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Optimum dosage of granular phosphorus fertilizer on the yield of young pods of *Phaseolus vulgaris* L.

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Abstract. The growth and yield of erect snap bean pods *Phaseolus vulgaris* L. could be improved among other things by the application of optimum dosage of appropriate source of phosphate fertilizer. The goal of this experiment was to find out optimum dosage of granular phosphorus fertilizer that was effective to increase yield of erect snap bean plants. Research activities have been carried out at Experimental Garden of Indonesian Vegetable Research Institute (IVEGRI) from January to March 2010 in Lembang - Bandung, West Java. A Randomized Block Design with four replications was set up in the field. Treatments comprised of five level dosages of granular phosphorus fertilizer, *viz*. 50; 75; 100; 125 and 150 kg P_2O_5/ha^{-1}, and control (without P fertilizer) with four replications. P and basic fertilizers were applied at two days before planting the seed. Seed were planted in double rows and two seed per hole in the row. The rows were covered by black silver plastic mulch. Erect snap bean plants were maintained optimally and protected intensively from pests and diseases infestations since in the beginning by the application of proper kinds and dosage of pesticides. Variable measured were vegetative growth and yield of young pods. Research results showed that P fertilizer increase number of flower cluster per plant. Optimum dosage for yield of young pods was 90.8 kg P_2O_5/ha^{-1} with 34.06 kg yield young pods per plot.
Key Words: Agronomic efficiency, harvesting time, erect snaps bean, flower cluster per plant, vegetative growth.

Introduction. Snap bean (*Phaseolus vulgaris* L.) is a potential vegetable crop, has a high economic value and nutrient contents. Snap bean was consumed as fresh young pods. Erect snap bean productivity in farmer level is about 7.75 ton/ha^{-1} lower than it's potential productivity about >15 ton/ha^{-1} (Zahara et al 1980). The reasons why snap bean productivity in farmer level is low, *i.e.*: (1) not used high quality cultivar, (2) different on planting time, (3) different on planting space, (4) not used Good Agriculture Practice, including fertilizer and fertilization.

Phosphorus is one of the major nutrients that have been identified as limited resources that would end up earlier than predicted at the rate of current consumption (Malavipathirana et al 2013). Meanwhile, phosphorus concentration in the plant treated with phosphate fertilizer is higher than where organic fertilizer was applied (cow and chicken manure) (Uddin et al 2012). Combination of poultry manure, inorganic phosphorus fertilizer and phosphate through solubilizing bacteria increase P uptake and PUE until 24 % (Zafar et al 2011).

Increasing weight of snap bean seed was done by phosphorus fertilizer application using TSP fertilizer as a phosphorus source. Seed yield of six erect snap bean cultivar increase about 22 % by 135 kg P_2O_5 compare than control (without phosphorus fertilizer) (Sumpena & Hilman 2000). In the market, there was a lot of phosphorus fertilizer *i.e.*: SP-18, SP-36, NPK (16-16-16), etc. whose could improve plant growth and increase vegetable yield especially erect snap bean. But, application of GPS-20 granular fertilizer as a phosphorus source to increase erect snap bean productivity not yet known. So, the research was done to find out effectivity of GPS-20 granular fertilizer on erect snap bean growth and yield and to know the optimum dosage for them.

Material and Method. GPS-20 is a granular fertilizer as a phosphorus source and content 20 % P_2O_5, 30 % CaO, 2 % SiO_2, 0,3 % MgO, 3 % Fe_2O_3 + Al_2O_3 and 4 % H_2O.

GPS-20 was easy to application because it's granular forming, not dusty, and has multifunctions such as: source of P and Ca, increase pH level and also could supply micronutreint such as Si, Mg, Fe and Al. Size of GPS-20 granular fertilizer is about 2 - 6 mm per granule.

The experiment was conducted at Lembang Experimental Field of Indonesian Vegetables Research Institute (IVEGRI) (1200 m abs) from December 2009 to February 2010. Type of soil is Andisol with low pH (5.1), very low total N 0,67 %, medium P_2O_5 concentration (7.0 ppm), and very high K content (134.8 ppm). Randomized Block Design with six treatments and four replications was used. The six treatments were: (1) P1 = 0 kg P_2O_5 (control), (2) P2 = 50 kg P_2O_5/ ha, (3) P3 = 75 kg P_2O_5/ha, (4) P4 = 100 kg P_2O_5/ha, (5) P5 = 125 kg P_2O_5, (6) P6 = 150 kg P_2O_5/ ha.

All treatments got basic fertilization, they were: (1) horse manure 10 ton per ha, (2) Urea fertilizer dosage 363 kg per ha, (3) KCl fertilizer dossage 278 kg per ha. Basic fertilizers (horse manure, urea and KCl) and GPS-20 fertilizer were applied once time when surface tillage depth 15 cm doing with mixture them with soil on the bed. After that bed was cover by black silver mulch.

Erect snap bean seed LE-147 was sowing on the plant hole as two seed each hole, with planting space 20 x 50 cm on 5 x 4 m plot size. Number of population was 100 plant per plot and plots were covered by dark silver mulch. The advantages of black silver mulch application are: (1) keep stability of soil temperature in rainy season, (2) decrease soil borne disease, (3) decrease nutrient leaching by rain, (4) reduce weeds.

The parameters were observed are: vegetative growth of erect snap bean, harvesting time from begin until the end, erect snap bean production, quality of young pods and PAE. Agronomic efficiency of applied fertilizer P (PAE) was calculated by Siddiqi & Glass (1981) methods with modification:

$$PAE = \frac{\text{young pods yield in plots with fertilizer - young pods yield in control plots}}{\text{quantum of applied P fertilizer}}$$

Results and Discussion. Erect snap bean was sowing on 6 January 2010, and flowering on 10 February 2010 (35 days). Young pods were harvested start from 1 March 2010 (53 days) until 16 March 2010 (69 days). Harvest interval was 3 days with number of harvest was 5 times or 15 day harvest period.

Visually, erect snap bean with GPS-20 application growth normally. There were no phytotoxicity symptoms and other abnormal symptoms. Leave color was green and normal. This situation proof that was no phosphorus deficiency on erect snaps bean plants. Phosphorus deficiency signing by dark green of leaves color, stunning growth, late mature, purple spot and streaks on the leaves (Thompson & Throeh 1979).

Phosphorus fertilizer not significantly affects erect snap bean growth (Table 1). Because phosphorus was absorbed by plant root and distributed to all plant organ, but phosphorus concentration on reproductive organs was such as in seed (Bennet et al 1962).

Table 1

Effect of granular phosphorus fertilizer on height of plant

Treatments	*Height of plant (cm)*		
	2 wap	*3 wap*	*4 wap*
Control (without P)	9.28	14.78	28.57
50 kg P_2O_5/ha	8.75	14.60	27.20
75 kg P_2O_5/ha	9.64	15.97	29.06
100 kg P_2O_5/ha	9.00	15.69	28.02
125 kg P_2O_5/ha	9.29	15.51	27.89
150 kg P_2O_5/ha	7.22	14.86	27.91
CV (%)	7.86^{ns}	5.26^{ns}	6.45^{ns}

wap – weeks after planting, ns- not significant.

In table 2 are showed that P fertilizer increase number of flower cluster per plant, but do not increase number of pods, length of pods and diameter of pods. Distribution of phosphorus concentration on generative organs from begun (Bennet et al 1962) make number of cluster significantly higher than control.

Table 2

Effect of phosphorous fertilizer on yield component of erect snaps bean

Treatments	*Yield component of erect snaps bean*			
	Number of flower cluster per plant	*Number of pods*	*Length of pods (cm)*	*Diameter of pods (cm)*
Control (without P)	16.67[b]	39.96	16.75	0.69
50 kg P_2O_5/ha	18.96[a]	33.75	16.47	0.65
75 kg P_2O_5/ha	19.08[a]	44.67	16.56	0.71
100 kg P_2O_5/ha	19.00[a]	43.91	16.46	0.69
125 kg P_2O_5/ha	18.58[a]	37.87	16.37	0.67
150 kg P_2O_5/ha	18.50[a]	37.37	16.33	0.65
CV (%)	8.13	16.21	2.79	8.50

In the next step, a flower on the cluster growth becomes a young pods bean. But, number of pods is not significantly different on all treatments. It would be happen because of flower abortion. Flower abortion could happen because of a not perfect pollination and fertilization. GPS-20 fertilizer dosage 100 kg P_2O_5/ha^{-1} increase weight of young pods per plant, weight of young pods per plot (15 m^2) and total production per ha compare than control (Table 3).

Table 3

Effect of phosphorous fertilizer on erect snaps bean production

Treatments	*Production of erect snaps bean*		
	Weight of pods per plant (g)	*Weight of pods per plot (kg/15m²)*	*Production (ton/ha⁻¹)*
Control (without P)	139.29[b]	26.80[b]	10.18[b]
50 kg P_2O_5/ha	145.18[ab]	27.87[ab]	10.59[ab]
75 kg P_2O_5/ha	155.82[ab]	29.92[ab]	11.37[ab]
100 kg P_2O_5/ha	164.42[a]	31.57[a]	12.00[a]
125 kg P_2O_5/ha	154.31[ab]	29.63[ab]	11.26[ab]
150 kg P_2O_5/ha	141.39[b]	27.15[ab]	10.32[ab]
CV	9.00	7.50	9.00

Application of phosphorous fertilizer in a dosage of 100 kg P_2O_5 increase yield of erect snap bean production. Phosphorus is essential unsure which function as a component on structure of DNA, RNA, enzyme, ATP, ADP, NADPH which act on growth and development of vegetative and generative organs (flower, fruit and pods) (Maschner 1986). Phosphorus deficiency reduces plant growth, opaque-green coloration of the old leaves, or bronze-red or purple coloration. Absence of P causes a reduction in fresh matter production of the plants aerial parts and roots, plants diameter and P content in the leaves (Bertossi et al 2013).

On level of 150 kg per ha, yield of erect snap bean young pods was decreased. It would be happen because dosage of phosphorus was higher than erect snap bean needed so there were no balances on soil nutrient and delay other nutrient uptake *i.e.* zinc. Phosphorus and zinc have antagonistic effect on the absorption and translocation of each other in plants. P-induced Zn deficiency is more usual than Zn-induced P deficiency (Soltangheisi et al 2013). Phosphorus absorption efficiency is increased by increasing level of phosphorous until 500 kg per ha. But, increasing phosphorous level decrease the number of phosphorous efficiency aerial part of intake plant (Bertossi et al 2013).

Phosphorous optimum dosage is shown on figure 1. Optimum dosage for yield of young pods was 90.8 kg P_2O_5/ha^{-1} with 34.06 kg yield young pods per plot (15 m^2). High level of phosphorous do not increased the yield. P absorption and use efficiency are influenced by the use of micronutrients. Micronutrients such as boron and zinc influence P absorption at different dosage (Bertossi et al 2013).

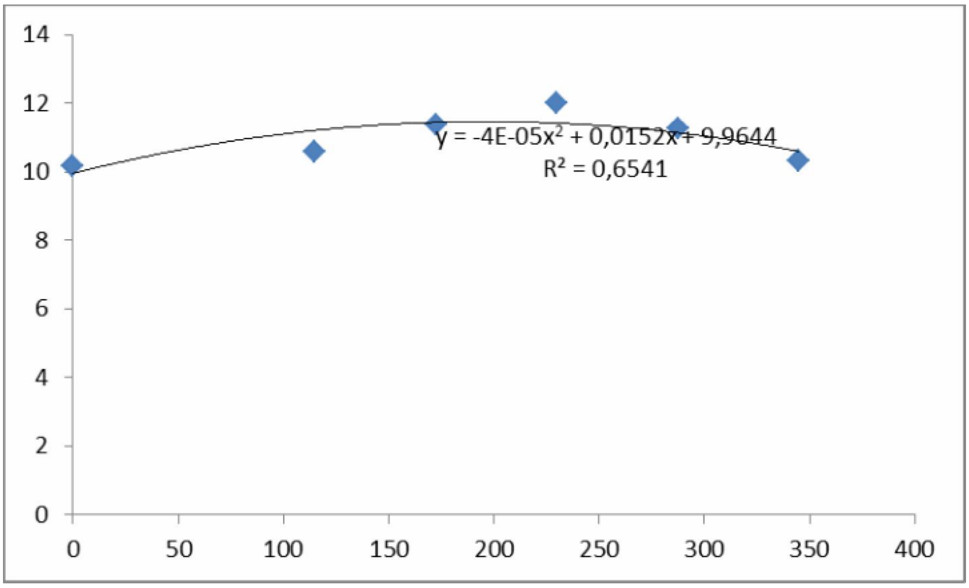

Figure 1. Response of young pods yield on phosporous level.

Agronomic efficiency of applied fertilizer P (PAE) is shown on figure 2. The number range from 1.17 to 23.85. The highest PAE were reached by 100 kg/ha P_2O_5 with 23.5 PAE. On maize the PAE value ranged from 12 to 26 (Zafar et al 2011).

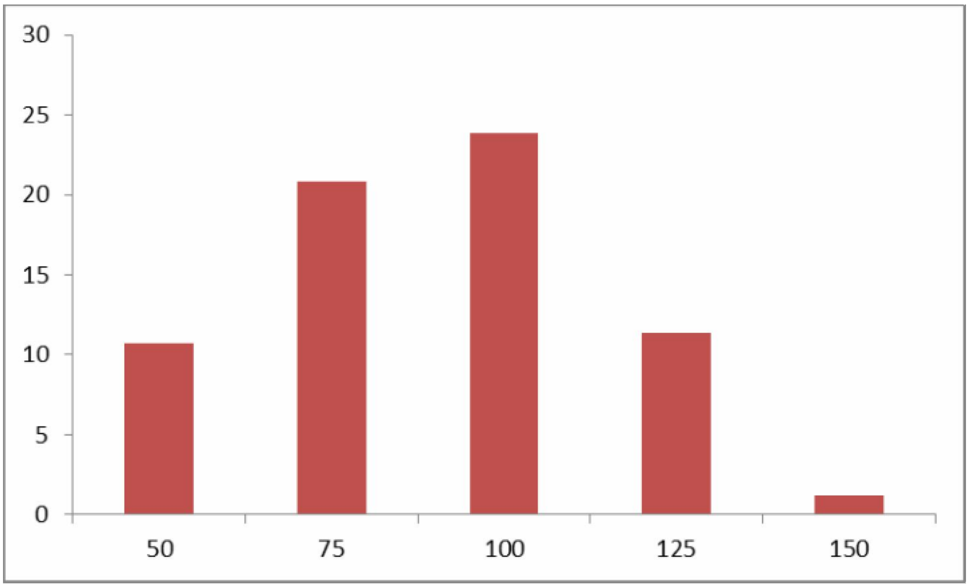

Figure 2. Agronomic efficiency of applied fertilizer P (PAE) on snap bean.

Conclusions. Production of young pods and yield components were increased significantly by application of phosphorous fertilizer. Optimum dosage for yield of young pods was 90.8 kg P_2O_5/ha^{-1} with 34.06 kg yield young pods per plot.

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