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Evaluation of Silica and Zinc in Growth and Yield of Peanuts

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ABSTRACT

Nuts have a unique nutritional composition and are good sources of unsaturated fatty acids, dietary fiber, minerals, vitamins and other bioactive compounds. This study aimed at determining the evaluation of the administration of silica and zinc on the growth and yield of peanuts. The best plant height was obtained in the treatment of 200 kg SiO_2/ha and 7.5 kg compared to all treatments applied. The best number of leaves was in the administration of silica 200 kg SiO_2/ha with zinc 5 kg Zn/ha compared to remaining treatments. The highest crop growth rate (CGR) was in the interaction between 150 kg SiO_2/ ha and 5 kg Zn/ha (0.087 g/day). The highest pithy pod was the interaction between the treatment of 150 kg SiO_2/ha and 5 kg Zn/ha (22 pieces). The highest chlorophyll-a was in the interaction between 200 kg SiO_2/ha and 2.5 kg Zn/ha (0.216 mg/g leaf) compared to all remaining treatments. The highest pod production was achieved by the interaction between 200 kg SiO_2/ha and 2.5 kg Zn/ha (3.008 t/ha). The highest yield index was achieved in the interaction between 200 kg SiO_2/ha and 0 kg Zn/ha (0.43).

Key words : Peanuts, silicate, zinc, CGR, pod production

INTRODUCTION

Peanut (*Arachis hypogaea*), from the legume family, is an important crop worldwide. Asia is a major producer of peanuts which account for 60% of world production. Peanut seeds have high nutritional and commercial value due to the content of protein, fatty acids, carbohydrates, fiber, in addition to vitamins, calcium and phosphorus (Arya *et al.*, 2016). Nuts have a unique nutritional composition and are a good source of unsaturated fatty acids, dietary fiber, minerals, vitamins, and other bioactive compounds (Guasch-Ferré *et al.*, 2017).

Silicon (Si) is the second most abundant mineral element in soil after oxygen and is also a major structural component of cell walls in some monocot species. Silica is an element that is beneficial for plant growth and is agronomically important for increasing and maintaining rice productivity. In addition to increasing rice yield, silica can also increase nutrient availability (N, P, K, Ca, Mg, S and Zn), reduce nutrient toxicity (Fe, Mn, P and Al), and minimize biotic and abiotic stress on plants (Rao and Susmitha, 2017). Silica plays a role in plant tolerance to abiotic stress by increasing the activity of enzymes and antioxidant metabolites and helps in increasing the efficiency of osmoregulators by influencing water content levels, reducing water loss from transpiration, regulating nutrient adequacy and limiting the absorption of toxic ions (Alsaeedia *et al.*, 2019). Silica layer with a thickness of 2.5 m below the cuticle produces a cuticle-silicon double layer that can inhibit or delay pest penetration (Rodrigues and Datnoff, 2015).

The micronutrient needed by plants is zinc (Zn). Zn is an essential microelement that acts as a co-factor for more than 300 types of enzymes that play a role in nucleic acid metabolism, cell division and protein synthesis. In addition, it can improve plant health and productivity, and increase resistance to pest attacks (Fauziah *et al*, 2018). Zinc appears to be a major player in animal and plant immune responses. Zn is absorbed by plants as cations (Zn^{2+}) and P is taken up by plants as phosphate anions ($H_2PO_4^{1-}$ or HPO_4^{2-}). Regarding the interaction of Zn and P, many studies have been carried out and all of them confirmed that the imbalance of Zn and P in plants, due to excessive accumulation of P, caused deficiency of Zn (Amanullah and Inamullah, 2016). This study aimed at determining the evaluation of the administration of silica and zinc on the growth and yield of peanuts.

MATERIALS AND METHODS

This research was conducted on 28 April-18 September 2019 in Mranggen District, Demak Regency, which is located at 6°43'26'' - 7°09'43'' South Latitude and 110°27'58'' - 110°48'47'' East Longitude. The altitude of the place is 0 to 100 m above sea level, and the air temperature is 24-33°C. The analysis was continued at the Laboratory of Physiology and Plant Breeding, Faculty of Animal Husbandry and Agriculture, Diponegoro University, Semarang. The experimental soil pH was 7.1, glad the NPK content was 0.16, 0.04 and 0.31%, while Zn was 56.36 ppm.

This study was conducted using a factorial completely randomized design (CRD) consisting of two factors. The first factor was the application of silica fertilizer with four levels, namely, S_0 = 0 kg SiO_2/ha (control), S_1 = 100 kg SiO_2/ha, S_2 = 150 kg SiO_2/ha and S_3 = 200 kg SiO_2/ha. The second factor was the application of Zn fertilizer with four dose levels, namely, Z_0 = 0 kg Zn/ha (control), Z_1 = 2.5 kg Zn/ha, Z_2 = 5.0 kg Zn/ha and Z_3 = 7.5 kg Zn/ha with each treatment carried out three times so that there were 48 experimental units.

Observations were made on quantitative parameters including plant height (measured from the soil surface to the main stem growing point), chlorophyll a, b and total leaf chlorophyll content, number of pithy pods to calculate the number of pods containing seeds in each plant, crop growth rate (CGR), yield of pea pods and harvest index. The data obtained were then analyzed using the ANOVA test, with a significance level of 5%. For the treatment that had a significant effect, further analysis was carried out using the DMRT (Duncan Multiple Range Test) tests at the 5% level.

RESULTS AND DISCUSSION

Silicate dose and Zn dose gave effect on plant height (Table 1). Duncan's multiple range test showed that the best plant height was in the treatment of 200 kg SiO_2/ha and 7.5 kg Zn/ha

Table 1. Plant height, leaf number, CGR and number of pithy pods per cluster by application of silicate and zinc

Treatment		Plant height (cm)	Leaf number	CGR (g/day)	No. of pithy pods/clump
Silicate (SiO_2)	Zinc (ZnO)				
0	0	45^{f}	27^{i}	45^{n}	8^{l}
	2.5	45^{f}	28^{h}	48^{m}	10^{h}
	5	47^{e}	29^{g}	66^{h}	10^{h}
	7.5	47^{e}	29^{g}	66^{h}	12^{g}
100	0	48^{d}	30^{f}	68^{g}	13^{e}
	2.5	48^{d}	30^{f}	73^{f}	15^{e}
	5	48^{d}	30^{f}	61^{l}	15^{e}
	7.5	50^{d}	30^{f}	78^{c}	16^{d}
150	0	50^{c}	32^{e}	73^{f}	18^{c}
	2.5	50^{c}	32^{e}	79^{b}	19^{b}
	5	50.67^{c}	32^{e}	87^{a}	22^{a}
	7.5	50.67^{c}	34^{d}	75^{d}	18^{c}
200	0	51.67^{b}	36^{c}	74^{e}	18^{c}
	2.5	52^{b}	36^{c}	65^{j}	16^{d}
	5	52^{b}	41^{a}	64^{j}	15^{e}
	7.5	53^{a}	38^{b}	62^{k}	15^{e}
Silicate (SiO_2)					
	0	46.00^{d}	28.25^{d}	5.63^{d}	10.00^{d}
	2.5	48.50^{c}	30.50^{c}	7.00^{b}	14.75^{c}
	5	50.42^{b}	33.00^{b}	7.85^{a}	19.25^{a}
	7.5	52.17^{a}	37.75^{a}	6.63^{c}	16.00^{b}
Zinc (ZnO)					
	0	48.67^{c}	31.25^{d}	6.50^{d}	14.25^{d}
	2.5	48.83^{c}	31.50^{c}	6.60^{c}	15.00^{c}
	5	49.42^{b}	33.25^{b}	6.90^{b}	15.50^{a}
	7.5	50.67^{a}	33.50^{a}	7.00^{a}	15.25^{b}
Silicate (SiO_2)		*	*	*	*
Zinc (ZnO)		*	*	*	*
Silicate (SiO_2) × Zinc (ZnO)		*	*	*	*

Various superscripts in the same column are significantly different ($P<0.05$).

compared to all other treatments. Plant height due to the treatment of 200 kg SiO_2/ha and 7.5 kg Zn/ha was 17.7% higher than 0 kg SiO_2/ha and 0 kg Zn/ha.

The highest number of leaves was by the administration of silica 200 kg SiO_2/ha with zinc 5 kg/ha as compared to all treatments applied. 51.85% higher number of leaves was obtained by silica 200 kg SiO_2/ha with zinc 5 kg/ha than 0 kg SiO_2/ha and 0 kg Zn/ha. The highest CGR was the interaction between 150 kg SiO_2/ha and 5 kg Zn/ha (0.087 g/day) which was 93.33%; significantly higher than 0 kg SiO_2/ha and 0 kg Zn/ha. The plant growth rate was dry matter production per unit time. The application of micronutrients enhanced plant growth through increased plant photosynthesis and other physiological activities, whereas proper spacing had a positive influence on plant nutrient absorption (Islam *et al.*, 2018). CGR increases until flowering after which it begins to decline, regardless of treatment. This can be attributed to better soil aeration, less competition which favours more root growth and photosynthetic activity (Sridevi and Chellamuthu, 2015). The plant growth rate (CGR) increased significantly with each increase in nitrogen level (Purbajanti *et al.*, 2016). Silicon uptake depends on the concentration of silicon in the soil solution, pH and soil moisture content. Two possible mechanisms (active and passive) were proposed for the uptake of silicon by plants (Alsaeedia *et al.*, 2019). In plants, enzymes either containing Zn, or activated by it, were involved in carbohydrate metabolism, protein synthesis maintenance of cell membrane integrity, regulation of auxin synthesis and pollen formation (Castillo-Gonzalez *et al.*, 2019).

The highest pithy pod was obtained in the interaction between the treatment of 150 kg SiO_2/ha and 5 kg Zn/ha (22 pieces) which was 175% significantly higher than 0 kg SiO_2/ha and 0 kg Zn/ha. The pods occurred after the gynophore penetrated the soil. Full pods will be reached from day 44 to day 52 after planting. The formation of pods was influenced by the dose of phosphate fertilizer as indicated by the number of pithy pods per clump. The dose of 100 kg/ha showed higher results than the dose of 150 kg/ha. Many empty pods were seen due to the late filing of pods resulting in decreased yield (Rahman *et al.*, 2019).

The interaction between dosage of silicate and dose of Zn had a significant effect on chlorophyll- a. Similarly, dosage of silicate and dosage of Zn also affected chlorophyll-a. The highest chlorophyll-a was the interaction between 200 kg SiO_2/ha with 2.5 kg Zn/ha (0.216 mg/ha g leaves) compared to all treatments. The highest chlorophyll-a was the interaction between 200 kg SiO_2/ha and 2.5 kg Zn/ha, which was 170% higher than 0 kg SiO_2/ha and 0 kg Zn/ha (Table 2).

Chlorophyll-b was 0.163 mg/g leaf in the interaction between 100 kg SiO_2/ha with 5.0 kg Zn/ha. Compared to the treatment of 0 kg SiO_2/ha and 0 kg Zn/ha, it was 87.55% higher in the treatment of 100 kg SiO_2/ha with 5.0 kg Zn/ha. Chlorophyll-a and chlorophyll-b are important pigments of plant photosystems. In addition, chlorophyll-a is the main photosynthetic pigment in plants that helps in production of energy in plants. The concentration of chlorophyll-a is 2-3 times more than secondary chlorophyll-b (Kamble *et al.*, 2015).

Total chlorophyll is inconsistent. Total chlorophyll results were the same between 100, 150 and 200 SiO_2/ha, with 0, 2.5, 5 and 7.5 Zn/ha. Factors affecting leaf chlorophyll content were verified through controlled experiments using several plant species. However, to date, it is unclear how leaf Chl. content varied between plant species, plant functional groups, and communities in natural forests, especially at large scales (Li *et al.*, 2018).

Beta-carotene of 0.413 mg/g leaf was the interaction between 200 kg SiO_2/ha and 5 kg Zn/ha. Compared to the treatment of 0 kg SiO_2/ha and 0 kg Zn/ha, it was 77.25% higher in the treatment of 200 kg SiO_2/ha with 5.0 kg Zn/ha. Beta-carotene was a major precursor of vitamin A and its metabolite retinoic acid, a potent nuclear receptor activator involved in the regulation of lipid metabolism and anti-inflammatory macrophage polarization (Zhou *et al.*, 2020). The most important provitamin A carotenoid was – carotene. Another provitamin A carotenoids included – carotene and cryptoxanthin (Ghosh *et al.,* 2019).

The highest pod production was achieved in the interaction between 200 kg SiO_2/ha and 2.5 kg Zn/ha (3.008 t/ha; Fig.1). Yield response to plant density had a high degree of fitness

Table 2. Chlorophyll and beta carotene content of peanuts due to silicate and zinc treatment

Treatment		Chlorophyll-a (mg/g leaf)	Chlrophyll-b (mg/g leaf)	Total chlorophyll (mg/g leaf)	Beta carotene (mg/g leaf)
Silicate (SiO_2)	Zinc (ZnO)				
0	0	0.08^{d}	0.087^{d}	1.37^{c}	0.233^{d}
	2.5	0.09^{cd}	0.087^{d}	2.02^{abc}	0.280^{cd}
	5	0.12^{bcd}	0.087^{d}	1.37^{c}	0.320^{bc}
	7.5	0.11^{bcd}	0.157^{ab}	2.07^{abc}	0.300^{bcd}
100	0	0.143^{bcd}	0.13^{abc}	2.02^{abc}	0.410^{a}
	2.5	0.123^{bcd}	0.113^{cd}	2.39^{abc}	0.353^{ab}
	5	0.120^{bcd}	0.163^{a}	3.05^{a}	0.353^{abc}
	7.5	0.117^{bcd}	0.143^{abc}	2.06^{abc}	0.330^{abc}
150	0	0.09^{cd}	0.133^{abc}	2.34^{abc}	0.340^{abc}
	2.5	0.103^{bcd}	0.143^{abc}	2.03^{abc}	0.347^{abc}
	5	0.16^{b}	0.127^{bc}	1.72^{bc}	0.347^{abc}
	7.5	0.137^{bcd}	0.127^{bc}	2.02^{abc}	$O.330^{abc}$
200	0	0.15^{bc}	0.13^{abc}	3.04^{a}	0.310^{bcd}
	2.5	0.216^{a}	0.133^{abc}	2.68^{ab}	0.330^{abc}
	5	0.14^{bcd}	0.136^{abc}	3.05^{a}	0.413^{a}
	7.5	0.103^{bcd}	0.140^{abc}	1.69^{bc}	0.350^{abc}
Silicate (SiO_2)					
	0	0.100^{b}	0.116^{b}	1.71^{c}	0.283^{b}
	2.5	0.126^{b}	0.137^{a}	2.38^{ab}	0.366^{a}
	5	0.124^{b}	$0. 133^{a}$	2.02^{bc}	0.347^{a}
	7.5	0.153^{a}	0.135^{a}	2.62^{a}	0.353^{a}
Zinc (ZnO)					
	0	0.118^{a}	0.132^{ab}	2.19^{a}	0.326^{a}
	2.5	0.133^{a}	0.119^{b}	2.27^{a}	0.328^{a}
	5	0.135^{a}	0.128^{ab}	2.29^{a}	0.364^{a}
	7.5	0.117^{a}	0.142^{a}	1.96^{a}	0.332^{a}
Silicate (SiO_2)		*	*	*	*
Zinc (ZnO)		*	*	*	*
Silicate (SiO_2) × Zinc (ZnO)		*	*	*	*

Various superscripts in the same column are significantly different ($P<0.05$).

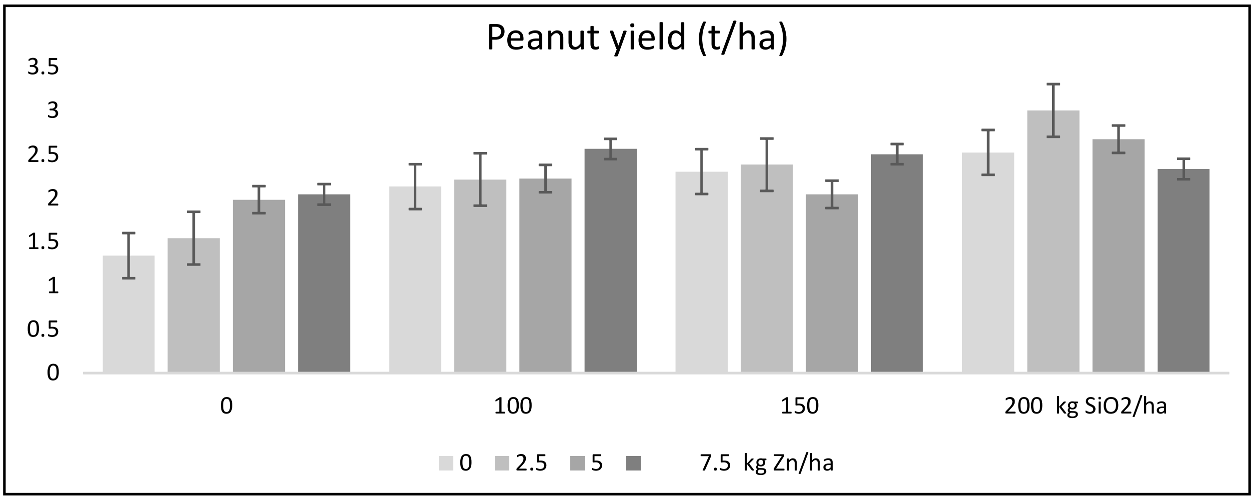

Fig. 1. Peanut yield affected by silica and zinc treatment.

for a wide range of environmental and crop conditions (Morla *et al.*, 2018). The highest yield index was achieved by the interaction between 200 kg SiO_2/ha and 0 kg Zn/ha (0.43; Fig. 2).

According to this study, Chl-a, Chl-b and total chlorophyll (Chl. a+b) increased in the application of silicate and zinc compared to without silicate (SiO_2) and without zinc (ZnO). Beneficial effects of Si have been observed under stress of Zn toxicity in some plant species such as rice. Si supply increased shoot

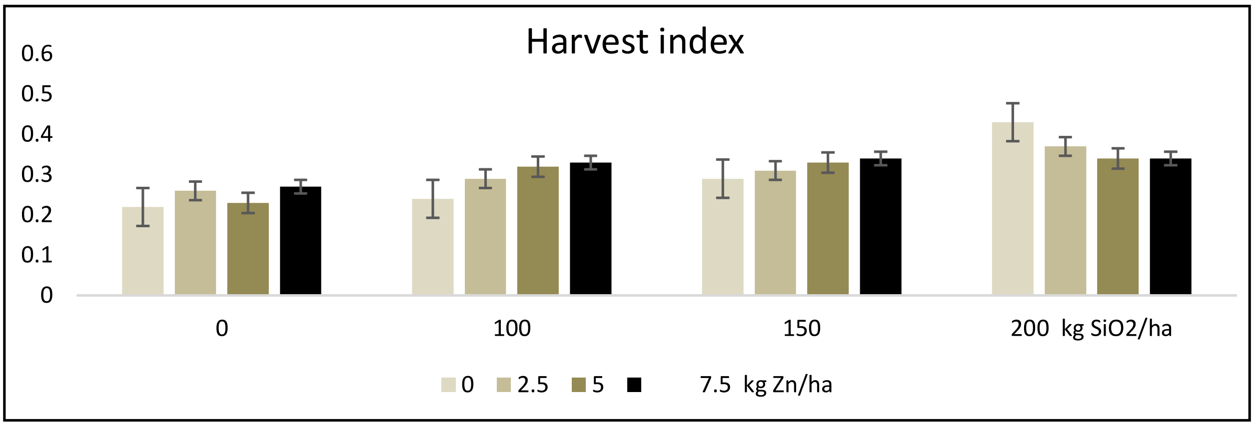

Fig. 2. Harvest index affected by silica and zinc treatment.

biomass and grain yield under low Zn conditions, which was associated with increased Zn concentration in shoots. On the other hand, scientists have reported that additional applications of Zn, Si, B and Zeolite nanoparticles increased chlorophyll formation and plant photosynthetic activity. Silicon supplementation has been widely reported to improve photosynthetic parameters under salinity stress conditions (Mahmoud *et al.*, 2020). The highest yield of peanut pods was 200 kg SiO_2/ha and 2.5 kg Zn/ha. Meanwhile, the highest yield index was in 200 SiO_2/ha and 0 Zn/ha. This was in accordance with the research of Liu *et al.* (2016) on maize. These results have important implications for guiding the rational application of Zn fertilizers and increasing the yield of summer maize seeds in Henan province.

CONCLUSION

Evaluation of silica and zinc in peanuts yielded positive results. The element Si ad Zn can cause a synergistic effect, which was indicated by significantly boosted yields of plant height, the number of leaves, CGR, pithy pod, chlorophyll a, chlorophyll b, total chlorophyll and increased pod production compared to without silicate and zinc. The synergistic effect of the combined treatment still requires further investigation.

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REFERENCES

Alsaeedia, A., El-Ramady, H., Alshaalb, T., El-Garawanyc, M., El-hawatd, N. and Al-Otaibie, A. (2019). Silica nanoparticles boost growth and productivity of cucumber under water deficit and salinity stresses by balancing nutrients uptake. *Plant Phy. Biochem.* **139** : 01-10.

Amanullah and Inamullah. (2016). Dry matter partitioning and harvest index differ in rice genotypes with variable rates of phosphorus and zinc nutrition. *Rice Sci.* **23** : 78-87.

Arya, S. S., Salve, A. R. and Chauhan, S. (2016). Peanuts as functional food : A review. *J. Food Sci. Technol.* **53** : 31-41.

Castillo-Gonzalez, J., Ojeda-Barrios, D., Hernandez-Rodriguez, A., Abadia, J., Sanchez, E., Parraquezada, R., Vallesaragon, M. and Sida-Arreola, J. A. P. (2019). Zinc nutritional status of pecan trees influences physiological and nutritional indicators, the metabolism of oxidative stress, and yield and fruit quality. *Not. Bot. Horti. Agrobo.* **47** : 531-537.

Fauziah, F., Wulansari dan, R. and Rezamela, E. (2018). The effect of Zn and Cu micro fertilizers and soil fertilizers on the development of Empoasca sp. in the tea plant area. *Jurnal Agrikultura* **29** : 26-34.

Ghosh, S., Adak, K., Saha, P., Upadhyay, S., Ghosh, A., Das, P. and Chatterjee, A. (2019). Beta-carotene retention as retinol activity equivalent at different cooking and storage variants. *Int. Food Res. J.* **26** : 355-361.

Guasch-Ferré, M., Liu, X., Malik, V. S., Sun, Q., Willett, W. C., Manson, J. E., Rexrode, K. M., Li, Y., Hu, F. B. and Bhupathiraju, S.

N. (2017). Nut consumption and risk of cardiovascular disease. *J. Am. College Cardio.* **70**. *https://doi.org/10.1016/j.jacc.2017.09.035.*

Islam, M. D., Miah, M. Y., Kamal, M. Z. U. and Farhana, N. (2018). Effects of micronutrient and spacing on growth and chlorophyll content of rice. *Int. J. Enviro. Agric. Biotech. (IJEAB)* **3** : 1765-1771.

Kamble, P. N., Giri, S. P., Mane, R. S. and Tiwana, A. (2015). Estimation of chlorophyll content in young and adult leaves of some selected plants. *Uni. J. Environ. Res. Tech.* **5** : 306-310.

Li, Y., He, N., Hou, J., Xu, L., Liu, C., Zhang, J., Wang, Q., Zhang, X. and Wu, X. (2018). Factors influencing leaf chlorophyll content in natural forests at the Biome scale. *Front. Ecol. Evol.* **6** : 64. *doi : 10.3389/fevo.2018.00064.*

Liu, H., Gan, W., Rengel, Z. and Zhao, P. (2016). Effects of zinc fertilizer rate and application method on photosynthetic characteristics and grain yield of summer maize. *J. Soil Sci. Plant Nutr.* **16** : 550-562.

Mahmoud, A. W. M., Abdeldaym, E. A., Abdelaziz, S. M., El-Sawy, M. B. I. and Mottaleb, S. A. (2020). Synergetic effects of zinc, boron, silicon and zeolite nanoparticles on confer tolerance in potato plants subjected to salinity. *Agronomy* **10** : 19. *doi:10.3390/agronomy10010019.*

Morla, F. D., Giayetto, O., Fernandez, E. M., Cerioni, G. A. and Cerliani, C. (2018). Plant density and peanut crop yield (*Arachis hypogaea*) in the peanut growing region of Cordoba (Argentina). *Peanut Sci.* **45** : 82-86.

Purbajanti, E. D., Kusmiyati, F., Slamet, W. and Adinurani, P. G. (2016). Chlorophyll, crop growth rate and forage yield of Brachiaria (*Brachiaria brizantha* Stapf.) as the result of goat manure in various nitrogen dosages. *AIP Conf. Proc.* **1755** : 130013. *https://doi.org/10.1063/1.4958557.*

Rahman, N., Suntoro and Sekya, A. T. (2019). Peanut growth and gynophore formation on boron and phosphorus applications. *Sains Tanah J. Soil Sci. Agroclimatology* **16** : 57-66.

Rao, G. B. and Susmitha, P. (2017). Silicon uptake, transportation and accumulation in rice. *J. Pharmacog. Phytochem.* **6** : 290-293.

Rodrigues, F. A. and Datnoff, L. E. (2015). Silicon and plant disease. Springer International Publ., Switzerland.

Sridevi, V. and Chellamuthu, V. (2015). Growth analysis and yield of rice as affected by different system of rice intensification (SRI) practices. *IMPACT : Int. J. Res. App. Natu. Social Sci.* **3** : 29-36.

Zhou, F., Wu, X., Pinos, I., Abraham, B. M., Barrett, T. J., von Lintig, J., Fisher1, E. A. and Amengual, J. (2020). Carotene conversion to vitamin A delays atherosclerosis progression by decreasing hepatic lipid secretion in mice. *J. Lipid Res.* **61** : 1491-1503.

Zhou, L., Gu, X., Cheng, S., Yang, G., Shu, M. and Sun, Q. (2020). Analysis of plant height changes of lodged maize using UAV-LiDAR data. *Agriculture* **10** : 146. *doi:10.3390/agriculture10050146.*