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Guano and Rice-Hull Ash Application for Flowering Induction on Orange Jessamine (*Murraya paniculata* (L.) Jack)

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Abstract

Orange jessamine (*Murraya paniculata* (L.) Jack) has high economical values due to its medicinal properties. Orange jessamine leaves contain mexotionin and coumarin. Orange jessamine flowers contain scopoletin that can lower blood pressure and can be used as an anti-inflammatory agent and as anti-allergic. Orange jessamine is often used as an ornamental plant because it has beautiful flowers similar to jasmine, has nice scent, and red color fruits. The aim of this research is to study the effects of guano and rice-hull ash application on flowering induction of orange jessamine. The research was conducted at an organic experimental farm, Bogor Agricultural University, Dramaga (6°30' – 6°45' S, 106°30'-106°45' E) from December 2014 to June 2015 using randomized complete block design. The experiment used four treatments, i.e. guano at 0.4 kg per plant, combination of guano (0.4 kg per plant) and rice-hull ash (3.0 kg per plant), rice-hull ash 3.0 kg per plant and without fertilisation as control. The results showed that the application of rice-hull ash increased plant height and leaf number. Guano application significantly increased the intensity of leaf color in mature orange jessamine leaves. Rice-hull ash application increased flower number at 12 and 20 weeks after application.

Keywords: chlorophyll, flower number, flower weight, NPK value, organic farming

Introduction

Murraya paniculata (L.) Jack commonly known as orange jessamine is a tropical shrub belonging to the Rutaceae family and originated from South East Asia (Olawore et al., 2005). These plants can grow up to an altitude of 400 m above sea level. In Indonesia, this plant grows in Central Java and East Java (Kartasapoetra, 2004).

The herbal and natural products of folk medicine have been used by men since the beginning of the human race (Gautam et al., 2012), including orange jessamine. The leaves are stimulant and astringent, they are reportedly used in the form of an infusion to treat dysentery in Philippines (Gautam et al., 2012). Orange jessamine barks contain mexotionin and coumarin that can be used to treat toothache and mucous membranes injury, whereas the roots have been used to treat rheumatics and coughs (Gautam et al., 2012). Flowers of this plant contain scopoletin, a compound that can lower blood pressure and can be used as an anti-inflammatory agent and as anti-allergic (Sulaksana and Jayusman, 2005).

Orange jessamine is often used as an ornamental plant because it has beautiful flowers similar to jasmine, has nice scent, and red color fruits (Dwi, 2007). Potted orange jessamine is of major importance in the Italian ornamental plant industry, particularly for European markets (Olawore et al., 2005). However, the flowering of orange jessamine is irregular.

Fertilization, particularly using potassium (K)-containing fertilizer, can stimulate flowering (Erwiyono et al., 2006). Suwarno and Idris (2007) reported that guano is rich in Nitrogen (N) and Phosphorus (P); N, P, and K content in guano is 2.09, 3.2 and 0.9%, respectively (Shetty et al., 2013). Rice-hull ash can loosen the soil structure so it will facilitate the plant roots to absorb nutrients more efficiently (Pane et al., 2014). Rice-hull ash has 97% silica (Si) content, 2% potassium (K) and 1% nitrogen per kg dry weight (Kiswondo, 2011). This research was conducted to explore the effects of guano and rice-hull ash application on flowering induction of orange jessamine.

Material and Methods

Plant Materials

The experiment was conducted from December 2014 to June 2015 at the IPB organic experimental farm, Cikarawang, Bogor Agricultural University, Bogor, Indonesia, above 250 m above sea level. The type of soil is Latosol. Leaf analysis was conducted at Bogor Agricultural University laboratory. The experiment used 38-month-old plants with planting distance of 1 m x 1 m. Chicken manure was applied as soil conditioner at 5 kg per plant at 38 months after planting (MAP). The experimental design used in this research was randomized complete block design with fertilization as a treatment (single factor)

Treatments

Treatments were 0.4 kg guano per plant, combination of 0.4 kg guano + 3.0 kg rice-hull ash per plant, 3.0 kg rice-hull ash per plant, and without fertilization as control. Treatments were applied twice during the experiment, i.e. in December 2014 and March 2015. Each experimental unit consisted of one plant with five replications. Chicken manure as soil conditioner was applied 5 kg per plant one month before treatment (in November 2014) and plants were pruned one day before fertilizer application. The aims of pruning and chicken manure application are to create homogenous environment for plant.

Plant Height

The height was scored once a month from January to June 2015. Plant height was measured at eight weeks after application (WAP) from the stem above the ground to the top of the main plant on the same side of each plant.

Leaf Number, Leaf Fresh Weight and Leaf Dry Weight

Leaf number was scored every month from January to June 2015. Leaf number and leaf fresh weight were calculated using the following formula:

Leaf number = number of branches per plant x number of leaves per branch.

Fresh leaf weight = number of leaves per plant divided by 100 X weight of 100 mature leaves.

Dry leaf weight was obtained by drying the fresh leaves in oven at 60°C for 3 x 24 hours.

Number of Flowers per Plant and Flower Weight

Flower number per plant was recorded when 75 % of the plant population bloomed. Flower weight = flower number/10 x weight of 10 flowers.

Leaf Color Intensity

Leaf color intensity was scored by measuring green intensity level on mature leaves and young leaves using SPAD.

Leaf N, P, and K Leaf Analysis

Analysis on leaf N, P and K was conducted at 12 WAP by harvesting the 5th mature leaves from branches of each plant totaling of 100 leaves. The leaves were detached from the stems and were oven-dried (60 °C) for 3 x 24 hours. Total nitrogen was analyzed using Kjedhal method, and total P and K using HNO_3 + $HClO_4$ method.

Data Analysis

Data were analyzed using ANOVA, followed by Duncan Multiple Range Test (DMRT) at the 5 % level of significance using SAS 9 for Windows.

Table 1. N, P and K content of guano and rice-hull ash (%) and their nutrient contribution to orange jessamine plants.

Treatment	Elemental content per kg (%)			Total nutrient contribution from guano[3)] and rice-hull ash[4)] to each plant (g per plant)		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Without fertilisation	0	0	0	0	0	0
Guano[1)]	2.09	3.2	0.9	20	30	7
Rice-hull ash[2)]	1.72	0.5	1.75	100	30	105

Note: [1)]From Shetty et al. (2013); [2)]Data from Soil Research Station (Balittanah), Cimanggu (2015); [3)] nutrient contribution from two applications of 0.4kg guano per plant; [4)] nutrient contribution from two applications of 6 kg rice-hull ash per plant

Results

Soil Chemical Properties

The results of soil chemical analysis (Table 2) showed that the soil in the study area was slightly acidic, low in organic matter and high in phosphorus.

Effect of Guano and Rice-Hull Ash Application on Plant Height

Overall, plant height was affected by the treatments from 4 to 24 WAP. Fertilizer application significantly increased plant height at 24 WAP ($P<0.05$). Plants treated with 3.0 kg rice hull ash per plant were 5.36% taller than control (Figure 1).

Table 2. Soil chemical properties at 38 months after planting (MAP)

Chemical variables	Methods	Value	Criteria[1)]
pH H_20	-	6.6	Slightly acidic
pH KCL	-	5.7	Slightly acidic
Organic-C (%)	Walkey and Black	1.43	Low
Organic-N (%)	Kjedahl	0.15	Low
C/N	-	10	Low
HCl 25%			
P_2O_5 (mg 100 g^{-1})	Extractant Bray	99	Very high
K_2O (mg 100 g^{-1})	Extractant Bray	9	Very low
P_2O_5 (ppm)	Olsen	50	High

Note: [1)] Based on criteria in Hardjowigeno (2010).

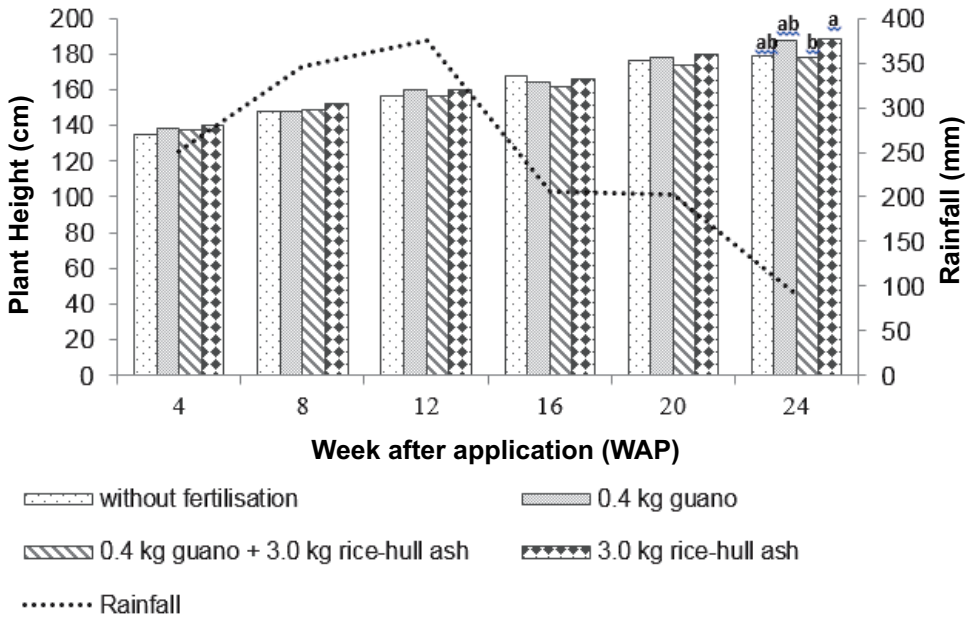

Figure 1. Correlation between orange jessamine height with average monthly rainfall

Effects of Guano and Rice-Hull Ash Application on Height of Previously Pruned Plants

Pruning was conducted to maintain vegetative phase and stimulate new bud development (PPTK, 2006). Guano application at 0.4 kg per plant increased height of the previously pruned plants by 1.35 % from 8 WAP to 12 WAT. Plants treated with rice-hull ash at 3.0 kg per plant were 0.93 % taller than control at 16 WAT.

Effect of Guano and Rice-Hull Ash Application on Leaf Number per Plant

Increases in leaf number fluctuated during 24 weeks of observation (Figure 2). Application of guano and rice-hull ash significantly increased leaf number per plant at 20 WAP; plants treated with rice-hull ash had 103.9 % more leaves than control.

Table 3. Effects of guano and rice-hull ash application on height of previously pruned plants

Guano + rice-hull ash application (kg per plant)	Height of previously pruned plant (cm)						Total height increase (cm)
	Week after treatment (WAT)						
	0	8	12	16	20	24	
0	100	102.00ab	104.20	107.40	115.40a	117.40a	17.40
0.4 + 0	100	103.80a	105.20	106.40	108.80b	110.20b	10.20
0.4 + 3.0	100	100.40b	102.40	107.80	110.00b	111.60b	11.60
0 + 3.0	100	101.601b	101.80	108.40	110.00b	111.30b	11.30
F-test		*	tn	tn	**	**	
CV (%)	-	1.66	1.91	1.84	2.18	2.09	-

Note: Numbers with the same letters on the same column means not significantly different based on DMRT at 5 %

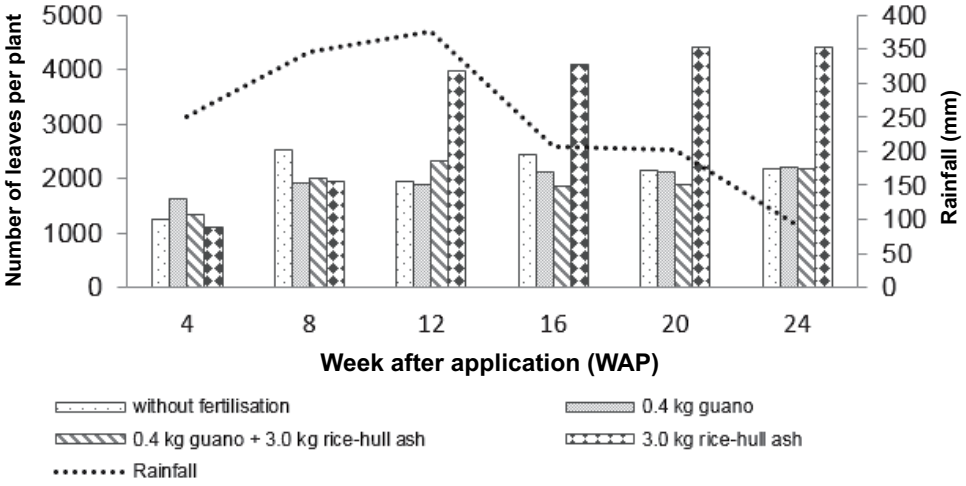

Figure 2. Effects of guano and rice-hull ash application on leaf number per plant at 4 to 24 weeks after treatment.

Effect of Guano and Rice-Hull Ash Application on Flower Number per Plant and Time to Anthesis

Orange jessamine plants flowered between 8 to 20 WAP. The flowering peaks, indicated by the highest number of flowers per plant during the course of the study, occurred on 12 and 20 WAP. The peak of flowering occurred at week 12 and this coincided with the high monthly rainfall (376 mm). Plants treated with rice-hull ash had 113.5 % more flowers compared to control (Figure 3). Low monthly rainfall (201.9 mm) on the 20th week coincided with a decrease in flower number (Figure 3).

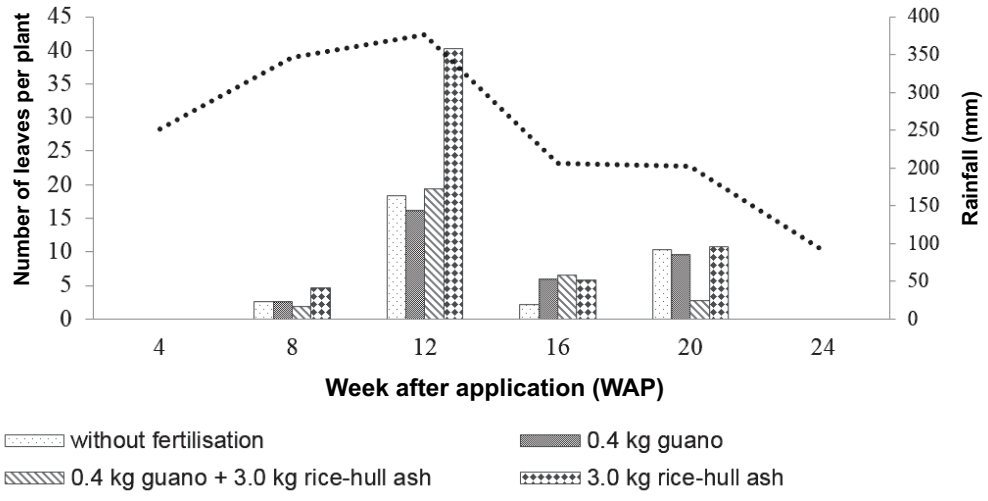

Figure 3. Number of flowers per plant and monthly rainfall (mm) during December 2014 - June 2015.

Effect of Guano and Rice-Hull Ash Application on Flower Weight at 12 and 20 WAP

The highest flower weight at 12th and 20th weeks was obtained from plants treated with 3.0 kg rice-hull ash per plant. Plants treated with 0.4 kg guano + 3.0 kg rice-hull ash per plant had lower flower weight compared to control at 20 WAT. Decreased flower weight may be related to the decreasing precipitation from 12 to 20 WAP (Figure 4).

Effect of Guano and Rice-Hull Ash Application on Leaf Color Intensity

Fertilisation did not affect leaf color intensity of the young leaves, but significantly intensify the green color of mature leaves. Plants treated with 0.4 kg guano per plants had higher leaf color intensity of 10.67 % than control. Guano has high N content which impacted leaf color intensity, therefore the leaf became darker green (Setiawan et al., 2006).

Table 4. Color intensity of orange jessamine leaves.

Guano + rice-hull ash application (kg per plant)	Leaf color intensity [1)]	
	Mature leaves	Young leaves
0	69.88b	34.540
0.4 + 0	77.34a	37.420
0.4 + 3.0	76.44a	29.520
0 + 3.0	72.40ab	35.460
F-test	*	tn
CV (%)	5.61	21.04

Note : [1)] Leaf color intensity was measured using SPAD. Numbers with the different letters on the same column were different on DMRT at 5 %.

Leaf N, P and K content

Nitrogen content of the guano-treated plants, measured from the fifth leaf of each plant, was 0.01 % higher than that of control (Table 5). Guano can improve nitrogen absorption in plants (Herbiani, 2008). Plants treated with a combination of 0.4 kg guano and 3.0 kg rice-hull ash per plant had high P content whereas plants treated with 3.0 kg rice-hull ash had K value of 0.19 % higher than control (Table 5).

Discussion

Data on 24 WAT showed that even though statistically insignificant, plants fertilized with rice hull ash at 3.0 kg per plant were taller than 0.4 kg guano-treated and control plants (Figure 1). Rice-hull ash contributed the highest Nitrogen (N) and Potassium (K) to orange jessamine plants (Table 1). Plants treated with 3.0 kg rice-hull ash per plant had the highest K total value and high N total value (Table 5). Setiawan et al. (2006) study reported that increases of nitrogen absorption were influential in increasing plant height.

Taller plants have more branches and leaves (Handajaningsih and Wibisono, 2009), and this was in line with the results of this study in that plants treated with 3.0 kg rice-hull ash per plants were taller and had more leaves than control (Figure 2). Plants grown in K-rich soil had dense foliage (Rukmi, 2009) whereas K-deficient plants have a lower photosynthetic activity; hence lower energy is available for growth (Suminarti, 2010).

Table 5. Nitrogen (N), Phosphorus (P) and Potassium (K) content of orange jessamine leaves.

Guano + rice-hull ash (kg per plant)	Leaf N, P, and K (%)					
	N total	Category[1)]	P total	Category[2)]	K total	Category[2)]
0 + 0	2.97	High	0.26	High	2.66	High
0.4 + 0	2.98	High	0.27	High	2.59	High
0.4 + 3.0	2.88	High	0.28	High	2.68	High
0 + 3.0	2.97	High	0.23	Medium	2.85	High
F-test	tn		tn		tn	
KK (%)	9.20		22.55		15.86	

Notes: [1)] Criteria according to Susanto (2009); [2)] Criteria according to Embleton et al. (1978).

Rainfall during the course of the experiment might play a role in the absorption of nutrients, as high rainfall usually coincides with profuse flowering in orange jessamine. Plants treated with 0.4 kg guano + 3.0 kg rice-hull ash per plant had more leaves at 12 WAT, possibly due to high rainfall during that period. When the rainfall was low at 16 WAT the number of leaves per plant was also decreased (Figure 2). Lack of water might disturb water movement within the plant, and can lead to senescence, resulting in decreased number of leaves.

Apart from potassium, rice-hull ash also contains high (97 %) silica (Kiswondo, 2011). Tropical soils are generally low in plant-available Si and would benefit from Si fertilization (Korndörfer and Lepsch, 2001), and Si application could enhance crop yield by promoting desirable plant physiological processes (Kondörfer and Lepsch, 2001). Silica plays a role in increasing photosynthesis and this will affect plant growth, including increases in leaf and flower number (Mukasyafah, 2011). Matichenkov et al. (2000) stated that Silicon (Si) fertilizer applied into the soil initiates two processes. The first process involves an increase in the concentration of mono silicic acids resulting in the transformation of slightly soluble phosphates (P) into plant-available phosphates (P). This is because SiO_4^{4-} has greater electronegativity than PO_4^{3-} so that it can replace the PO_4^{3-} that is suspended in the soil. Secondly Si fertilizer adsorbs P, thereby decreases P leaching by 30-90% as described by equations below (Matichenkov and Calvert, 2002):

$$2Al(H_2PO_4)_3 + 2Si(OH)_4 + 5H^+ \rightarrow Al_2Si_2O_5 + 5H_3PO_4 + 5H_2O$$

$$2FePO_4 + Si(OH)_4 + 2H^+ \rightarrow Fe_2SiO_4 + 2H_3PO_4$$

Orange jessamine treated with 0.4 kg rice-hull ash per plant had more leaves even though the monthly rainfall decreased at 16 and 24 WAP. This might be related to the fact that rice-hull ash contains Si that has been reported to promote plant's resilience to drought (Djajadi, 2013).

Plants treated with 3.0 kg rice-hull ash per plant had more flower (Figure 3) due to a medium range of P and high K content compared to other treatments (Table 5). One of the functions of potassium (K) in plants is to promote carbohydrates metabolism, so higher K could increase the content of carbohydrates in the plant. The increase in carbohydrate is directly proportional to the increasing of C/N ratio so that flowering occurs (Darmawan, 2014). This result is also in accordance with a study by Erwiyono et al. (2006) that potassium fertilization increased flower number in Cacao plants and reduced flower drops (Purnamayani et al., 2012).

Conclusion

Application of 3.0 kg rice-hull ash per plant increased plant height, number of leaves and number of flower of 38-month-old plants during 24 weeks of study. Application of 0.4 kg guano per plant promoted vegetative growth of orange jessamine but did not increase number of flower per plant.

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