass**	**Yield**
	t/ha	
Cow manure (A)		
0.00 t CM/ha	6.40^b	5.67^b
10.0 t CM/ha	9.32^a	7.14^a
Irrigation method (B)		
CF	8.00	6.45
AWDI	7.92	6.46
Lime (C)		
0.00 t $CaCO_3$/ha	6.91^c	5.77^c
1.50 t $CaCO_3$/ha	7.55^b	6.65^b
2.00 t $CaCO_3$/ha	8.81^a	7.03^a
F (A)	**	**
F (B)	ns	ns
F ©	**	**
F (A* B)	**	**
F (A*C)	**	**
F (B*C)	**	**
F (A*B*C)	**	**
CV (%)	12.8	21.1

The results of Table 7 showed that rice biomass was remarkable differences among the treatments of CM application and control at 1%. The addition treatments of 10.0 tCM/ha obtained an average biomass of 9.32 t/ha, which was 1.5 times higher than that of control treatment (NPK only), which had the biomass of 6.40 t/ha. Comparision of the treatments with different irrigation methods, there was not significant differences in the rice biomass at level of 5%. The average rice biomass of the CF and AWD irrigation were 8.0 and 7.92 t/ha, respectively. At the same time, the postharvest rice biomass was different between the lime treatments compared with the non-liming treatments at the level 1%. The average rice biomass of three lime addition treatments that ranged from 6.91 to 8.81 t/ha had the highest and lowest biomass weight of 2.00 t$CaCO_3$/ha and non-lime application, respectively. Results of Table 7 also showed the interaction effects among Cow manure (A), irrigation method (B) and lime rates (C) applied to the soil on rice biomass and remarkable differences among the treatments at level 1%.

There were differences in the postharvest rice yield among treatments at the 1% level. The average rice yield of the treatments of NPK application alone (5.67 t/ha) were lower 1.3 times than that of 10.0 t CM/ ha application (7.14 t/ha). However, the rice yield of the CF and AWDI treatments that was insignificantly different at 5% was 6.45 and 6.46 t/ha, respectively. This proved that rice Jasmine 85 planted in CF method on An Phu land did not have higher yields than AWDI conditions (Table 7). Furthermore, There were sufficient differences in the rice yield among lime addition treatments of three rates (0.0, 1.5 and 2.0 t$CaCO_3$/ha). Specifically, in the non-liming treatments, the average rice yield was 5.77 tons/ha and the lowest value compared with two lime amendment treatments,

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which had the average yield of 6.65 t/ha (1.5 $tCaCO_3$/ha) and 7.03 t/ha (2.0 $tCaCO_3$/ha). Results of the analysis showed that the effects of lime application on the soil in An Phu is likely to help increase the rice yield in the experiment. The effects among cow manure (A), irrigation method (B) and lime rates (C) applied to the soil on rice yield and remarkable differences among the treatments at level 1%. In summary, the lime and CM addition treatments (1.5, 2.00 $tCaCO_3$/ha and 10.0tCM/ha) all gave higher rice biomass and yield than the control treatments without liming and CM application. However, rice biomass and yield of CF and ADW irrigation were insignificantly different at 5%.

4. CONCLUSION

The study results showed an amelioration in the rice yield and quality when using with AWD irrigation via the yield and quality augmentation while lowering Cd concentration. Further, AWDI enhances positive nutritions in rice grains and be preferred over CF. This study result is required by more utilizing of AWD irrigation for local tillers in rice cultivation to not only profit from its irrigated water economy but also significantly raise yield and reduce Cd uptake of rice Jasmine 85. The rice quality could be better marketed and thus raise sales and tillers's income. Furthermore, this research appeal to researchers for a deeper study of other organic manures and lime rates based on the AWD irrigation.

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