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THREE-YEAR EFFECT OF ORGANIC FERTILIZER USE ON PADDY RICE

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Azolla, chicken manure (CM), indigo, rice straw and wild sunflower were the organic materials (OM) incorporated into the soil 7 to 30 days before transplanting (DBT) depending on peak of nutrient release. Inorganic fertilizer (IF), commercial organic fertilizer (COF) with ½ of the recommended IF rate applied 7 DBT, and zero fertilizer treatments, were included as checks.

After 6 continuous rice cropping seasons (3 wet and 3 dry seasons), all the fertilized plants regardless of sources had higher average yields than the unfertilized plants. CM was as good as IF in terms of nutrient supplement and grain yield. Although its yield was lower than the IF, rice straw showed higher supply of K than the other OM used in all the cropping seasons. The use of sunflower and COF gave stable yields in the first 2 years but decreased in the 3rd year of usage. However, sunflower and COF yielded 12 to 15% higher than the unfertilized plots. Generally, there was a decreasing trend of yield and nutrients after 2 continuous years of OM application. Likewise, there was a drop of N and K during the mid-tillering stage of the rice plants. This would imply the need of integrating inorganic with organic materials to increase and sustain rice growth and grain yield.

Keywords inorganic fertilizer, N, organic fertilizers, K, yields

INTRODUCTION

The current low yields and the yield decline occurring in continuously irrigated rice is attributed partly to the decreasing N-supplying capacity of the soil (Cassman & others 1995) especially in the crop's reproductive stage (Kropff & others 1993). The rice plant sources out its N mostly from the inherent soil N (Nishida 2000) during its first growth stages rather than from the basally applied N. Therefore, it is important to increase or at least sustain the inherent N-supplying capacity of the soil. One approach is to increase the organic matter in the soil by nutrient recycling, eg, incorporation of farm wastes into the soil.

Rice straw and chicken manure are two of the most common farm wastes in the lowland while commercial organic fertilizers are already available and market-accessible. Sunflower, commonly found on the slopes of the Cordillera Range in Luzon and along river banks, is widely used as an organic material in the rice seedbed in the highlands. Azolla, now considered a weed in the Cordillera or in the cool, elevated rice terraces, can give as much as 2.89% N while indigo, very common as dye in the Ilocos Region, can give as high as 2.9% N. These organic materials, being accessible to farmers, were evaluated for their sustainability as potential sources not only of N but also of the other major elements necessary for paddy rice. However, there is a question of whether the long-term use of organic materials (OM) is sustainable in terms of soil fertility and crop productivity in paddy rice. To determine this, the sufficiency of the sole application of OM compared to the pure use of inorganic fertilizer at higher recommended rates was measured by (a) observing nutrient dynamics for each growth stages of rice expressed in days after transplanting (DAT), (b) recording nutrient dynamics for every season of the research implementation, and (c) measuring grain yield per cropping season. This research work also aimed at developing the right management strategies on the use of the different available organic materials or fertilizers in paddy soil.

MATERIALS & METHODS

The project was conducted at the Central Experimental Station (CES) of the Philippine Rice Research Institute (PhilRice) at Maligaya, Science City of Muñoz, Nueva Ecija for 3 dry seasons (DS) and 3 wet seasons (WS). The CES is classified as Maligaya clay soil, which is typically fine, montmorillionitic, isohyper-thermic ustic epiaquerts. It has a bulk density of 1.33 g/m^3 and pH ranging from 5.8 (by $CaCl_2$) to 6.31 (by water). Its organic carbon is 1.32%; ammonium N, 0.72 cmol/kg; Olsen P, 75.02 ppm; exchangeable K, 0.10 cmol/kg; and the available Zn is 1.48 ppm.

Organic materials (OM), that is, azolla, chicken manure (CM), indigo, and wild sunflower were incorporated into the soil 2 days before transplanting (DBT), the chicken manure 7 DBT and the rice straw 4 weeks before transplanting. The commercial organic fertilizer (COF) was incorporated 7 DBT and half of the inorganic fertilizer (IF) rate was applied and incorporated 1 DBT. The application was based on the peak of N availability according to the mineralization rate (Javier & others 1999). The other half of the IF was applied at early panicle initiation (EPI). Zero fertilizer treatment was included as check. These treatments were laid out in randomized complete block design (RCBD) and replicated 4 times. The assigned 89 m^2-plot per treatment stayed as it is for the 6 cropping seasons. Modification was only done on the 5th cropping season where 3 varieties (PSB Rc18, PSB Rc72H, PSB Rc80) were superimposed within the treatment plots. However, on the 3rd cropping year, azolla and indigo were discontinued due to lack of materials. Azolla, though it has high N content, cannot survive well in a place of high humidity, high soil and water temperature and stagnant water, conditions of which are observed at the CES. Hence, azolla and indigo are omitted in the presentation of the results. Fresh soil samples were taken from each experimental plot and extracted immediately to determine the dynamics of N, P, K and Zn. Yield and yield components were taken every cropping season.

The suspected nutrient imbalances in the continuous use of inorganic fertilizer and use of organic materials alone (Study 1) are being developed into a sustainable technology through a defined balanced fertilizer strategy (Study 2). Simultaneously, therefore, a study was conducted to balance the fertilizer use strategy using combinations of inorganic fertilizer (120-40-100 kg NPK/ha), organic materials like chicken manure (0.5 t/ha), rice straw compost (2.5 t/ha) and legumes, micronutrients (6 kg Rhizocote/ha), and ZnSO4 sulfate (15 kg/ha). Soil samples were taken from the experimental sites before the research was conducted. These were analyzed for NPK content. Plant samples (leaf and Y leaf) were taken at tillering stage and at panicle initiation stage for the same analysis. Yield per season were taken at harvest.

RESULTS

Sole use of organic fertilizers

Nutrient dynamics per growing stage

The trends of the means of the available soil N, P, K and Zn in the 6 cropping seasons are presented in Figure 1. There was a general decrease of soil ammonium N and K from 14 DAT to 28 DAT; this stabilized thereafter at a low level. Soil P and Zn were more or less stable throughout the cropping season. Highest soil N was observed in plots where IF was applied, the peak of which was at 7 days after incorporation. This was the general trend even for the OM-treated plots though they showed lower N levels than the IF-, CM- and COF-treated plots. It is assumed that from 7 to 14 DAT, the N uptake had commenced, subsequently requiring higher amounts of N. At this point, topdressing of N should be done. Although inorganic N was applied at early panicle initiation (approximately 42 DAT), the soil N level apparently was still low for the rice plant especially in the dry season.

As regards the soil K, most of the fertilized plots showed sufficient K, more than the critical level of 0.20 me/100 g soil, from the transplanting date up to maximum tillering (approx. 28 DAT). The highest soil K level was noticeably observed from the rice straw-applied plots throughout the growth stages of the rice plant. All the other organic materials including the inorganic K had decreased at 56 DAT, d be done to supply the needs of the rice plant in the later stages particularly at the grain-filling stage.

Soil P and Zn seemed not much affected by the different fertilizer materials, though the values were higher in the fertilized than in the unfertilized plots. It is observed that soil P was highest in plots with CM.

Nutrient dynamics per cropping season

The means of the nutrients per season are presented in Figure 2. Generally, soil N was higher in the WS than the DS with IF plots showing the highest among the other treatments. In all the first 3 cropping seasons, CM and COF had almost the same soil NH4-N next to IF. However, at the 4th season, soil N due to COF had decreased to a level lower than those of the rice straw and the wild sunflower treatments. CM showed consistently higher values than the other treatments in all the cropping seasons. For the soil K, there was a general decrease at the 4th cropping season in all treatments except rice straw, which showed an increase. Apparently, there has been an accumulation of soil K by continuous application of straw. On the other hand, CM started to increase lower than the critical K value. Apparently, even the K supply at flowering stage by the different fertilizers including the IF was insufficient. Another topdressing of K should

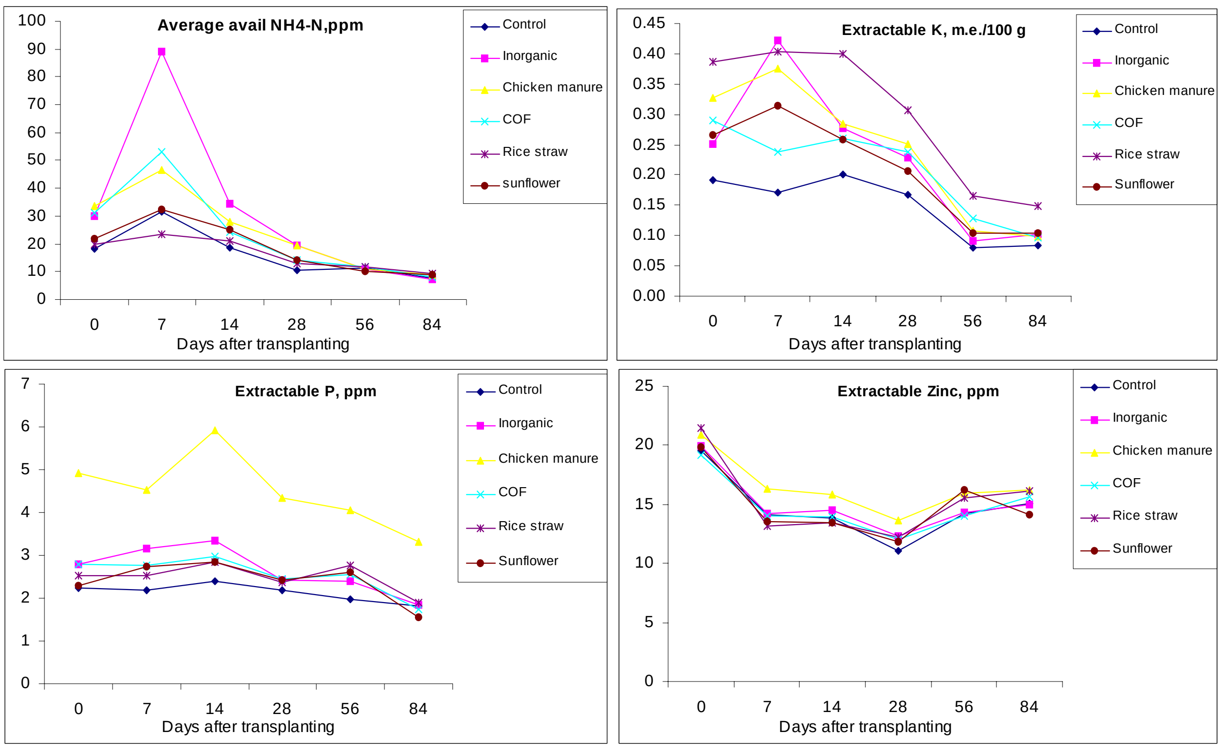

Figure 1 Available* nitrogen, potassium, phosphorous, and zinc determined from Maligaya clay soils amended with different organic and inorganic fertilizers. DS 1999-WS2001. (*averaged from 6 cropping seasons)

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Grain yield per season

After 6 cropping seasons, PSB Rc18 showed yield increase only with CM. CM gave a 25.8% yield increase while the IF gave only 2.9%. All the rest did not give any better yield than IF. The use of sunflower, rice straw and COF, however gave 18, 13 and 17% yield increases, respectively, over that of the unfertilized (Table 1 and Figure 3). Except from CM and IF, the yield of PSB Rc18 decreased at the 3rd year of sole OM application.

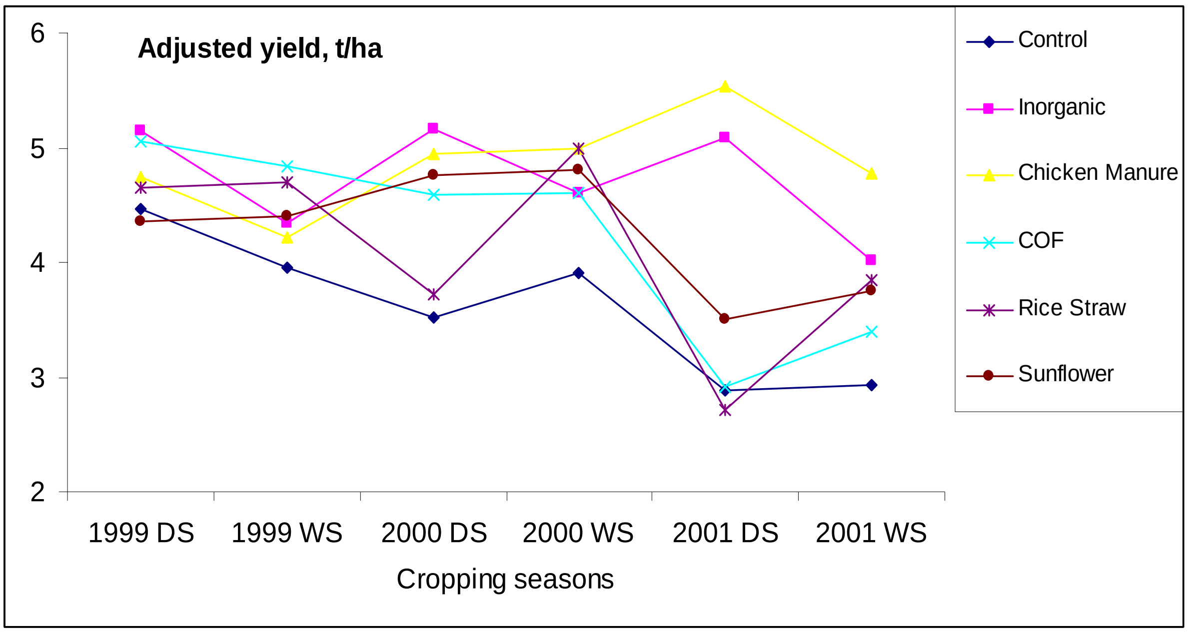

Figure 2. Average grain yield as affected by the different fertilizer treatments applied to Maligaya clay soils series from dry season 1991 to wet season 2001. Muñoz, Nueva Ecija.

The decrease can be explained by the nutrient dynamics observed per cropping season. The yield decrease indicates that some advocates are wrong when they assume that the sole use of organic fertilizer is enough to boost grain production. Organic fertilizer may just play a supplementary role but not as sole nutrient source as far as high rice yield production is concerned.

Effect of organic fertilizers on yields

With the assumption that there might have been some different varietal responses to the use of OM, cultivars PSB Rc82, RC18 and Rc72H were transplanted in the same plots for 2 cropping seasons.

There were no significant yield differences among the superimposed varieties to the fertilizer treatments especially in the wet season (Table 2). In the dry season where nutrient requirement is higher, the yields of the three varieties were low (3.72 t/ha). Their yield potentials were not maximized by the sole use of commercial organic fertilizer most especially for the hybrid rice, Mestizo or PSB Rc72H. In all the 3 varieties, higher yields were obtained when with IF solely applied (5.16 t/ha) and with the sole application of CM (5.39 t/ha). As explained previously in this paper, chicken manure is a potential source of N, P, K and Zn

Development of balanced nutrients for irrigated lowland rice

The yields of the different integrated fertilizer treatments employed in this study were higher (Table 3). Apparently, balancing the nutrient by a mixture of inorganic and organic soil amendments is more efficient than the sole use of organic fertilizer materials. Although there were no significant yield differences among the treatments, numerically the combination of rice straw compost, sulfur, Zn and complete fertilizer is the best. The data suggests that in organic

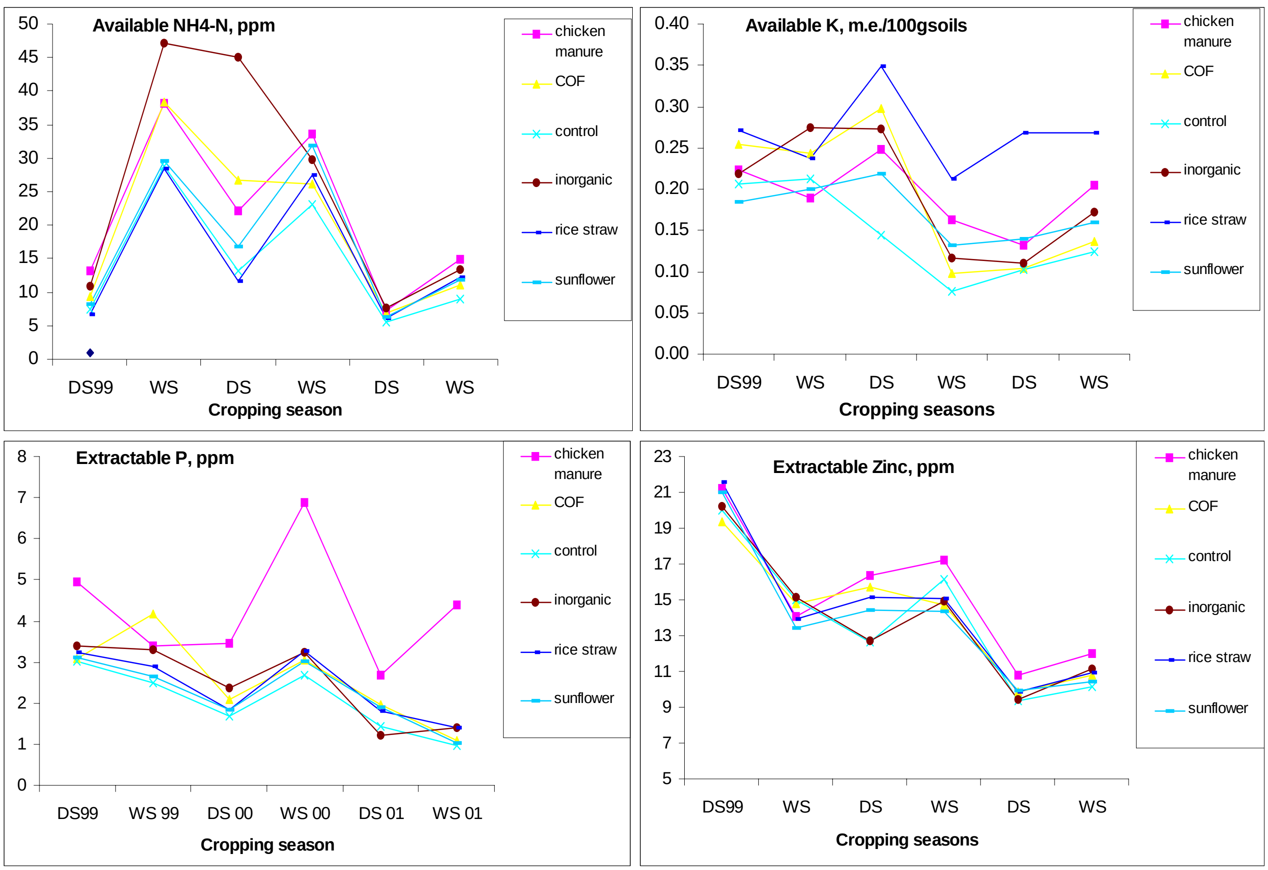

Figure 3. Available nitrogen, phosphorous, potassium and zinc determined in Maligaya clay soils amended with different organic fertilizers. DS 1999 to WS 2001.

Table 1. Average grain yield per season (t/ha) of PSB Rc18 as affected by different fertilizer treatments under Maligaya clay soil series. Maligaya, Muñoz, Nueva Ecija.

Fertilizer Treatments	Cropping Seasons 1999 DS	1999 WS	2000 DS	2000 WS	2001 DS	2001 WS	3-Year Average
Control	4.47	3.96	3.52	3.90	2.88	2.93	3.61
Inorganic	5.15	4.34	5.16	4.60	5.08	4.02	4.73
Chicken Manure	4.75	4.21	4.94	5.00	5.53	4.78	4.87
COF	5.06	4.83	4.59	4.60	2.92	3.39	4.23
Rice Straw	4.65	4.70	3.72	5.00	2.72	3.84	4.11
Sunflower	4.36	4.40	4.76	4.80	3.50	3.75	4.26

fertilizers, micronutrients like S and Zn are lacking, and the available amounts of NPK are not really sufficient to boost the yield of rice. Organic fertilizers, however, are necessary for maintaining soil fertility.

While the yield was lower than the expected yield for dry season, the average yield taken was reasonable as the test variety was direct-seeded. Transplanted rice still yields higher than direct-seeded rice.

SUMMARY & IMPLICATIONS

After 6 continuous rice cropping seasons (3 wet and 3 dry), all the fertilized plants regardless of fertilizer sources had higher average yields than the unfertilized plants. Chicken manure was as good as the inorganic fertilizer in terms of nutrient supplement and grain yield. Although yield was lower than that with the IF, rice straw showed a higher supply of K than the other organic fertilizer materials used in all the cropping seasons. The use of sunflower and commercial organic fertilizer gave stable yields in the first 2 years but decreased in the 3rd year of usage. They, however, yielded 12 to 15% higher than the unfertilized plots. Generally, there was a decreasing trend of yield and nutrients after 2 continuous years of organic fertilizer application. Likewise, there was a drop of N and K during the mid-tillering stage of the rice plants.

The low and decreasing yields implies the need for integrating organic with inorganic fertilizer to increase and sustain yield. The low levels of soil nutrients from organic fertilizer materials across seasons and growth stages of the rice plant, were indicators of their role as supplementary only and not as main source of nutrients for irrigated lowland rice. The potential of the high-yielding irrigated lowland varieties was not maximized by the use of organic fertilizers alone. Balancing the inorganic fertilizers with organic materials or with inorganic micronutrients can further increase grain yield production.

Individually, in the long run rice straw as a nutrient source can supply a good amount of K, chicken manure N and P , and wild sunflower N.

LITERATURE CITED

Cassman KG, SK De Datta, DC Olk, J Alcantara, M Samson, J Descalsota & M Dizon. 1995. Yield decline and the N economy of long-term experiments on continuously irrigated rice systems in the tropics. *In* R Lal & BA Steward (ed), **Soil Management: Experimental Basis For Sustainability And Environmental Quality**. Boca Raton, FL: CRC Press. 181-222

Javier EF & RE Tabien. 1999. Long term organic fertilizer use in paddy rice. Annual Report 1999. Unpublished. PhilRice, Maligaya, Muñoz, Nueva Ecija

Kropff MJ, KG Cassman, HH van Laar & S Peng. 1993. Nitrogen and yield potential of irrigated rice. *Plants & Soils* 155.1/156: 391-394
Nishida M. 2000. Improving N use efficiency in direct seeded rice. JICA report. 25

Table 3 Average grain yield, tons/ha of 3 high yielding varieties as affected by the different fertilizer treatments in Maligaya clay soil series, Maligaya, Muñoz, Nueva Ecija. CY 2002.

Fertilizer Treatments	Irrigated Lowland Varieties			
	PSB Rc82	PSB Rc18	PSB Rc72H	Average
	Dry season, 2001			
Control	2.44 c	2.88 bc	3.87 bc	3.06
Inorganic	4.13 ab	5.08 a	6.25 a	5.16
Chicken Manure	4.74 a	5.53 a	5.91 a	5.39
Commercial Organic Fertilizer	3.12 bc	2.92 bc	4.09 bc	3.38
Sunflower	3.06 bc	3.50 b	4.70 b	3.75
Rice straw	2.49 c	2.72 bc	3.52 c	2.91
	Wet season, 2001			
Control	3.02 c	2.93 c	3.56 bc	3.17 d
Inorganic	4.36 a	4.02 ab	4.50 a	4.29 ab
Chicken Manure	4.17 ab	4.78 a	4.44 ab	4.46 a
Com.Org.Fert.	3.34 bc	3.39 bc	3.53 c	3.42 cd
Sunflower	3.72 abc	3.75 bc	4.01 abc	3.82 bc
Rice straw	3.80 abc	3.84 bc	4.05 abc	3.90 abc

Means in a column with the same letter are not significantly different from each other at 5% level of confidence by DMRT. No letter means they are statistically the same.

Table 2. Adjusted grain yield (t/ha) of PSB Rc28 as affected by different integrated fertilizer managements and strategies under the Maligaya condition. PhilRice, Maligaya, Muñoz, Nueva Ecija. DS 2001.

Fertilizer Management*	1999 WS	2000DS	2000WS	2001 DS
NPK + RSC	6.39 b	5.96 a	5.73 a	6.38 a
NPK + RSC +Zn	6.01 a	6.31 b	5.42 a	6.39 a
NPK + RSC + Micronutrients	6.65 b	6.31 b	5.29 a	6.34 a
NPK + RSC + legume	6.63 b	6.00 a	5.46 a	6.50 a
NPKS + RSC + Zn			5.36 a	6.58 a
NPK + CM			5.37 a	6.16 a
NPK			5.30 a	6.52 a
Mean Yield per season	6.42	6.15	5.42	6.41

Means within columns followed by the same letter are not significantly different at 5% level by DMRT.

*NPK = 90-40-100 kg/ha in the WS and 120-40-100 kg NPK/ha, RSC = rice straw compost at 2.5 t/ha, CM = chicken manure at 0.5 t/ha dry weight basis, micronutrient (6 kg Rhizocote/ha)