UDC 633; DOI 10.18551/rjoas.2022-02.12

TIME SYNCHRONIZATION OF VP3 BIOFERTILIZER APPLICATION TO INCREASE YIELD OF THREE LEGUMES AND THEIR EFFECT ON THE DYNAMICS OF SOIL BACTERIAL POPULATIONS

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ABSTRACT
This study was to determine the time synchronization of biofertilizer application towards the growth and yield of 3 different legumes (green bean, yard long bean, mung bean) and examining that effect to the dynamics of the population of soil bacteria. The research design used was a simple randomized block design (RAK) with 8 treatments and 3 replications. ANOVA and multivariate analysis was used to detect the impact of treatment to selected variable such as: plant height, number of leaves, number of flowers and pods and yields (weight of pod). The result showed that the best application of VP3 biofertilizer on green bean yields was found under TKHA1V. Meanwhile, the greatest long bean yield were detected under the treatment of TKHB1G whilst the best treatment to obtain the highest mung bean yields was under TKHB2VG (soil were incubation for 1 week before planting and VP3 biofertilizer were applied at 7 days after planting). This difference is mainly due to the crop physiological behaviour. This information was important for basis recommendations of VP3 biofertilizer application in the field. Discriminant analysis can show treatment groupings based on the variables of agronomic properties and production of legumes, each of which has a different response to the given treatment with discriminant analysis values ranging from 69 – 72% for SCORE a (X axis) and 19 -23% for SCORE 2 (Y axis).

KEY WORDS
Biofertilizer, nutrient, soil, legume, vermicompost.

Beans are major commodities which can be group into legumineous vegetable, cultivated for many decades (Islam et al., 2016). This product was originated from America and becoming a source of food for human or animal since this contain rich in protein and vitamin (Valdez-Perez et al., 2011). Among various beans in Indonesia, 3 major bean products in many regions which achieved their popularity are: green bean, yard long bean and mung bean which include to the group of legume crop. Most human dietary protein are fulfilled from grain legume (Htwe et al., 2019). Legume itself can be associated with bacteria and their inoculation help to maintain nutrient uptake at optimum level. These commodities are responsive to the application or fertilizer which contain phosphorous (P) (Li et al. 2011; Ranjbar-Mohaddam and Aminpanah, 2015) or Nitrogen (N) (Sindhuja et al., 2021). For achieving better legume yields, a optimum quantities of nutrient are required, which usually being fulfilled using an-organic fertilizer in massive doses, but the over dose of using inorganic fertilizer causing residual effect which will be harmful to the environmental. Degradation in ecosystem can be minimize when organic fertilizer was employed to combat the negative effect and rehabilitated degraded environment (Francis and Daniel, 2004; Pagliali et al., 2004). However, the application of biofertilizer under the combination with organic or inorganic fertilizer on legume crop is rarely informed. If any mostly biofertlizer applications were conducted for food crop (i.e. corn, rice). The use of biofertilizer can minimizing cost for fertilizer use since it has been contained plant growth promoting bacteria agent (Htwe et al., 2019).

Biofertilizer is commonly used as an alternative or complementary to chemical fertilizers to increase soil fertility and crop production (Mukhlis and Lestari, 2013; Peter and Satish, 2015). Biofertilizer itself is a substance that contains living microorganisms, which have ability to make nutrients available to plants through biological processes (Hegde et al., 1999; Vessy, 2003). The advantage of using biofertilizers in crop cultivation is that it can increase efficiency of fertilization to increase production yields of a plant and the agricultural system can be sustainable, also increase soil fertility and soil and plant health (Shen, 1997) and could absorb Nitrogen from the atmosphere (Chen, 2006). In the application of biofertilizers, farmers usually apply it together with compost intended to enrich the availability of nutrients for plants so that plants can absorb nutrients needed for plant growth and can increase crop yields (Saraswati et al., 2014). In addition, compost is also a source of energy and nutrients for microbes in the soil for the decomposition process to produce humus that can improve physical, chemical and biological properties of the soil (Setyorini et al., 2006). Improvement of soil physical properties includes soil structure, which can increase soil micro and macro pores so that groundwater absorption and air movement (aeration) in the soil become better. With the physical improvement of soil, plants can easily absorb nutrients available in the soil so that it helps the growth process and increases crop yields (Fawzy et al., 2012; Zafar et al., 2011).

This study was to determine the time synchronization of VP3 biofertilizer (made from extracted vermicompost combine with selected bacteria) application which had been formulated by Arfarita et al., (2019b) and then tested in a greenhouse with compost. The VP3 biofertilizer formulation contains soil bacteria, including *Bacillus licheniformis* as N-free fixation (Arfarita et al., 2019a), *Pantoea ananatis* (Arfarita et al., 2017) as P-solubilizing bacteria and *Pseudomonas plecoglossida* as exopolysachcharaide-producing bacteria (Arfarita et al., 2016b) which has been formulated with a vermiwash carrier. According to Musnamar (2003), the application of biofertilizer with vermiwash greatly affects fresh weight and affects plant length. This shows that liquid formulation of biofertilizer made from vermiwash carrier is not only able to improve soil fertility, but also provides additional growth hormones and nutrients that make root and stem vigor of plants stronger and help plant growth and yields to be better. This study was tested on the yield potential of 3 legumes (green beans, yard long beans and green beans) and observed the population dynamics of soil bacteria as indicators of soil microbiological fertility. Synchronization of application time was also observed in this study, because several studies showed that there were differences in plant response to application time and biofertilizer application period. As reported by Nurhayati (2012), the application of biofertilizer at planting and the interval of application every 20 days did not have a significant effect on the growth of potato plants. However, another study revealed that the application of biofertilzer with three applications resulted in the best number of pods and pod weight compared to the application of 1 and 2 times to soybean plants (Anggriani et al., 2016). It was also reported by Asroh (2010), that the application of biofertilizer with an interval of 2 weeks can increase the growth and production of corn plants. Another study revealed that giving biofertilizer 2 times at the time of planting at age of 21 and 35 days after planting gave the best fresh weight yields for bean plants (Rizqiani et al., 2007). The application of 75 % RDn through inorganic + 25 % RDN through vermicompost + biofertlizer (Rhizobium + PSB) resulted in highest yield on yardlong bean (Sindhuja et al., 2021). Biofertilizer accompanied with 13 kg urea ha^{-1} are the best option to improve mungbean yield (Mondal et al., 2012). Previous finding also described that application of P fertilizer at the rate of 100 kg ha^{-1} along with biofertilizer application was achieved the best yield of green bean (Ranjbar-Mohaddam and Aminpanah, 2015).

This liquid biological fertilizer product has never been applied, so in this study we also observed the population dynamics of soil bacteria in the application of biofertilizer during the growing season in the greenhouse. Sutedjo et al., (1996) stated that the population of soil bacteria is influenced by organic matter content, suitable climatic conditions, types of vegetation and well-available moisture. The type of vegetation determines because plant roots carry out metabolic activities so that they release metabolites called exudates into the soil that can affect microorganisms in the rhizosphere. As stated by Gibson (1981), that

metabolic activity and metabolites released by plants through roots, are determinants of the microbiological state of the soil in the root area of plants. The population of soil bacteria varies because the development of soil bacteria is very dependent on soil conditions (Soepardi, 1983). Therefore, in addition to synchronizing the time of application of the VP3 biofertilizer, this study also observed the dynamics of the population of soil bacteria for 80 days after planting until the generative phase of 3 legumes which were carried out in a composite manner after going through a preliminary test.

METHODS OF RESEARCH

The research was conducted at greenhouse facilities of Faculty of Agriculture and the Microbiology Laboratory at Integrated Lab of University of Islam Malang. The types of plants used in this study were 3 legume plants, namely beans, long beans and green beans. The research design used was a simple randomized block design (SRD) with 8 treatments which were repeated 3 times to obtain 24 plots. Each plant has a different research plot. Soil nutrient status were determined using composite soil sample to detect Nitrogen content using Kjedahl method, while the determination of soil P and K were using spectrophotometer technique.

The treatments used in this study are described in Table 1. Application of VP3 biofertilizer on bean consisted of several treatments, as follows: TKHA1V (VP3 biofertilizer were applied 7 days before planting + 4 days after planting), TKHA1G (VP3 biofertilizer were applied 7 days before planting + at 31 days after planting), TKHA2VG (VP3 biofertilizer were applied 7 days before planting + 4 days after planting + 31 days after planting), TKHB1V (VP3 biofertilizer were applied at planting + 4 days after planting), TKHB1G (VP3 biofertilizer were applied at planting + 31 days after planting), TKHB2VG (VP3 biofertilizer were applied at planting + 4 days after planting + 31 days after planting). In long beans, the treatments were TKHA1V (VP3 biofertilizer were applied 7 days before planting + 7 days after planting), TKHA1G (VP3 biofertilizer were applied 7 days before planting + 32 days after planting), TKHA2VG (VP3 biofertilizer were applied 7 days before planting + 7 days after planting + 32 days after planting) , TKHB1V (VP3 biofertilizer were applied at planting + 7 days after planting), TKHB1G (VP3 biofertilizer were applied at planting + 32 days after planting), TKHB2VG (VP3 bioferrtliser were applied at planting + 7 days after planting + 32 days after planting). For green beans, treatment as follow: TKHA1V (VP3 biofertilizer was applied 7 days before planting + 7 days after planting), TKHA1G (VP3 biofertilizer were applied 7 days before planting + 30 days after planting), TKHA2VG (VP3 biofertilizer were applied 7 days before planting + 7 days after planting + 30 days after planting), TKHB1V (VP3 biofertilizer were applied at planting + 7 days after planting), TKHB1G (VP3 biofertilizer were applied at planting + 30 days after planting, TKHB2VG (VP3 biofertilizer were applied at planting + 7 days after planting + 30 days after planting).

Table 1 – Treatments for three legumes and the codes

No	Code	Treatments
1	TB	Control
2	TK	Compost
3	TKHA1V	Compost + 2 times application of VP3 biofertilizer (7 days before planting + vegetative phase)
4	TKHA1G	Compost + 2 times application of VP3 biofertilizer (7 days before planting + generative phase)
5	TKHA2VG	Compost + 3 times application of VP3 biofertilizer (7 days before planting + vegetative phase + generative phase
6	TKHB1V	Compost + 2 times application of VP3 biofertilizer (at planting + vegetative phase)
7	TKHB1G	Compost +2 times application of VP3 biofertilizer (at planting + generative phase)
8	TKHB2VG	Compost + 3 times application of VP3 biofertilizer (at planting + vegetative phase + generative phase)

The vegetative phase of green beans was at 7 days after planting and the generative phase was at 34 days after planting (BALITAS, 2013). The vegetative phase of long yard bean plants is 10 days after planting and the generative phase is 35 days after planting in

long yard beans (Haryanto, 2007). For mung bean, the vegetative phase is 10 days after planting and the generative phase is 33 days after planting (BALITKABI, 2016). Parameters which were detected described in Table 2.

Table 2 – Variable of legume to be measured and method

Aspect	Variable	Methods
Agronomy	Number of leaves	calculated from leaves that have fully opened per plant (strands)
	Plant height	measured from the base of the stem on the ground to the point of growth of the main stem of the plant (cm)
	Amount of Flowers	calculated from the time the first flower appears until the plant no longer produces flowers. Flowers that are counted are flowers that have fully bloomed (buds)
	Percentage of flowers into pods	calculated from the number of pods formed in one plant divided by the number of flowers formed then multiplied by 100% (%)
	Amount of pods	calculated from the number of pods harvested (fruit)
	Pod weight	calculated from the weight of the harvested pods (grams) on beans and long beans
	Seed weight	calculated from the weight of harvested pods (grams) on green bean plants
Soil	Soil bacterial population dynamics	Total Plate Count (log cfu/gram) on PCA medium
	Soil N	Total soil N using Kjeldhal
	Soil P and K	Spectrofotometer

The planting medium was soil free of inorganic fertilizers which was then mixed with compost. Each polybag contained 8 kg of soil and 80 grams of compost then mixed evenly. Meanwhile, the application of VP3 biofertilizer with an incubation period was carried out by mixing the VP3 biofertilizer with water according to the dose, then sprinkled on a mixture of soil and compost, stirred evenly, covered with black plastic for 1 week, after that it was put into a polybag.

The grren bean seeds used were “Lebat 3” variety, the long beans were “Kanton Tavi” variety and the mung beans were Vima 1. Prior to planting, the seeds of all plants were pretreated with fungicides to prevent fungal infections. Before planting, the soil media in polybags must be watered with water until it was saturated and wait until the water in the planting media was absorbed until field capacity. Each polybag was planted with 5 seeds of chickpeas/beans/beans and after growing, each polybag was left with the 2 best plants. Plant maintenance was watering regularly by looking at the condition of soil moisture in polybags. At the beginning of growth, watering was done more often because the roots of the plant are still shallow. During the pod filling period, the plants need sufficient water and were stopped when the pods were fully formed. Watering requires 250 ml of water per polybag in the early growth phase and 500 ml/polybag in the productive phase. And for weeding was done if there are weeds that grow in polybags and interfere with plant growth.

The dynamics of the total population of soil bacteria were observed using spread plate method obtained from a series of 10 g soil sample dilutions with 90 mL of 0.05% peptone mixed for 5 minutes. The resulting spread plate was then incubated in an incubator for 24 hours and bacterial colony that had grown on the media were calculated as Total Plate Count (log cfu/gram).

Plant height was measured using tape measure, started from the soil surface to the apical meristem point, whilst the number of leaves and flower were counted manually using hand counter. The yield were collected after harvesting period of each crop were achieved.

Harvesting of green bean to measure the yield was conducted when the young pods were whitish green, straight in shape, sweet and crunchy in taste, 20 cm long, 0.8 cm wide, the pod skin texture was smooth, and the weight per pod was about 8-10 grams. Long beans harvesting was carried out if the pod size was around 20 cm; the pod maturity level was relatively young, appearance of the seeds does not stand out, fresh green and still solid. Mung bean yield were collected when the pods were dark brown or black. Crop yield was randomly selected from the population by destructive sampling. The weight of crop yields was measured using digital balance.

Statistical analysis was employed ANOVA approaches with the F-test at level of 5% and it was completed with LSD test under the software of GenStat version 18.00. Multivariate analyses were used to cluster the treatment based on selected variable/parameter.

RESULTS AND DISCUSSION

Soil chemical properties amongst the treatment were significantly affected by the treatment ($P<0.05$) (Table 3). It can be seen that treatment of TKHB2VG resulted in the highest soil Nitrogen (N), Phosphorous (P) and Potassium (K) content, which was almost 2 times higher than control. In term of soil N, P and K content, the treatment of TKHB2VG was not significantly different to the treatment of TKHB1G, and TKHA2VG.

Table 3 – Soil chemical properties

Treatments	Soil chemical properties		
	N	P_2O_5	K_2O
TB	0.38 ab	22.54 a	35.13 b
TK	0.30 a	20.57 a	30.34 a
TKHA1V	0.41 b	25.29 b	40.10 c
TKHA1G	0.48 bc	26.93 b	40.93 c
TKHA2VG	0.50 c	27.40 bc	41.98 c
TKHB1V	0.45 b	26.15 b	42.38 cd
TKHB1G	0.50 c	28.67 c	42.81 cd
TKHB2VG	0.52 c	29.54 c	43.60 c

Note: TB = Control, TK = Compost, TKHA1V = Compost + 2 times application of VP3 biofertilizer (7 days before planting + vegetative phase), TKHA1G = Compost + 2 times application of VP3 biofertilizer (7 days before planting + generative phase), TKHA2VG = Compost + 3 times application of VP3 biofertilizer (7 days before planting + vegetative phase + generative phase, TKHB1V = Compost + 2 times application of VP3 biofertilizer (at planting + vegetative phase), TKHB1G = Compost +2 times application of VP3 biofertilizer (at planting + generative phase), TKHB2VG = Compost + 3 times application of VP3 biofertilizer (at planting + vegetative phase + generative phase). Numbers accompanied by the same letter in the same column show no significant difference in the 5% LSD test.

Figure 1 showed that soil bacteria population of composite sample from 3 legumes (green bean, long bean, mung bean) were increased up to 20 DAP before it were slighty decreased to form a sigmoid curve at 80th DAP. In detail, it was shown in table 9, that indicated the greatest population of soil bacteria at 80th DAP was detected under the treatment of TKHB2VG (VP3 biofertilizer were applied at planting + vegetative phase + generative phase) with bacteria population to reach about 11, 5 log CFU/g, whlist the lowest has been observed under the treatment of TK (soil with amended compost only) with total number of bacteria at about 8.82 log CFU/g (Table 4).

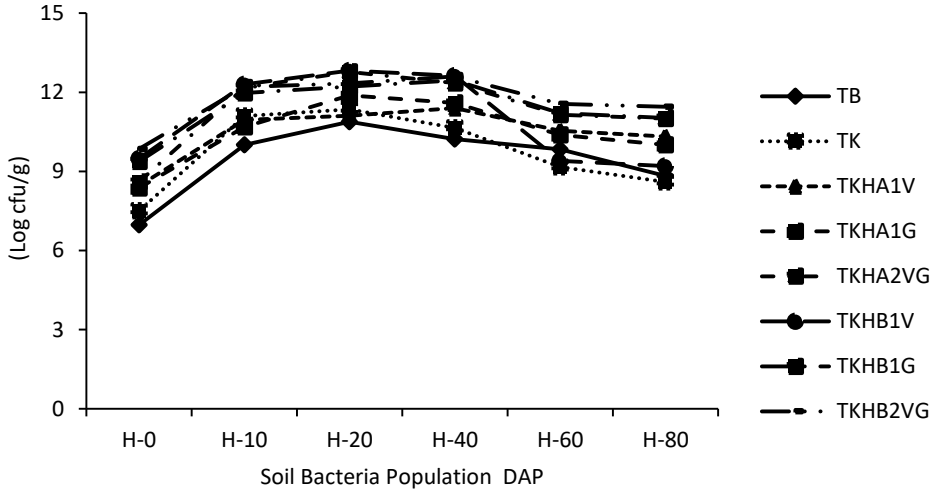

Figure 1 – The dynamics of soil bacteria population during 80 days of observation

Table 4 – Soil bacteria population in dynamic of 80 days of observation from 3 different legumes

Treatments	Soil bacteria population (Log cfu/gram)					
	0 DAP	10 DAP	20 DAP	40 DAP	60 DAP	80 DAP
TB	6.96 a	10.00 a	10.87 a	10.22 a	9.83 c	8.82 b
TK	7.50 b	11.09 d	11.34 bc	10.64 b	9.17 a	8.60 a
TKHA1V	8.45 cd	10.95 c	11.11 ab	11.39 c	10.54 e	10.32 e
TKHA1G	8.36 c	10.68 b	11.88 cd	11.60 d	10.38 d	10.00 d
TKHA2VG	8.60 cde	12.17 f	12.77 g	12.35 e	11.14 f	11.00 f
TKHB1V	9.477 fg	12.30 h	12.82 g	12.63 h	9.39 b	9.30 c
TKHB1G	9.369 ef	11.97 e	12.20 de	12.44 f	11.21 g	11.01 fg
TKHB2VG	9.845 g	12.20 fg	12.33 ef	12.60 g	11.55 h	11.44 h
LSD 5%	0.407	0.039	0.378	0.027	0.061	0.149

Note: TB = Control, TK = Compost, TKHA1V = Compost + 2 times application of VP3 biofertilizer (7 days before planting + vegetative phase), TKHA1G = Compost + 2 times application of VP3 biofertilizer (7 days before planting + generative phase), TKHA2VG = Compost + 3 times application of VP3 biofertilizer (7 days before planting + vegetative phase + generative phase, TKHB1V = Compost + 2 times application of VP3 biofertilizer (at planting + vegetative phase), TKHB1G = Compost +2 times application of VP3 biofertilizer (at planting + generative phase), TKHB2VG = Compost + 3 times application of VP3 biofertilizer (at planting + vegetative phase + generative phase). Numbers accompanied by the same letter in the same column show no significant difference in the 5% LSD test.

VP3 biofertilizer used in this experiment for all treatment, except for TB and TK, contained 3 functional bacteria, which are: free nitrogen fixing (Arfarita et al., 2019a), phosphate solubilizing bacteria (Arfarita et al., 2017) and exopolysaccharide-producing bacteria (Arfarita et al., 2017, Arfarita et al., 2016b).

At the beginning of the application (0 DAP) of VP3 biofertilizer into the soil, bacteria was positioned at the process of adaptation in the new environment when it were placed to soil. At the 20th DAP, the population of soil bacteria was positioned at the peak phase (exponential phase). In this phase, soil bacteria have a high population due to the addition of compost and the addition of VP3 biofertilizer application which is used as an energy source for the formation of new cells and for reproduction has been decomposed. (Parwanayoni, 2008). At the 40th and 60th DAP, the populations of soil bacteria were in the stationary phase before it was slightly decreased compare to those value at the peak phase. At the 80th DAP, the population of soil bacteria was reached at the stationary phase but had not yet reached the death phase because at that time watering was still being carried out so that the water content in the soil was sufficiently for supporting soil bacteria colony. In addition, the possibility of root exudates from legumes that can stimulate the growth of soil bacteria and the canopy of plants that can maintain soil moisture (Parwanayoni, 2008).

Previously, synergistic effect or organic, inorganic and biofertilizer on soil microbial activity in rhizospheric soil of green pea has been reported by Kaur et al., (2017). The result shown that less than 60 days after the treatment of inorganic fertilizer + farm yard manure + biofertilizer resulted in the total bacterial count to about 150 x 10^7 CFU g^{-1} soil. The releasing nutrient from manure along with the production of phytohormone supported microflora growth and populations (Kaur et al., 2017). The population of soil bacteria under the application of organic and bio fertilizer in black pepper reported to be enriched significantly and reached the highest population when the treatment was carried out using the treatment of applying 10 kg farm yard manure + 50 g Azospririlium + 50 g phospobacteria + 200 g VAM. This treatment obtained the total population of bacteria to be about 19.54 to 26.44 CFU g^{-1} at flowering and harvesting stage which was higher than control or other treatment (Ravanachandar and Lakshmanan, 2019). In addition, the use of biofertilizer could promote an increasing of bacterial population to about 576 x 10^5 CFU/ g soil under the treatment of soil which was inoculated with Azospirilium and POME (Palm Oli Mill Effluent), which was a slightly higher than soil which was inoculated with *Azotobacter* and POME, resulted in the total bacterial population to about 573 x 10^5 CFU/g soil (Suliasih and Widawati, 2018). It has been suspected that consortium phosphorous solubilizing bacteria and other species or under the addition of biofertilizer which combined with other organic or inorganic fertilizer was a better option to increase soil biota population and growth (Awathy et al., 2017; Kuntal das et al., 2007; Suliasih and Widawati, 2018). The addition of organic material could provide adequate nutrients to soil which could be consumed by soil microbe (Muzaffar et al., 2013).

The results of ANOVA showed that treatment affected plant height (P<0.05) (Table 5). In term of green bean height, the greatest height at 56 DAP was obtained under the treatment of TKHA1V which was used the treatment of VP3 biofertilizer were applied 7 days before planting + 4 days after planting. This treatment was not significantly different to the treatment of TKHB1G, whereas VP3 biofertilizer were applied at the day of planting and 30 days after planting. In term of long yard bean, the treatment only gave a significant effect (P<0,05) to plant height up to 42 DAP. After this period there was no significant different among the treats was detected. The effect of treatment to long yard bean height green bean resulted in the greatest height at the treatment of TKHA1G, even though this was not significantly different to other treatment except with the treatment of TB, TK and TKHB1G. The treatment of TKHA2VG treatment were found to be the greatest plant height at 56 DAP with the application of VP3 biofertilizer were applied 7 days before planting + 7 days after planting + 30 days after planting This treatment was not significantly different to the treatment of TKHB2VG, detected at 56 DAP (Table 5).

Table 5 – Plant height of 3 legumes (green beans, yard long beans and mung beans)

Plant	Treatments	average of plant height (cm) (DAP)							
		7	14	21	28	35	42	49	56
Green beans	TB	12.067 e	16.00 ab	76.67 ef	112.00 c	127.0 bc	143.0 abc	143.0 a	155.7 ab
	TK	9.733 cde	16.33 ab	64.50 cd	96.13 ab	108.5 a	158.3 bc	165.0 ab	169.7 cd
	TKHA1V	9.500 bcd	15.67 ab	79.37 f	110.30 bc	144.9 c	161.7 c	164.7 ab	172.0 d
	TKHA1G	6.733 a	13.33 a	56.67 bcd	90.77 a	107.9 a	133.7 ab	143.0 a	148.3 a
	TKHA2VG	8.667 abc	14.17 a	54.33 abc	96.83 ab	118.8 ab	149.7 abc	156.0 ab	170.0 cd
	TKHB1V	11.600 de	20.83 c	66.67 de	92.97 a	107.9 a	129.0 a	144.0 a	159.3 bc
	TKHB1G	7.300 ab	13.33 a	43.83 a	93.83 a	114.2 ab	162.3 c	169.3 b	175.3 d
	TKHB2VG	7.333 ab	11.50 a	46.67 ab	103.33 abc	118.7 ab	138.3 abc	143.7 a	161.0 bc
	LSD 5%	2.33	3.17	11.39	14.59	18.25	24.86	24.70	10.95
Yard long beans	TB	10.97 b	21.33 ab	28.67 a	66.00 ab	99.3 a	116.7 ab	126.7 a	145.7 a
	TK	12.53 bc	20.67 a	40.33 b	71.50 ab	94.3 a	103.0 a	124.7 a	129.7 a
	TKHA1V	13.60 c	23.63 c	61.33 c	83.80 c	113.5 ab	125.7 abc	117.3 a	133.3 a
	TKHA1G	11.63 b	23.17 bc	58.83 c	111.73 d	140.3 c	151.67 c	143.3 a	143.8 a
	TKHA2VG	13.83 c	21.93 abc	39.13 b	105.33 d	123.7 bc	138.0 bc	141.0 a	140.7 a
	TKHB1V	11.90 b	22.87 bc	52.73 c	101.57 d	128.3 bc	138.0 bc	145.5 a	143.7 a
	TKHB1G	11.77 b	23.17 bc	55.80 c	75.50 bc	109.3 ab	122.0 ab	123.7 a	124.3 a
	TKHB2VG	8.87 a	21.20 ab	27.90 a	62.33 a	111.3 ab	130.3 abc	131.5 a	126.3 a
	LSD 5%	1.68	2.126	9.48	12.01	22.32	28.37	34.64	31.05
Mung beans	TB	7.433 a	14.83 a	21.67 a	27.83 ab	33.00 ab	39.40 bc	44.07 bc	48.33 bc
	TK	9.000 bcd	15.50 abc	23.77 b	28.57 bcd	31.63 a	38.73 ab	44.33 bc	48.43 bc
	TKHA1V	9.833 d	16.33 c	24.33 b	29.00 d	34.40 c	39.00 abc	43.20 ab	48.10 b
	TKHA1G	10.167 d	15.17 ab	23.97 b	27.87 abc	34.17 bc	38.23 a	42.17 a	46.87 a
	TKHA2VG	9.333 cd	15.83 abc	25.73 c	28.83 cd	34.67 c	40.90 d	45.00 c	49.60 d
	TKHB1V	8.000 ab	15.50 abc	23.40 b	27.17 a	34.33 bc	38.33 ab	43.67 abc	48.07 b
	TKHB1G	8.400 abc	15.83 abc	23.67 b	27.83 ab	34.33 bc	39.17 abc	43.67 abc	47.93 b
	TKHB2VG	8.400 abc	16.00 bc	24.00 b	28.90 d	34.67 c	40.03 cd	45.10 c	49.20 cd
	LSD 5%	1.29	1.13	1.31	0.98	1.39	1.16	1.66	0.94

Note: TB = Control, TK = Compost, TKHA1V = Compost + 2 times application of VP3 biofertilizer (7 days before planting + vegetative phase), TKHA1G = Compost + 2 times application of VP3 biofertilizer (7 days before planting + generative phase), TKHA2VG = Compost + 3 times application of VP3 biofertilizer (7 days before planting + vegetative phase + generative phase, TKHB1V = Compost + 2 times application of VP3 biofertilizer (at planting + vegetative phase), TKHB1G = Compost +2 times application of VP3 biofertilizer (at planting + generative phase), TKHB2VG = Compost + 3 times application of VP3 biofertilizer (at planting + vegetative phase + generative phase). Numbers accompanied by the same letter in the same column show no significant difference in the 5% LSD test.

Under the treatment of TKHB2VG which was not significantly different to the treatment of TKHB1G, TKHA2VG and TKHA1G, the highest level of sufficiency on soil Nitrogen, Phosphor and Potassium were found. This was the evidence that that highest level of nutrient in soil was be able to support crop growth. This result was in line with the research of Oliver *et al.,* (2014) which stated that nitrogen in sufficient quantities provides good plant growth. Barraclough (1989) added that nitrogen is indispensable for the formation of vegetative parts such as stems, leaves and roots. Phosphorus can increase vegetative growth including plant height (Syamsiyah, 2008). Phosphorus plays a role in increasing phosphate sugar which plays a role in the dark phase reaction in photosynthesis, which will increase the rate of photosynthesis so that the photosynthetic produced, will be allocated for

plant height growth. Hudai *et al.,* (2007) stated that phosphorus plays a role in reactions in the dark phase of photosynthesis, respiration and various other metabolic processes. Increased availability of phosphorus as a result of the application of VP3 biofertilizer with compost. The high absorption of phosphorus increases the formation of ATP which can be used by plants as energy in the growth process, including for plant height growth. Increase in plant height occurs due to cell division and an increase in the number of cells that require energy in the form of ATP.

The application of organic fertilizer in the form of vermicompost produced the greater height at 72.87 cm under the treatment of VC and the lowest was to about 47.89 cm following farmer choice technique (Islam et al., 2016). This value was lower than the value of plant height of yard long beans in this study. In addition, the plant height of Mung bean was range between 20.9 to 25.7 cm following the application of biofertlizer making from rice starch (Peter and Satish, 2015) which was lower than those value of Mung bean in this study which was reached to about 46 to 48 cm. This difference may due to the different use of type of biofertilizer, soil, genetic varieties and geographical position. However, the plant height of Mung bean in this study was within the range of Mung bean plant height of biofertilizer contained *Bradirhyzobium*, under combination of with nitrogen and phosphorous which could reach to about 45.93 to 69.73 cm (Sallah Uddin et al., 2009). Plant height of green bean added with various sources of fertilizer was within the range of 33 to 43 cm (Santosa et al., 2017) which was lower than 50% of green bean height in this study which reached to about 148 to 175 cm at 56 DAP.

Table 4 – The number of leaves on green beans, yard long beans and mung beans

Plant	Treatments	Number of Leaves (cm) on the Day After Planting (DAP)							
		7	14	21	28	35	42	49	56
Green beans	TB	2.00 a	5.00 a	12.00 a	18.33 a	30.33 a	34.00 a	47.00 a	36.00 ab
	TK	2.00 a	5.00 a	13.67 abc	22.33 bc	37.00 b	41.00 bc	50.33 a	35.33 ab
	TKHA1V	2.00 a	5.00 a	14.00 bcd	26.67 d	33.67 ab	37.00 ab	47.33 a	43.67 cd
	TKHA1G	2.00 a	5.00 a	13.67 abc	24.67 bcd	30.33 a	40.00 bc	50.33 a	42.00 bcd
	TKHA2VG	2.00 a	5.33 a	15.67 d	28.00 d	33.00 ab	37.67 ab	52.00 a	45.33 d
	TKHB1V	2.00 a	5.00 a	13.67 abc	21.67 ab	36.67 b	46.67 d	53.67 a	31.33 a
	TKHB1G	2.00 a	5.33 a	15.33 cd	26.33 d	37.00 b	43.67 cd	48.00 a	37.67 abc
	TKHB2VG	2.00 a	5.00 a	13.33 ab	26.00 cd	32.00 a	37.67 ab	46.33 a	37.00 abc
	LSD 5%	NS	0.52	1.68	3.77	4.21	5.15	14.39	7.32
Yard long beans	TB	2.00 a	4.66 ab	11.00 a	15.00 ab	22.33 cd	25.00 ab	26.00 a	20.33 b
	TK	2.00 a	5.00 ab	11.00 a	15.67 abc	24.33 d	30.67 b	34.00 b	25.67 b
	TKHA1V	2.00 a	7.66 c	11.00 a	16.33 bcd	18.67 ab	21.33 a	23.33 a	24.33 b
	TKHA1G	2.00 a	5.33 b	11.00 a	17.67 d	20.67 bc	23.67 a	25.67 a	20.67 b
	TKHA2VG	2.00 a	4.33 a	11.00 a	16.67 cd	19.67 ab	22.33 a	25.33 a	27.33 b
	TKHB1V	2.00 a	5.00 ab	11.00 a	14.33 a	18.00 a	20.00 a	23.67 a	12.00 a
	TKHB1G	2.00 a	5.00 ab	11.00 a	17.33 d	21.00 bc	26.00 ab	26.00 a	24.67 b
	TKHB2VG	2.00 a	5.00 ab	9.67 a	14.33 a	19.67 ab	26.33 ab	26.67 a	27.33 b
	LSD 5%	NS	0.76	1.78	1.66	2.63	6.90	4.29	8.21
Mung Beans	TB	2.00 a	5.00 ab	8.00 bc	9.33 a	10.7 a	12.67 ab	15.00 ab	12.67 a
	TK	2.00 a	4.67 a	7.33 a	10.33 b	11.33 ab	12.33 a	15.33 abc	12.67 a
	TKHA1V	2.00 a	5.00 ab	7.66 ab	10.33 b	11.67 b	12.33 a	15.33 abc	13.00 a
	TKHA1G	2.00 a	5.00 ab	8.00 bc	10.00 b	11.33 ab	12.67 ab	14.33 a	13.00 a
	TKHA2VG	2.00 a	5.66 b	8.33 c	10.33 b	11.67 b	13.00 ab	16.00 bc	14.00 b
	TKHB1V	2.00 a	5.00 ab	7.67 ab	10.33 b	11.67 b	12.33 a	15.67 bc	12.67 a
	TKHB1G	2.00 a	5.00 ab	8.00 bc	10.00 b	11.67 b	13.33 b	15.67 bc	13.33 ab
	TKHB2VG	2.00 a	5.33 ab	7.67 ab	10.33 b	11.33 ab	13.00 ab	16.33 c	13.00 a
	LSD 5%	NS	0.86	0.61	0.52	0.70	0.72	1.23	0.71

Note: TB = Control, TK = Compost, TKHA1V = Compost + 2 times application of VP3 biofertilizer (7 days before planting + vegetative phase), TKHA1G = Compost + 2 times application of VP3 biofertilizer (7 days before planting + generative phase), TKHA2VG = Compost + 3 times application of VP3 biofertilizer (7 days before planting + vegetative phase + generative phase, TKHB1V = Compost + 2 times application of VP3 biofertilizer (at planting + vegetative phase), TKHB1G = Compost +2 times application of VP3 biofertilizer (at planting + generative phase), TKHB2VG = Compost + 3 times application of VP3 biofertilizer (at planting + vegetative phase + generative phase). Numbers accompanied by the same letter in the same column show no significant difference in the 5% LSD test.

The results of ANOVA showed that the treatment was significantly affected (P<0,05) the number of leaves of green beans, long yard beans and mung beans, following an observation on number of leaves after 14 DAP (Table 4). These results indicate that the

optimum number of leaves were achieved at the period of 42-49 DAP before it was decresing in the following weeks which indicated that there no significant effect of the treatment to those variable. The highest number of leaves on green bean at 42 DAP were detected at the treatment of TKHB1V and the lowest were at the treatment of TB which was 40% lower than those treatment of TKHB1V.

For comparison, the number of mung bean leaves under control treatment was found to be about 5.5 leaves which was lower than treatment of rice starch biofertilizer, reached to about 6.7 leaves (Peter and Satish, 2015). This value was 50% lower than those average of number leaves mung bean per plant in this study. In contrast, the number of mung bean leaves under the application of *Bradirhyzonium* biofertlizer added with inorganic fertilizer achieved the maximum number to about 21-30 leaves per plant (Salah Uddin et al., 2009). Under the addition of different sources of fertilizer (organic and inorganic) the number of green bean range to about 20-29 leaves per plant (Santosa et al., 2017) which was lower compare to the value of number of leaves of green bean in this study, reached to about 46-53 leaves per plant at maximum growth.

The significant response ($P<0.05$) of the treatment were detected using ANOVA toward results of number of flower of green bean, yardlong bean and mung bean (Table 5). The difference of number of flower of yardlong bean and mung bean were started at the 6th week after planting, except the number of flower of green bean which significantly different amongst the treatment since 5th weeks after planting.

Table 5 – Average number of flowers on green beans, yard long beans and mung beans

Plant	Treatments	Average number of flowers (florets) on Week-		
		5	6	7
Green Beans	TB	4.33 cd	4.33 a	4.66 a
	TK	5.33 de	5.00 ab	5.00 a
	TKHA1V	1.00 ab	4.67 a	4.66 a
	TKHA1G	7.66 f	6.67 b	3.00 a
	TKHA2VG	6.33 ef	4.33 a	10.33 b
	TKHB1V	0.66 a	4.33 a	5.00 a
	TKHB1G	2.66 bc	4.67 a	8.00 b
	TKHB2VG	2.00 ab	5.33 ab	5.00 a
	LSD 5%	1.857	1.756	2.948
Yard long beans	TB	2.00 a	12.33 cd	14.67 abc
	TK	1.00 a	12.33 cd	10.00 ab
	TKHA1V	1.66 a	12.67 cd	6.67 a
	TKHA1G	1.33 a	13.00 d	16.67 bc
	TKHA2VG	1.00 a	14.33 d	18.67 c
	TKHB1V	0.66 a	7.33 ab	17.67 bc
	TKHB1G	0.33 a	10.00 bc	13.33 abc
	TKHB2VG	1.00 a	7.00 a	12.67 abc
	LSD 5%	2.517	2.963	8.002
Mung Beans	TB	2.00 a	12.33 cd	14.67 abc
	TK	1.00 a	12.33 cd	10.00 ab
	TKHA1V	1.66 a	12. 67 cd	6.67 a
	TKHA1G	1.33 a	13.00 d	16.67 bc
	TKHA2VG	1.00 a	14.33 d	18. 67 c
	TKHB1V	0.66 a	7.33 ab	17.67 bc
	TKHB1G	0.33 a	10.00 bc	13.33 abc
	TKHB2VG	1.00 a	7.00 a	12.67 abc
	LSD 5%	2.517	2.963	8.002

Note: TB = Control, TK = Compost, TKHA1V = Compost + 2 times application of VP3 biofertilizer (7 days before planting + vegetative phase), TKHA1G = Compost + 2 times application of VP3 biofertilizer (7 days before planting + generative phase), TKHA2VG = Compost + 3 times application of VP3 biofertilizer (7 days before planting + vegetative phase + generative phase, TKHB1V = Compost + 2 times application of VP3 biofertilizer (at planting + vegetative phase), TKHB1G = Compost +2 times application of VP3 biofertilizer (at planting + generative phase), TKHB2VG = Compost + 3 times application of VP3 biofertilizer (at planting + vegetative phase + generative phase). Numbers accompanied by the same letter in the same column show no significant difference in the 5% LSD test.

The highest number of flower at the 7th week after planting was detected at the treatment of TKHA2VG for all beans which were significantly different to other treatment. More quantity of flowers in the treatment of VP3 biofertilizer shows that the biofertilizer could improve the physical and chemical properties of the soil which then created conditions for the

availability of N and P nutrients in the soil. Nutrients N and P are macro nutrients that play a role in the flowering process of plants. In the process of flower formation, N is only needed in small amounts, while P is needed in large quantities. The beginning of the generative phase is marked by the formation of plant flower buds, in this phase the plants need P and K nutrients more dominant than N nutrients. According to Chen et al., (2013), the P and K nutrients contained in the compost are decomposed by microbes so that it can be available to beans, long yard beans and green beans so as to stimulate the formation of flowers. Beside that biofertilizer contained those above nutrients for supporting plant growth (Islam et al., 2016; Baziramakenga and Simard, 2001). It has been revealed that Biofertilizer successfully promote mung bean growth (Khanum and Buiyyan, 2007) as there was an indication that this material rich with giberrelic acid (GA) (Mondal et al., 2013) and indole acetic acid (IAA) (Asad et al., 2004) which could also stimulate flowering (Mondal et al., 2013).

Table 6 shows the average number of pods of beans yard, long beans and green beans which was significantly ($P<0.05$) affected by the treatment. Similar to the pattern of number of flowers, the greatest number of pods was obtained at the treatment of TKHA2VG at 7th week after planting. This may due the sufficiency of nutrient, enzyme and secondary metabolite release from the biofertilizer during decomposition process, including the releasing of phosphorous content.

Table 6 – Average number of pods on beans, longyard beans and green beans

Plant	Treatments	Average number of flowers (florets) on Week-		
		5	6	7
Green Beans	TB	`2.00 ab	3.66 a	3.66 ab
	TK	5.00 c	3.33 a	4.33 ab
	TKHA1V	0.00 a	4.33 a	4.00 ab
	TKHA1G	2.66 b	4.33 a	2.00 a
	TKHA2VG	1.33 ab	4.00 a	7.66 c
	TKHB1V	0.33 a	3.66 a	3.00 ab
	TKHB1G	0.66 ab	4.00 a	6.33 bc
	TKHB2VG	0.66 ab	4.33 a	4.00 ab
	LSD 5%	2.305	1.616	4.145
Yard long beans	TB	0.66 a	4.66 a	13.00 bcd
	TK	1.33 a	3.33 a	7.67 a
	TKHA1V	0.33 a	12.66 b	5.67 a
	TKHA1G	0.33 a	7.66 ab	15.00 cd
	TKHA2VG	0.66 a	12.66 b	16.33 d
	TKHB1V	0.33 a	4.66 a	13.67 bcd
	TKHB1G	0.33 a	7.33 a	12.67 bc
	TKHB2VG	0.66 a	6.33 a	11.33 b
	LSD 5%	1.047	5.316	3.623
Mung Beans	TB	0.66 a	4.66 a	13.00 bcd
	TK	1.33 a	3.33 a	7.67 a
	TKHA1V	0.33 a	12.66 b	5.67 a
	TKHA1G	0.33 a	7.66 ab	15.00 cd
	TKHA2VG	0.66 a	12.66 b	16.33 d
	TKHB1V	0.33 a	4.66 a	13.67 bcd
	TKHB1G	0.33 a	7.33 a	12.67 bc
	TKHB2VG	0.66 a	6.33 a	11.33 b
	LSD 5%	1.047	5.316	3.623

Note: TB = Control, TK = Compost, TKHA1V = Compost + 2 times application of VP3 biofertilizer (7 days before planting + vegetative phase), TKHA1G = Compost + 2 times application of VP3 biofertilizer (7 days before planting + generative phase), TKHA2VG = Compost + 3 times application of VP3 biofertilizer (7 days before planting + vegetative phase + generative phase, TKHB1V = Compost + 2 times application of VP3 biofertilizer (at planting + vegetative phase), TKHB1G = Compost +2 times application of VP3 biofertilizer (at planting + generative phase), TKHB2VG = Compost + 3 times application of VP3 biofertilizer (at planting + vegetative phase + generative phase). Numbers accompanied by the same letter in the same column show no significant difference in the 5% LSD test.

Soares et al., (2016) stated that P stimulates the formation of flowers, fruit, seeds, and also accelerates fruit ripening. The availability of P nutrients can accelerate the flowering and ripening of fruit, seeds and increase grain production. P is needed by plants from the beginning of their growth until harvest, so their needs must be met throughout their life. Soares et al., (2016) stated that P stimulates the formation of flowers, fruit and seeds, is able

to accelerate fruit ripening. The availability of P nutrients can accelerate the flowering and ripening of fruit, seeds and increase grain production.

The application of VP3 biofertilizer with compost will affect the bacterial population in the soil. The bacteria contained in the VP3 biofertilizer such as phosphate solubilizing bacteria can increase compost degradation so that nutrients are available for beans, long beans and green beans. According to Simanungkalit et al., (2006) that phosphate solubilizing bacteria will help in dissolving phosphate so that P nutrients can be available for beans, long beans and green beans which affect the number of pods and pod weight which will be high. Phosphorus plays an important role in increasing plant reproductive growth, including the formation of flowers and seeds. Most of the phosphorus absorbed by plants is stored in seeds. Thus, if the P nutrient available to plants is insufficient, it can reduce seed size, seed number and viability. In addition, the availability of optimal P nutrients in the soil can increase the number of seeds, germination, seed weight and harvest index (Chen et al., 2013). High concentrations of P nutrients can increase the number of soybean pods (Shaheen et al., 2007). Nutrient P is a component in phytin, an important compound of P storage in seeds (Abdalla, 2002). The pods contain protein, carbohydrates, fat, thiamine, Ca and Fe and the seeds contain significant amounts of thymine, niacin and folic acid (Tsvetkova and Georgiev, 2007).

The number of pods formed is less than the number of flowers formed due to the loss of flowers and fruit (pods). Flower fall can be due to disease and pests as well as physiological problems. At the time the flower enters the fertilization phase, where the flower has changed color from purplish white to yellow, then at that time the flower is very susceptible to loss because the flower stalk becomes not too strong when on the branch of the plant Akram et al., (2017) stated that potassium is the most influential factor in flower loss. The availability of potassium for plants can strengthen the plant body so that flowers, fruits and leaves do not fall off easily. In addition, potassium can also help the formation of protein and carbohydrates and increase plant resistance to drought stress (Nasser et al., 2001). Flower and fruit loss occurs due to sensitivity of the abscission zone to ethylene (Bangert, 2000). Ethylene is a hormone that promotes strong hair loss and is widespread in various plant organs. Ethylene induces the synthesis and secretion of cell wall-degrading hydrolases. The increased secretion of the hydrolase enzyme causes damage to the cell wall of the abscission zone and the process of loss of plant organs occurs (Iqbal et al., 2017). Physiologically, flower and fruit loss correlates with limited photosynthetic supply and nutrient adequacy (Brown, 1997), as well as hormonal regulation in the abscission zone (Bangert, 2000). Fruit loss occurs due to the active abscission layer, which is the layer located near the base of the fruit stalk. The small parenchyma cells in this layer have very thin walls and no fiber cells around the vascular tissue. This layer will be weakened when enzymes hydrolyze polysaccharides in the cell wall, resulting in fruit loss. Abscission is controlled by changes in the balance of ethylene and auxin. Thus, when the auxin concentration is low, the abscission layer cells become sensitive to ethylene. Ethylene induces the synthesis of enzymes that digest cellulose and other components of the cell wall (Han et al., 1989).

The period and interval application of VP3 biofertilizer was significantly affected ($P<0.05$) the yield of 3 different legume (green beans, longyard beans and mung beans). In term of green bean yield, the best yileds was obtained under the treatment of TKHA1 which was used the treatment of incubated soil for 1 week before planting and the biofertilizer was applied at 31 DAP. TKHB1G treatment under longyard bean experiment gave the best results, whereas VP3 biofertilizer were applied at the day of planting and 30 days after planting. Meanwhile, under green bean experiment TKHB2VG treatment was obtained the greatest yields with the application VP 3 biofertilizer by incubated soil for 1 week before planting and VP3 biofertilizer were applied at 7 days after planting). On average there was an increasing on total weight of pod.

Crop yields are closely related to the number of flowers produced and the percentage of flowers into pods. The results of this study showed that the number of pods produced by plants (beans, long yard beans and green beans) was less than the number of flowers produced, but the percentage of flowers into pods was high. This is in accordance with what

was stated by Suyanto and Musalamah (2010) that the percentage of flowers into pods is quite high, because the number of flowers that fall is only a maximum of 40% of the total number of flowers formed. Many reports reveal, pod plants have a fairly large number of flowers and early pods with a flower miscarriage rate of around 43-81%. In term of yardlong bean production under various combination of organic manure + vermicompost + biofertlizer, yield obtained were within the range of 185 to 263 g (Sindhuja et al. 2021) which was higher 2 times than those value in this study which was at about 67-111 g.

Table 8 – Average of Yield on green beans, longyard beans and green beans

Plant	Treatments	Average of Pods Weight/Seeds Weight (g) on Week-			Total of Pods Weight/Seeds Weight
		9	10	11	
Green bean	TB	27.43 bcd	22.98 a	26.34 ab	120.95 ab
	TK	32.17 cd	40.26 b	26.17 ab	179.42 c
	TKHA1V	38.18 d	28.85 a	29.50 bc	177.89 c
	TKHA1G	27.86 bcd	21.74 a	23.19 ab	133.69 b
	TKHA2VG	23.19 bc	21.90 a	21.08 a	119.51 ab
	TKHB1V	9.11 a	21.00 a	28.55 bc	100.32 a
	TKHB1G	17.14 ab	20.17 a	34.18 c	132.45 b
	TKHB2VG	18.32 ab	22.98 a	23.35 ab	107.91 ab
	LSD 5%	11.52	10.08	7.115	31.17
Yard long beans	TB	24.05 a	15.67 ab	14.70 ab	67.29 a
	TK	26.14 ab	15.59 ab	19.32 c	80.30 abc
	TKHA1V	31.80 abc	14.49 a	16.44 bc	86.74 bcd
	TKHA1G	42.64 cd	15.18 ab	13.06 a	92.76 cde
	TKHA2VG	46.64 d	20.46 abc	16.23 bc	104.09 ef
	TKHB1V	44.25 d	25.57 cd	16.55 bc	99.70 def
	TKHB1G	36.21 bcd	27.04 d	14.41 ab	111.26 f
	TKHB2VG	24.88 a	20.79 bc	12.64 a	75.37 ab
	LSD 5%	10.90	5.998	3.106	16.69
Mung beans	TB	3.34 bc	4.93 b	4.93 abc	13.21 bc
	TK	1.58 a	4.19 ab	5.36 bcd	11.13 a
	TKHA1V	3.74 c	4.91 b	6.00 de	13.89 bc
	TKHA1G	2.57 abc	3.71 a	4.37 a	10.66 a
	TKHA2VG	2.28 ab	4.19 ab	4.85 ab	11.32 a
	TKHB1V	3.00 bc	4.59 b	4.46 a	12.06 ab
	TKHB1G	3.23 bc	4.26 ab	5.79 cde	13.29 bc
	TKHB2VG	3.18 bc	4.69 b	6.33 e	14.66 c
	LSD 5%	1.245	0.7633	0.884	1.788

Note: TB = Control, TK = Compost, TKHA1V = Compost + 2 times application of VP3 biofertilizer (7 days before planting + vegetative phase), TKHA1G = Compost + 2 times application of VP3 biofertilizer (7 days before planting + generative phase), TKHA2VG = Compost + 3 times application of VP3 biofertilizer (7 days before planting + vegetative phase + generative phase, TKHB1V = Compost + 2 times application of VP3 biofertilizer (at planting + vegetative phase), TKHB1G = Compost +2 times application of VP3 biofertilizer (at planting + generative phase), TKHB2VG = Compost + 3 times application of VP3 biofertilizer (at planting + vegetative phase + generative phase). Numbers accompanied by the same letter in the same column show no significant difference in the 5% LSD test.

The process of flowering and pod formation are influenced by genetic factors from crop such as resistance to pests and diseases, besides that there are other factors such as air temperature, wind, physical disturbances and the availability of certain elements. The fertilization phase in plants is very susceptible to pod loss because the flower stalks are not too strong when they are on the branch of the plant. Akram et al., (2017) stated that potassium is the most influential factor in flower loss. The availability of potassium nutrients for plants can strengthen the plant body so that flowers, fruits and leaves do not fall off easily, besides that potassium nutrients can also help the formation of protein and carbohydrates and increase plant resistance to drought stress (Nasser et al., 2001).

Discriminant analysis is a statistical technique used to classify an individual or observation into a class or group based on a set of variables (Johnson & Wichern 2007). Forming the optimal discriminant function requires some assumptions on the data used. These assumptions include, among others, that the data on the independent variables should have a multivariate normal distribution and that there is a similarity between the variance-covariance matrices between groups. The multi-variable data used in this study were: plant height, number of leaves, number of flowers, number of pods and weight of pods on each legume plant, namely: green beans, long beans and mung beans. The effect of

treatment in this study can be determined from the distance and position of each treatment into two dimensional discriminant analysis graph (Figure 3a, 3b. and 3c). The treatment had a significant effect (P<0.05) if it was stated that the treatment groups did not overlap with one another, and vice versa, if the overlapping of one treatment with another indicated that there was no significant effect between the treatments.

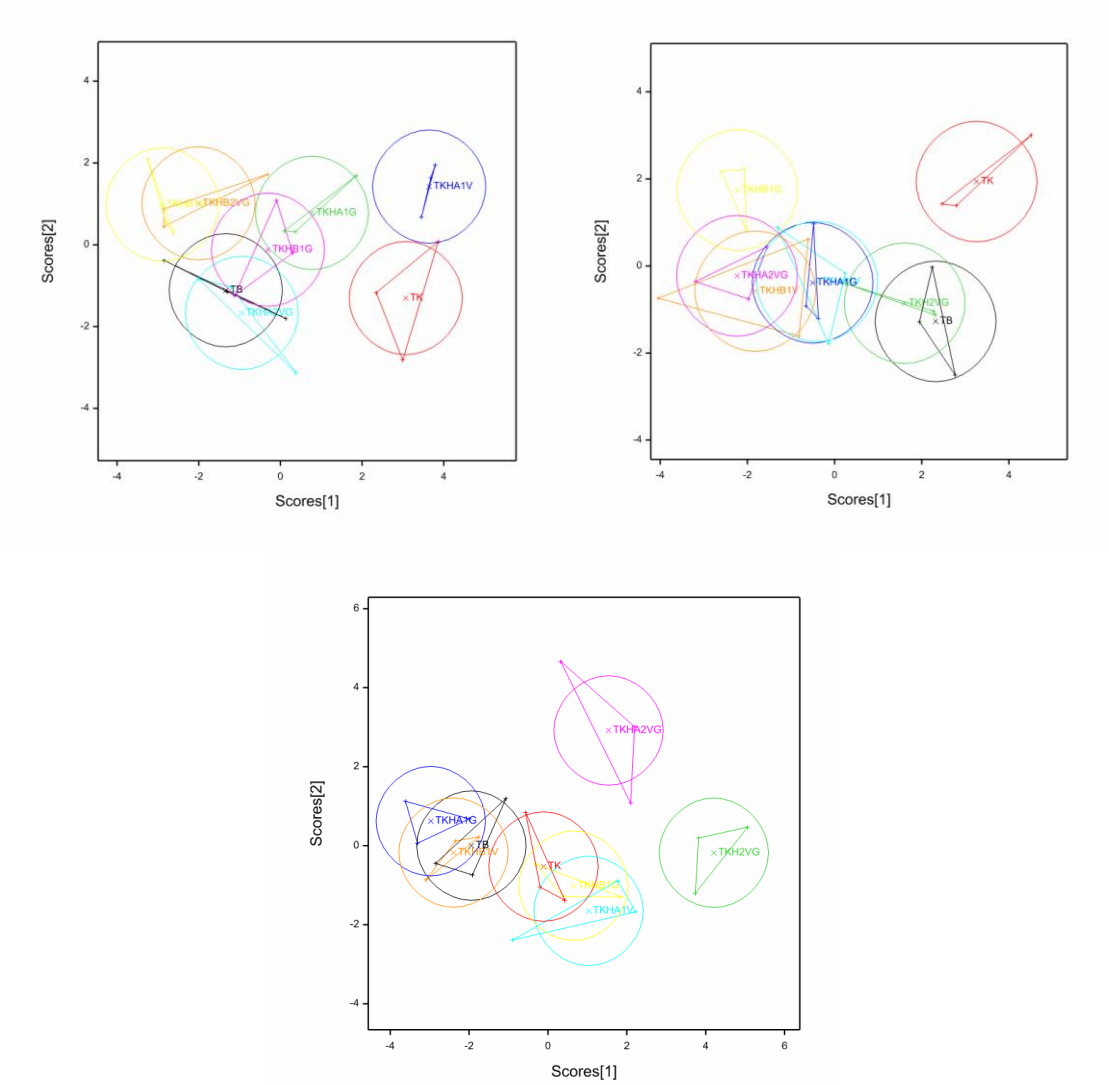

Figure 3 – Discriminant analysis based on agronomic and production variable of legume crop (3a. green bean, 3b.long yard bean and 3c.mung bean)

Discriminant analysis on green bean showed that there was a grouping of treatments based on the selected variables, where the TKHB treatment was not significantly different and became one group with the TKHB2VG treatment. The other groups that are grouped together and overlapping are the TB and TKHA2VG treatments, as well as TKHB1G and TKHA1G, while the TKHA1V and TK treatments are in another position and have a clear distance from the two groups mentioned above and it can be concluded that these three treatments are also significantly different one another. The values of SCORE 1 (X axis) and SCORE 2 (Y axis) are 72 and 23%, respectively, of the overall analysis of the selected variables (Figure 3a). In term of long bean experiment, the results of the discriminant analysis showed that there was a grouping of treatments based on the selected variables, where the TKHA2VG treatment was not significantly different and became one group with TKHB1V, TKHA1G, and TKHA1V treatments. The other groups that are grouped together and overlapping are the TKHA2VG and TB treatments, while the TK, TKHB1G treatment is in

another position and has a clear distance from the two groups above and it can be concluded that these two treatments are also significantly different from each other. The value of the discriminant analysis shows that SCORE 1 (X axis) and SCORE 2 (Y axis) represent 72 and 19% of the overall analysis of the existing variables (Figure 3b.). The results of the descriptive analysis on mung beans showed a different pattern where in this plant the TKHA2VG and TKH2VG treatments were in a position far apart which indicated that these two treatments were significantly different from each other with a SCORE 1 value (X axis) and a SCORE 2 value (Y axis) of 69 and 21% of the overall analysis of the observed variables. Another group was found in the TKHA1G treatment which overlapped with the TB treatment, and TKHB1V which showed no significant difference between the four treatments, as well as the TK, TKHB1G and TKHA1V treatments (Figure 3c)

CONCLUSION

The impact of VP3 biofertilizer at 3 selected legume crops (green beans, long beans and mung beans) on various variables such as number of leaves, plant height, number of flowers, number of pods, pod weight, seed weight was different. The best result of the application of VP3 biofertilizer on green bean yields was found under the treatment of TKHA1V. Meanwhile, the greatest long bean yield were detected under the treatment of TKHB1G whilst the best treatment to obtain the highest mung bean yields was under TKHB2VG treatment (soil were incubation for 1 week before planting and VP3 biofertilizer were applied at 7 days after planting). This difference is mainly due to the crop physiological behaviour. This information was important for basis recommendations of VP3 biofertilizer application in the field. Descriminat analysis can show treatment groupings based on the variables of agronomic properties and production of legumes, each of which has a different response to the given treatment with discriminant analysis values ranging from 69 – 72% for SCORE a (X axis) and 19 -23% for SCORE 2 (Y axis).

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