ISSN: 1412-4718, eISSN: 2581-138x

Wicaksono FY · Khairunnisa S · Irwan AW · Nurmala T

The addition of phosphorus and potassium fertilizer in the generative stage of Job's tears affects yield components, yield, and yield quality

Abstract. Job's tears (*Coix lacryma-jobi* L.) is an indeterminate food crop that requires more than one-time application of fertilizer. This study aims to determine the effect of additional doses of phosphorus and potassium at the beginning of the generative phase as side dressing fertilization on yield components, yield, and yield quality of the Job's tears plant. The research was conducted in dry season March - August 2021 at the Experimental Field of the Faculty of Agriculture, Universitas Padjadjaran at Jatinangor, Sumedang Regency around 750 m above sea level. The experimental design used randomized block design (RBD) consisting of nine treatments and three replications, namely P and K fertilizers, respectively at doses of: 0, 20, 30, 40, and 50 kg/ha through one or two frequencies of fertilization. Data analysis used analysis of variance and Scott-Knott test at 5% significance level. The results showed that the application of phosphorus and potassium fertilizers affected the number of panicles, seed weight, and harvest index, but no one effect on other yield components and yield quality. The yield component and the Job's tears yield were decreased compared to previous studies, which were carried out in sufficient water conditions.

Keywords: Drought · Job's tears · Phosphorus · Potassium

Submitted: 8 April 2022, Accepted: 17 May 2023, Published: 10 August 2023
DOI: http://dx.doi.org/10.24198/kultivasi.v22i2.39004

Wicaksono FY[1]· Khairunnisa S[2] · Irwan AW[1] · Nurmala T[1]*
[1] Department of Agronomy, Faculty of Agriculture, Universitas Padjadjaran, Jalan Raya Bandung Sumedang km. 21, Sumedang 45363, Indonesia
[2] Study Program of Agrotechnology, Faculty of Agriculture, Universitas Padjadjaran, Jalan Raya Bandung Sumedang km. 21, Sumedang 45363, Indonesia
*Correspondence: tati.nurmala@unpad.ac.id

Jurnal Kultivasi Vol. 22 (2) Agustus 2023
ISSN: 1412-4718, eISSN: 2581-138x

Introduction

Indonesia's population growth is increasing from year to year. Based on Indonesia Statistics (2021), Indonesia's population in September 2020 was 270.2 million people. The average population growth rate of Indonesia increased by 1.25 percent per year in 2010-2020. Certainly, increasing population will increase food needs (Prosekov & Ivanova, 2018). So far, most Indonesians consume rice as a staple food (Widyanti et al., 2014). Thus, developing local food through the food diversification program is the government's effort to strengthen community food security (Rozaki, 2020).

Job's tears (*Coix lacryma-jobi* L.) is an alternative food crop that has good nutrition, health benefit, and easy to cultivate in tropical area, especially Indonesia (Nurmala et al., 2017). Job's tears seeds contain 76.40% carbohydrates, 7.90% fat, and 14.10% protein (Grubben et al., 1996). In addition, Job's tears can also be used as a functional food to treat diseases such as diabetes, kidney and liver diseases, lung cancer, and rheumatism (Irawanto et al., 2017). Origin of Job's tears is from Southeast Asia so that the climate in Indonesia is suitable for the growth of Job's tears (Iamsupasit, 1996).

The yield and harvest index of Job's tears from farmers production are still low (Wicaksono et al., 2022). This problem caused by failure of fertilizer dosage and fertilization method, farmers usually give one time fertilization. Job's tears is indeterminate plant that requires more than one time fertilization like other indeterminate plants (Kaschuk et al., 2016). Thus, the Job's tears plant requires additional fertilization in its growth phase, especially the generative stage which determines yield of seed.

Generative stage of plants need phosphorus and potassium fertilizer (Szczepanek & Siwik-Ziomek, 2019). Phosphorus is needed for the formation of ATP, germination, photosynthesis, respiration, growth of young plants, growth of roots and leaves, flowering and seed formation, storing dry matter in cereal seeds, and increasing yield components, yield and yield quality (Gahoonia et al., 1999; Chaichi et al., 2008; Malhotra et al., 2018; Seneweera & Conroy, 1997), while potassium is needed to fight pests and diseases, photosynthesis, osmoregulation, enzyme activation, protein synthesis and ion transport (Dhillon et al., 2019; Zörb et al., 2014). Potassium also affects the yield, yield, and quality of seeds (Brennan & Bolland, 2009; Ali et al., 2003).

The application of additional fertilizer in generative stage of Job's tears has never been studied. It is expected that yield and quality of Job's tears seeds will increase with the addition of this fertilizer.

Materials and Methods

The research was carried out from March to August 2021 at the Experimental Field of the Faculty of Agriculture, Universitas Padjadjaran in Jatinangor, Sumedang. The altitude of the research location is around 750 m above sea level. The research site has a temperature of 21.8 – 23.0^{o}C, humidity 86 – 91%, and belongs to the C3 agro-climatological zone according to Oldeman's classification. Rainfall during the study was 490 (March), 44.5 (April), 120.5 (May), 85.5 (June), 16 (July), and 10 mm (August). The site soil had pH 7.22 (neutral), organic C 1.26% (low), total N 0.11% (low), C/N 11.45 (high), total P_2O_5 34.98 mg/100 g (moderate), available P_2O_5 1.95 ppm (very low), K_2O 4.44 mg/100 g (very low), and cation exchange capacity 24.96 (moderate).

The materials that used in this research were Job's tears seeds cv. Watani Wado, chicken manure, NPK fertilizer (15:15:15), SP-36 fertilizer (36% P), KCl fertilizer (55% K), profenofos insecticide, and mancozeb fungicide. The tools used in this study were tape measure, analytical balance, caliper, Wagner penetrometer, farming equipment, and AGR-RM40 dehuller machine.

The research was an experiment, which used a randomized block design (RBD) with nine treatments and three replications, so there were 27 plots. Each plot was 12 m^2 that consisted of 50 plants. The treatment was:
A = without additional P and K (control),
B = additional P and K 20 kg/ha, respectively, in one time application at 16 weeks after sowing (WAS),
C = additional P and K 20 kg/ha, respectively, in two times application at 16 and 18 WAS,
D = additional P and K 30 kg/ha, respectively, in one time application at 16 WAS,
E = additional P and K 30 kg/ha, respectively, in two times application at 16 and 18 WAS,

F = additional P and K 40 kg/ha, respectively, in one time application at 16 WAS,
G = additional P and K 40 kg/ha, respectively, in two times application at 16 and 18 WAS,
H = additional P and K 50 kg/ha, respectively, in one time application at 16 WAS
I = additional P and K 50 kg/ha, respectively, in two times application at 16 and 18 WAS,

Land preparation consisted of weed clearing, plowing and plots making. Plots were made with a width of 3 m and a length of 4 m. Plots distance was 0.3 m, while replications distance was 1 m. Plant spacing was 60 cm x 40 cm. Manure was given a week before planting at a dose of 2 tons/ha.

Seeds were mixed with fungicide, then two Job's tears seeds were planted in a hole with a depth of about 3 cm and covered by soil. Fertilizing of NPK at a dose of 200 kg/ha was given at 3 WAS by side dressing. The application of SP-36 and KCl fertilizer according to the treatment was given at 16 WAS (14 days after the flowers appeared) and 18 WAS (28 days after the flowers appeared) by side dressing.

Plant cultivation included weeding, pest and disease control. Weeds was controlled by mechanically weeding. Control of grasshopper was carried out by spraying insecticide, while fungicide controlled black mildew. Water supply for plant was given by surface irrigation.

Job's tears can be harvested at seed physiological mature, which is 165 days after sowing (DAS). Physically, dry and yellowish leaves indicated that seeds can be harvested. On the other hand, seeds having a shiny white color, filled or pithy, and hard when pressed by hand.

Observations were carried out by counting or measuring the components of yield, yield, and yield quality. The yield components consisted of the number of productive tillers, the number of panicles per tiller, the number of seeds per panicle, and the weight of 100 seeds. Yield were measured by seed weight per plant and harvest index, while yield quality were seed hardness, seed size, seed extraction ratio and polishing ratio.

The number of productive tillers, number of panicle, and the number of seed were counted at the age of 15 weeks after sowing. The number of productive tillers was counted based on the number of tillers that produce flowers at the reproductive stage. The number of panicle was counted per tiller, while the number of seed was counted per panicle. Weight of 100 seeds and grain weight per plant was measured after harvest using an analytical scale at 14% moisture content. The harvest index is measured by comparing seed weight with plant biological weight. Seed size was measured using a caliper, while seed hardness was measured using a penetrometer. Seed extraction ratio was measured by dividing weight of hulled seed by weight of unhulled seed. Polishing ratio was measured by comparing the milled seeds with the Job's tears polished seed standard.

Data were analyzed using SPSS software version 25. Differences between treatments were identified using Scott-Knott test at 5% significance level.

Results and Discussion

Results. Addition of P and K fertilizers did not increase the number of productive tillers, the number of seeds, or the weight of 100 seeds of Job's tears plants compared to the control (Table 1). On the other hand, P and K fertilizer treatment at a dose of 30-40 kg/ha with a frequency of 1 or 2 times increased the number of panicles.

Crop yields can be increased by addition of P and K fertilizer (Table 2). Giving P and K fertilizers 20 or 30 kg/ha, either 1 or 2 times in the generative stage gave the best seed weight, while dose of 20 or 40 kg/ha that given 1 or 2 times and dose of 50 kg/ha that given 1 time application was better than control. The addition of P and K fertilizers at a dose of 50 kg that given twice did not increase yields compared to the control. The addition of P and K fertilizers at a dose of 20-40 kg/ha, either once or twice increased the harvest index compared to the control. The application of P and K fertilizers at a dose of 50 kg/ha which was given 1 time also increased yields, but the application 2 times gave the same results as the control.

In contrast to the yield and yield components, the addition of P and K fertilizers did not increase yield quality. The addition of P and K fertilizers did not give any difference in seed diameter, seed hardness, seed extraction ratio and polishing ratio compared to the control.

Jurnal Kultivasi Vol. 22 (2) Agustus 2023
ISSN: 1412-4718, eISSN: 2581-138x

Table 1. The effect of addition of P and K fertilizers on the yield components of job's tears plants

Treatments	Number of Productive Tillers	Number of Panicles	Number of Seeds	Weight of 100 Seeds (g)
A = without additional P and K (control)	2.33 a	16.16 a	2.35 a	11.11 a
B = additional P and K 20 kg/ha, respectively, in one time application	4.00 a	13.11 a	2.39 a	12.60 a
C = additional P and K 20 kg/ha, respectively, in two times application	2.92 a	15.06 a	3.01 a	11.95 a
D = additional P and K 30 kg/ha, respectively, in one time application	3.42 a	18.23 b	2.74 a	12.12 a
E = additional P and K 30 kg/ha, respectively, in two times application	4.50 a	19.49 b	2.34 a	11.73 a
F = additional P and K 40 kg/ha, respectively, in one time application	2.50 a	16.50 b	2.94 a	11.76 a
G = additional P and K 40 kg/ha, respectively, in two times application	2.67 a	19.35 b	2.37 a	11.95 a
H = additional P and K 50 kg/ha, respectively, in one time application	3.33 a	13.44 a	2.99 a	12.26 a
I = additional P and K 50 kg/ha, respectively, in two times application	3.00 a	15.12 a	2.30 a	11.96 a

Note: The mean value of the treatment in the same column followed by the same letter was not different based on Scott-Knott test at the 5% significance level.

Table 2. The effect of addition of P and K fertilizers on the yield of job's tears plants

Treatments	Seed Weight per Plant (g)	Harvest Index
A = without additional P and K (control)	9.83 a	0.28 a
B = additional P and K 20 kg/ha, respectively, in one time application	15.79 b	0.34 b
C = additional P and K 20 kg/ha, respectively, in two times application	15.82 b	0.42 b
D = additional P and K 30 kg/ha, respectively, in one time application	20.70 c	0.41 b
E = additional P and K 30 kg/ha, respectively, in two times application	24.07 c	0.39 b
F = additional P and K 40 kg/ha, respectively, in one time application	14.26 b	0.42 b
G = additional P and K 40 kg/ha, respectively, in two times application	14.63 b	0.42 b
H = additional P and K 50 kg/ha, respectively, in one time application	16.41 b	0.46 b
I = additional P and K 50 kg/ha, respectively, in two times application	12.48 a	0.32 a

Note: The mean value of the treatment in the same column followed by the same letter was not different based on Scott-Knott test at the 5% significance level.

Table 3. The Effect of addition of P and K fertilizers on the yield quality of job's tears plants

Treatments	Seed Diameter (mm)	Seed Hardness (kgf)	Seed Extraction Ratio (%)	Polishing Ratio (%)
A = without additional P and K (control)	6.56 a	7.02 a	55.52 a	77.08 a
B = additional P and K 20 kg/ha, respectively, in one time application	6.68 a	7.09 a	56.25 a	79.50 a
C = additional P and K 20 kg/ha, respectively, in two times application	6.40 a	7.00 a	58.43 a	78.92 a
D = additional P and K 30 kg/ha, respectively, in one time application	6.47 a	6.90 a	60.03 a	79.33 a
E = additional P and K 30 kg/ha, respectively, in two times application	6.37 a	6.94 a	55.93 a	79.00 a
F = additional P and K 40 kg/ha, respectively, in one time application	6.33 a	7.04 a	54.95 a	79.58 a
G = additional P and K 40 kg/ha, respectively, in two times application	6.40 a	7.06 a	56.19 a	80.00 a
H = additional P and K 50 kg/ha, respectively, in one time application	6.61 a	6.99 a	57.15 a	79.42 a
I = additional P and K 50 kg/ha, respectively, in two times application	6.55 a	7.03 a	56.71 a	79.25 a

Note: The mean value of the treatment in the same column followed by the same letter was not different based on Scott-Knott test at the 5% significance level.

Discussion. Dry season that occurs during generative stage of plants (April – August) causes water shortages. The yield and yield components of Job's tears were smaller than previous studies which were conducted in sufficient water condition (Ruminta et al., 2017; Ruminta et al., 2018; Nurmala et al., 2016). Lack of water cause a decrease in phosphorus and potassium uptake (Ge et al., 2012; Bakhshandeh et al., 2020; Raza et al., 2012; Nawaz et al., 2012; Bista et al., 2018). This was shown by P and K treatments did not increase yield components or yield quality and only affected the number of panicles, seed weight, and harvest index. Nonetheless, there were several studies that state that potassium uptake in drought conditions actually increases (Raza et al., 2012). On the other hand, previous studies stated that the provision of phosphorus and potassium could increase yield components and yield quality (Chaichi et al., 2008; Malhotra et al., 2018; Seneweera & Conroy, 1997; Brennan & Bolland, 2009; Ali et al., 2003).

Adding phosphorus and potassium fertilizer 30-40 kg/ha increased the number of panicles, either in one or two applications. The data showed that the dose affected more than the frequency of fertilizer application. Increasing the dose of phosphorus has been known to increase the number of flowers (Vosnjak et al., 2021; Malhotra et al., 2018). The same thing happened for increasing the dose of potassium (Fageria & Oliveira, 2014; Fageria, 2015). However, giving too much phosphorus and potassium (50 kg/ha) did not increase the number of panicles (Islam & Muttaleb, 2016; Banerjee et al., 2018).

On crop yield, the best doses of phosphorus and potassium were narrowed at 30 kg/ha, either 1 or 2 applications. The analogy in the number of panicles observation, an increase in the doses of phosphorus and potassium increased yield, but the provision of too many doses of phosphorus and potassium did not increase the yield. In this case, the number of panicles as a yield component increased due to the application of phosphorus and potassium, causing an increase in plant yield. Increasing a yield component could result in the increasing of yield (O'Connor et al., 2018; Huang et al., 2011). The interesting thing was that twice application of 50 kg P and K fertilizer did not increase yields, compared to one time application. This was inconsistent compared to the same frequency of fertilization at other fertilizer doses.

The harvest index is affected by crop yield (Wnuk et al., 2013; Li et al., 2015). With an increase in seed weight due to the provision of

phosphorus and potassium, the harvest index also increased compared to the control. However, the dose of 30 kg/ha, which gave the best seed weight, did not increase harvest index compared to doses of 20, 40, or 50 kg/ha. This probably happens because the provision of phosphorus and potassium can increase biological weight (Dai et al., 2016; Bilal et al., 2021; Maurya et al., 2014).

Conclusions

The addition of phosphorus and potassium in the generative stage of Job's tears increased the number of panicles, seed weight, and harvest index but did not affect other yield components and yield quality.

Acknowledgment

The researchers would like to thank Universitas Padjadjaran for funding this research through the Academic Leadership Grant scheme, so that the research can be carried out properly.

References

Ali MA, Hoss MA, Mondal MF, Farooque AM. 2003. Effect of nitrogen and potassium on yield and quality of carrot. Pakistan Journal of Biological Sciences, 6(18): 1574–1577. https://doi.org/10.3923/pjbs.2003.1574.1577

Bakhshandeh E, Gholamhosseini M, Yaghoubian Y, Pirdashti H. 2020. Plant growth promoting microorganisms can improve germination, seedling growth and potassium uptake of soybean under drought and salt stress. Plant Growth Regulation, 90(1): 123–136. https://doi.org/10.1007/s10725-019-00556-5

Banerjee H, Ray K, Dutta S, Majumdar K, Satyanarayana T, Timsina J. 2018. Optimizing potassium application for hybrid rice (Oryza sativa L.) in coastal saline soils of West Bengal, India. Agronomy, 8(12): 292. https://doi.org/10.3390/agronomy8120292

Bilal S, Hazafa A, Ashraf I, Alamri S, Siddiqui MH, Ramzan A, … Naeem M. 2021. Comparative effect of inoculation of phosphorus-solubilizing bacteria and phosphorus as sustainable fertilizer on yield and quality of mung bean (Vigna radiata L.). Plants, 10(10): 2079. https://doi.org/10.3390/plants10102079

Bista D, Heckathorn S, Jayawardena D, Mishra S, Boldt J. 2018. Effects of drought on nutrient uptake and the levels of nutrient-uptake proteins in roots of drought-sensitive and -tolerant grasses. Plants, 7(2): 28. https://doi.org/10.3390/plants7020028

Brennan RF, Bolland MDA. 2009. Comparing the nitrogen and potassium requirements of canola and wheat for yield and grain quality. Journal of Plant Nutrition, 32(12): 2008–2026. https://doi.org/10.1080/01904160903308127

Chaichi, MR, Khalili A, Akbari N. 2008. Limited irrigation and phosphorus fertilizer effects on yield and yield components of grain sorghum (Sorghum bicolor L.var. Kimia). J. Agric. & Environ. Sci, 3(5): 697–702.

Dai J, Bean B, Brown B, Bruening W, Edwards J, Flowers M, … Wiersma J. 2016. Harvest index and straw yield of five classes of wheat. Biomass and Bioenergy, 85: 223–227. https://doi.org/10.1016/j.biombioe.2015.12.023

Dhillon JS, Eickhoff EM, Mullen RW, Raun WR. 2019. World potassium use efficiency in cereal crops. Agronomy Journal, 111(2): 889–896. https://doi.org/10.2134/agronj2018.07.0462

Fageria NK. 2015. Potassium requirements of lowland rice. Communications in Soil Science and Plant Analysis, 46(12): 1459–1472. https://doi.org/10.1080/00103624.2015.1043444

Fageria NK, Oliveira JP. 2014. Nitrogen, phosphorus and potassium interactions in upland rice. Journal of Plant Nutrition, 37(10): 1586–1600. https://doi.org/10.1080/01904167.2014.920362

Gahoonia TS, Nielsen NE, Lyshede OB. 1999. Phosphorus (P) acquisition of cereal cultivars in the field at three levels of P fertilization. Plant and Soil, 211(2): 269–281. https://doi.org/10.1023/A:1004742032367

Ge T-D, Sun N-B, Bai L-P, Tong C-L, Sui F-G. 2012. Effects of drought stress on phosphorus and potassium uptake dynamics in summer maize (Zea mays) throughout the growth cycle. Acta

Physiologiae Plantarum, 34(6): 2179–2186. https://doi.org/10.1007/s11738-012-1018-7

Grubben GJH, Partohardjono S, van der Hoek, HN. 1996. Introduction. In GJH Grubben & S. Partohardjono (Eds.), Plant Resources of South-East Asia No 10. Cereals. (pp. 1–74). Leiden: Backhuys Publisher.

Huang M, Zou Y, Jiang P, Xia B, Ibrahim Md, Ao H. 2011. Relationship between grain yield and yield components in super hybrid rice. Agricultural Sciences in China, 10(10): 1537–1544. https://doi.org/10.1016/S1671-2927(11)60149-1

Iamsupasit. (1996). Coix lacryma-jobi L. In GJH Grubben & S Partohardjono (Eds.), Plant Resources of South-East Asia No 10. Cereals. (pp. 84–90). Leiden: Backhuys Publisher.

Islam A, Muttaleb A. 2016. Effect of potassium fertilization on yield and potassium nutrition of Boro rice in a wetland ecosystem of Bangladesh. Archives of Agronomy and Soil Science, 62(11): 1530–1540. https://doi.org/10.1080/03650340.2016.1157259

Kaschuk G, Nogueira MA, de Luca MJ, Hungria M. 2016. Response of determinate and indeterminate soybean cultivars to basal and topdressing N fertilization compared to sole inoculation with Bradyrhizobium. Field Crops Research, 195: 21–27. https://doi.org/10.1016/j.fcr.2016.05.010

Li J, Xie RZ, Wang KR, Ming B, Guo YQ, Zhang GQ, Li SK. 2015. Variations in maize dry matter, harvest index, and grain yield with plant density. Agronomy Journal, 107(3): 829–834. https://doi.org/10.2134/agronj14.0522

Malhotra H, Vandana, Sharma S, Pandey R. 2018. Phosphorus nutrition: Plant growth in response to deficiency and excess. Plant Nutrients and Abiotic Stress Tolerance: 171–190. https://doi.org/10.1007/978-981-10-9044-8_7

Maurya P, Kumar V, Maurya KK, Kumawat N, Kumar R, Yadav MP. 2014. Effect of potassium application on growth and yield of wheat varieties. N Save Nature to Survive, 9(4): 1371–1373. Retrieved from www.thebioscan.in

Nawaz F, Ahmad R, Waraich EA, Naeem MS, Shabbir RN. 2012. Nutrient uptake, physiological responses, and yield attributes of wheat (Triticum aestivum L.) exposed to early and late drought stress. Journal of Plant Nutrition, 35(6): 961–974. https://doi.org/10.1080/01904167.2012.663637

Nurmala T, Ruminta, Wicaksono FY. 2017. Pengembangan pangan lokal Job's tears sebagai pangan multifungsi dalam rangka pemberdayaan petani di lahan marginal. Prosiding Semnas Pekan Agroteknologi 2017, 3 Desember 2017. Sumedang: UNPAD Press.

Nurmala T, Yuniarti A, Syahfitri N. 2016. Pengaruh berbagai dosis pupuk silika organik dan tingkat kekerasan biji terhadap pertumbuhan dan hasil tanaman Job's tears pulut (Coix lacryma- Jobi.L) genotip 37". Kultivasi, 15(2). https://doi.org/10.24198/kultivasi.v15i2.11896

O'Connor K, Hayes B, Topp B. 2018. Prospects for increasing yield in macadamia using component traits and genomics. Tree Genetics & Genomes, 14(1), 7. https://doi.org/10.1007/s11295-017-1221-1

Prosekov AY, Ivanova SA. 2018. Food security: The challenge of the present. Geoforum, 91: 73–77. https://doi.org/10.1016/j.geoforum.2018.02.030

Raza MAS, Saleem MF, Ashraf MY, Ali A, Asghar HN. 2012. Glycinebetaine applied under drought improved the physiological efficiency of wheat (Triticum aestivum L.) plant. Soil and Environment, 31(1): 67–71.

Rozaki, Z. 2020. COVID-19, Agriculture, and Food Security in Indonesia. Reviews in Agricultural Science, 8: 243–260.

Ruminta, Nurmala T, Wicaksono FY. 2017. Growth and yield of job's tears (Coix lacryma-jobi L.) response to different types of oldeman climate classification and row spacing in west java Indonesia. Journal of Agronomy, 16(2). https://doi.org/10.3923/ja.2017.76.82

Ruminta, Nurmala T, Yuwariah Y, Pratiwi NY. 2018. Respon pertumbuhan dan hasil tanaman Job's tears pada panen awal akibat pemberian dosis pupuk biosilika dan paklobutrazol di lahan kering Jatinangor. Kultivasi, 17(3). https://doi.org/10.24198/kultivasi.v17i3.18438

Seneweera SP, Conroy JP. 1997. Growth, grain yield and quality of rice (Oryza sativa L.) in response to elevated CO2 and phosphorus nutrition. Soil Science and Plant Nutrition, 43(sup1): 1131–1136. https://doi.org/

10.1080/00380768.1997.11863730

Szczepanek M, Siwik-Ziomek A. 2019. P and K accumulation by rapeseed as affected by biostimulant under different NPK and S fertilization doses. Agronomy, 9(9): 477. https://doi.org/10.3390/agronomy9090477

Vosnjak M, Likar M, Osterc G. 2021. The effect of mycorrhizal inoculum and phosphorus treatment on growth and flowering of Ajania (Ajania pacifica (Nakai) Bremer et Humphries) plant. Horticulturae, 7(7): 178. https://doi.org/10.3390/horticulturae7070178

Wicaksono FY, Sinniah UR, Ruminta, Sumadi, Nurmala T. 2022. Characteristics of physiology, phenology, and drought susceptibility index of two varieties of Job's tears under water deficit stress. Biodiversitas, 23(1): 381–387. https://doi.org/10.13057/biodiv/d230139

Widyanti A, Sunaryo I, Kumalasari AD. 2014. Reducing the dependency on rice as staple food in Indonesia - A behavior intervention approach. Journal of the International Society for Southeast Asian Agricultural Sciences, 20(1): 93–103.

Wnuk A, Górny AG, Bocianowski J, Kozak M. 2013. Visualizing harvest index in crops. Communications in Biometry and Crop Science, 8(2): 48–59.

Zörb C, Senbayram M, Peiter E. 2014. Potassium in agriculture – Status and perspectives. Journal of Plant Physiology, 171(9): 656–669. https://doi.org/10.1016/j.jplph.2013.08.008