Effects of Residual Organic Manure and Supplemental Inorganic Fertilizers on Performance of Subsequent Maize Crop and Soil Chemical Properties

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Abstract
Field experiments were conducted during 2014 and 2015 to evaluate the effects of residual organic fertilizers with supplemental inorganic fertilizers on performance of subsequent maize crop and soil chemical properties at Field 2, Faculty of Agriculture, Universiti Putra Malaysia, Serdang, Selangor, Malaysia. In the first season, the trial was conducted by using 4 nutrient management treatment (control, 100% poultry manure (PM), 100% NPK and 50% NPK + 50% PM) in 3 cropping system (sole maize, sole soybean and maize + soybean intercropping). The following trial was conducted by using the first experimental plot. After harvest of the crops in the first experiment, the biomass was left and incorporated manually into the soil before planting the subsequent maize crop. The experiment comprised of 14 treatments, 12 based on the first experiment and two additional treatments for comparison (control and 100% NPK). The treatments were laid down in a randomized complete block design (RCBD) with three replications. The results showed that all fertilizer treatments increased growth, yield and yield components of the subsequent maize crop. However, incorporation of maize residue alone was ineffective in increasing yield of the subsequent maize crop. The combination of crop residue with residual PM enhanced soil pH, organic matter and nutrient availability in the soil. The combined application of soybean residue + 50% residual PM + 50% phosphorous and potassium (PK) fertilizer and soybean residue + 100% PK gave maize yield same level as 100% NPK. Therefore, it can be recommended that substitution of 50% inorganic fertilizer with residual PM and substitution of N fertilizer in soybean residue is recommended to increase yield of maize and improve soil chemical properties.
Keywords: crop residue, NPK fertilizer, poultry manure, residue, yield
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INTRODUCTION

Currently, the emphasis has been shifted from individual crop to cropping system as a whole since the responses of the component crop in the cropping system are influenced by the previous crops and the applied inputs (Silva *et al*., 2006). The available nutrients in organic manure are not fully accessible to the crops in the current season (Rosen & Bierman, 2005). Organic manure, besides providing nutrients to the existing crop, usually leaves a considerable residual nutrient on the subsequent crops in the cropping system. The residual effect of organic manure applied to the soil refers to the carry-over effect of the application on the subsequent crop (Silva *et al.*, 2006). Decomposition of organic manure and the release of nutrients are more gradual and stored for a longer period in the soil, thus ensuring longer residual effect and improved crop yields (Paul & Beauchamp, 1994). Similarly, incorporation of crop residues in agricultural soils is primarily a means to maintain soil organic matter which results in enhanced biological activity, physical properties and nutrient availability (Antil & Narwal, 2007). The most immediate effect of residue application is on the availability of nitrogen to the succeeding crop as a result of mineralization–immobilization processes (Hadas *et al.*, 2004). Crop residues, mainly leguminous residues, have a great nitrogen benefit and reduce the need for mineral N fertilizer application by smallholder farmers and widen their gross benefit in maize production (Svubure *et al.,* 2010).

Maize (*Zea mays L*) is one of the important cereal crops in the world next to wheat and rice. Maize serves as a staple food for over 900 million people in the developing countries, and it is the most dependable crop to bring about food self-reliance and independence (Zerihun *et al*., 2013). Maize is a high yield potential, which needs balanced use of organic manures and inorganic fertilizers to produce desired yield. Integrated use of organic residues and inorganic fertilizers can sustain soil fertility and soil organic matter required for sustainable high yields and maximum benefits for smallholder farming in the tropics (Shahzad *et al.,* 2015; Vanlauwe *et al*., 2010). Keeping the above points in view, the present investigation was undertaken with the objective of determining the residual effect of poultry manure applied to the previous crop with incorporation of crop residue with and without supplemental inorganic fertilizers on yield, of succeeding maize crop and soil chemical properties.

Materials and Methods

An experiment was conducted in 2014 and 2015 at Field 2, Faculty of Agriculture, Universiti Putra Malaysia

(UPM) Serdang, Selangor, Malaysia. The site is located at altitude of 3: 02' N, a longitude of 101: 42' E and an altitude of 31 m above sea level. Total annual rainfall was 2689 mm with a monthly average of 224 mm. The minimum and maximum average temperatures were 25.06 °C and 32.66 ºC, respectively. The soil type of experimental site was classified as Bungor series (Typic Paleudult). Data on initial physical and chemical properties of soil at experimental site are presented in Table 1.

In the first season, the trial was conducted by using 4 nutrient management treatment (control, 100% poultry manure (PM), 100% NPK and 50% NPK + 50% PM) in 3 cropping system (sole maize, sole soybean and maize + soybean intercropping). The following experiment was conducted by using the first experimental plot. After harvest crops of the first experiment, the biomass was left and incorporated manually into the soil before planting the subsequent maize crop. The experiment comprises of 14 treatments as shown in Table 2. Treatments 1-4 were from plots of the previous maize crop where the treatments were no fertilizer, 100% NPK fertilizer, 100% PM and 50% NPK + 50% PM, respectively. Treatments 5-8 were from plots of the previous soybean crop where the treatments were no fertilizer, 100% NPK fertilizer, 100% PM and 50% NPK + 50% PM, respectively. Treatments 8-12 were from plots of the previous maize + soybean intercropping where the treatments were no fertilizer, 100% NPK fertilizer, 100% PM and 50% NPK + 50% PM, respectively. Treatments 11 and 12 are additional plots which were not fertilized (control) and applied with 100% NPK, respectively. The treatments were laid down in randomized complete block design (RCBD) with three replications.

Land preparation, planting, field management and harvesting

After harvest of the planted crops in the first experiment, the biomasses of the crops were weighed and left on the plots. The residues were weighed, chopped (10-15 cm) and manually incorporated in the top 0-30 cm using hoes. The application rates of the residue were depending on the biomass produced in the respective plots. The nutrient composition of the residue was analyzed in the laboratory before application (Table 2). The amount of $N:P_2O_5:K_2O$ for 100% NPK treatment were, 120:80:60, respectively, and $P_2O_5:K_2O$ for 100% PK fertilizer were, 80: 60 kg/ha, respectively.

The first trial was planted on May 20, 2014 and harvested on August 5, 2014. Whereas, the crop in the second season was planted on October 5, 2014 and harvested on January 5, 2015.

The amount of PM in the first season was calculated based on N equivalence (120 and 20 kg ha^{-1} for maize and soybean, respectively) and applied on dry weight basis two weeks prior to planting. The amount of PM in sole maize, sole soybean and intercropping plot were 3 t ha^{-1}, 0.4 t ha^{-1} and 2 t ha^{-1}, respectively. The chemical composition of PM is presented in Table 3. The amount of $N: P_2O_5:K_2O$ for 100% NPK treatment were 120:80:60 and 20:80:60 kg ha^{-1} for maize and soybean, respectively. The application rate of NPK for both crops was based on the result of the initial soil analysis and the nutrient requirement for the crops (Table 1 and 4). Urea (46% N), triple super phosphate (TSP) (46% P_2O_5) and Muriate of potash (MOP) (46% K_2O) were used as the source of N, P and K respectively. The full dose of P and K and one-third of N fertilizer were applied at the sowing time. The remaining two- third of N fertilizer was added at 8-leaf stage of maize as a topdressing while for soybean plots full dose of N, P and K were applied at planting. Other agronomic practices were kept uniform for all treatments.

Measured variables taken were include plant height, cob length, number of kernels per cob, 1000 kernel weight, green cob weight, marketable cobs/ha, green cob yield (kg/ ha), biomass yield (kg/ha) and harvest index (HI).

Soil sampling and analysis

Composite initial soil samples at a depth of 0-30 cm were taken from ten random spots within the experimental site prior to treatment application and after harvest from each plot. The composite samples were air-dried, sieved to pass through a 2 mm mesh and analyzed for selected physico-chemical properties, including texture (percentage of sand, silt, and clay), pH, total nitrogen, organic matter content, available phosphorus, exchangeable K and cation exchange capacity (CEC). The soil organic carbon content, total nitrogen and sulfur were determined by dry combustion with CHNS LECO analyzer (Jimenez & Ladha, 1993). Soil pH was determined using the glass electrode pH meter in a 1:2.5 soil to water ratio (Van Reeuwijk, 1992), and cation exchange capacity was measured by ammonium acetate method (NH_4OAC) by saturating the soil with 1N NH_4OAC and displacing it with 1N K_2SO_4 (Chapman, 1965). Exchangeable K was extracted with 1N NH_4OAc at pH 7 and the extract was analysed using an Atomic Absorption Spectrophotometer (Perkin-Elmer, Massachusetts, USA). Available phosphorus was determined by the Bray-II method (Bray and Kurtz, 1945) and determined by an Auto-Analyzer (Lachat instrument, WI, USA). Soil texture was determined by the pipette method (Day, 1965). The texture class was determined using the United States Department of Agriculture (USDA) soil textural triangle.

Statistical analysis

The data collected were subjected to statistical analysis appropriate to RCBD. Analyses of variance (ANOVA) were carried out using SAS (Version 9.4) Statistical Software Package. Duncan's Multiple Range Test (DMRT) was used to compare treatment means at 0.05% probability levels. Pearson correlation was conducted to determine the relationship among the variables taken.

Result and Discussion

Treatments applied had a significant effect on growth and yield characteristics of maize (Table 4). The highest plant height (203, 204 and 203 cm), cob length (34.8, 37.2 and 37.8 cm), number of kernels per cob (519, 509 and 520), 1000 kernel weight (684, 683 and 694 g) and green cob weight (560, 550 and 533 g) were obtained from application of 100% NPK, combined application of soybean residue + 100% PK and soybean residue + 50% residual PM + 50% PK, respectively. In contrast, the lowest plant height (94 and 105 cm), cob length (20.6 and 20.8 cm), 1000 kernel weight (283 and 318 g), number of kernels per cob (286 and 286 g) and green cob weight (200 and 208 g) were obtained from control and the application of sole maize residue. Improvement in physical and chemical properties of soil treated with crop residue, residual PM, and inorganic fertilizers resulted in better growth. Maize growth in the combination of soybean residue, residual PM and PK fertilizer was comparable with sole application of NPK fertilizer. This shows that maize performed very well without addition of any inorganic N fertilizer if soybean residues and PM are applied. This might be due to the better availability of soil N possibly resulting from the decomposition of the incorporated soybean residue and residual PM. In addition, the highest plant height (203 cm) of the maize under 100% NPK was due to the fact that nutrients released early from the inorganic fertilizer and maize being a destructive feeder could use it for its growth. A similar finding was reported by Kravchenko and Thelen (2007) who indicated that addition of crop residues improved plant growth, relative chlorophyll content and plant height of corn.

Effects of organic manure residues and inorganic fertilizer on yield characteristics of maize is presented in Table 5. Treatments applied had a significant effect on yield characteristics of maize. Sole application of 100% NPK, combined application of soybean residue + 100% PK, and soybean residue + 50% residual PM + 50% PK fertilizer gave highest marketable cob (61,045, 61,867 and 62,517, respectively), green cob yield (37,290, 36,500 and 37,010 kg/ha, respectively), biomass yield (47,545, 44,550 and 45,873 kg/ha, respectively), and harvest index (78, 82 and 81%, respectively). The increase in green cob and biomass yield under combined application of soybean residue along with the residual PM and PK fertilizer soybean residue + PK fertilizer and sole application of NPK were the reflections of improved plant growth and yield components of the crop. In these treatments, greater growth and leaf area might have increased the photosynthetic activity, which contributed to higher accumulation of carbohydrates. The relatively higher amount of carbohydrate could have promoted the growth rate and, thus increased the yield. This might be due to integrated application of organic and inorganic fertilizers may increase residue decomposition and plant use efficiency of nutrients from both organic manure and inorganic fertilizer. The result is in agreement with Gitari and Friesen (2002) and Ayoola and Makinde (2007) who reported the maximum yield in a combination of organic and inorganic fertilizer. Akintoye and Olaniyan (2012) also found higher green cob yields of sweet corn from the application of N, P and K fertilizer.

The increased yield in combined application of soybean residue + PK fertilizer (36,500 kg/ha) and soybean residue + 50% residual PM + 50% PK fertilizer (37,010 kg/ha) as the same level as 100% NPK fertilizer (37,290 kg/ha) shows that maize yield can be sustained without the addition of any inorganic N fertilizer if soybean residues and PM are applied. This was probably due to higher N availability caused by greater mineralization of N from soybean residue and PM. This might increase the N uptake and therefore increased the photosynthesis rate and subsequently photosynthetic partitioning towards the developing grain. This result is consistent with Khan *et al.* (2008) who reported that returning of soybean residue without applying N fertilizer increased the subsequent wheat yield by 44.9%. Similarly, Aulakh (2010) reported higher yields, N and P uptake and nutrient use-efficiency in the incorporation of groundnut crop residues in combination with inorganic fertilizers.

Correlation of various maize traits with green cob yield as affected by organic and inorganic fertilizer

Correlation of green cob yield with yield components are presented in Table 6. There was a significant ($P<0.0001$) positive correlation between green cob yield and plant height ($R^2 = 0.95$), cob length ($R^2 = 0.94$), green cob weight ($R^2 = 0.99$), number of kernels per cob ($R^2 = 0.97$), thousands kernel weight ($R^2 = 0.99$), biological yield ($R^2 = 0.99$) and harvest index ($R^2 = 0.98$), LAI ($R^2 = 0.88$), CGR ($R^2 = 0.96$), relative chlorophyll content ($R^2 = 0.93$).

Soil chemical properties

Implemented treatments had a significant effect on all measured soil chemical properties (Table 7). The results revealed an increase in soil chemical properties due to the sole and combined application of organic residue. The increase in soil pH due to the incorporation of crop residues and residual poultry manure was attributed to increased microbial activity during the process of decomposition and organic matter formation. The decomposition of organic matter resulted in the release of more exchangeable bases such as K, Ca, and Mg that reduce the soil acidity near to neutrality. The result is in agreement with the study done in different parts of tropics (Lee *et al.*, 2006) where the application of organic materials such as crop residues, green manure, and compost improved soil pH, available nutrients, organic matter content, and reduced exchangeable acidity. Hue (1992) also reported an increase in soil pH after incorporation of crop residue due to the release of NH_3 from decomposing organic materials and the production of OH^- ions.

The increase in organic matter attributed to the direct addition of organic matter through crop residue and PM and as a result of decomposition. This is because organic matter is the major product of decomposition (Ogbodo, 2011). The result is supported by Mungai and Motavalli (2006) who reported that incorporation of a mixture of cereal and legume residue significantly increased the maintenance of soil organic C and N. The slow decomposing residues have a steady impact on soil structure and provide a long-term impact on increasing levels of soil organic matter (Cattaneo *et al.*, 2014).

Organic materials enhance the nutrient availability of the soil through a gradual release of nutrients and lessening of nutrient losses. The availability of soil N, P and K in the soil were improved by the addition of different crop residue and residual poultry manure. The increase in total soil nitrogen when soybean residue was incorporated alone or in combination with maize was due to the ability of legume to fix atmospheric N in the soil. Similarly, Crookston *et al.* (1991) and Meese *et al*. (1991) reported that the soybean N credit varies by cropping season, yield of the previous soybean crop and soil organic matter content. Hadas *et al*. (2004) also reported a significant effect of using organic amendments on N availability to the following crop due to their mineralization. The organic materials can likewise diminish P fixation by covering the fixation site on the soil colloids and by creating chelates with Al, Fe, and Mn particles, therefore increase the P availability. Similar results were reported by Babhulkar *et al.* (2000) . In addition, the release of organic acid during microbial decomposition of organic matter which might have facilitated the solubility of native phosphates by hindering of P-sorption sites (Diack *et al*., 2000).

The increment in the available K content in treatments with residual poultry manures was due to the beneficial effects of poultry manures in releasing K_2O during decomposition and the direct addition of K_2O to the available pool of the soil. In addition, soybean and maize residue are very rich in K which added more K to the soil. The increase in soil organic matter could improve soil K availability and CEC since soil organic matter comprises of cation exchange sites that preserve exchangeable K (Johnston *et al*., 2009). Similar beneficial effect of FYM and crop residue on the available K content of the soil was reported by Mathan and Mahendran (1994) and Surekha *et al*. (2003), respectively. Similarly, Mbah and Nneji (2011) reported that retention of crop residue significantly increased exchangeable bases and CEC of the soil compared to the control. In contrast, Rosenani *et al*. (2003) reported no significant effect of maize and groundnut crop residue on soil CEC in the first year of application. Integrated nutrient management by the use of organic manures is practiced to maintain fertility status of the soil thereby enhanced crop productivity. It also benefits to sustain the productive of the cropping systems. These findings are supported by Marimuthu *et al.* (2014) who concluded that crop productivity and soil fertility status can be sustained with integrated plant nutrient management practices. Ali *et al.* (2009) also reported that the combination of crop residue, organic manure and inorganic fertilizer to rice cropping system improved soil organic carbon and NPK contents compared to control.

Conclusions

Based on the results, sole and combined application of crop residue, inorganic fertilizer, and residual PM gave significantly higher growth, yield and yield component of maize than that of the control. The incorporation of soybean residue or maize + soybean residue from the previous crop managed to increase maize yield without additional N fertilizer. On the other hand, incorporation of maize residue alone gave no increase in yield over the control. Among the treatments applied, the combined application of soybean residue + 100% PK and soybean residue + residue of 50% PM + 50% PK increased maize yield to the same level as 100% NPK fertilizer. In addition, residual PM and crop residue from the previous crop can improve soil nutrient and soil organic matter. Organic residues, such as crop residue and poultry manure are cheap and easily available sources of nutrients for smallholder farmers compared to expensive inorganic fertilizer and also they are environmentally friendly. Therefore, substitution of N fertilizer with soybean residue and substitution of 50% NPK fertilizer with PM is recommended to increase yield of maize and improve soil fertility.

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Table 1: Initial physical and chemical properties of experimental soil (n=3)

Soil Properties	Value
pH	5.62 ± 0.19
Total N (%)	0.08 ± 0.01
Available P (mg/kg)	16.0 ± 1.95
Exchangeable K (cmolc/kg)	0.33 ± 0.12
S (mg/kg)	49.6 ± 17.18
CEC (cmolc/kg)	14.5 ± 0.37
OM (%)	2.2 ± 0.32
Texture	Sandy loam
Clay (%)	18.98
Sand (%)	65.73
Silt (%)	15.25

Table 2: Treatment combinations

Treatment no.	Description
1	Maize residue (MR)
2	Maize residue + 100% PK
3	Maize residue + residual 50% PM + 50% PK
4	Maize residue + residual 100% PM
5	Soybean residue
6	Soybean residue + 100% PK
7	Soybean residue + residual 50% PM + 50% PK
8	Soybean residue + residual 100% PM
9	Maize + soybean residue
10	Maize + soybean residue + 100% PK
11	Maize + soybean residue + residual 50% PM +50% PK
12	Maize + soybean residue + residual 100% PM
13	Control (no fertilizer and no residue)
14	100% NPK

Table 3: Chemical composition of poultry manure

Nutrient Element	Values (%)
N	4.50
P	1.08
K	1.66
Ca	1.43
Mg	0.60
pH	7.10

Table 4. Effects of organic manure residues and inorganic fertilizer on agronomic and yield traits of maize

Treatment	PH (cm)	CL (cm)	NK/C	TKW (g)	GCW (g)
Control	94g	20.6e	283f	286h	200g
100% NPK	203a	34.8a	684a	519a	560a
MR	105f	20.8e	318ef	286h	208g
MR + 100% PK	162d	23.3de	389d	325gh	308e
MR + 100 % RPM	163d	22.7e	423d	339efg	350cd
MR + 50% RPM + 50% PK	167d	27.8bc	484c	387cde	378c
SR	166d	25cd	409d	353def	325de
SR + 100% PK	204a	37.2a	683a	509a	550a
SR + 100% RPM	189b	30.8b	539bc	431bc	445b
SR + 50% RPM + 50% PK	203a	37.8a	694a	520a	533a
MSR	118e	22.5de	369de	302gh	259f
MSR + 100% PK	177c	28.5bc	551b	408bc	432b
MSR + 100 % RPM	178c	27.8bc	489c	400bcd	376c
MSR + 50% RPM + 50% PK	178c	29.8b	573b	442b	433b

Means in the same column followed by the same letters are not significantly different (DMRT $_{0.05}$),PH = plant height, CL =cob length, GCW= green cob weight, NK/C = number of kernels per cob, TKW = thousand kernel weight, MR= maize residue, SR= soybean residue, MSR= maize + soybean residue, RPM= residual poultry manure, PM= poultry manure, PK= phosphorus and potassium fertilizer

Table 5. Effects of organic manure residues and inorganic fertilizer on yield characteristics of maize

Treatment	MC/ha (no.)	GCY (kg/ha)	BY (kg/ha)	HI (%)
Control	31,437e	10,323h	18,527f	56fg
100% NPK	61,045a	37,290a	47,545a	78ab
MR	35,084e	11,237h	21,377ef	52g
MR + 100% PK	46,672d	20,217e	30,037d	67e
MR + 100 % RPM	47,227cd	20,890e	30,850d	68e
MR + 50% RPM + 50% PK	45,203d	23,893d	34,042c	70de
SR	44,972d	17,173f	28,528d	60f
SR + 100% PK	61,867a	36,500a	44,550a	82a
SR + 100 % RPM	50,316bcd	27,160c	37,280b	73dc
SR + 50% RPM + 50% PK	62,517a	37,010a	45,873a	81ab
MSR	44,289d	14,020g	24,122e	58f
MSR + 100% PK	55,604abc	29,620b	38,958b	76bc
MSR + 100 % RPM	51,905bcd	24,943d	36,050bc	69de
MSR + 50% RPM + 50% PK	56,551ab	29,377b	38,612b	76bc

Means in the same column followed by the same letters are not significantly different (DMRT $_{0.05}$), MC=marketable cobs, GCY= green cob yield, BY= biomass yield, HI= harvest index, MR= maize residue, SR= soybean residue, MSR= maize + soybean residue, RPM= residual poultry manure, PM= poultry manure, PK= phosphorus and potassium fertilizer

Table 6 . Pearson linear correlation coefficients between green cob yield and yield component as affected by organic and inorganic fertilizer

	GCY	PH	CL	CW	NKPP	TGW	BY	HI
GCY	1							
PH	0.95***	1						
CL	0.94***	0.90***	1					
CW	0.99***	0.92***	0.97***	1				
NKPP	0.97***	0.94***	0.98***	0.98***	1			
TGW	0.99***	0.95***	0.94***	0.98***	0.98***	1		
BY	0.99***	0.96***	0.94***	0.99***	0.97***	0.98***	1	
HI	0.98***	0.94***	0.89***	0.95***	0.93***	0.97***	0.97***	1

*, **, *** significant level at P<0.05, 0.001, 0.0001, GCY = green cob yield, PH = plant height, CL =cob length, GCW= green cob weight, NKPC = number of kernels per cob, TGW = thousand grain weight, BY= biomass yield, HI= harvest index

Table 7. Effects of organic manure residues and inorganic fertilizer on soil chemical properties

Treatment	pH	OM (%)	TN (%)	S (mg/kg)	Av. P (mg/kg)	Ex.K (cmolc/kg)	CEC (cmolc/kg)
Control	4.73e	1.84h	0.06h	36.7d	13.7i	0.15e	13.9h
100% NPK	4.86e	1.94h	0.08gh	51.2d	15.0i	0.16e	15.9h
MR	5.82cd	2.75fg	0.10fg	74.7a	20.4h	0.31d	18.9ef
MR + 100% PK	5.54d	2.93efg	0.11fg	76.2abc	26.3gf	0.44c	21.1cde
MR + 100 % RPM	6.72a	4.62a	0.24abc	83.2abc	35.7abc	0.58ab	29.1a
MR + 50% RPM + 50% PK	6.34ab	3.75cd	0.19e	75.2abc	31.8cd	0.50bc	21.6bcde
SR	5.58cd	2.74fg	0.22cde	68.2bcd	23.67gh	0.29d	20.4def
SR + 100% PK	5.83cd	2.58g	0.20de	59.5bcd	27.0efg	0.47c	23.5bcd
SR + 100 % RPM	6.79a	4.57ab	0.27a	81.4abc	38.1a	0.59a	30.4a
SR + 50% RPM a 50% PK	6.45ab	3.96bcd	0.24bc	72.0abc	30.6de	0.51bc	28.5a
MSR	5.73cd	3.33edf	0.12f	100.2a	20.2h	0.33d	17.4f
MSR + 100% PK	5.62cd	3.49de	0.19de	78.0abc	29.9def	0.48c	24.0bc
MSR + 100 % RPM	6.69a	4.89a	0.25a	95.2a	37.2ab	0.64a	29.9a
MSR + 50% RPM + 50% PK	6.03bc	4.26abc	0.22cd	79.6abc	33.4bcd	0.51bc	24.7b

Means in the same column followed by the same letters are not significantly different ($DMRT_{0.05}$), MR= maize residue, SR= soybean residue, MSR= maize + soybean residue, RPM= residual poultry manure, PM= poultry manure, PK= phosphorus and potassium fertilizer, Av. P= available P, Ex. K= exchangeable K