Response of Rice Growth as The Results of Phosphate Fertilizer in Different Planting System Applications

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ABSTRACT

The study aimed to evaluate the effect of phosphate fertilizers and planting systems on plant height, shoot/root ratio, and root length. The experiment has been conducted at Experimental Station and Training Center for Agriculture Development, Padjadjaran University at Jelekong distric, Bandung Regency, West Java, at 628 m above sea level, from May 2012 until August 2012. It was arranged in Factorial Design with three replications. The first factor was planting system (conventional, legowo 2:1 , and twin seedling) and the second factor was phosphate fertilizer (0 kg ha^{-1} ; 25 kg ha^{-1}; 50 kg ha^{-1}; 75 kg ha^{-1}; and 100 kg ha^{-1}).The experimental results has indicated that there are no interaction on shoot/root ratio and root length, but there was an independent effect on plant height in twin seedling system.

***Keywords** : rice, planting system, phosphate fertilizer, vegetative growth*

INTRODUCTION

Increased rice production is currently facing various problems including the decline in land productivity. The cause of the decline is land management regulation, lack of attention to environmental and land conservation. Intensive exploitation of wetland resulting declining in soil fertility, such as using of inorganic fertilizers continuously, and not utilized rice straw which is source of organic matter (Las *et al.*, 2010).

One attempt to improve rice production is carried out by phosphate fertilizer and organic matter application. Phosphate is an immobile compounds and indispensable to rice plants especially during the early growth. The function of phosphate is important for plant growth and promotes root development, tillering, early flowering and performs other function activities, particularly in synthesis of protein (Panhawar *et al.*, 2011 *in* Tabar, 2012) . Phosphorus deficiency not only slows the growth of buds but also influence reproductive organ and showed stunted growth, dark blue-green leaves and purple (Winarni, 2012).

Compost has been considered as a valuable soil amendment for centuries. Most people are aware that using compost is an effective way to increase healthy plant production, help save money, reduce the use of chemical fertilizers, and

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conserve natural resources. Compost provides a stable enchancing soil quality and crop production. When correctly applied, compost has the following beneficial effects on soil properties, thus creating suitable conditions for root development and consequently promoting higher yield and higher quality of crops (Chen and Wu, 2005). Soil organic matter is the key to the success of sustainable agriculture system by maintaining the organic matter content of about 2%, but in the tropics, organic ingredients are generally less than 2% due to the rapid decomposition process (Handayanto and Hairiah, 2000).

Increased rice production can be done by changing planting system, increasing plant population, and areal extension. However it must be conditioned so that there is interaction between plant and environment in achieving optimal growing factors. In rice cultivation system, Indonesia have several planting systems, namely conventional , legowo, and lately twin seedling. Conventional is a planting method that has been using by farmers for a long time which is transition from irregular planting system, while twin seedlings is planting system which use two seeds on planting hole with a distance of 5 cm. The twin seedlings with spacing of 30 cm x 35 cm can increase rice production 6-8 ton ha^{-1} which is 50% compared to conventional system (Simarmata, 2008).

MATERIALS AND METHODS

Materials used for the experiment is Ciherang rice varieties with 90% germination derived from the Central Rice Research Sukamandi, composted rice straw, urea (46% N), phosphate (36% P2O5), KCl (50% K2O), 50 EC insecticide Regent was given at 55 days after planting with a dose of 2 ml l-1, and 56 WP fungicide Nordox given at 65 days after planting with a dose of 2.5 g l^{-1}.The experiment was arranged in Factorial Design with three replications. The first factor was planting system (conventional, legowo 2:1 , and twin seedling) and the second factor was phosphate fertilizer (0 kg ha^{-1}; 25 kg ha^{-1}; 50 kg ha^{-1}; 75 kg ha^{-1}; and 100 kg ha^{-1}).

RESULTS AND DISCUSSION

Table 1. Effects of phosphate fertilizers and planting systems on plant height (cm)

Treatment	Age		
	30 DAP	40 DAP	50 DAP
Planting systems			
st_1 (conventional)	45,59 a	57,36 a	64,67 a
st_2 (legowo 2:1)	47,82 a	59,00 ab	64,59 a
st_3 (twin seedling)	46,85 a	61,40 b	67,88 b
Phosphate fertilizers			
p_0 (0 kg ha^{-1})	46,03 a	58,09 a	65,39 a
p_1 (25 kg ha^{-1})	46,31 a	58,91 a	65,58 a
p_2 (50 kg ha^{-1})	47,53 a	59,62 a	65,33 a

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p_3 (75 kg ha^{-1})	47,42 a	60,64 a	65,93 a
p_4 (100 kg ha^{-1})	46,47 a	59,00 a	66,32 a

Remarks: The figures followed by the same lowercase letters are not significantly different based on Duncan's Multiple Range Test at the 0.05 level test.

Table 2. Effects of phosphate fertilizers and planting systems on shoot/root ratio

Treatment	10 DAP	20 DAP	30 DAP	40 DAP	50 DAP
Planting Systems					
st_1 (conventional)	2,02 a	1,52 a	2,91 a	1,47 a	2,21 a
st_2 (legowo 2:1)	2,40 a	1,50 a	2,51 a	1,80 a	2,51 a
st_3 (twin seedling)	2,03 a	1,36 a	2,07 a	1,59 a	2,38 a
Phosphate Fertilizers					
p_0 (0 kg ha^{-1})	2,36 a	1,39 a	2,52 a	1,74 a	2,75 a
p_1 (25 kg ha^{-1})	2,19 a	1,47 a	2,51 a	1,63 a	2,34 a
p_2 (50 kg ha^{-1})	1,95 a	1,50 a	2,20 a	1,75 a	1,96 a
p_3 (75 kg ha^{-1})	1,62 a	1,38 a	2,93 a	1,60 a	2,32 a
p_4 (100 kg ha^{-1})	2,64 a	1,56 a	2,32 a	1,38 a	2,44 a

Remarks: The figures followed by the same lowercase letters are not significantly different based on Duncan's Multiple Range Test at the 0.05 level test.

Table 3. Effects of phosphate fertilizers and planting systems on root length

Treatment	10 DAP	20 DAP	30 DAP	40 DAP	50 DAP
Planting Systems					
st_1 (conventional)	11,97 a	15,98 a	21,70 a	26,33 a	30,32 a
st_2 (legowo 2:1)	11,51 a	14,30 a	21,83 a	26,58 a	30,42 a
st_3 (twin seedling)	11,33 a	15,85 a	22,17 a	28,01 a	31,33 a
Phosphate Fertilizers					
p_0 (0 kg ha^{-1})	10,63 a	16,26 a	21,61 a	28,24 a	31,19 a
p_1 (25 kg ha^{-1})	11,94 a	15,69 a	22,67 a	27,29 a	31,14 a
p_2 (50 kg ha^{-1})	11,38 a	14,61 a	21,78 a	27,78 a	29,17 a
p_3 (75 kg ha^{-1})	11,89 a	14,33 a	20,94 a	25,72 a	31,17 a
p_4 (100 kg ha^{-1})	12,17 a	16,00 a	22,50 a	26,33 a	30,78 a

Remarks: The figures followed by the same lowercase letters are not significantly different based on Duncan's Multiple Range Test at the 0.05 level test.

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Results of variance analysis showed that the treatment of various planting systems and phosphate fertilizer did not interact to plant height 30, 40, and 50 DAP (**Table. 1**). Plant growth is often defined as an increase in size, weight, or number of cells. The size of the plant as an indicator of the growth which can be seen as a one-dimensional (plant height) and two-dimensional (broad leaf) (Lakitan, 1996).

Plant height related to the length of the vegetative phase such as increasing the number of tillers, root length, and leaf area. Variations on vegetative phase causing the difference in the age of rice plant. Rice varieties that have longer aged (150 days) have higher plant height than the medium aged (105-120 days). Reproductive phase on rice plant in the tropic climate has the same time which is 65 days , while the vegetative phase will be different (Makarim and Suhartatik, 2009 ; Yoshida, 1981; De Datta, 1981). In the early phases of plant growth, there will be a competition between root and shoot growth.

By using twin seedling (st3) system Indicated that the age of 40 and 50 DAP gave an independent effect on plant height compared with conventional system was equal to 5-7%, but there were not significantly different from legowo 2: 1 (st_2).The best plant height growth was achieved by twin seedlings (st_3) (61.40 and 67.88 cm). Presumably that twin seedling had the distance of 5 cm at any point in planting, so it will reduce competition in the early stage (Simarmata, 2008). Populations in twin seedlings (st_3) has fewer plants than the other planting systems, so it has an optimum growth factors for plant height. As well as Legowo (st_2) planting system gave the highest plant height which was not significantly different from twin seedlings (st_3), hence legowo 2:1 planting system has a greater population, also gives a wider space for plants to obtain more sunlight which is used in photosynthesis. According to Tryni *et al.*, 2004 *in* Aribawa *et al.*, 2012, legowo 2: 1 will make all the rows of clumps of plants are on the edge, therefore plants able to take more advantage of growth factors such as sunlight, water, CO_2 and can produce higher rice yield than middle plant (Harjadi, 1996).

Results of variance analysis showed that the treatment of various planting systems and phosphate fertilizer did not interact to shoot and root ratio (**Table.2**). Shoot and ratio is ratio between shoot dry weight and root dry weight. If the shoot/root ratio has a greater value ; photosynthate is aimed to the top of the plant (shoot) and respectively. Roots may be considered as soil inhabiting, heterotrophic organisms which indirectly symbiosis with autotrophic above-ground parts (shoots) by exchangng carbohydrates for water and nutrients (Van Noordwijk et al., 1998 *in* Chiangmai and Yodmingkhwan, 2011). However, intergrations between roots and shoots go far beyond such symbiotic exchanges (Van Noordwijk et al., 1996 *in* Chiangmai and Yodmingkhwan, 2011).

Various doses of phosphate fertilizers and planting systems did not influence on shoot / root ratio 10, 20, 30,40, and 50 DAP. Phosphate is immobile compound , mostly bound by soil particles, partly as a P-organic and few which is available for plants. P uptake by plant roots can only take place through interception and diffusion and phosphate efficiency is generally very low, ranging between 15-20% (Adiningsih, 2004). Phosphorus compounds are not very soluble, therefore the amount of available phosphorus in the soil tends to be far less than plant requries (Johnston and Steen, 2000).

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Distribution of photosynthate in plant is influenced by biotic and abiotic factors. One of abiotic factor that affecting is light. Rice is belonging to C3 plant group, when light intensity is high, photosynthesis process is not running efficient (Wirahadikusumah,1985). Plant growth specified by the photosynthetic activity (photosynthate), synthesis of dry matter during respiration, and determined by nutrients translocation from source to sink. Compound that serve as transport agents (photosynthate and nutrients) in plants tissue is water (Jumin, 1992). The bottom part of leaves will transport photosynthate to roots; while the upper leaves will send more to seeds, fruits, and young leaves (Lakitan, 1995).

Transport from the roots to the canopy occurs in xylem vessels are controlled by the hydrostatic pressure difference and pressure difference of water potential. The difference in pressure between the water potential of roots and canopy is very sharp in the day when the stomata are open. Flow of solution from the roots to the canopy in the xylem is one-way, while the solution in the phloem flow can move in both directions. (Lakitan,1995).The rate of plant growth is regulated by the presence of minimum factors (Agustina, 2004), therefore it is not indicated that phosphate is a limiting factor. The provision of Phosphate level did not give a real difference. According to Wijaya (2008), there are several factors that affect the absorption of nutrients by the roots in the xylem vessels, namely: (1) concentration of the solution, the higher concentration of external ions effected on the ion concentration pattern of xylem solution (2) The increase of temperature will trigger the nutrients into the xylem vessels (3) Expenditures ions into xylem vessels is closely related to root respiration, resulting in oxygen deprivation resulting in decreased spending ions into the xylem, (4) root carbohydrate status, spending ions to xylem vessels is influenced by the carbohydrate content of the roots. The higher the carbohydrate content of the roots of the greater expense ions into xylem vessels. Carbohydrate content of the roots is influenced by plant photosynthetic activity.

Results of variance analysis showed that the treatment of various planting systems and phosphate fertilizer did not interact on root lenght (**Table.3**). Phosphate plays a role in improving the growth of plant roots including density, and lateral root growth (Wijaya, 2008). Subsequent Wissuwa (2005) *in* Wissuwa *et al.*, 2005 stated that P deficiency stimulated root elongation in rice. Benefits of a shift to lateral root growth would be a concentration of roots in the relatively P-rich topsoil (topsoil foraging) and it remains to be seen whether species with a fibrous root system (maize, rice) can achieve the same through changes in root growth angles.

The rice plant belonged to fibrous roots. Primary root (radicle) which grow when germinated with other roots that emerge from seed near skutellum called seminal roots. If there is physical disruption to the primary root, the other seminal root growth will be accelerated (Chang, Bardenas, 1976; Gould, 1968, Murata 1969 *in* Makarim and Suhartatik ,2009) the roots of rice plants haven't got secondary growth (Esau, 1977 *in* Makarim and Suhartatik, 2009) thus, the diameter of roots will not change much since grown. Root system of the plant is not only controlled by the genetic of plant also that the root systems of plants may be affected by the condition of the soil or growing medium of plants. Factors affecting the distribution patterns of other root is a mechanical barrier, soil temperature, aeration, water and nutrient availability (Lakitan, 1996).

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CONCLUSION

The experimental results has indicated that there are no interactions on shoot/root ratio and root length, but there is an independent effect on plant height in twin seedling planting system.

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