Growth and yield of soybean plants on intercropping systems with different phosphorus dosage

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Abstract. The intercropping system with the right dose of phosphorus will show higher yields than the monoculture planting system. The study was carried out with the aim of: (i) comparing crop yields between intercropping and monoculture planting systems, (ii) comparing the efficiency of land use of each planting system, and (iii) phosphorus doses which provide the highest yield for each cropping system. The study was conducted at the Experimental Garden of the Faculty of Agriculture, University of Sultan Ageng Tirtayasa Cikuya Karang Kitri District Serang, starting from April to July 2019. The experiment used a factorial randomized block design. The first factor is the planting system consisting of three levels, namely the system of soybean monoculture planting, maize monoculture planting system, and intercropping system of soybean+corn. The second factor is the dose of phosphorus fertilizer consisting of two levels, namely 25 kg.ha\(^{-1}\) and 100 kg.ha\(^{-1}\). Each treatment combination was repeated three times. To find out the purpose of the study used the Land Equity Ratio (LER) indicator and Variant Analysis of observational data which included: plant height, number of leaves, weight per plant, crop weight per plot and seed dry weight. The plant growth with corn monoculture is better than intercropping system. The yield of plants with intercropping systems is higher than that of monoculture systems. Plant yields in both cropping systems (intercropping and monoculture) were higher by giving phosphorus doses of 100 kg.ha\(^{-1}\) compared to 25 kg.ha\(^{-1}\).

Keywords: intercropping, monoculture, phosphorus doses

1. Introduction

Indonesia's population continues to grow at a rate of population growth for seven years (2010-2016) at an average of 1.36% [1]. The increase in population causes the demand for agricultural products both in terms of type, number and quality also increases. National corn demand continues to increase reaching 8.6 million tons per year or around 665 thousand tons / month [2]. According [3] that in 2005-2015, the growth rate of corn harvest area fluctuated, while for the average corn production in Indonesia in 2005-2015 amounted to 43.42 ku/ha. [4] stated that in 2016 soybean supply experienced a deficit of 1.61 million tons. Therefore, in an effort to increase crop productivity, it is necessary to use land efficiently. Efforts to improve the efficiency of land use include cultivation of intercropping systems such as corn intercropping with beans. Intercropping is planting more than one plant at the same time or during the planting period in the same place [5].

To increase the production of soy and corn required fertilizer. One of the fertilizers needed is Posfor. [6] states that P plays a role in plant growth (stem, roots, twigs and leaves). Phosphate is needed by plants for the formation of cells in the root tissue and the stem that grows as well as strengthens the stem, so it is not easily collapsed [7]. In soybean, phosphates are required for maximum root star activity.
than is necessary for the formation of root nits. This fact shows that the maximum seed yield requires phosphate fertilizer sufficient to ensure the fixation process of N₂ maximum [8]. A serious phosphate deficiency can slow down and postpone the primordial, so that the seed is produced wrinkles, mild, sprouts small and ripe early. It should be considered in order to direct the production of both quality and quantity [9].

The study was carried out with the aim of: (i) comparing crop yields between intercropping and monoculture planting systems, (ii) comparing the efficiency of land use of each planting system, and (iii) phosphorus doses which provide the highest yield for each cropping system.

2. Materials and Method

The materials used are: SP-36, urea, KCl, compost, corn and soybean. Tools used include: analytic scales, ruler, and camera.

The study was conducted at the Experimental Garden of the Faculty of Agriculture, University of Sultan Ageng Tirtayasa Cikuya Karang Kitri District Serang, starting from April to July 2019. The experiment used a factorial randomized block design. The first factor is the planting system consisting of three levels, namely the system of soybean monoculture planting, maize monoculture planting system, and intercropping system of soybean+corn. The second factor is the dose of phosphorus fertilizer consisting of two levels, namely 25 kg.ha⁻¹ and 100 kg.ha⁻¹. Each treatment combination was repeated three times. If the variance analysis shows effected, will continue with test DMRT 5%.

3. Results and Discussion

Table 1. High crop with intercropping system treatment and fertilizer posfor at age 14 DAP, 21 DAP, 28 DAP, 35 DAP, 42 DAP and 49 DAP (on centimetre).

| Days After Planting | Phosphorus Doses | T1 (monoculture corn) | T2 (monoculture soybean) | T3 (intercropping system of soybean+corn) | Average |
|---------------------|------------------|-----------------------|--------------------------|------------------------------------------|---------|
| 14                  | P1 (25 kg.ha⁻¹)  | 23.57                 | 7.10                     | 27.45                                    | 19.37   |
|                     | P2 (100 kg.ha⁻¹) | 30.66                 | 8.15                     | 23.73                                    | 20.84   |
|                     | Average          | 27.12 a               | 7.62 b                   | 25.59 a                                  |         |
| 21                  | P1 (25 kg.ha⁻¹)  | 35.80                 | 12.45                    | 39.47                                    | 29.24   |
|                     | P2 (100 kg.ha⁻¹) | 49.60                 | 9.30                     | 32.55                                    | 30.48   |
|                     | Average          | 42.70 a               | 10.87 b                  | 36.00 a                                  |         |
| 28                  | P1 (25 kg.ha⁻¹)  | 61.00                 | 16.00                    | 55.90                                    | 52.38   |
|                     | P2 (100 kg.ha⁻¹) | 66.79                 | 11.00                    | 43.78                                    | 48.96   |
|                     | Average          | 63.89 a               | 13.50                    | 49.84 a                                  |         |
| 35                  | P1 (25 kg.ha⁻¹)  | 74.95                 | 26.50                    | 71.65                                    | 66.61   |
|                     | P2 (100 kg.ha⁻¹) | 104.40                | 16.50                    | 63.90                                    | 74.48   |
|                     | Average          | 89.67 a               | 21.50 c                  | 67.77 b                                  |         |
| 42                  | P1 (25 kg.ha⁻¹)  | 101.96                | 42.52                    | 100.65                                   | 92.90   |
|                     | P2 (100 kg.ha⁻¹) | 128.37                | 38.60                    | 105.47                                   | 105.72  |
|                     | Average          | 115.16 a              | 40.56 b                  | 103.05 a                                 |         |
| 49                  | P1 (25 kg.ha⁻¹)  | 121.33                | 54.68                    | 130.18                                   | 115.60  |
|                     | P2 (100 kg.ha⁻¹) | 142.50                | 41.12                    | 119.17                                   | 118.02  |
|                     | Average          | 131.92 a              | 47.90 b                  | 124.67 a                                 |         |

Description: numbers followed by the same letters in the same line showed no significant according to Duncan Multiple Range Test 5%
Table 2. Number of leaves with the intercropping system treatment and fertilizer posfor at age 14 DAP, 21 DAP, 28 DAP, 35 DAP, 42 DAP and 49 DAP (on centimetre).

| Days after planting | Phosphorus Doses | T1 (monoculture Corn) | T2 (monoculture soybean) | T3 (intercropping system of soybean+corn) | Average |
|---------------------|------------------|-----------------------|--------------------------|------------------------------------------|---------|
| 14                  | P1 (25 kg.ha⁻¹)  | 2.20                  | 1.15                     | 2.18                                     | 1.84    |
|                     | P2 (100 kg.ha⁻¹) | 2.21                  | 2.57                     | 1.93                                     | 2.23    |
|                     | Average          | 2.20 a                | 1.86 b                   | 2.05 a                                   |         |
| 21                  | P1 (25 kg.ha⁻¹)  | 6.26                  | 2.45                     | 5.33                                     | 4.68    |
|                     | P2 (100 kg.ha⁻¹) | 6.06                  | 5.20                     | 5.33                                     | 5.53    |
|                     | Average          | 6.16 a                | 3.82 b                   | 5.33 a                                   |         |
| 28                  | P1 (25 kg.ha⁻¹)  | 8.53                  | 3.60                     | 7.06                                     | 7.20    |
|                     | P2 (100 kg.ha⁻¹) | 8.33                  | 8.00                     | 7.46                                     | 7.91    |
|                     | Average          | 8.43 a                | 5.80 b                   | 7.26 ab                                  |         |
| 35                  | P1 (25 kg.ha⁻¹)  | 10.60                 | 2.40                     | 5.93                                     | 7.42    |
|                     | P2 (100 kg.ha⁻¹) | 8.13                  | 5.00                     | 6.40                                     | 6.94    |
|                     | Average          | 9.36 a                | 3.70 b                   | 6.16 ab                                  |         |
| 42                  | P1 (25 kg.ha⁻¹)  | 9.66                  | 6.80                     | 7.93                                     | 8.51    |
|                     | P2 (100 kg.ha⁻¹) | 9.06                  | 8.40                     | 9.06                                     | 8.97    |
|                     | Average          | 9.36                  | 7.60                     | 8.50                                     |         |
| 49                  | P1 (25 kg.ha⁻¹)  | 10.13                 | 9.00                     | 8.06                                     | 9.08    |
|                     | P2 (100 kg.ha⁻¹) | 9.40                  | 8.80                     | 9.00                                     | 9.14    |
|                     | Average          | 9.76                  | 8.90                     | 8.53                                     |         |

Description: numbers followed by the same letters in the same line showed no significant according to Duncan Multiple Range Test 5%.

Table 3. Effect of intercropping and fertilizer system treatment on weight per plant (on gram).

| Phosphorus Doses | T1 (monoculture Corn) | T2 (monoculture soybean) | T3 (intercropping system of soybean+corn) | Average |
|------------------|-----------------------|--------------------------|------------------------------------------|---------|
| P1 (25 kg.ha⁻¹)  | 71.67                 | 10.00                    | 35.66                                    | 35.04   |
| P2 (100 kg.ha⁻¹) | 51.11                 | 12.29                    | 44.03                                    | 37.99   |
| Average          | 59.33 a               | 10.92 b                  | 39.01 a                                  |         |

Description: numbers followed by the same letters in the same line showed no significant according to Duncan Multiple Range Test 5%.

Table 4. Effect of intercropping and phosphorus fertilizer treatment on crop weight per plot (on gram).

| Phosphorus Doses | T1 (monoculture Corn) | T2 (monoculture soybean) | T3 (intercropping system of soybean+corn) | Average |
|------------------|-----------------------|--------------------------|------------------------------------------|---------|
| P1 (25 kg.ha⁻¹)  | 860.0                 | 700.1                    | 1069.9                                   | 878.8   |
| P2 (100 kg.ha⁻¹) | 613.3                 | 860.0                    | 1320.7                                   | 885.9   |
| Average          | 712.0                 | 764.1                    | 1170.2                                   |         |
The planting system treatment affects the crop height in 7-49 DAP. Phosphor treatment did not effect on the crop height parameters in the DAP 7-49. There is no interaction between the treatment of the planting system and nutrient fertilizer on the high parameter of the plant (Table 1). Table 1 shows that the height of the plant inside the corn monoculture is greater than the intercropping system (soybean and corn) and the soybean monoculture system. In the high parameters of the plant in both the planting system (intercropping and monoculture) higher by giving a dose of phosphorus 100 kg. Ha⁻¹ compared to 25 kg. Ha⁻¹.

Treatment system of planting and phosphorus fertilizer did not effect on the number of leaf parameters. There is no interaction between the processing of the planting system and phosphorus fertilizer on the number of leaves (Table 2). Table 2 shows that the number of leaves in corn monoculture is much more than the intercropping system (soybean and corn) and soybean monoculture system. On the number of leaves in both the planting system (intercropping and monoculture) higher by giving a dose of phosphorus 100 kg. Ha⁻¹ compared to 25 kg. Ha⁻¹.

This may be because in the intercropping system of corn and soybeans there is a competition in taking nutrients, water and different light between the corn plant and the soybean plant in the vegetative phase. This is in line with the statement [10] stating that increased cereal growth will make the growth of nuts depressed. The research of [11] states that there are inter-specific rivalries such as water, light, air and nutrients other than corn (C4) are more aggressive than soy (C3). [12], shows that corn plants are more dominant and more competitive compared to Cowpea with competition ratio value of 1.89 vs 0.52.

Phosphorous fertilizer at a dose 100 kg. Ha⁻¹ increases plant growth compared to 25 kg. Ha⁻¹ because of the provision of phosphate fertilizer supports the growth of plants in both monoculture systems and intercropping. The high growth of plants is a plant growth in the vegetative phase where cell division and enlargement occur in a special tissue called meristems. [13] state that eventually meristem produce new cells at the end of the roots or stems, causing the plant to grow taller or longer. P fertilizer works to stimulate root growth and development. The roots will absorb water and nutrients into the leaves into carbohydrates that will be transplanted into the parts of plants that require food and energy reserves.

The planting system treatment affects weight per plant. Phosphorus fertilizer treatment did not affect the weight per plant. There is no interaction between the processing of the planting system and the phosphorus fertilizer in the weight parameter per plant (Table 3). In the weight parameters of plants per plot treatment of planting system and phosphorus fertilizer does not affect the weight parameter of the plant per plot. There is no interaction between the processing of the planting system and phosphorus fertilizer on the weight parameter of the plant per plot (Table 4). The weight per plant in the processing of corn monoculture is greater than that of soybean monoculture and the intercropping system (soy + corn) which is suspected because corn plants do not experience much competition or competition in sunlight or Nutrients in the soil, so photosynthesis of the monoculture system would be good to increase the growth of corn. According to [14] that the dry weight of plants shows the efficiency of the
photosynthesis process. The larger the photosynthate is produced, the greater the dry weight is generated. The greater the dry weight of the plant, the better the growth of plants and nutrients and the water absorbed by the plant is also better. It is powered by [15] The larger the heavy dry plant, the better the growth of plants and nutrients and the water absorbed by the plant is also better. [16] adds that the more sunlight received by plants can add photosynthetic products utilized by plants for growth and metabolism.

Dose of phosphorus at a dose 100 kg. Ha\(^{-1}\) and 25 kg. Ha\(^{-1}\) did not effect on weight parameters per plant and plant weight per plot. It is suspected that the dose of phosphorus fertilizer is not high enough and did not been absorbed completely by the roots to increase the dry weight of the plant so it did not help significantly improve photosynthesis. According to [17] dry plant material is strongly influenced by the optimal process of photosynthesis. The dry weight formed reflects the amount of photosynthate as a result of photosynthesis, because the dry material depends heavily on the rate of photosynthesis. [18] argue that plant growth can be shown to one or more organs, expressed in dry weight.

In table 5 indicates that the weight of 100 seeds with a higher intercropping system than soybean monoculture system and corn monoculture system. The weight of 100 seeds in both the planting system (intercropping and monoculture) is higher by providing a dose of phosphorus 100 kg. Ha\(^{-1}\) compared to 25 kg. Ha\(^{-1}\). It is suspected that soybeans can increase corn production as N fixation is provided by soy for the availability of corn production. According to [19] One of the important elements in crop production is N. Most of the nitrogen is transferred in the generative phase which is able to stimulate the formation of cob on corn (Zea Mays). The translocation of nitrogen nutrients that take place well on the plant affects the growth, cob size and weight of corn seeds. According to [20], the planting of intercropping will give higher production between nuts and food crops.

Phosphorus fertilizer at a dose of 100 kg. Ha\(^{-1}\), produces a weight of 100 seeds compared to 25 kg. Ha\(^{-1}\). It is suspected that phosphate fertilizer affects crop production in both monoculture systems and intercropping systems. According to [21], element P can increase the protein content and weight of the seeds which in turn affects the crop yield. Large seed size delivers high total dried seed yield. [22] states the accumulation of proteins in the seed prescribed by the adequacy of P-plants, therefore the deficiency of P in plants will produce low growth rates and inhibit the formation of nodules. According to [23] the replenishment of the seeds comes from photosynthates produced after flowering and relocation of the stored photosintat.

**Conclusion**

The plant growth with corn monoculture is better than intercropping system. The yield of plants with intercropping systems is higher than that of monoculture systems. Plant yields in both cropping systems (intercropping and monoculture) were higher by giving phosphorus doses of 100 kg ha\(^{-1}\) compared to 25 kg ha\(^{-1}\).

**References**

[1] BPS. 2019. Population growth rate by province. https://www.bps.go.id/statictable/2009/02/20/1268/laju-pertumbuhan-penduduk-menurut-provinsi.html. Accessed on 5 Agustus 2019.

[2] KEMENPERIN. 2016. RI Imports Corn at 2.4 Million Tons. Tersedia online di http://kemenperin.go.id/artikel/13892/2016,-RI-Import- Jagung-2,4-Juta-Ton. Accessed on 5 Agustus 2019.

[3] Kementerian Pertanian. 2015. Corn Farm Food Commodity Outlook. Pusat Data dan Sistem Informasi Pertanian. Jakarta.

[4] Pusat Data dan Sistem Informasi Pertanian. 2015. Outlook on Agricultural Commodities for Soybean Food Crops. Pusat Data dan Sistem Informasi Pertanian. Jakarta.

[5] Indriati, T. R. 2009. *Effect of Organic Fertilizer Doses and Plant Populations on Growth and Yields of Soybean Glycine max L and Corn (Zea mays L.).* Tesis. Sekolah Pascasarjana, Universitas Sebelas Maret, Surakarta.

[6] Embleton, T.W., W.W. Jones, C.K. Lebanauskas, and W. Reuther. 1973. *Leaf Analysis as a Diagnostic Tool and Guide to Fertilization.* In W. Reather (Ed.). The Citrus Industry. Rev. Ed. Univ. Calif. Agr. Sci. Barkely: 3:183-210.
[7] Aleel, K.G. 2008. *Phosphate Accumulation in Plant: Signaling*. *Plant Physiol.* 148:3-5.
[8] Somaatmadja, S. 1985. Increasing Soybean Production Through Assembling Varieties. Balai Penelitian Tanaman Pangan. Bogor.
[9] Lingga, P. 1989. *Instructions for use of fertilizers*. Penebar Swadaya. Jakarta.
[10] Ariel, C. E., Eduardo, O. A., Benito, G. E., & Lidia, G. 2013. Effects of two plant arrangements in corn (Zea mays L.) and soybean (Glycine max L. Merril) intercropping on soil nitrogen and phosphorus status and growth of component crops at an Argentinean Argiudoll. *American J. of Agriculture and Forestry*. 1(2): 22-31.
[11] Muoneke CO, Ogwuche MAO, Kalu BA. 2007. Effect of maize planting density on the performance of maize/soybean intercropping system in a Guinea savannah agro-ecosystem. *African. J. of Agricultural Research*. 2(12): 667-677.
[12] Alla, W.A.H., E.M. Shalaby, R.A. Dawood, and A.A. Zohry. 2014. *Effect of cowpea (Vigna sinensis L.) with maize (Zea mays L.) intercropping on yield and its components*. *International Scholarly and Scientific Research & Innovation*. 8(11): 1258–1264.
[13] Gardner, F. P., R. B. Pearce daan R. L. Mitchell. 1991. *Physiology Cultivation Plant*. Translation H. Susilo. UI Press. Jakarta.
[14] Musfal. 2010. Potential of arbuscular mycorrhizal fungi to increase crop yields of corn. *Jurnal Litbang Pertanian*. 29(4):154-158.
[15] Zuchri, A. 2007. Optimization of Peanut and Corn Crop Results in Intercropping through Planting Row Arrangement and Corn Leaf Composting. Jurusan Budidaya Pertanian Fakultas Pertanian Unijoyo. Embryo 4(2):157-163.
[16] Warsana, E. 2009. Potential Kerandang (Canavalia virosa) as Alternative Animal Feed and Food Sources. Balai Pengkajian Teknologi Pertanian, Yogyakarta. Seminar Nasional Teknologi Peternakan dan Veteriner: 765-769.
[17] Dwijosepoetro, D. 1981. *Introduction Plant physiology*. PT. Gramedia Pustaka Utama. Jakarta.
[18] Tisdale, S.L. dan W.L. Nelson. 1975. Soil Fertility and Fertilizers. Third Edition. Mac. Millian Publishing Company, Inc. New York.
[19] Sirajuddin, M., dan S. A. Lasmin. 2010. *Response to growth and yield of sweet corn (Zea mays saccharata) at various times of nitrogen fertilizer and straw mulch thickness*. Jurusan Budidaya Pertanian, Fakultas Pertanian, Universitas Tadulako, Palu, Sulawesi Tengah. *Jurnal Agroland*. 17(3):184-191.
[20] Mwangi, D. M., G. Cadisch., W. Thorpe And K. E. Giller. 2004. *Harvesting Management Options for Legumes Intercropped in Napier Grass in The Central Highlands of Kenya*. *Tropical Grasslands*. 38:234-244.
[21] Saerong. 2008. Effect of Phosphorus and Potassium on the Growth and Yield of Peanuts in Dry Land. Balai Pengkajian Teknologi Pertanian. Temu Teknis Fungsional Non Peneliti. Malang.
[22] Mitsuhashi, N., M. Ohnishi, Y. Sekiguchi, K. Y.U. Kwon, Y.T. Chang, S.K. Chung, Y. Inoue, R.J. Reid, H. Yagisawa,and T. Mimura. 2005. *Phytic acid synthesis and vacuolar accumulation in suspensioncultured cells of Catharanthus rosueus induced by high concentration of inorganic phosphate and cations*. *Plant Physiol.* 138:1607-1614.
[23] Goldworthy dan Fisher. 1992. *The Physiology of Tropical Fields Crops* (Translation dari *The Physiology of Tropical Fields Crops* by Tohari). Gadjah Mada University Press. Yogyakarta.