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RESEARCH ARTICLE

PEANUT GROWTH AND GYNOPHORE FORMATION ON BORON AND PHOSPHOR APPLICATIONS

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ABSTRACT

Soil is an important factor in peanut cultivation as a nutrient provider. In recent years, peanut production has dwindled due to the decrease in soil fertility. Boron as a micronutrient can maximize peanut production through optimum viability of flowers and phosphor as essential nutrients for peanut to improve its pod filling. This study aims to examine the application of boron and phosphor growth and formation of peanut gynophore. The research was conducted from September 2017 to January 2018 in Sambirembe village, Magetan. The experiment uses randomized complete block design (RCBD) with the first factor applied on the dose of boron fertilizer (0, 1, 2 3 kg ha^{-1}) and the second was on the dose of phosphor fertilizer (0, 75, 100, 150 kg ha^{-1}), repeated 3 times. Boron application resulted in the highest plant height at the fourth week by 10.45%. The application of 1 kg ha^{-1} boron without phosphorus (0 kg ha^{-1}) yielded the highest gynophore formation, i.e. 42 gynophore formation.

Keywords: micronutrient, chlorophyll, root nodule

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INTRODUCTION

Peanuts are the second largest legume commodity in Indonesia after soybeans (Azis et al., 2011). Peanuts are also a strategic commodity of food crops which help increase income and improve community nutrition because they contain a tremendous amount of protein. In recent years, peanuts production has decreased sharply. The Central Statistics Agency (Badan Pusat Statistik/BPS) stated that peanut production was 701 thousand tons in 2013 and 605 thousand tons in 2015 (BPS, 2015). Within two years, peanut production fell by 28%. Such decline was caused by a decrease in soil fertility impacting its productivity to decline as well (Setiawan et al., 2018). Taufik & Kristiono (2015) asserted that P needs in all phases of growth were 0.2-0.5%, for pod formation 0.2-0.35% and at flowering phase 0.25-0.5% while B nutrient requirements in all phases of growth were 20-60 ppm, and for pod formation phase 20-50 ppm and flowering phase was 25-60 ppm. The availability of essential nutrients such as P is still very low at 0.777 mg 100^{-1} and B 6.29 ppm (Table 1).

Peanut production is determined by the percentage of pod formation. Pod formation is strongly influenced by the percentage of flowering. The higher the number of flowers that make up the pod, the higher the production of peanuts. The interest generated

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on a daily basis will increase to a maximum and decrease to near zero during filling pods (Trustinah et al., 1987; Çalifikan et al., 2008). According to Ketring et al. (1982), more than 93% of fruits would undergo fertilization, but about 12% of the embryos fade away during the first two weeks. Fertile flowers will form gynophore peanuts. Gynophore appears on the 4-5 days after the flower blooms and then it extends and penetrates into the soil to form pods.

Pods occur after gynophore has penetrated the soil. Full pods would be reached on the 44th day until the 52nd day after planting. Pod formation is influenced by phosphate fertilizer dosage which is indicated by the number of pithy pods per clump. Dose administration of 100 kg ha^{-1} showed higher results compared to a dose of 150 kg ha^{-1}. Many empty pods were noticed due to late pod filling resulting in crop decline (Azis et al., 2011 and Novizan, 2010).

The growth and development of peanut seeds can be increased by the application of phosphoric nutrients (Lal, 2002). The lack of nutrients in phosphor causes peanuts to grow in lower heights, with small pale green leaves, and pods in tiny shape and the results of which are very low (Sumarno, 1987). With more P available in the soil, then more P nutrient with will be absorbed by plants. Plants absorb P in the form of $H_2O_4^-$, HPO_4^{2-} and PO_4^{3-}. $H_2O_4^-$ with a lot more remain available for plants to absorb. With 100 kg ha^{-1} of phosphate fertilizer administered, it can increase the weight of 100 dry seeds because the element of phosphate needed for seed formation is in large quantities (Azis et al., 2011). Phosphate plays an important role in the process of forming cells and enhances the fat content in seeds. The weight of 100 seeds shows the quality of seeds that are influenced by the variety and ability of plants in photosynthesis.

Boron is a micronutrient that has a role in the transport of carbohydrates, so the presence of which can increase assimilate transport for plant growth and development (Robinson, 1995). The addition of Boron can increase the chlorophyll content and the number of stomata so that it will affect photosynthesis and produce optimum assimilates (Sakya et al., 2008) and will increase food reserves in seeds. Rosliani et al. (2012) stated that Boron can increase flowering and fruit formation in shallots, in broccoli (Firoz et al., 2008), and melons (Wahyuni et al., 2014) and able to increase pollen viability and pollen tube growth. Based on the description above, it is necessary to do research on the role of Boron and Phosphor on peanut growth and gynophore formation.

MATERIALS AND METHODS

The study was conducted in September 2017 until January 2018 in Sambirembe Village, Magetan with an altitude of 103 m above the sea level. The type of soil used is inceptisol soil with soil characteristic shown in table 1. The study used Factorial Randomized Complete Block Design (RCBD) with a factor of Boron 4 levels (0, 1, 2, and 3 kg ha^{-1}) and SP-36 4 levels (0, 75, 100, and 150 kg ha^{-1}) obtaining 16 combinations of treatments repeated 3 times.

The materials used in this study are peanut seeds, a variety of Kancil, Boron (H_3BO_3), SP-36, organic fertilizers, and chemicals (aquadest, NaOH, acetone 80%, HCl, H_2SO_4, as an observation variable measure).

Soil processing is done by hoeing and leveling the soil and making an experimental map with a total area of 125 m^2. The Peanut seeds of Kancil variety were planted in a 3 cm deep using a spacing of 25 x 20 cm, with one seed planted at each hole. The maintenance includes weeding, sowing and controlling pests and diseases.

Table 1. Soil characteristics

No	Parameter	Value	Unit	Assessment
1	pH	5.51	-	Low/acid
2	P_2O_5	0.777	mg 100^{-1}	Very low
3	K_2O	1.03	mg 100^{-1}	Very low
4	Organic C	0.2	%	Very low
5	Total N	0.135	%	Very low
6	C/N	1.481	-	Very low
7	B	6.29	ppm	Very low

Source: Balai Penelitian Tanah (2005)

Table 2. Average of plant height, LA, LAI, and Biomass of various treatment of boron and phosphor dose

Treatment	Plant height (cm)	LA (cm^2)	LAI	Biomass (g)
Boron Dose (kg ha^{-1})				
0	23.30^b	35.96^a	0.090^a	14.74^a
1	26.02^c	37.20^a	0.092^a	14.45^a
2	23.75^b	39.26^a	0.100^a	15.69^a
3	21.66^a	40.14^a	0.099^a	16.78^a
Phosphor Dose(kg ha^{-1})				
0	22.18^a	33.96^a	0.097^a	13.59^a
75	23.90^a	38.56^a	0.100^a	17.22^a
100	24.89^a	39.42^a	0.086^a	14.58^a
150	23.95^a	40.61^a	0.096^a	16.27^a
Interaction	(ns)	(ns)	(ns)	(ns)

Remarks: The numbers followed by asymmetric letters in the same column showed no significant difference according to the DMRT (Duncan's Multiple Range Test) standards of 5%. The number followed by the same letters in the same column is not significantly different (ns) at $\alpha=0.05$, (character; LA: Leaf Area; LAI: Leaf Area Index)

Observation variables included fourth-week plant height, leaf area (LA) and fourth-week leaf area index (LAI), biomass, number of flowers, chlorophyll content a, b and total, number of root nodules and number of gynophore formed. The obtained data were analyzed using variance analysis (ANOVA) with 5% significance test and if it shows significant differences, then followed by Duncan's Multiple Range Test (DMRT) at 5% level.

A sample of peanut leaves axis is taken and then extracted to analyze its chlorophyll content using Spectrophotometry method. There are three stages of measuring chlorophyll content, namely preparing a chlorophyll solution, transmitting calibration and measuring chlorophyll. Chlorophyll content can be calculated using the following formula:

chlorophyll a = X = 12.7 x A663 – 2.69 x A646
chlorophyll b = Y = 22.9 x A646 – 4.68 x A663
Total chlorophyll (a+b) = Z = 8.02 x A663 + 20.20 x A645

Soil pH analysis was carried out using the electrometric method (Rayment & Higginson, 1992) and van Reeuwijik (1993), Boron content by Morgan Wolf methods (Jones Jr. & Wolf, 1984), N content by distillation method (Black, 1965), P-available content using the Olsen method (Olsen et al., 1954), and soil K with 25% HCl Extraction method (Sudjadi et al., 1971).

Boron application was given twice to plants aged 3.5 weeks after plant (WAP) by spraying on plants for half a dose of each application (Handayani, 2014). The SP-36 fertilizer was applied when the plants aged was 3 WAP. Manure application spread around the plant took place on the afternoons.

RESULTS

Based on the analysis of each plant height (Table 2), only boron significantly showed different results. On the fourth week, the peanut height reached 10.45% (23.30 of 26.02 cm), which was taller without boron application compared to the dose administered in 1 kg ha^{-1}.

Table 2 showed no significant effect between boron and phosphor doses on LA, LAI on the fourth week and peanut biomass. With the application of boron 3 kg ha^{-1} on LA experimented on peanut seems to be the highest which is 40.14 cm^2 and the highest for phosphor up to 150 kg ha^{-1} is 39.42 cm^2. Peanuts without boron and phosphor have the lowest LA compared to other treatments (Table 2). LAI showed no significant results in each treatment. For boron doses administration of up to 3 kg ha^{-1} LAI showed a value of 0.09-0.1 whereas with the provision of phosphor up to 150 kg ha^{-1} showed a value of 0.87-0.1.

Table 3. Average of chlorophyll a, b and total at the various treatment of boron and phosphor dose

Boron Dose (kg ha^{-1})	Chlorophyll a				
	Phosphor Dose (kg ha^{-1})				
	0	75	100	150	Average
0	16.24^{h}	7.47^{a}	11.06^{c}	12.34^{e}	11.77
1	5.29^{a}	19.08^{j}	15.58^{g}	12.05^{de}	13.00
2	16.05^{gh}	14.80^{f}	18.25^{i}	12.06^{de}	15.29
3	11.96^{de}	11.46^{cd}	20.41^{k}	16.23^{h}	15.01
Average	12.38	13.20	16.32	13.17	(s)
	Chlorophyll b				
0	11,84^{def}	6.66^{ab}	6.49a^{b}	6.10^{ab}	7.77
1	18.63^{g}	12.57^{def}	10.51^{b}	6.46^{ab}	12.04
2	7.71^{abc}	14.28^{ef}	6.25^{ab}	12.14^{def}	10.09
3	9.43^{bcd}	5.16^{b}	14.67^{f}	10.52^{cde}	9.94
Average	11.90	9.66	9.48	8.80	(s)
	Total Chlorophyll				
0	24.57^{g}	11.46^{a}	15.66^{b}	18.26^{d}	17.48
1	24.57^{g}	31.66^{j}	26.00^{h}	18.52^{d}	25.18
2	23.72^{f}	29.14^{i}	24.40^{g}	24.20^{fg}	25.36
3	21.38^{e}	16.60^{c}	35.03^{k}	25.77^{h}	24.69
Average	23.56	22.21	25.27	21.68	(s)

Remarks: The number in the matrix (B X P) followed by a different superscript in the same character, shows significant differences in DMRT at 5% level; (s) significant

Table 4. Average root nodules under boron and phosphor treatments

Boron Dose (kg ha^{-1})	Number of root nodules				
	Phosphor Dose (kg ha^{-1})				
	0	75	100	150	Average
0	94.33^{a}	107.66^{bcd}	101.33^{abc}	94.00^{a}	99.33
1	107.00^{bcd}	113.66^{ab}	123.33^{efg}	98.66^{ab}	110.66
2	106.66^{bcd}	118.00^{b}	102.00^{abc}	124.66^{b}	112.83
3	112.33^{cde}	108.66^{a}	130.00^{g}	113.00^{cdef}	115.99
Average	105.08	111.99	114.16	107.58	(s)

Remarks: The number in the matrix (B×P) followed by a different superscript in the same character; showed significant differences in DMRT at 5% level; (s) significant

Biomass seems to have the most accurate estimation to determine growth. Photosynthesis is shown by increasing plant biomass. The higher rate of photosynthesis resulted in higher biomass. Application of boron of up to 3 kg ha^{-1} showed an increase from 14.74 to 16.78 g but not significantly different. Application of phosphorus with doses up to 150 kg ha^{-1} in peanuts showed no significant difference in results. The highest yield on phosphorus is the dose of 75 kg ha^{-1} and the lowest is without phosphorus.

The results of the analysis of variance (Table 3) showed an interaction on the application of different doses of boron and phosphorus to the content of chlorophyll a, b and total. In boron 0 kg ha^{-1} application with the addition of phosphorus up to 150 kg ha^{-1} had the highest yield on 0 kg ha^{-1} boron and 0 kg ha^{-1} phosphorus in chlorophyll a, b and total. In boron 1 kg ha^{-1} application with the addition of phosphorus up to 150 kg ha^{-1} chlorophyll a and the highest total on the addition of phosphorus 75 kg ha^{-1} and chlorophyll b without phosphorus. In boron 2 kg ha^{-1} application with the addition of phosphorus up to 150 kg ha^{-1} indicated the highest results on the addition of phosphorus 75 kg ha^{-1} in chlorophyll b and total while chlorophyll a was the highest with the addition of phosphorus 100 kg ha^{-1}. In boron 3 kg ha^{-1} application with the addition of phosphorus up to 150 kg ha^{-1} showed the highest results on the addition of 100 kg ha^{-1} phosphorus to chlorophyll a, b and total.

Based on Table 4, there were significant interactions on the treatment of boron and phosphorus doses on the number of peanut root nodules. The application of 0 kg ha^{-1} boron combined with 75 kg ha^{-1} phosphorus indicated the highest root nodules (107.66). The addition of phosphorus 150 kg ha^{-1} decreased the number of root nodules to 7.73% than phosphorus dose of 75 kg ha^{-1} (94.00 and 107.66, respectively). The application of boron 1 kg ha^{-1} with 100 kg ha^{-1} phosphorus displayed the highest increase in root nodules (123.33). 2 kg ha^{-1} boron combined with phosphorus 150 kg ha^{-1} resulting in the highest yield (124.66), which was not significantly different with that of 75 kg ha^{-1} phosphorus (118.00). The application of boron 3 kg ha^{-1} combined with 100 kg ha^{-1} phosphorus yielded the highest root nodules, i.e. 130.00, which was insignificantly different than those 0 and 150 kg ha^{-1} Phosphorus, respectively.

Table 5 presents the interaction of boron and phosphorus dose affected the gynophore formation. 0 kg ha^{-1} boron combined with 75 kg ha^{-1} and 150 kg ha^{-1} phosphorus resulted in the highest gynophore, namely 31.33 and 31.00, respectively. The addition of 100 kg ha^{-1} phosphorus resulted in lower gynophore than 75 kg ha^{-1} by 25.8% lower (23.00 and 31.33, respectively). The application of 1 kg ha^{-1} boron without phosphorus yielded the highest gynophore (42), while the addition of 150 kg ha^{-1} phosphorus led to 56.35% lower gynophore formation (18.33) than that of control. The application of 2 kg ha^{-1} boron combined with 100 and 150 kg ha^{-1} phosphorus showed the highest gynophore, i.e. 34.00 and 33.33, respectively. In the meantime, 3 kg ha^{-1} boron combined with 75 kg ha^{-1} phosphorus resulted in the highest gynophore (33.00), while it was the lowest under the combination with 150 kg ha^{-1} phosphorus (25.66).

There was no interaction between the treatment of boron and phosphorus dosage (Table 6). However, the application of phosphorus resulted in different effects at the fourth and fifth weeks. The higher dose of phosphorus increased the number of flowers at the fourth and fifth weeks. At the fourth week, the application 100 and 150 kg ha^{-1} phosphorus resulted in 19.5% higher flowers number (6.41) than control (5.16).

Table 5. Average number of gynophore formed of various treatment of boron and phosphorus dose

Boron Dose (kg ha^{-1})	Number of Gynophore formed				
	Phosphor Dose (kg ha^{-1})				
	0	75	100	150	Average
0	16.00^{a}	31.33^{de}	23.00^{b}	31.00^{de}	25.33
1	42^{f}	22.33^{b}	29.00^{cd}	18.33^{a}	25.91
2	25.00^{bc}	26.00^{bc}	34.00^{e}	33.33^{de}	29.58
3	32.66^{de}	33.00^{de}	32.66^{de}	25.66^{bc}	30.99
Average	26.91	28.16	29.66	27.08	(s)

Remarks: The number in the matrix (B X P) followed by a different superscript in the same character, showed significant differences in DMRT at 5% level, (s) significant

Table 6. Boron and Phosphorus dosages on the number of flowers

Treatment	Number of flowers					
	4 WAP	5 WAP	6 WAP	7 WAP	8WAP	Total flowers
Boron Dose (kg ha^{-1})						
0	5.83^{a}	10.66^{a}	11.33^{a}	6.00^{a}	1.91^{a}	35.58^{a}
1	5.83^{a}	10.25^{a}	11.08^{a}	4.41^{a}	3.08^{a}	34.66^{a}
2	6.16^{a}	10.58^{a}	11.16^{a}	3.75^{a}	2.83^{a}	34.75^{a}
3	6.00^{a}	10.66^{a}	11.66^{a}	6.16^{a}	1.91^{a}	36.08^{a}
Phosphor Dose (kg ha^{-1})						
0	5.16^{a}	10.58^{b}	12.00^{a}	5.58^{a}	1.91^{a}	35.41^{a}
75	5.83^{b}	9.41^{a}	10.83^{a}	4.25^{a}	2.50^{a}	32.41^{a}
100	6.41^{c}	10.75^{b}	11.08^{a}	4.50^{a}	2.41^{a}	35.25^{a}
150	6.41^{c}	11.41^{b}	11.33^{a}	6.00^{a}	2.91^{a}	38.00^{a}
Interaction	(ns)	(ns)	(ns)	(ns)	(ns)	(ns)

Remarks: The numbers followed by superscript were different in the same column; (ns) nonsignificant difference; WAP: Week after plant

At the fifth week, 100 kg ha^{-1} and 150 kg ha^{-1} phosphorus yielded 7.27% higher flowers number (10.75) than that of 75 kg ha^{-1} phosphorus (9.41), however, insignificant to control. The flowers number generated on a daily basis and would increase to a maximum level but decreased to near zero during pods filling.

DISCUSSION

Optimization of boron and phosphorus in peanuts cultivation depends on nutrient uptake from the soil by plant roots, which can be measured using the number of root nodules (Table 4). Falalou et al. (2018) explained that root properties showed a significant reduction of density and dry matter in a phosphorus-deficient state. Çikili et al., (2015), explained that the high addition of boron up to 32 mg g^{-1} may increase the biomass of peanut roots. Nutrients that can be absorbed and used by plants to form components such as chlorophyll a, b and total (Table 3), also photosynthetic materials to produce carbohydrates and assimilates which can be shown by plant biomass (Table 2). Furthermore, plants also need abiotic components such as light and temperatures, which can be captured by leaves and calculated as LA and LAI (Table 2). The results of photosynthesis products will be used by plants for flower formation (Table 6) and formation of groundnut gynophore (Table 5).

There was no interaction of boron and phosphorus, while the highest root nodules were found under the combination of 3 kg ha^{-1} boron and 100 kg ha^{-1} phosphorus (130.00) shown in Table 4. Peanuts have the ability to form root nodules and anchor N in the air due to symbiosis with Rhizobium (Suryantini, 2015). Furlan et al. (2017) added that root nodules protect peanuts from drought stress so that nutrient absorption in the soil remains good. This is in line with the data on the number of root nodules (Table 4), where phosphorus is needed for maximum root nodule formation. This also corresponds to Yakubu et al. (2010) that giving 40 kg ha^{-1} of P_2O_5 phosphorus may increase the number of root nodules with the number of N tethered was 169%. In the meantime, boron is thought to plays a role as a root extension, so that long roots will increase the number of root nodules in peanuts (Yih & Clark, 1965). Root nodules that help absorb nutrients in the soil are used by plants to form photosynthetic components, such as chlorophyll a, b and total content, are influenced by both boron and phosphorus (Table 3). The most optimal chlorophyll a, b and total content was under the application of 3 and 100 kg ha^{-1} boron and phosphorus, respectively, which were also supported by the high number of root nodules (Table 4). Suntoro (2002) states that an increase in soil nutrient availability would increase nutrient uptake optimally. This corresponds with Suharja & Sutarno (2009) asserting that chemical fertilization (ZA, SP-36, and KCl) and manure increased the chlorophyll content in chili. Sakya et al. (2008) state that the addition of 0.9 ppm boron increased the chlorophyll content and the number of stomata, so that affected photosynthesis and produced optimum assimilates, as well as boosted food reserves in seeds.

The application of 1 kg ha^{-1} boron resulted in the highest plant height (Table 2) which was 26.02 cm. This is supported by the high total chlorophyll content under 1 kg ha^{-1} boron dose which reaches 24.57 mg g^{-1} (Table 3). Quamruzzaman et al. (2018a) state that boron is able to increase gas replacement in leaves, physiological growth, reproductive growth and improvement of plant nutrition and form a positive correlation between vegetative, physiological and produce higher metabolism. Giving the right dose of boron can increase plant growth (Shah et al., 2017; Rosliani et al., 2012). Robinson (1995) states that boron increases the assimilate and carbohydrate transport which also increase plant growth and development. Boron also plays a role in the division of the apical meristem and in the mitotic division at the growing point cell, whereas optimal cell division will increase plant height (Salisbury & Ross, 1995).

The number of flowers (Table 6) shows there was no interaction between boron and phosphorus. Phosphorus application significantly influenced the number of flowers only at the fourth and fifth weeks. Lal (2002) stated phosphorus is very necessary for the growth and development of peanut seeds, while Sufianto (2011) explained only 62%-98% peanut flowers remained from the total flowers appeared. Gynophore formation in peanuts could be influenced by the huge amount of budding flowers and those meant for fruits. The higher the number of flowers, the higher the possibility of gynophore formation in peanuts. Based on Table 5, it is known that the highest yield of gynophore is formed under the application of boron 3 kg ha^{-1} combined with 100 and 150 kg ha^{-1} phosphorus. This is in line with the number of peanut flowers (Table 6). Rosliani et al. (2012) reported the application of boron increased flowering and fruit formation in shallot plants.

Boron has an important role in stigma receptive to increase pollination by making pollen grain fertile. Boron has also influenced the ability to retain flower and fruit setting in peanut hence increase pods number (Quamruzzaman et al., 2018b). Quamruzzaman et al. (2016) also reported pod yields and germination increased with boron application of 2 kg ha^{-1} and accelerated flowering 4-5 days compared to control. Boron has a positive effect on vegetative growth and peanut germination.

CONCLUSION

1. The application of 1 kg ha^{-1} boron resulted in higher plant height by 10.45% (21.66 of 26.02 cm) in the fourth week.
2. The highest gynophore formation (42) was obtained under the application of boron 1 kg ha^{-1} combined with 0 kg ha^{-1} phosphorus. Overall, the application of boron and the combination with phosphorus increased the total formation of gynophore.

SUGGESTION

Flowering viability is necessary to be observed, as it will support the number of flowers and the formation of gynophore data.

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