GROWTH RESPONSE AND PRODUCTION OF RED AND GREEN OKRA PLANT EFFECT OF ORGANIC FERTILIZER

Abstract

The effect of nitrogen on metabolism, dry matter production, growth, and development of plants has been well investigated. Extensive research has been conducted on organic fertilizers especially the compost. This study investigated the effect of compost on fruit yield, nitrogen use efficiency agronomic efficiency, supplied nitrogen recovery efficiency, and supplied nitrogen physiological efficiency in okra (*Abelmoschus esculentus* (L.) Moench). A completely randomized experimental design of 2 x 4 factorial pattern with three replications was used in this study. Factor I was the okra species (green okra, red okra), and factor II was the dose of compost (0, 50, 100 and 150 kg N ha^{-1}). Kind of okra has different effects on the parameters observed. Results showed that Green okra and red okra showed increased yields due to the increase in the nitrogen dose through compost. Agronomic efficiency of green okra and red okra increased with increasing doses of compost. Nitrogen recovery efficiency of green okra and red okra also increased with increasing doses of compost. Nitrogen physiological efficiency of green okra and red okra increased with increasing compost doses. An increase in compost doses resulted in increased nitrogen uptake, fruit yield, Agronomic efficiency, nitrogen recovery efficiency, and nitrogen physiological efficiency of both green and red okra. Increased compost doses resulted in decreased nitrogen use efficiency in green okra. Green okra is more efficient in using organic nitrogen from compost.

Keywords: agronomic efficiency, *Abelmoschus esculentus* (L.) Moench, compost, fruit yields, Nitrogen use efficiency.

INTRODUCTION

Okra (*Abelmoschus esculentus* (L.) Moench) is a member of the Malvaceae important vegetable growing in tropical and subtropical regions of the world consisting of about 2,300 species consisting of cotton (Gossypium spp.) and cocoa (*Theobroma cacao*) (Aliyu and Ajala, 2016). Important vegetable crops are grown in tropical and subtropical regions of the world (Gemede *et al*., 2015). The nutritional composition of edible okra includes crude fiber (27.33%) and total ash (14.05%) (Adewole and Ilesanmi, 2011). The growth and yield of okra depends on many factors including seed quality, nutrition, climatic conditions and cultural practices (Shahid *et al*., 2013). The okra plant is rich in nutrients, and its leaves and fruit are consumed as vegetables in the diet. In addition, okra has many therapeutic benefits: antidiabetic, antihyperlipidemic, antioxidant activity, and prevention of diseases associated with cell damage, treating dysentery, and diarrhea (Degni *et al.,* 2021.

Organic fertilizers such as manure, poultry manure, vermicompost. are very active and important for the soil. It provides most of the macro and micronutrients, protects the soil against erosion, supplies the cementing agent for the formation of the desired soil aggregates, and loosens the soil. The application of vermicompost and poultry manure further increases the yield and yield attributes of okra (Chowdhury et al., 2014). Organic matter in the form of compost is the decomposition of plant biomass that has been described through the activity of soil microorganisms. Green waste (GW) is an important part of municipal waste (MSW). The composition of GW varies greatly due to the diversity of source materials, vegetation types, and climatic conditions. C/N ratio higher than 25, deficit of essential nutrients, namely nitrogen (0.5-1.5%), phosphorus (0.1-0.2%) and potassium (0.4-0.8%) and high content of stubborn organic compounds (lignin) (Reyes-Torres *et al,* 2018).

Based on the description above, the researchers conducted a study on the effect of green waste compost to try to produce two types of okra, the stove, and the efficiency of nitrogen use. The objectives of this research were: (1) the effect of giving compost on okra crop yields, (2) the optimum dose of compost that needed to be given.

MATERIALS AND METHODS

The research was conducted from January to May 2017 in the experimental garden of the Faculty of Animal Husbandry and Agriculture, Diponegoro University, Semarang, Indonesia. The research location is at an altitude of 250 m above sea level. The soil at the experimental site had Oxisol, clay texture, soil pH 6.5, Ntotal 0.18%, Ptotal 0.18%, K_2O 0.23% and C 1.52%. Compost consists of Ntotal 1.32%, Ptotal 0.18%, K_2O 0.85 and C 11.51%. Plot size 3 x 3 square meters. Okra plants were planted with a spacing of 50 × 50 cm. The seeds used are green okra and red okra. A completely randomized trial design with a 2 x 4 factorial pattern with three replications was used in this study. Factor I was the type of okra (green okra, red okra), and factor II was the compost dose (0, 50, 100 and 150 kg N ha−1). Okra plants were harvested when the fruit length reached 10 cm.

Nitrogen absorption by plants is calculated according to the following formula:

absorption N = N × weight DM

Total nitrogen content was measured according to the Kjeldahl method. Nitrogen utilization efficiency, defined as okra fruit dry matter yield/per unit applied nitrogen; agronomic efficiency (AE), plant recovery efficiency of applied nitrogen, and physiological efficiency of applied nitrogen were calculated as described by Zhu et al., (2017), Ding et al., (2018) with modifications for okra plants, according to the following equations. :

Agronomic Efficiency = (grain yield in plots receiving N fertilizer - grain in control zero N)/ amount of N fertilizer applied

Plant recovery efficiency of applied nitrogen (NRE)% = total plant N uptake in aboveground biomass, respectively, with fertilizer application N (kg ha−1) - total plant N uptake in aboveground biomass, respectively, in the treatment of N removal (kg ha−1)/ the amount of fertilizer N applied (kg ha−1).

Physiological efficiency of applied nitrogen (NPE) is an index of the physiological efficiency of nitrogen absorbed defined as the ratio of kg grain production to kg of nitrogen absorbed in the production of above-ground dry matter (okra and straw) at maturity.

Statistic analysis

All data were statistically analyzed using analysis of variance (ANOVA) for a completely randomized block design, and a real difference test was used for mean separation ($P < 0.05$) following the procedure of Steel and Torrie (1990).

RESULTS AND DISCUSSION

Result

Okra fruit

In this study, compost applied as organic fertilizer resulted in a significant increase in the physical and biochemical parameters of experimental plants compared to control plants given organic fertilizer without compost (control). In addition, the addition of compost can increase the organic content of the soil. The ANOVA results showed a significant interaction effect between okra species and different compost doses in terms of okra fruit. Different okra types and compost dosage significantly affected the yields associated with okra fruit. Green okra increased about 23.22% to 118.78% after supplementation with compost nitrogen dose of 50 to 150 kg N ha−1 compared to no compost. Red okra increased 13.3% to 60.83% after supplementation with compost nitrogen dose of 50 to 150 kg N ha−1 compared to no compost dose (Table 1).

Nitrogen Okra Fruit

Different types of okra and compost dosage had a significant effect on fruit nitrogen(Table 1). Green okra fruit nitrogen increased with increasing compost dose, which increased 14.6% to 119.7% at a supplementary dose of 50 to 150 kg N ha−1 of compost nitrogen compared to no compost dose. Red okra fruit nitrogen increased with increasing compost dose, which increased 14.17% to 68.0% at 50 to 150 kg N ha−1 of compost nitrogen supplementation compared to no compost dose.

Table 1. Leaf area index, okra yield and rootstock, nitrogen content in okra fruit, nitrogen content in stover, nitrogen use efficiency and agronomic efficiency due to compost fertilization

Kind of Okra	Ncompost dosage	Leaf area index	Yield (kg.9m^{-2})	Straw(kg.9m^{-2})	N okra (g/kg)	Nbrang (g/kg)
Green okra	0	0.34^{d}	6.830^{d}	7.28^{b}	191.45^{d}	188.06^{bc}
	50	0.50^{c}	8.416^{c}	7.39^{b}	219.41^{c}	178.70^{c}
	100	**0.62^{c}**	9.983^{b}	8.72^{ab}	280.92^{b}	192.18^{bc}
	150	0.82^{b}	14.943^{a}	10.29^{a}	420.72^{a}	226.26^{ab}
Red okra	0	0.27^{d}	2.750^{e}	7.29^{b}	73.08^{f}	188.37^{bc}
	50	0.78^{b}	3.116^{f}	7.83^{b}	85.16^{f}	234.11^{ab}
	100	0.79^{b}	3.290^{f}	7.64^{b}	88.19^{f}	198.11^{bc}

	150	0.98^{a}	4.423^{f}	9.26^{a}	122.78^{e}	251.32^{a}
Green okra		0.57^{b}	10.043^{a}	8.42^{a}	278.12^{a}	196.30^{b}
Red okra		0.71^{a}	3.395^{b}	8.14^{a}	92.31^{b}	217.98^{a}
	0	0.31^{c}	4.790^{d}	7.28^{b}	132.26^{d}	188.22^{b}
	50	0.64^{b}	5.767^{c}	7.61^{b}	152.28^{c}	206.41^{ab}
	100	0.70^{b}	6.636^{b}	8.17^{b}	184.55^{b}	195.14^{b}
	150	0.90^{a}	9.683^{a}	10.06^{a}	271.75^{a}	238.79^{a}
Kind of Okra		*	*	*	*	*
N compost dosage		*	*	*	*	*
Okra*Compost		*	*	*	*	*

Straw Yield

The type of okra did not significantly affect the yield of straw(Table 1). The dose of compost had a significant effect on the production of straw. The production of green okra straw increased with increasing compost dose, which increased 1.51% to 41.34 5% at the addition of 50 to 150 kg N ha−1 of compost nitrogen dose compared to no compost dose. The production of red okra straw increased by 7.44% to 27.02% with 50 to 150 kg N ha−1 dose of nitrogen compost compared to no compost dose.

Straw nitrogen

The type of okra had a significant effect on the nitrogen yield of straw. The compost dose showed a significant effect on straw nitrogen (Table 1). Nitrogen absorption by green okra increased with increasing compost dose, which increased by 2.19% to 20.31% at a supplementary dose of 50 to 150 kg N ha−1 of compost nitrogen compared to no compost dose. The nitrogen content of red okra increased by 24.28% to 33.41% after GWC nitrogen supplementation at a dose of 50 to 150 kg N ha−1 compared to no compost dose.

Nitrogen Use Efficiency

Different types of okra and compost dosage significantly affected NUE (Table 2). NUE of green okra decreased with increasing compost dose by 41% after supplementation with compost nitrogen dose of 50 to 150 kg N ha−1. NUE of red okra also decreased with compost dose, which decreased by 47% to 53% after supplementation with compost nitrogen dose of 50 to 150 kg N ha−1.

Agronomic Efficiency (AE)

Different types of okra and compost dosage significantly affected agronomic efficiency. Agronomic efficiency (AE) of green okra increased with increasing compost dose, which increased from 99% to 411.6% after supplementation with compost nitrogen dose of 50 to 150 kg N ha−1. The agronomic efficiency of red okra increased with increasing compost dose, which increased from 48% to 360% after supplementation of compost nitrogen dose of 50 to 150 kg N ha−1. Different types of okra and compost dosage significantly affected the agronomic efficiency.

Applied Nitrogen Recovery Efficiency (NRE)

The type of okra and the dose of compost had a significant effect on NRE (Table 2). The NRE of green okra increased with increasing compost dose. NRE of red okra increased with increasing compost dose at a supplementary dose of 50 to 150 kg N ha-1 of compost nitrogen.

Applied Nitrogen Physiological Efficiency (NPE)

Okra types and compost dosages differed significantly in terms of NPE (Table 2). The NPE of green okra increased with increasing compost dose, which increased from 56% to 170.45% after supplementation with compost nitrogen dose of 50 to 150 kg N ha−1. NPE of red okra increased with increasing compost dose, which increased from 36.36% to 669.09% after supplementation with compost nitrogen dose of 50 to 150 kg N .ha−1.

NPE is dry matter above the soil, namely nitrogen fertilizer minus DM in the control divided by nitrogen fertilizer minus control nitrogen. The value of NPE in both types of okra increased with increasing nitrogen dose. This implies that the Nitrogen originating in the compost is capable of overhauling and using plants to provide plant physiological growth. For green okra, there was an increase in NPE by 55% to 166% due to compost from 100 to 150 kg N ha^{-1}. In red okra, there was an increase from 36% to 672.7% at a dose of 100 to 150 kg N ha^{-1} of compost.

Table 2. Efficiency of nitrogen use, agronomic efficiency, recovery efficiency of applied nitrogen and physiological efficiency of applied nitrogen due to compost fertilization

Kind of Okra	Ncompost dosage	NUE	Ag ef	R E	Nphys
Green okra	0	0.00^{e}	0.00^{d}	0.00^{e}	0.00^{f}
	50	4.21^{a}	4.36^{c}	37.05^{de}	0.17^{d}
	100	2.49^{b}	8.66^{b}	93.65^{bc}	0.27^{c}
	150	2.49^{b}	22.30^{a}	178.27^{a}	0.47^{b}
Red okra	0	0.00^{e}	0.00^{d}	0.00^{e}	0.00^{f}
	50	1.58^{c}	1.00^{d}	105.42^{b}	0.08^{de}
	100	0.82^{d}	1.48^{d}	39.28^{cde}	0.14^{e}
	150	0.73^{d}	4.60^{c}	75.10^{bcd}	0.84^{a}
Green okra		2.29^{a}	8.83^{a}	77.24^{a}	0.23^{a}
Red okra		0.79^{b}	1.77^{b}	54.95^{a}	0.26^{a}
	0	0.00^{c}	0.00^{d}	0.00^{c}	0.00^{d}
	50	2.89^{a}	2.68^{c}	71.24^{b}	0.13^{c}
	100	1.65^{b}	5.07^{b}	66.47^{b}	0.20^{b}
	150	1.61^{b}	13.45^{a}	126.68^{a}	0.66^{a}
Kind of Okra		*	*	*	*
N compost dosage		*	*	*	*
Okra*Compost		*	*	*	*

Discussion

The beneficial effects of organic fertilizers are due to their potential to promote microbial activity, increase nutrient availability, and enhance plant photosynthesis. In addition, the addition of organic fertilizers to the soil not only increases the availability of direct nutrients but also functions as a slow-release fertilizer to provide N, P, and K. The nitrogen content of the soil affects plant growth. Plant roots absorb soil nitrogen, especially nitrate (NO_3^-) and ammonium (NH_4^+), and then assimilate this inorganic nitrogen into the amino acid glutamine starting with the conversion of nitrate to ammonium (Goron and

Raizada, 2017). Nitrogen release from most of these sources is slow and highly dependent on mineralization processes in the soil, which are sensitive to various soil conditions, including humidity and temperature (Tiemens-Hulscher *et al*., 2014). Based on Purbajanti *et al*., 2019 that food crop biomass and N accumulation depend on physiological processes in plants. N absorption, C intake and growth rate, as well as C and N allocation in organs and in plants have their own characteristics. Soil conditions with large amounts of available N, plant N uptake depends on the availability and distribution of soil N and on roots. If the available N content is sufficient, then the N uptake is highly dependent on the rate of plant growth. Plant growth and development requires nitrogen because nitrogen is an important part of the structure of chloroplasts and proteins. Nitrogen deficiency is easily recognized in horticultural crops, but the effect of excess nitrogen on horticultural crop quality has not been studied.

Nitrogen is an important input factor required for plant growth and biomass production. The nitrogen concentration in the dry matter of straw increased linearly from 0.32% to 0.71% over the nitrogen treatment range (nitrogen supply levels ranging from 48 to 288 kg nitrogen ha−1) (Murosuka *et al*., 2014). Organic fertilizers are applied in the form of compost, and hence, large amounts of nitrogen are not available. Green okra shows greater value than red okra. Environmental factors such as temperature, rainfall, and texture affect the efficiency of nitrogen use, because they affect plant growth and development. Plant management includes parameters such as plant density, plant spatial planning, nitrogen fertilizer dosage, fertilization, and water (Benincasa *et al.*, 2011). Nitrogen utilization efficiency (NUE) can be defined as yield per unit of nitrogen available to plants (Wang and Peng, 2017), and it is the term used to indicate the relative balance between the amount of N fertilizer absorbed and used by plants. crop versus the amount of “lost” N fertilizer. Another way of thinking about NUE is in terms of the amount of grain harvested versus N supplied (Aynehband *et al*., 2012). Based on the results of this study, NUE decreased due to the addition of compost dose, while for red okra NUE increased from 41% to 53% with the given compost dose. It seems appropriate to investigate cereals that are only able to take up and use 30% to 50% of the available nitrogen (Beatty and Wong, 2017). Four commonly used agronomic indices to describe nutrient efficiency: partial factor productivity, ie kg yield per kg nutrient, are applied; agronomic efficiency, namely increasing yields per kg of applied nutrients; real recovery efficiency, i.e. kg of nutrients taken per kg of nutrients applied; and physiological efficiency, namely an increase in yield of kg per kg of nutrients absorbed (Sigua *et al.*, 2013). Agronomic Efficiency (AE) shows an increase in yield per unit of nitrogen applied. Nitrogen AE (NAE) was also calculated to assess the potential for increased yield in response to different nitrogen fertilization levels (Tedone *et al*., 2018). AE is affected by the amount of nitrogen fertilizer. Both AE and recovery efficiency can characterize the nutritional effect. Average AE nitrogen (AEN) has been reported to be 9.4 kg/kg (Chuan *et al*., 2016).

NRE shows the total nitrogen from the accumulation of nitrogen fertilizer above the soil minus the total nitrogen accumulated above the control zero soil divided by the amount of nitrogen applied (Hou *et al.*, 2019). The NRE values obtained in this study indicate an inconsistent effect. EBT of green okra increased from 37.19% to 178.27% with increasing nitrogen dose from GWC. This result contradicts the results of Chuan *et al.*, (2016), who reported that the value of EBT for rice could reach 50% to 80%. Red okra had inconsistent effects, where increasing the compost dose to 100 kg N ha^{-1} resulted in a 78.5% decrease in EBT, but with 150 kg N ha^{-1} nitrogen, it further decreased to 35.04%.

The availability of nitrogen mainly affects the pattern of biomass allocation between vegetative and reproductive organs of plants because nitrogen concentrations are much more stable in plants. The application of compost revitalizes the biological activity of the soil and reverses the negative effects of chemical fertilizers. Changes in compost with chemical fertilizers increase soil biomass, soil respiration, enzymatic activity, and nitrification rate (Sharma *et al.*, 2017). Nitrogen release from most sources of organic matter is slow and highly dependent on the mineralization process in the soil and is sensitive to various soil conditions, including humidity and temperature (Taiwo, 2011).

CONCLUSION

The analyzed compost dose resulted in an increase in Nitrogen uptake, and yields of green and red okra. Increasing the compost dose did result in a decrease in the efficiency of nitrogen use in green okra. In addition, with increasing doses of compost, agronomic efficiency, nitrogen recovery efficiency and physiological nitrogen efficiency also increased in green and red *Abelmoschus esculentus* plants. Green okra is more efficient in utilizing organic nitrogen from compost.

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