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The Influence of Organic and Inorganic Fertilizers on the Growth and Yield of Green Bean, *Phaseolus vulgaris* L. Grown in Dry and Rainy Season

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ABSTRACT

Research aimed to study the influence of organic and inorganic fertilizers on growth and yield of green bean (*Phaseolus vulgaris* L.). It was conducted in Andisol soil, Batu, East Java, 900 m above sea level, 24-27°C for dry season (from May to July 2013) and rainy season (from January to March 2014). A randomized block design was used to arrange five treatments such as 1) no fertilizers applied; 2) five t ha^{-1} cow manure; 3) 10 t ha^{-1} cow manure; 4) 50 kg N ha^{-1}, 150 kg P_2O_5 ha^{-1} and 50 kg K_2O ha^{-1}; and 5) 100 kg N ha^{-1}, 300 kg P_2O_5 ha^{-1} and 100 kg K_2O ha^{-1}. All treatments of bean was planted in 4 x 3 m^2 of plot size and 25 x 20 cm^2 of plant spacing. Treatment of 100 kg N ha^{-1}, 300 kg P_2O_5 ha^{-1} and 100 kg K_2O ha^{-1} resulted in the highest growth (plant height, leaf number/plant, and leaf area/plant) and yield of pod fresh weight (12.46 t ha^{-1}, in 2013; 16.51 t ha^{-1}, in 2014). The lowest growth and yield was showed by no fertilizer application (6.23 t ha^{-1}, in 2013; 8.36 t ha^{-1}, in 2014).

Keywords: dry and rainy seasons; green beans; inorganic fertilizers; organic fertilizers

INTRODUCTION

Phaseolus vulgaris L., is commonly known as common bean, dry bean, French bean, and green bean (Gepts, 1998; Łabuda & Brodaczewska, 2007; Moniruzzaman, Islam, & Hasan, 2008; Câmara, Urrea, & Schlegel, 2013; Petry, Boy, Wirth, & Hurrell, 2015, and Swegarden, Sheaffer, & Michaels, 2016), the most important food legume in the world such as Eastern Africa and Latin America (Petry, Boy, Wirth, & Hurrell, 2015) and Indonesia (Directorate General of Horticulture, 2015). Green bean is one of the common names for *P. vulgaris* that harvested before the seed development phase (Gepts, 1998). Bean is a good source of protein, folic acid, dietary fiber and complex carbohydrates (Jones, 1999). Câmara, Urrea, & Schlegel (2013) explained that *P. vulgaris* contain high levels of chemically diverse components (phenols, resistance starch, vitamins, and fructooligosaccharides). Some components contained in the *P. vulgaris* have shown to protect against such conditions as oxidative stress, cardiovascular disease, diabetes, metabolic syndrome, and many types of cancer, thereby positioning this legume as an excellent functional food (Câmara, Urrea, & Schlegel, 2013).

Directorate General of Horticulture (2015) reported that the production of green bean in Indonesia is 318,214 t, the harvest area 28,632 ha and the productivity is 11.11 t ha^{-1}. In Indonesia, green beans can be grown in all of the provinces. The central area production of green beans is in Sumatra and Java. West Java as the widest area (6,111 ha) and West Sulawesi as the narrowest area (9 ha) produce 94,623 t (15.48 t ha^{-1} productivity) and of 15 t (1.77 t ha^{-1} productivity) respectively. Each area is mostly up land, high temperature and low rainfall.

In India, commercial cultivation of French bean, similar to other vegetables, inherits the inclusion of higher doses of nitrogen for better growth and yield as the plants are capable of fixing atmospheric nitrogen from the environment by microbes. However, feeding of plants for nitrogen through the application of fertilizers as well as organic manures has been proved to be beneficial for higher yield (Reddy, 2008; Maske, Kadam, Tidke, & Pawar, 2009).

Band et al. (2007) reported that related to human population explosion, the demand for the crop has increased significantly, leading to the extensive use of chemical fertilizers without any consideration for soil health and quality, which is a critical factor for realizing sustainable yield. The chemical fertilizers application not only increases production cost but gradually decreases the partial productivity and causes high risk to the sustenance of the basic system. The minimum application of organic manures has also caused soils deficient in macro and micro nutrients.

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The balance of organic and inorganic fertilizer use is the key to manage the soil nutrients properly. (Triwulaningrum, 2009). That is due to the organic fertilizer and inorganic fertilizer contributed many advantages of each. Application of inorganic fertilizer is a faster way to maintain the productivity of crop because the nutrients are releasing nutrients (e.g. NPK nutrients) form which is easily available to plants. While the organic matter may consist of manure organic (cow manure, green manure) able to improve the physical, chemical, and biological soil.

The use of organic and inorganic fertilizer able to increase yield of green bean (Duaja, 2015) and also using cultivars, plant spacing, dosages of organic and inorganic fertilizers and irrigation (Sherawat & Singh, 2009; Datt, Dubey, & Chaudhary, 2013; Ghosh, Biswas, & Dhangrah, 2014).

Besides application of organic and inorganic fertilizers for increasing the yield of green bean, the farmers also considered the time of planting for grown in that plants particularly in relation with the availability of water. In upland areas in which the water for plants growing only depends on the rainfall (rainy season). Respectively, rainy and dry seasons in Java Island commonly occur from October to March and from April to September (Indonesian Meteorological, Climatological, and Geophysical Agency, 2017).

Green bean can easily be grown in a field as well as in Homestead garden if the soil is managed properly. The use of organic and inorganic fertilizers is able to increase yield of green bean (Jagdale, Khawale, Baviskar, Doshinge, & Kore, 2005; Duaja, 2015), and also the use of cultivars, plant spacing, dosages of organic and inorganic fertilizer (Sawargaonkar, Shinde, Sirdeshpande, Kshirsagar, 2009; Sherawat & Singh, 2009; Ghosh, Biswas, & Dhangrah, 2014).

This study aimed to elucidate the influence of organic and inorganic fertilizers on growth and yield of green bean, *P. vulgaris* grown in dry and rainy season.

MATERIALS AND METHODS

A field experiment was conducted in the dry season (from May to July 2013), and in the rainy season (from January to April 2014). Five treatments such as 1) no fertilizer; 2) 5 t ha^{-1} cow manure; 3) 10 t ha^{-1} cow manure; 4) 50 kg N ha^{-1} of ZA, 150 kg P_2O_5 ha^{-1} of SP36 and 50 kg K_2O ha^{-1} of KCl; and 5) 100 kg N ha^{-1} of ZA, 300 kg P_2O_5 ha^{-1} of SP36 and 100 kg K_2O ha^{-1} of KCl were arranged in a randomized block design with four replicates.

Green bean, gypsy variety seeds were sown at plant spacing of 40 x 20 cm and used a plot size 4.0 x 1.2 m. All doses of cow manure, P_2O_5, K_2O and 1/3 dose of N were applied at planting of green bean and the rest 2/3 dose of N was applied at 28 days after planting (dap). In dry season of 2013, the plants were irrigated twice at 14 and 28 dap.

At 49 dap, a heigh of the plant (PH), the number of leaves per plant (LNpP), and leaf area per plant (LApP), were measured. The number of pods per plant (PoNpP) was observed at 56, 60, 64, and 68 dap. The pod fresh weight per pod (PoFWpPo), the pod fresh weight per hectare (PoFWpH) of the bean were measured from harvested area (per m^2 = 12.5 plants). All plant growth variables and yield per plant were measured from selected five plant samples. Soil samples from each treatment were also collected for chemical analysis on the last harvest.

The data obtained were analyzed statistically using the Excel program for Windows 7.0 version. Significant results were further analyzed using LSD 5 %.

RESULTS AND DISCUSSION

There were responses of growth and yield of green beans that applied by inorganic and organic fertilizers and planted in the dry and rainy seasons. Plant height, the number of leaves per hill (sheet), leaf area (cm^2) at 56 dap in the dry season of 2013 and the rainy season of 2014 were presented in Table 1 and Table 2.

Application of inorganic fertilizers 100 kg N ha^{-1}, 300 kg P_2O_5 ha^{-1} and 100 kg K_2O ha^{-1} resulted in plant height, leaf number per plant, leaf area per plant with values 43.85 cm, 26.14 sheets, 3327.84 cm^2 and 4.06, respectively. Singh (2000) reported that high–pod yields (13.5 and 14.9 t ha^{-1}) were produced by the application of 150 kg Nitrogen.

The number of pod per plant, pod fresh weight per plant and per ha of green beans treated by no fertilizer resulted an average of 7.54 pods, 5.86 g/pod and 6.23 t ha^{-1}. The application of five and 10 t ha^{-1} cow manures yielded an average of 7.15 and 9.05 g/pods or increased 14.76 and 45.26 % (Table 3).

Table 1. Averages of the growth and yield variables of green bean Gypsy variety were recorded from each treatment in dry season, 2013

Treatments	PH (cm)	LNpP	LApP (cm^2)	PoNpP	PoFWpPo (g)	PoFW pH (t ha^{-1})
No fertilizer	33.44a	20.83a	2003.64a	7.54a	5.86a	6.23a
5 t ha^{-1} cow manure	35.53b	22.68a	2521.35b	8.62b	6.26ab	7.15b
10 t ha^{-1} cow manure	40.11c	24.39c	2843.61c	11.41c	6.85bc	9.05c
50 kg N ha^{-1}, 150 kg P_2O_5 ha^{-1}, 50 kg K_2O ha^{-1}	41.06c	24.95c	3066.42c	12.21d	7.08c	9.94d
100 kg N ha^{-1}, 300 kg P_2O_5 ha^{-1}, 100 kg K_2O ha^{-1}	43.85d	26.14d	3327.84d	13.68e	7.24c	11.81e
LSD 5 %	1.19	1.17	212.78	0.51	0.49	0.55
CV %	6.93	11.12	17.43	10.81	16.67	14.12

Remarks: Plant Height (PH), Leaf Number per Plant (LNpP), Leaf Area per Plant (LApP), Pod Number per Plant (PoNpP), Pod Fresh Weight per Pod (PoFWpPo), and Pod Fresh Weight per Ha (PoFWpH). Number followed by the same letter in each coloum was no significantly different (tested by LSD 5 %)

Table 2. Averages of the growth and yield variables of green bean Gypsy variety were recorded from each treatment in rainy season 2014

Treatments	PH (cm)	LNpP	LApP (cm^2)	PoNpP	PoFWpPo (g)	PoFW pH (t ha^{-1})
No fertilizer	38.31a	22.23a	2216.33a	9.72a	6.88a	8.32a
5 t ha^{-1} cow manure	42.01b	24.42b	2523.26b	10.33a	7.18abc	9.46b
10 t ha^{-1} cow manure	43.41c	26.41c	2850.82c	12.11b	7.58bc	11.29c
50 kg N ha^{-1}, 150 kg P_2O_5 ha^{-1}, 50 kg K_2O ha^{-1}	43.14c	27.72c	3127.88d	14.38c	7.66c	14.55d
100 kg N ha^{-1}, 300 kg P_2O_5 ha^{-1}, 100 kg K_2O ha^{-1}	46.05d	29.28d	3346.77e	16.69d	8.09cd	16.58e
LSD 5 %	1.19	1.35	208.13	0.79	0.56	0.59
CV %	10.13	11.75	16.72	14.19	17.04	11.22

Remarks: Plant Height (PH), Leaf Number per Plant (LNpP), Leaf Area per Plant (LApP), Pod Number per Plant (PoNpP), Pod Fresh Weight per Pod (PoFWpPo), and Pod Fresh Weight per Ha (PoFWpH). Number followed by the same letter in each coloum was no significantly different (tested by LSD 5 %)

Table 3. Percentages of increasing growth and yield of green beans Gypsy variety planted in rainy season 2014 to dry season 2013 for six variables

Treatments	PH	LNpP	LApP	PoNpP	PoFWp/P	PoFW
				(%)		
No fertilizer	14.56	6.72	10.61	28.91	17.40	33.54
5 t ha^{-1} cow manure	18.23	7.67	0.07	19.83	14.69	32.30
10 t ha^{-1} cow manure	8.22	8.28	0.25	6.13	10.65	24.75
50 kg N ha^{-1}, 150 kg P_2O_5 ha^{-1}, 50 kg K_2O ha^{-1}	5.04	11.10	2.00	17.77	8.19	46.37
100 kg N ha^{-1}, 300 kg P_2O_5 ha^{-1}, 100 kg K_2O ha^{-1}	5.01	12.01	0.56	22.00	11.74	40.38

Remarks: Plant Height (PH), Leaf Number per Plant (LNpP), Leaf Area per Plant (LApP), Pod Number per Plant (PoNpP), Pod Fresh Weight per Plant (PoFWpP), and Pod Fresh Weight per Ha (PoFWpH)

The highest yield of green bean planted in the dry season (11.81 t ha^{-1}) was reached by application of 100 kg N ha^{-1}, 300 kg P_2O5 ha^{-1} and 100 kg K_2O ha^{-1}. It was 89.56 % higher than no fertilizer treatment. Application of fertilizers tends to affect the yield of green bean. Application of inorganic fertilizer produces a higher yield than organic fertilizer, because of an inorganic fertilizer releases nutrients faster than organic fertilizer (Safitry & Kartika, 2013). The highest yield of green bean planted in the rainy season of 2013 (16.58 t ha^{-1}) was also obtained by application of 100 kg N ha^{-1}, 300 kg P_2O5 ha^{-1} and 100 kg K_2O ha^{-1}. This was 99.27 % higher than no fertilizer treatment, and it was 40.38 % higher than dry season in 2014. Meanwhile, the yield was significantly affected by fertilizer application (Ghosh, Biswas, & Dhangrah, 2014) respectively that the highest green pod yield (14.38 t ha^{-1}) was obtained on 80, 150 and 80 kg NPK ha^{-1}.

The results of experiment as well as reported that the yield of green beans varied depending on methods of cultivation such as the use of cultivars, fertilizer and plant spacing (Maske, Kadam, Tidke, & Pawar, 2009; Djuariah, Rosliani, Kurniawan, & Lukman, 2016), dosages and kinds of fertilizers applied (Sherawat & Singh, 2009), time of planting date, application plant regulator, hormones, vermicompost, and biofertilizer (Safitry & Kartika, 2013; Duaja, 2015). This indicates that soils in the tropical as well in subtropical mostly are in shortage of N and responsive to inorganic and organic fertilizers application).

Before planting the green bean in the dry season, the soil had a low content of N (0.11 %) and medium content of cow manure (0.35 %). After planted and treated with organic and inorganic fertilizers, N content of the soil was 0.13 %. The soil N content before planting green bean in rainy season was 0.05 % (Table 4). After planted with the green bean and treated with organic and inorganic fertilizers, N content of the soil was lower (0.09 – 0.13 %) than soil condition before planting in the dry season.

In rainy season of 2014 and dry season 2013, soil P contents prior to experiment were very high (30.56 and 28.42 ppm P_2O_5, respectively). At harvest of green bean, the soil P content increased.

The change of P content in the soil after harvest ranged from 31.33-33.46 ppm P_2O_5 (for no fertilizer) to 43.16-48.26 ppm P_2O_5 (for 50 kg N ha^{-1}, 150 kg P_2O_5 ha^{-1} and 50 kg K_2O ha^{-1}). This indicated that the P soil status was still very high, although the requirement of green bean is high.

At harvest of green bean, K content in the soil decreased from an average of 0.16 me (no fertilizer) up to 0.24 me (100 kg N ha^{-1}, 300 kg P_2O_5 ha^{-1} and 100 kg K_2O ha^{-1}). Meanwhile, in the dry season, K content in soil was higher than that in the rainy season (Table 5). It assumed that K content in soil on rainy season 2014 was in low concentration (with an average of 0.35 me).

Table 4. The nutrient properties of soil before planting, cow manure and soils after planting green bean Gypsy variety on each treatment in rainy season 2014

Nutrients	pH (H_2O)	% C	C/N	% OM	% N	P_2O_5 (ppm)	K (me.$100g^{-1}$)	CEC (me.$100g^{-1}$)
Before planting:								
Soil	5.79	0.79	15.80	1.36	0.05	30.56	0.35	10.78
Cow Manure	6.72	9.14	26.11	16.24	0.35	0.21	0.90	8.11
Soil after planting:								
No fertilizer	6.93	1.02	11.33	2.02	0.09	31.33	0.16	8.43
5 t ha^{-1} cow manure	7.02	1.12	10.18	2.17	0.11	32.65	0.18	8.28
10 t ha^{-1} cow manure	7.12	1.04	8.66	2.28	0.12	33.46	0.21	11.82
50 kg N ha^{-1}, 150 kg P_2O_5 ha^{-1} 50 kg K_2O ha^{-1}	7.04	1.01	9.18	2.11	0.11	43.16	0.22	9.02
100 kg N ha^{-1}, 300 kg P_2O_5 ha^{-1}, 100kg K_2O ha^{-1}	6.24	1.02	7.84	2.24	0.13	41.33	0.24	10.26

Remarks: Data were collected from Soil Laboratory, Technical Unit of Agribusness Development for Food Crops and Horticulture, Bedali, Malang regency, East Java

Table 5. The nutrient properties of soil before planting, cow manure, and soils after planting green bean Gypsy variety on each treatment in dry season 2013

Nutrients	pH (H_2O)	% C	C/N	% OM	% N	P_2O_5 (ppm)	K (me.$100g^{-1}$)	CEC (me.$100g^{-1}$)
Before planting:								
Soil Before Planting	7.09	1.24	10.88	2.14	0.11	28.42	0.51	10.91
Cow Manure	7.97	10.60	23.04	18.26	0.46	0.28	1.22	6.31
Soil after planting:								
No fertilizer	7.14	1.26	11.05	2.17	0.11	33.46	0.19	8.47
5 t ha^{-1} cow manure	7.27	1.32	9.42	2.27	0.14	34.46	0.19	8.33
10 t ha^{-1} cow manure	7.37	1.34	10.15	2.31	0.13	36.4	0.17	13.61
50 kg N ha^{-1}, 150 kg P_2O_5 ha^{-1}, 50 kg K_2O ha^{-1}	7.15	1.26	10.08	2.17	0.13	48.26	0.17	10.32
100 kg N ha^{-1}, 300 kg P_2O_5 ha^{-1}, 100 kg K_2O ha^{-1}	6.67	1.28	9.69	2.21	0.13	40.33	0.15	10.42

Remark: Data were collected from soil laboratory, technical unit of agribusiness development for food crops and horticulture, Bedali, Malang regency, East Java

Table 6. Precipitations during field experiment in dry and rainy seasons

Months	Dry season (2013)		Rainy season (2014)	
	Precipitations (mm)	Days	Precipitations (mm)	Days
May	41	7	-	-
June	4	1	-	-
July	0	0	-	-
January	-	-	398	24
February	-	-	193	17
March	-	-	210	11
Total	44	8	802	52

Note: Data were collected from Climatological Station of Experimental Garden, Punten, Batu, East Java.

The chemical composition of cow manure is varied, depends on the manure composting process on the soil. Aini, Sivapragasam, Vimala, & Mohamad Roff (2005) reported that N, P, and K contents in cow manure are 2.04, 0.76 and 0.82 %, respectively. It means that the N, P, and K contents in cow manure varied and influence the growth and yield of plants.

No fertilizer treatment affects the N status of soil and K contents were low however the P content was very high, both in rainy and dry seasons. For no fertilizer treatment, the green bean yield increased 33.5 %. Application of 5 t ha^{-1} cow manure increased the green bean yield by 32.3 %. Application of 100 kg N ha^{-1}, 300 kg P_2O_5 ha^{-1}, and 100 kg K_2O ha^{-1} increase the yield around 40.4 %.

Sherawat & Singh (2009) reported that the highest pod yield of 23.14 t ha^{-1} (average of 2005-2006 and 2006-2007) was reached through the application of 120-120-60-20-4-1 kg of N-P_2O_5-K_2O-S-Zn-B and 0.5 kg Mo ha^{-1} while added by 10 t ha^{-1} cow manure which followed by 120-80-60-20-4-1 kg of N-P2O5-K2O-S-Zn-B and 0.5 kg Mo ha^{-1} along with 10 t ha^{-1} cow manure. The response equations indicated an optimum level of 138.6 kg N, 131.5 kg P_2O_5, 63.4 kg K_2O and 17.4 kg S ha^{-1} for higher green fruit yield of French bean. Sherawat & Singh (2009) also mentioned that application of nitrogen and phosphorus significantly influenced the pod yield of French bean. Among the N levels, the highest grain yield (2.286 t ha^{-1}) by the application of 120 kg N ha^{-1} and the lowest grain yield (1.557 t ha^{-1}) was resulted in 0 kg N ha^{-1} (without N).

Based on total precipitation and rainy day, rainy season in 2014 was 18 (802 mm) and 6 times (52 days) higher than dry season respectively (Table 6), It seem that all variables such as plant height, leaf number per plant, leaf area per plant, pod number per plant, pod fresh weight per pod, and pod fresh weight per ha in rainy season 2014 were higher than dry season 2013. Podleśny and Podleśna (2011) reported that amount and distribution of rainfall have a strong impact on the development of morphological characteristics in lupin, i.e.: seed yields. Reichert et al. (2015) explained that during grain filling stage, limited rainfall can cause the low plant available water that resulted the negative effect on crop yield.

CONCLUSION

Green beans Gypsy variety which was grown in the dry season of 2013 showed the lower grow development (plant height, leaf number per plant, leaf area per leaf) and yield (number pods per plant, pod fresh weight, the weight of pod per area), than that grown in the rainy season of 2014.

Application of 100 kg N ha^{-1}, 300 kg P_2O_5 ha^{-1} and 100 kg K_2O ha^{-1} yielded 12.46 t ha^{-1} in the dry season of 2013. Meanwhile, the result of ca. 16.51 t ha^{-1} in 2014 was higher than without fertilizer. The lowest growth and yield of pod fresh weight in 2013 was 6.23 t ha^{-1}, while that in 2014 was 8.6 t ha^{-1}.

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