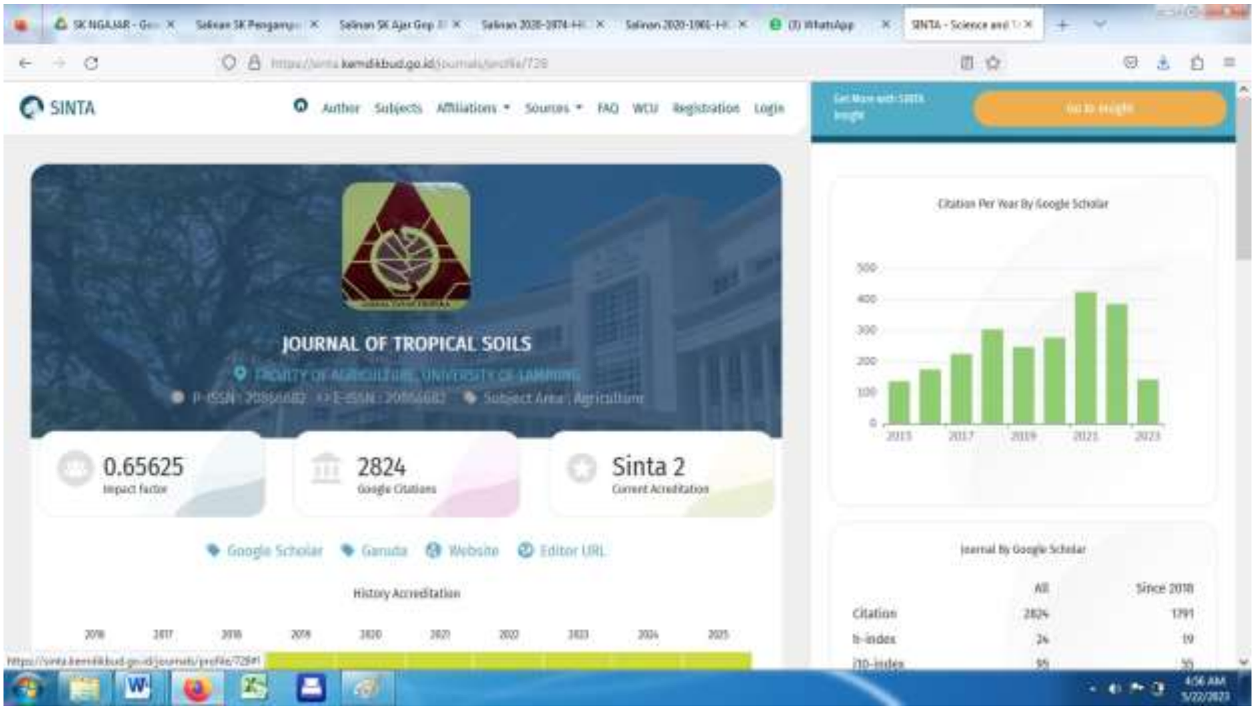

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The Nutrient Uptake Efficiency, Crop Productivity and Quality of Rice Bean in Dry Land

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ABSTRACT

Rice bean is a group of beans that are rich in carbohydrates, proteins and fats. This plant is resistant to pests and diseases, as well as the broad adaptability. This study aims to obtain an efficient fertilization pattern on rice bean cultivation in dry land. The treatments consisted of 9 fertilization patterns which were RP0: no fertilizer (control); RP1: 100% recommendation fertilizer (50 kg Urea and 100 kg SP-36 ha^{-1}); RP2: 5 Mg ha^{-1} manure plus 50% recommendation fertilizer; RP3: RP2 plus MVA; RP4: 5 Mg ha^{-1} *Crotalaria* sp compost plus 50% recommendation fertilizer; RP5: RP4 plus VAM; RP6: 2.5 t ha^{-1} manure, 2.5 Mg ha^{-1} *Crotalaria* sp compost plus 50% recommendation fertilizer; RP7: 1.5 Mg ha^{-1} manure, 1 Mg ha^{-1} *Crotalaria* sp compost plus 50% recommendation fertilizer; RP8: RP7 plus MVA. Fertilization treatments were arranged in RCBD and each treatment was repeated 3 times. The fertilization treatments had no significant effect on NUE. Productivity of rice bean in RP3 and RP5 reached 3.75 Mg ha^{-1}, in RP2 and RP4 achieved 2.64 Mg ha^{-1}, and in the control treatment reached 1.94 Mg ha^{-1}. Carbohydrate content in seeds increased by 20% in the fertilization treatments compared to the control. Protein and anthocyanin content in all treatments were not significantly different. The combination of 5 Mg organic fertilizer (manure and / or Crotalaria compost), 50% recommendation fertilizer plus MVA was an efficient fertilization pattern to improve P fertilizer uptake efficiency (PUE), productivity and quality of rice bean crop in dry land.

Keywords: Dry land, MVA, organic fertilizer, rice bean

INTRODUCTION

Rice bean (*Vigna umbellata* (Thunb.) Ohwi and Ohashi) is a leguminous plant which is potential to be developed on dry land because it is not only for broad adaptability, resistance to pests and diseases but it also has high nutrient contents. Carbohydrate and protein contents in rice beans reached 61.02% and 17.78%, respectively. The red rice bean contains anthocyanins (a group of antioxidant compounds) that is good for human health (Ujianto 2011).

In India and Taiwan, rice bean is utilized as food instead of rice. In Indonesia, rice bean virtually has been known by farmers by the name of runyem (Lombok) and kacang uci (West Java). However, since the 1980s, this plant has begun abandoned by farmers as a result of an ambitious program of self-sufficiency in rice-based food security. Meanwhile, the achievement of rice for self-sufficiency is still far from expectations. Therefore, to establish sustainable food security is no longer just rely on rice food but there should be diversification of food sources. One type of plant that is prospective and potential to be developed as an alternative food in dry land areas is rice bean.

Development of rice bean in upland is exposed to low soil fertility problems. In general, the soil in dry land was characterized by soil physical, chemical and biological as follows. The physical properties of soil are characterized by coarse soil texture (sand clay), low moisture content and soil moisture storage capacity and aggregate stability is not strong. Chemical properties of soil are characterized by low content of organic-C (less than 1%), cation exchange capacity (CEC) is low and the lack of N, P content-available, but it has high content of K elements and level of soil acidity pH is neutral. Biological properties of soil are characterized low number of soil microbes such as bacteria solvent recycler nutrient phosphate whose population is only about 104 cfu. g^{-1} soil, while in the fertile soil reaches 107 cfu g^{-1} soil (Kusumo *et al*. 2011). Such soil characteristics result in low productivity of crops cultivated in that dry land.

The most farmers use chemical fertilizer (Urea, SP-36 and KCl) in order to improve crop productivity in dry land. However, they do not realize that the amount of nutrients absorbed by the plant derived from chemical fertilizers in the soil with these characteristics is relatively low. It is linked to low C-organic content. While C-organic is a soil segment controlling the soil properties. Therefore, to increase the amount of nutrients that can be absorbed by plants, not only by providing the necessary chemical fertilizers but also by giving organic fertilizer to increase soil organic matter content (Ma'shum *et al*. 2003).

Furthermore, to improve the absorption of nutrients by plant roots can be done through the enrichment of soil microbes that are beneficial to plant growth. One type of soil microbes that facilitate the absorption of nutrients is Vesicular Arbuscular Mycorrhiza (VAM). Mycorrhiza improves growth and yield through its role in facilitating the P availability and P uptake as well asd other nutrients (Musfal 2010). Mycorrhizal inoculation of 15 g per corn plant in dry land could improve efficiency of the use of NPK fertilizer up to 50% with the results of shelled corn were not significantly different by giving 100% NPK fertilizer (Musfal 2010). In addition, it was also reported that mycorrhizal infected plants became more resistant to drought stress than non-mycorrhizal plant. How much mycorrhizal effectiveness in improving nutrient uptake by plant roots was determined by the soil environmental conditions and the suitability between host plants and VAM fungi (Quilambo 2003).

The purpose of this study was to obtain an efficient combination fertilization pattern for rice beans cultivated in dry land and their effects on the efficiency nutrient uptake, crop productivity and yield quality.

MATERIALS AND METHODS

The experiments were conducted on dry land in the Gumantar village, North Lombok regency, NTB. Soil type was Entisol with sandy loam soil texture, pH 5.53 (category acid), C-organic content was 0.82% (Walkey and Black method), N-total was 0.04% (Kjedalh method), P-available was 33.28 (Bray method I) and K_{dd} was 1 me % (by ammonium acetate extractor with pH 7).

The experiments were arranged in a randomized complete block design (RCBD) consisting of 9 fertilization pattern treatments, each treatment was replicated 3 times. The size of experiment plots was 3m × 3m. Nine fertilization patterns were as follows. RP0: no fertilizer (control); RP1: 100% of recommendation fertilizer (50 kg Urea and 100 kg SP-36 ha^{-1}); RP2: 5 Mg ha^{-1} manure plus 50% of recommendation fertilizer; RP3: RP2 treatment plus MVA; RP4: 5 Mg ha^{-1} *Crotalaria* sp compost and 50% recommendations fertilizer; RP 5: RP4 treatment plus VAM; RP 6: 2.5 Mg ha^{-1} manure, 2.5 Mg ha^{-1} *Crotalaria* sp compost and 50% recommendations fertilizer; RP7: 1.5 Mg ha^{-1} manure, 1 Mg ha^{-1} *Crotalaria* sp compost and 50% recommendations fertilizer; RP 8: RP7 treatment plus VAM.

In this experiment, plant used was red seed rice bean, result of pure line selection of the first phase of research activity, by the characteristic tolerant to drought (50-75% WHC) with the yield potential was up to 4 Mg.ha^{-1}. VAM inoculums used were from BPPT-Serpong, with "Technofert" trade mark. Manure was derived from the local site. *Crotalaria juncea* compost was derived from the local site.

The process of the planting was begun by giving manure and/or *Crotalaria* juncea compost during land processing. Planting was conducted by drilling with 3 rice bean seeds per planting hole. Thinning of the plants was conducted when the plant was 14 days after planting with 2 plants per planting hole. Spacing used was 40 cm (between rows) x 15 cm (within a row). The treatment of VAM was given by inoculating 10 g VAM at each planting hole. Chemical fertilizer (according to the treatment) was given by a bolt system by spacing 5-7 cm from the planting hole. The first watering was done a day before planting up to field capacity conditions, and the watering was then performed once every 10 - 12 days up to 10 days before first harvesting. The first harvesting was conducted when the plant was 72 days after planting, and harvesting is then conducted every 2 days as much as 9 times of harvesting.

The observed variable at the maximum vegetative phase (32 DAP) included: root infection by VAM, the number of nodules (nodule plant^{-1}) and the percentage of active root nodules (% total nodule), dry biomass weight of above plant (DBW g plant^{-1}, determined after drying on oven for 48 hours at a temperature of 65 ^{o}C), content of N and P in plant tissue (wet destruction method), uptake of N and P (g plant^{-1}, determined by multiplying the nutrient content and DBW), fertilizer N use efficiency (NUE) and fertilizer P use efficiency (PUE) defined by the formula :

$$NUE / PUE = ((B-A)/C) \times 100\%$$

B = uptake of nutrients (N or P) in plant tissue with fertilization.

A = uptake of nutrients (N or P) in plant tissue without fertilization.

C = nutrient content in the fertilizer given to the soil.

Production parameters included: the number of pods (pods plant^{-1}), seed weight per plant (g plant^{-1}), 100 seeds weight (g), plant productivity (Mg ha^{-1}) (as a result of conversion of grain weight (g plant^{-1}) multiplied by the population per ha). Parameters of the quality included the carbohydrate content (Spectrometry test method), protein content (Kjeldhal method) and anthocyanin content (using a spectrophotometer (Murray and Hackett 1991). Data were analyzed using analysis of variance at 5% significant level. If there was a real effect of treatment on the measured plant parameters would be conducted a further test using least significant difference (LSD) at the same significant level.

RESULTS AND DISCUSSION

The fertilization patterns tended to increase the degree of VAM infection and the number of root nodules. The high relative yield occured in the fertilization patterns of RP3 and RP5. At fertilization treatments of RP1, RP2, RP4, RP6, RP7, RP8 and the control (RP0), the degree of VMA infection were comparable between one another (Figure 1).

Infection of plant roots by VAM fungi on the fertilization treatments without inoculation of VAM (RP0, RP1, RP2, RP4, RP6, and RP7) indicated that there was the indigenous VAM spores on the experiment soils and the spores recognize rice bean plants as a host plant. Mosse (1988) suggested that VAM fungal spores will germinate on the suitable soil environment, suitable soil environmental conditions for seed germination is also suitable for germination of spores of mycorrhizal, and then spores construct appressorium for infecting surface of plant roots traced as host plants. Such situation occured on the experiment soil when rice bean plant was cultivated on that land. Root exudates of rice beans contain organic compounds that can stimulate the spore germination and the appressorium formation on the root surface. Shaw, et al. (2006) reported that the organic compounds that act as a stimulant in different interaction phases of symbiotic between microbes and higher plants were derived from the flavonoid group. Makoi (2009) explained that some of the flavonoid of *Vigna* family stimulated the germination of spores and growth of hyphae in the establishment of symbiosis between the roots and VAM fungi.

Furthermore, the experimental results showed that the patterns of fertilization which includes organic fertilizer inputs with different doses were not capable of building soil suitable environment to stimulate the growth and activity of indigenous VAM infect roots. Perhaps this was due to the input of organic fertilizer with a dose of 2.5-5 Mg. ha^{-1} had not been able to improve the status of soil organic matter content (OM) in the experimental soils (organic carbon in soils after planting 0.89%). Ma'shum, et al. (2003) reported that the maximum number of VAM spores was found in soils with organic carbon contents of 1-2%, meanwhile in soil containing organic carbon less than 0.5% there number of the spores were scrimpy.

Associated with an increase in the degrees of infection VAM relatively high in RP3 and RP5 compared with in R1, RP2, RP4, RP6 (fertilizing patterns without VAM inoculation) showed that VAM fungi inoculation resulted in the increase of root infection degrees. These results indicated that (1) VAM-introduction fungal species was compatible with the roots of rice bean plants; (2) inoculation of the VAM-introduction fungal species was not a competitor for the indigenous VAM fungi in colonizing the plant roots. From the experimental results suggested that many species of VAM fungi can infect the plant roots. In other words, the associations of VAM on the plant roots did not require the specific VAM fungi species. Scervino, *et al*. (2007) stated that the VAM fungi generally do not require specific host plants but VAM tend to favor certain host plants.

The number of nodules increased relatively high in RP3 and RP5 compared with other fertilization patterns (Figure 1). Increasing of the nodule number in RP3 and RP5 followed pattern of increases of the VAM infection degrees in RP3 and RP5. These results indicated that there was a positive impact of VAM inoculation on formation of nodules. Increasing of the nodule number could be associated with VAM role in increasing the absorbtion of P (Musfal, 2010), so the number of P uptake in the mycorrhizal plants was higher than the non mycorrhizal plants (Table 1). Legumes require high relative P amounts because phosphate is not only needed to meet the plant metabolism but also to stimulate the nodule formation and the N fixation by *Rhizobium* sp. Sutarwi (2012) reported that increasing doses of phosphate fertilizer significantly increased the number of nodules on peanut plants. Furthermore associated with the percentage of active nodules, the fertilization patterns did not affect significantly (Figure 1). This results showed the active nodule percentage on the fertilization patterns ranged from 40 to 50% of the total nodules formed.

Uptake of N and P describe the amount of N and P in the plant tissues. The amount of nutrients absorbed is calculated by the formula: nutrient content (%) multiplied by dry weight of the plant. By knowing the rate of absorption of nutrients, hence the nutrient uptake efficiency of fertilizer can be

Table 1. Content of N and P in plant tissues, N and P uptake and NUE and PUE in Various Fertilization Treatments

Fertilizer	N content in plant tissues (%)	P content in plant tissues (%)	N Uptake (g plant^{-1})	P Uptake (g plant^{-1})	NUE[1)] (%)	PUE[2)] (%)
RP0	3.26	0.23	0.094	0.007	-	-
RP1	3.50	0.22	0.152	0.010	60.52	20.78 a*
RP2	3.34	0.23	0.136	0.010	88.63	37.99 b
RP3	3.31	0.24	0.140	0.011	96.94	50.15 c
RP4	3.22	0.22	0.132	0.009	78.56	32.33 ab
RP5	3.43	0.24	0.150	0.011	117.93	51.93 c
RP6	3.31	0.23	0.136	0.009	87.40	35.45 b
RP7	3.27	0.22	0.123	0.010	61.59	38.15 b
RP8	3.28	0.23	0.145	0.009	87.52	31.49 a
Mean	**3.32**	**0.23**				
F-test 5%		-	NS	NS	NS	S
LSD 5%						14.19

* Values followed by the same letter are not significant different at 5 %
1) NUE = N Uptake Efficiency;
2) PUE = P Uptake Efficiency based on levels of P_2O_5
RP0: no fertilizer (control); RP1: 100% recommendation fertilizer (50 kg Urea and 100 kg SP-36 ha^{-1}). RP2: 5 Mg ha^{-1} manure plus 50% recommendation fertilizer; RP3: RP2 treatment plus MVA; RP4: 5 Mg ha^{-1} *Crotalaria* sp compost and 50% recommendation fertilizer; RP 5: RP4 treatment plus VAM; RP 6: 2.5 Mg ha^{-1} manure. 2.5 Mg ha^{-1} *Crotalaria* sp compost and 50% recommendation fertilizer; RP7: 1.5 Mg ha^{-1} manure. 1 Mg ha^{-1} *Crotalaria* sp compost and 50% recommendation fertilizer; RP 8: RP7 treatment plus VAM.

calculated by the formula: amount of nutrient uptake from fertilizer absorbed by plant divided by the nutrient content of the fertilizer dose multiplied by 100%.

Results of laboratory analysis showed that the average content of N and P in the plant tissues was 3.32% and 0.23%, respectively (Table 1). Base on statistical analysis results, the fertilization patterns did not significantly affect on N uptake, NUE, and P uptake (p>0.05. However, when the rate of N uptake in plant tissues from control treatment compared to N in plant tissues from fertilization treatments showed significant differences (Figure 2). The average N uptake of all fertilization treatments reached 48% was higher than the control. These results indicated that application of N fertilizers resulted in the increased uptake of N because of increasing N in soils. The results of soil analysis performed on the maximum vegetative phase of plants showed that N in soils on the control was lower than on the fertilization treatments, namely by 0.04% and 0.05% respectively, meanwhile N in soils before planting was 0.04 %. Nitrogen fertilizer was needed to get up the early growth of plant roots, because the nutrients contained in the cotyledons were used more for the growth of the above part plants (Salvagiotti *et al.* 2008). Furthermore, from the experimental results could be explained that as much as 50 kg urea fertilizer ha^{-1} needed as a plant growth starter. The rate of N fertilizer could be reduced to 25 kg urea ha^{-1} when it was given with organic fertilizer (manure and / or *Crotalaria juncea* compost) at a dose of at least 2.5 Mg ha^{-1} (either with or without inoculation VAM).

The result of NUE measurement showed that the value of NUE on rice bean plants did not reflect the value of the N fertilizer use efficiency. This was showed by the NUE value which exceeds 100% (occurred in RP5) because N in rice bean plant tissues was not only derived from N fertilizer but also from N fixation. Sisworo *et al.* (2013) reported that nitrogen in soybean plants derived from fertilizers, N fixation, and soils was each about 5, 39, and 56% of total N needed by plants.

Associated with the real effect of the treatments on the PUE could be explained as follows. Contribution of P fertilizer to the PUE ranged from 20.78 to 51.93. The highest PUE was obtained on RP3 and RP5 (up to ± 50%), then followed by RP2, RP4, RP6, RP7 (36%) and the lowest was found on RP1 (20.78%). Difference of PUE levels was strongly suspected because there was different dissolving rate of the SP-36 fertilizer in resulting the available P for plants. The results of soil analysis performed on the maximum vegetative phase of plants showed that the P-available in soils of the control was lower than in

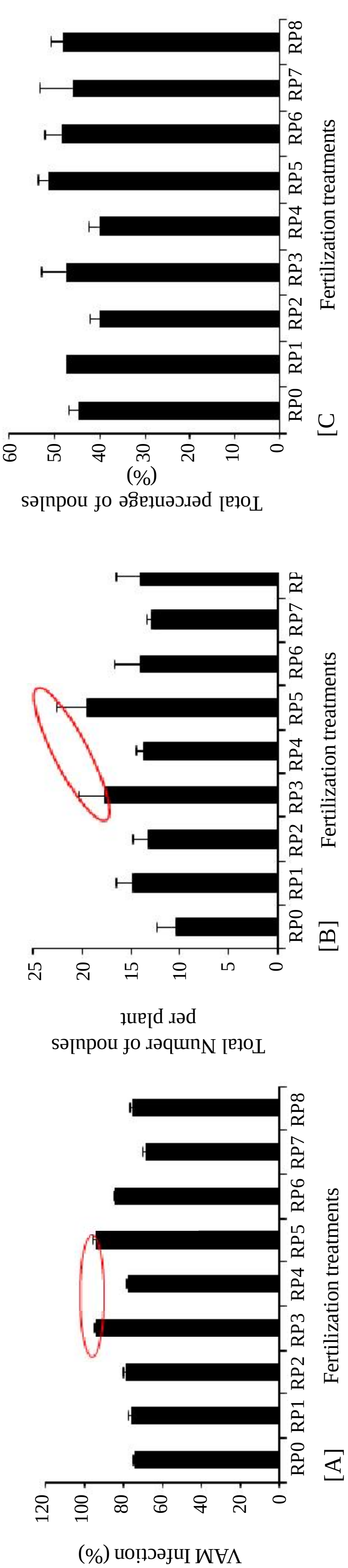

Figure 1. VAM Infection Degrees (%) [A], Total number of Nodules [B] and Total percentage of Active Nodules (% total nodule) [C] at Various Fertilization Treatments.

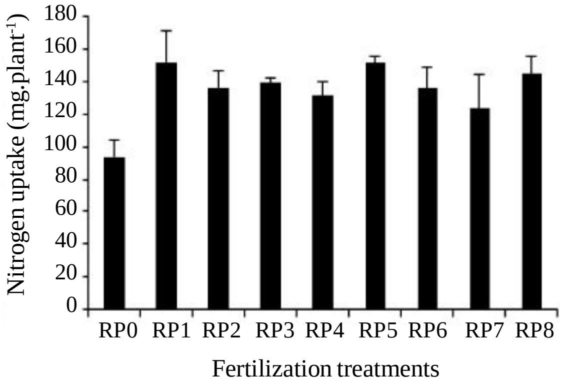

Figure 2. Nitrogen Uptake at Various Fertilization Treatments.

soils of the RP5, namely as many as 26.99 ppm and 33.75 ppm respectively, meanwhile the P-available in soils before planting was 33.28 ppm. Kusumo *et al.* (2011) reported that application of organic fertilizers could increase the amount of dissolved P in soils, so that there was more P that could be absorbed by plants. The application of organic fertilizers in soils increased the content of organic acids (humic and fulvic acid) that have function to dissolve the P fertilizer (Van der Maesen and Somaatmadja 1993).

Furthermore, refer to the experimental results it could be explained that increase of the P uptake in plants grown at dry land with status of organic matter in soils that was very low (initial soil analysis of C-organic 0.82%) was needed organic fertilizer input with a minimum dose of 2.5 t ha^{-1} both from manure and/ or *Crotalaria juncea* compost. Uptake of P still can be improved further with inoculation of biofertilizers-VAM. The rate of PUE in RP 3 and RP 5 was up to 38% higher than the PUE in RP 2 and RP 4. These results explained that there was a significant role of VAM to improve the P absorption derived from SP-36 fertilizer. Increased absorption of P was consistent with an increase in the degree of VAM infection that occurs in RP 3 and RP 5. Increasing the amount of P in mycorrhizal plant tissues can be explained as follows. In each segment of the VAM infected root structure formed hyphae that spread out (external hyphae) and extends into soils. The external hyphae help absorb P from places that are unreachable by root hairs (Simanungkalit *et al.* 2003).

In soils, nutrient P is not mobile and its movement toward the root surface was very slowly, following the diffusion flow (Shen *et al*. 2011). On the other hand, P absorption by root hairs takes place quickly. Speed of P movement toward the root surface is not aligned with speed of absorption-P by the root hairs as a result there often occurs depletion zone of P in the rhizosphere. Such circumstances lead to P absorption stopped momentarily because there was no available P for plants. This incident does not occur in mycorrhizal plants as the VAM external hyphae can traverse the depletion zone so that the plants can absorb phosphate from the zone which is not covered by the non-mycorrhizal plants (Simanungkalit *et al.* 2003). Kabirun (2002) explained that the volume of roaming mycorrhizal roots to absorb P up to 10 times greater than non-VAM plants. Therefore mycorrhizal plants can efficiently use P fertilizer.

The observed production components included the number of pods (pods. plant^{-1}), grain weight (g plant^{-1}), 100 grains weight (g) and plant productivity (Mg ha^{-1}). Crop productivity is the result of the conversion of grain weight (g plant^{-1}, each planting hole containing 2 plants) multiplied by 120,000 planting holes.ha^{-1}. The research results showed that the fertilization patterns were not significantly affected the number of pods (pods. plant^{-1}) and a significant effect on grain weight (g plant^{-1}), weight of 100 grains (and plant productivity (Mg ha^{-1}) (Figure 3). The number of pods per plant was calculated from all the pods formed without differentiate between empty and full. There was no significant effect of the fertilization patterns on the number of pods may be (1) the number of pods is one of the genetic characters of the crop, and (2) changes in the soil environment as a result of fertilization patterns did not affect the process of pollination. Van der Maesen and Somaatmadja (1993) described that the number of pods per plant reached more than 25. Formation of pods indicated that the process of pollination occures normally. Utilization of chemical fertilizers (Urea, SP-36) and organic fertilizer (manure and *Crotalaria juncea* compost) is unlikely to meet the needs of micro elements for rice bean plants so that the potential for crop pollination is controlled only by genetic characteristics of the plant. Simanungkalit *et al*. (2003) mentioned several micro elements such as Mn, Fe and Zn had important roles in the flowering phenology.

Against the grain weight per plant and weight of 100 grains showed that fertilization patterns tended to increase the two parameters that the results were relatively high in RP3 and RP5. This indicated that changes in the soil environment on the fertilization treatment could stimulate the plant metabolic processes in producing secondary metabolites stored in grains. Increase of PUE in RP 3 and RP 5 (Table 1) were followed by increase of grain weight per plant, weight of 100 grains and plant productivity (Figure 3) because there was the increase uptake of P and N in plant tissues (Table 1). The roles of P in plant metabolism, among others, as (1) the building elements of biological energy (2) constituent nucleotides, and (3) P also took part in the synthesis of proteins and carbohydrates (Salisbury and Ross, 1991).

Based on the experimental results could be showed that grain weight per plant and 100 grain weight in 100% of fertilizer recommendation (RP1) were comparable to fertilization treatments of 2.5 - 5 Mg organic fertilizer ha^{-1} plus 50% of fertilizer recommendation (RP2, RP4, RP6, RP7, and RP8). These results indicated that to build a plant growth medium which is equivalent to 100% of fertilizer recommendation was needed the input of at least 2.5 Mg of organic fertilizer per hectare plus 50% of fertilizer recommendation. However, such doses had not been able to optimize crop yields. Optimization of plant growth occured in RP3 and RP5 with a fertilization treatment that consisted of 5 t of organic fertilizer (manure and/ or *Crotalaria juncea* compost) per ha, 50% of fertilizer recommendation plus inoculation of VAM. Improved results that were high relative in RP 3 and RP 5 related to the role of external hyphae of VAM in improving on availability and absorption of P, soil structure and distribution of carbohydrates from roots to rhizosphere to stimulate microbial activity (Quilambo 2003). Beside that external hyphae of VAM also played an important role in increasing the absorption of water, N, K, Ca and Mg (Musfal 2010).

The data of weight of 100 grains presented in Figure 3 showed that there was improvement the weight from 8.26 g in the control to 8.59 g in the fertilization treatment without VAM and to 8.95 g in the fertilization treatment with VAM. Furthermore, it can be explained that crop productivity increased from 1.94 Mg ha^{-1} on the control treatment to 2.64 Mg ha^{-1} on the fertilization treatments without VAM (RP1, RP2, RP4, IDR6, Rp7) and to 3.95 Mg ha^{-1} on the fertilization with VAM (RP3 and RP5). In other words there was an increase of plant productivity by 50% on the fertilization patterns with VAM (RP3 and RP 5) compared to the fertilization patterns without VAM (RP2, RP4, RP6, and RP 7). These results indicated that rice bean plants grown in dry lands had very high dependence on VAM.

The observed yield quality components included the carbohydrates, proteins and anthocyanins in grains of rice bean. The experimental results showed that variety of the fertilization patterns did not significantly affect on contents of proteins and anthocyanins (Table 2). The mean contents of

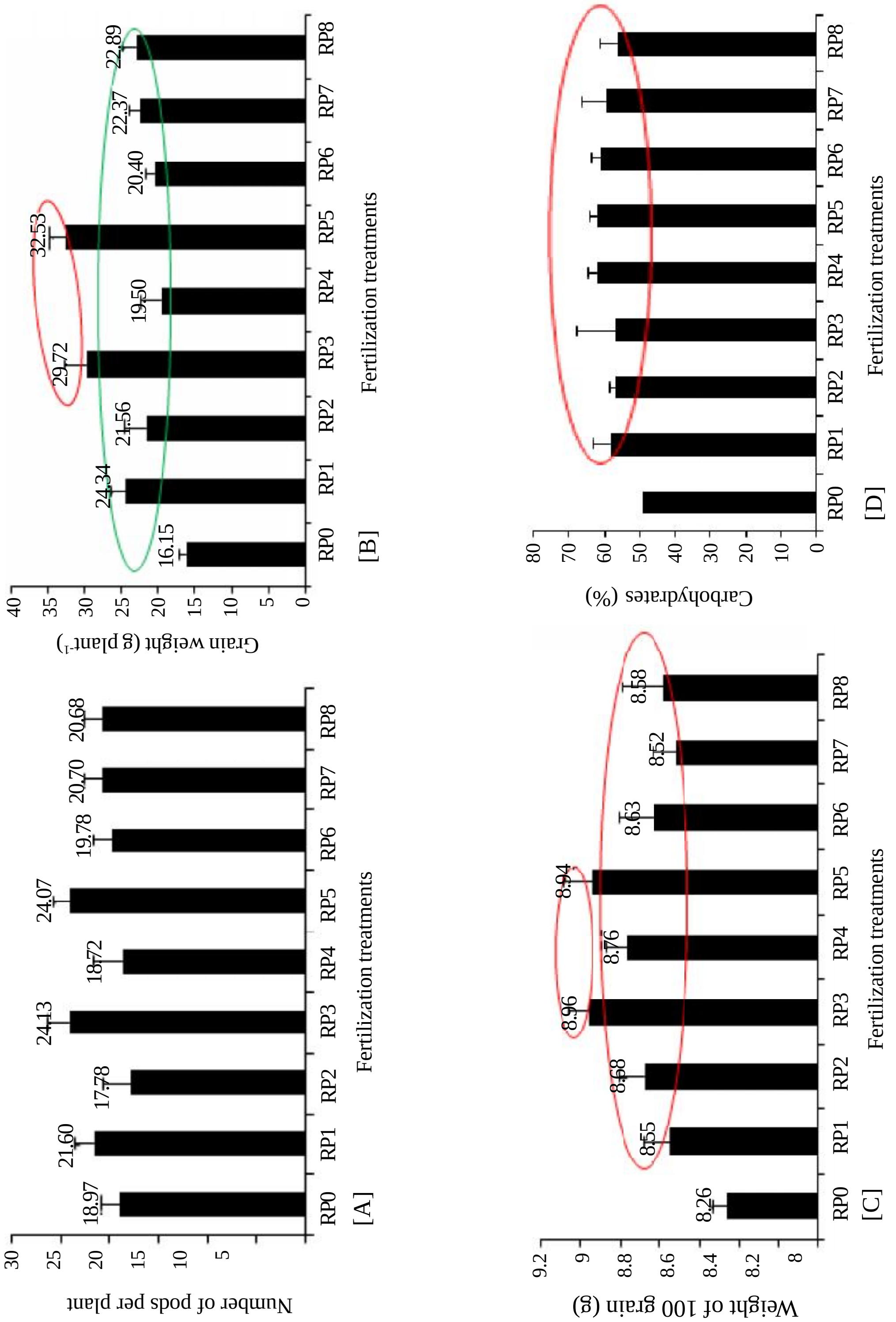

Figure 3. Number of pods per plant (pods. plant^{-1}) [A], seed weight (g. plant^{-1}) [B], weight of 100 seeds (g) [C] and plant productivity (t.ha^{-1}) at Various Fertilization Treatments [D].

proteins in grains of the rice bean was 16.11%. Protein content in grains of the majority of rice beans varied from 14.53 up to 32.16% with a mean content of 22.53% (Buergelt and Matthias von Oppen 2013). Average anthocyanin contents in bean rice grains was 11.97 mg g^{-1} in which this content near to brown rice anthocyanin contents of the Ciherang variety (13.1 mg 100g^{-1}) (Indrasari 2010). The data presented in Figure 4 showed that there was an increase of carbohydrate content as many as 20.55% with increased content from 49.04% in the control (RP0) to 59.12% in the fertilization treatment (the average contents of all fertilization treatments). Meanwhile, carbohydrate content of each fertilization treatment was not different significantly. Furthermore, it could be explained that synthesis of carbohydrates increased along with increasing uptake of N and P (Table 1). The average contents

Table 2. Carbohydrate and Anthocyanin Contents in Various Fertilization Patterns

Fertilization Treatments	Protein Content (%) ± SE	Anthocyanin Content (μg g^{-1}) ± SE
RP0	15.95± 0.79	10.83 ± 0.79
RP1	15.59± 0.64	10.67 ± 2.75
RP2	16.43± 0.33	13.10 ± 2.46
RP3	15.92± 0.41	12.90 ± 2.21
RP4	16.17± 0.69	10.57 ± 1.15
RP5	16.49± 0.19	10.87 ± 1.24
RP6	16.11± 0.79	12.43 ± 0.78
RP7	15.87± 0.19	13.27 ± 1.85
RP8	16.44± 0.20	13.10 ± 1.97
Mean	16.11± 0.43	11.97 ± 1.69

Note: RP0: no fertilizer (control); RP1: 100% recommendation fertilizer (50 kg Urea and 100 kg SP-36 ha^{-1}). RP2: 5 Mg ha^{-1} manure plus 50% recommendation fertilizer; RP3: RP2 treatment plus MVA; RP4: 5 Mg ha^{-1} *Crotalaria* sp compost and 50% recommendation fertilizer; RP 5: RP4 treatment plus VAM; RP 6: 2.5 Mg ha^{-1} manure. 2.5 Mg ha^{-1} *Crotalaria* sp compost and 50% recommendation fertilizer; RP7: 1.5 Mg ha^{-1} manure. 1 Mg ha^{-1} *Crotalaria* sp compost and 50% recommendation fertilizer; RP 8: RP7 treatment plus VAM.

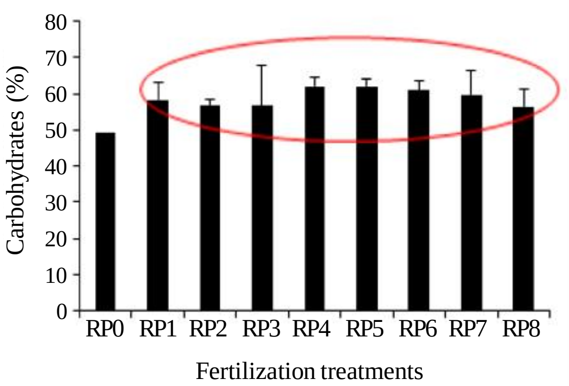

Figure 4. The Carbohydrate Content in Seeds at Various Fertilization Treatments.

of carbohydrates in plants exposed to fertilization treatment was 59.12%. The content of carbohydrates in this experiment was in the range of carbohydrate content in the majority of rice beans with a range of 58.15 to 71.99% (Buergelt and Matthias von oppen 2013).

CONCLUSIONS

Efficiency of N uptake in fertilized plants with the variety of fertilization patterns was not significantly different. N uptake of the fertilization patterns was 48% higher than the control.

Efficiency of P uptake on fertilization pattern with 5 Mg organic fertilizer per ha, 50% of recommendation fertilizer, plus VAM reaches 51.04%, followed consecutively by fertilization pattern with 5 Mg of organic fertilizer, 50% of recommendation fertilizer, without VAM was 35.98% and 100% of recomendation fertilizer was 20%.

Productivity of rice bean plants on fertilization pattern with 5 Mg organic fertilizer per ha, 50% of recommendation fertilizer, plus VAM reaches reached 3.75 Mg ha^{-1}. Productivity of plants given fertilization with 5 Mg organic fertilizer ha^{-1}, 50% of recommendation fertilizer, and without VAM was comparable to the 100% of recommendation fertilizer with a mean productivity was 2.64 Mg ha^{-1}. The plant productivity on the control treatment was 1.94 Mg ha^{-1}.

Carbohydrates in rice bean grains increased by 20% on the fertilized treatments compared to the control. Treatment of fertilization patterns did not give a significant effect on content of proteins and anthocyanins in rice bean grains.

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