RESEARCH ARTICLE
Indian Journal of Agricultural Research, Volume 55 Issue 6: 667-673 (December 2021)

Effect of NPK Fertilizer on Nutrient Uptake, Growth, Yield and Beta-carotene of Cutleaf Groundcherry (*Physalis angulata* L.) of Genotypes

W.S.D. Yamika[1], G.P. Simbolon[1], B. Waluyo[1], N. Aini[1]

10.18805/IJARe.A-637

ABSTRACT

Background: Cutleaf groundcherry (*Physalis angulata* L.) has vitamins that are good for health. There were several genotypes of cutleaf groundcherry that have the potential to be widely cultivation, but information of doses of NPK fertilizer for those genotypes was still limited. The objective of this experiment was to determine the response of cutleaf groundcherry to different rates of NPK fertilizer.

Methods: The experiment was conducted May-September 2019 in dry land field. The experiment used a factorial randomized block design with three replications. The first factor was genotypes cutleaf groundcherry (PA 01, PA 02 and PA 03) and the second factor was doses of NPK fertilizer (75, 150 and 225 kg ha^{-1} NPK).

Conclusion: The increased in doses of NPK fertilizer to 225 kg ha^{-1} NPK increased nutrient uptake, plant growth and fresh fruit weight for each genotype of cutleaf groundcherry. Meanwhile ascorbic acid content increased with a dose of 150 kg ha^{-1} NPK, but decreased with increased NPK fertilizer rates. The beta-carotene content with 75 kg ha^{-1} NPK fertilizer was higher than with 150 and 225 kg ha^{-1} doses. The increase of NPK fertilizer doses otherwise decreases the beta-carotene content for each genotype. Shoot dry weight, fresh fruits weight and ascorbic acid in PA 03 genotype higher than PA 01 and PA 02 genotypes.

Key words: Cutleaf groundcherry, Nutrient uptake, NPK fertilizer, *Physalis angulata*.

INTRODUCTION

Cutleaf groundcherry had been reputed to be a weed and reduced crop production, but now many studies have begun to examine the benefits of cutleaf groundcherry. The cutleaf groundcherry contains phytochemical compounds that have the potential to be developed as anti-inflammatory (Bastos *et al*., 2008; Rivera *et al.,* 2019), antibacterial (Yang *et al*., 2016; Erturk *et al*., 2017), anticancer (Fitria *et al*., 2011; El-kenawy *et al*., 2015; Tuan-Anh *et al*., 2018), antidiabetic (Zhang *et al*., 2018) and antitumour (Hseu *et al*., 2011) agents.

Cutleaf groundcherry is commonly found in Indonesia from lowlands up to an altitude of 1,600 meters above sea level (Nur and Jumin, 2016). There are many benefits of cutleaf groundcherry, but it is still rarely cultivated and information on cultivation techniques of cutleaf groundcherry is limited. The cutleaf groundcherry production can also be increased through a two-way approach, namely genetic improvement and cultivation technology, one way of which cultivation was through proper compound fertilization. We have some cutleaf groundcherry genotypes that have the potential to become commercial varieties. The genotypes require NPK fertilizer doses information to increased their growth and yield.

Plant requires macro nutrient such as nitrogen, phosphorus and potassium. Nitrogen is required in large amount to form amino acid and chlorophyll. Amino acid is the parts that form proteins, nucleic acids and enzymes. Nitrogen plays an important role in vegetative growth, particularly the number of branches, which affects fruit production (Marschner, 2003). Geisseler *et al*. (2020) reported greater amounts of nitrogen in the shoots than in the fruits in tomato.

Each variety of cutleaf groundcherry requires different nitrogen doses. El-Tohamy *et al*. (2009) reported that nitrogen doses up to 200 kg ha^{-1} increased fruit production, fruit diameter and growth attributes such as plant height, number of leaf, and nutrient uptake of *P. peruviana*. When applied to *P. angulata,* a dose 200 kg ha^{-1} N increases plant biomass whereas nitrogen doses higher than 400 kg ha^{-1} decreases plant biomass. Phenolic compound decreased with increasing nitrogen doses. Higher phenolic compound was found without applying nitrogen fertilizer, while applying nitrogen fertilizer decreased phenolic compound. Fertilization in high doses does not increased yield and instead reduced the yield (Leite *et al*., 2018).

Department of Agronomy, Faculty of Agriculture, Universitas Brawijaya, Malang, East Java-65145, Indonesia.

Corresponding Author: W.S.D. Yamika, Department of Agronomy, Faculty of Agriculture, Universitas Brawijaya, Malang, East Java-65145, Indonesia. Email: wiwinyamika@gmail.com

How to cite this article: Yamika, W.S.D., Simbolon, G.P., Waluyo, B. and Aini, N. (2021). Effect of NPK Fertilizer on Nutrient Uptake, Growth, Yield and Beta-carotene of Cutleaf Groundcherry (*Physalis angulata* L.) of Genotypes. Indian Journal of Agricultural Research. 55(6): 667-673. DOI: 10.18805/IJARe.A-637.

Submitted: 26-03-2021 **Accepted:** 05-06-2021 **Online:** 27-07-2021

Increasing nitrogen doses that exceeds the optimum level dose not correlate with increased fruit yield and quality. Chrysargyris *et al*. (2017) reported that increased nitrogen doses decreased the nitrogen uptake, reduced chlorophyll a and b and reduced plant quality of mint. The optimum dose of nitrogen for *P. peruviana* appeared to be 133 kg ha^{-1} as increasing nitrogen doses up to 160 and 200 kg ha^{-1} reduced yield by 4,7% and 16,88 % respectively (Albayrak *et al*., 2014).

MATERIALS AND METHODS

Experimental detail

A cutleaf grouncherry field experiment was conducted at Donowarih Village, Karangploso District, Malamg Regency East Java-Indonesia during May to September 2019. The study was conducted with a factorial randomized block design (RBD) consisting of two factors: NPK doses and the use of 3 cutleaf groundcherry genotypes. There were 9 combinations of treatments and 3 repetitions for three times, resulting in 27 experimental units. The first factor of NPK fertilizer doses consists of 3 levels, *i.e*. NPK fertilizer dose 75 kg ha^{-1}; NPK fertilizer dose of 150 kg ha^{-1}; NPK fertilizer dose 225 kg ha^{-1}. The second factor of cutleaf groundcherry genotypes consists of 3 genotypes, namely: PA 01; PA 02 and PA 03 genotypes.

Field experiment

The field experiment was conducted at dry land with pH 5.6, C-organic 1.52%, nitrogen total 0.16%, phosphorus 69 ppm, potassium 0.52 me 100 g^{-1}. The Temperature mean daily of field experiment was 22.90°C, relative humidity mean 73.26%, total rainfall May-September was 130.90 mm (Table 1). The germination of cutleaf groundcherry utilized a planting medium composed of soil, goat manure and sand with a ratio 1:1:1. The polybag for germination had a size of 8 × 9 cm. The seedlings were transplanted at 21 DAS (days after sowing) with plant spacing was 60 × 60 cm. We used NPK fertilizer which content N=16%, P=16%, K=16%. NPK fertilizer was applied three times (at 1, 7 and 28 days after transplanting) according to treatment doses. 75 kg ha^{-1} was equal to 1.03 g plant^{-1}, 150 kg ha^{-1} was equal to 2.06 g plant ^{1} and 225 kg ha^{-1} was equal to 3.09 g plant^{-1}.

The plants were irrigated with ground water every day in the morning. Weeding was done at three days interval by removing the weeds surrounding the plant. To support plant growth, 1 m stake from bamboo was installed near plant at 2 WAT (Weeks after transplanting). Cutleaf groundcherry fruit began to be harvested on 6 WAT with the harvest criteria being that fruit have a yellow color and the calyx has attained yellow color and were dried. The fruit were harvested once a week until 10 WAT or the plants no longer bore fruit.

Measurement

Plants were measured for growth parameters including leaf area and shoot dry weight. Leaf area was measured with a Leaf Area Meter (LAM) merk LI3000C. Shoot dry weight was measured by drying in an oven at 80°C for approximately 2 days and then weighing them. Plant yield was measured through the number of fruits per plant and fresh weight of fruit per plant.

For analysis N, P and K uptake, dried materials of shoot dry plants were brought in to be analyzed. Total nitrogen content was determined by semi micro kjeldhal method. Phosphorus content was determined by Spectrophotometry with a standard curve. Potassium was determined by Flamephotometry. Nutrient uptake was determined by multiplying the value of each nutrient and the dry weight of shoots (Adeli *et al*., 2005).

To measure fruit quality, fruit were analysed for beta-carotene, ascorbic acid and sugar as total soluble sugar (TSS). Beta-carotene was measured by the method described by (Arnon, 1949). Ascorbic acid was measured by the titration method described by (Sudarmadji *et al*., 1984). TSS was measured with a hand refractometer.

The collected data were analyzed using analysis of variance and then examined with F test at 5% error level and further with least significant difference (LSD) at 5% error level.

RESULTS AND DICUSSION

Plant growth

Doses of NPK fertilizer and genotypes was significant effect on plant growth attributes of cutleat groundcherry *i.e.* plant height, leaf area, number of leaf and shoot dry weight (Fig 1). Plant height of Cutleaf groundcherry genotypes had different response to increased fertilizer doses. In PA 01 genotype, the highest plant height (66.83 cm) was found with NPK 225 kg ha^{-1} (Fig 1A), while in PA 02 genotype addition of NPK 150 kg ha^{-1} and 225 kg ha^{-1} showed no significant differences for plant height (64.17 and 67.67 cm) and PA 03 genotype shown plant height of cutleat groundcherry addition of NPK 150 kg ha^{-1} higher (75.67 cm) than NPK

Table 1: The meteorological data of experiment locations Karangploso-Malang-East Java.

Climate data	Temperature minimum (°C)	Temperature maximum (°C)	Temperature mean daily (°C)	Relative humidity (%)	Total rainfall (mm)
May	19.83	29.02	24.07	77.13	72.60
June	17.76	28.00	22.56	73.94	0
July	17.44	27.75	21.97	75.28	58.30
August	17.38	28.23	22.35	71.91	0
September	18.13	29.97	23.53	68.03	0

75 kg ha^{-1} (65.33 cm) and NPK 225 kg ha^{-1} showed the highest plant height (77.50 cm). Similar result was reported by Siddiq *et al.* (2011).

Each genotype of cutleaf groundcherry has a different leaf area for each NPK application. The leaf area of the cutleaf groundcherry was directly proportional to the application of NPK fertilizer. In the PA 01, application of NPK 225 kg ha^{-1} increased leaf area 20.67% compared with application of NPK 75 kg ha^{-1} (Fig 1B). While, in PA 02 genotype, application of NPK 150 kg ha^{-1} increased leaf area 10.26% compared with application of NPK 75 kg ha^{-1} and application of NPK 225 kg ha^{-1} increased leaf area 33.83% compared with application of NPK 75 kg ha^{-1}. The highest of increased leaf area area was found in the application of NPK 225 kg ha^{-1} in PA 03 genotype was 62.13% compared with application of NPK 75 kg ha^{-1}. Similar was reported by Ali and Singh (2017); Sarfraz *et al.* (2021) that NPK fertilizer correlates with increasing photoassimilates, which the assimilate was used to increased leaf area, increase the number of leaf and leads to greater shoot dry weight.

The application NPK fertilizer doses did not significant increased number of leaf in PA 01 genotype, but in PA 02 and PA 03 genotypes significant increased number of leaf (Fig 1C). The maximum number of leaf per plant of PA 02 genotype (471.83) was found with NPK with a dose of 225 kg ha^{-1}, while in PA 03 genotype presented of NPK 150 kg ha^{-1} (461.17) and 225 kg ha^{-1} (468.67) were not significantly different. Similar was reported by Dalai *et al.* (2021) and Sarfraz *et al.* (2021).

The application of NPK fertilizer at a dose of 75 kg ha^{-1} showed the minimum shoot dry weight in PA 01, PA 02 and PA 03 (Fig 1D). In PA 01 genotype, the maximum shoot dry weight (52.33 g) was found in the application NPK with a dose 225 kg ha^{-1}, the same response in the PA 02 and PA 03 genotype the maximum shoot dry weight was found with NPK with a dose 225 kg ha^{-1} *i.e.* 83.17 g (PA 02) and 98.00 g (PA 03). Among three of genotypes, PA 03 had the highest shoot dry weight and plant growth. Similar was reported by Bonela *et al.* (2017) and Dalai *et al.* (2021).

Nutrient uptake

In observing nutrient uptake, each genotype had a different response to NPK doses. Application of higher doses of NPK increased the value of nutrient uptake. The highest nitrogen uptake in all genotypes (PA 01, PA 02 and PA 03) was found with the application of fertilizers with a dose of 225 kg ha^{-1} (Fig 2A). PA 03 genotype had higher nitrogen uptake compared than PA 01 and PA 02 genotypes. The phosphorus uptake in the PA 01, PA 02 and PA 03 genotypes were increased with increasing of doses NPK fertilizer. The phosphorus uptake was higher with the application NPK of 225 kg ha^{-1} (Fig 2B). The phosphorus uptake in the PA 01 and PA 03 genotypes were better than the PA 02 genotype. The potassium uptake in the PA 01 and PA 02 genotypes at

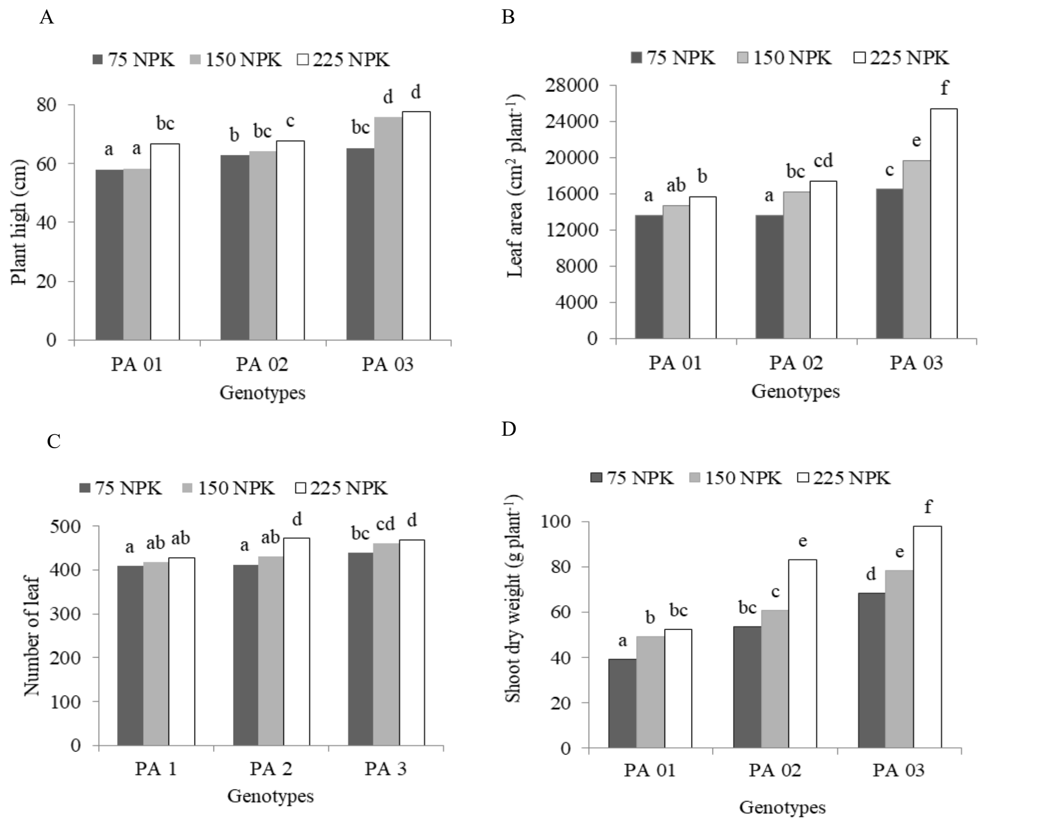

Fig 1: Effect NPK fertilizer on plant height (A), leaf area (B), number of leaf (C) and shoot dry weight (D) of genotypes.

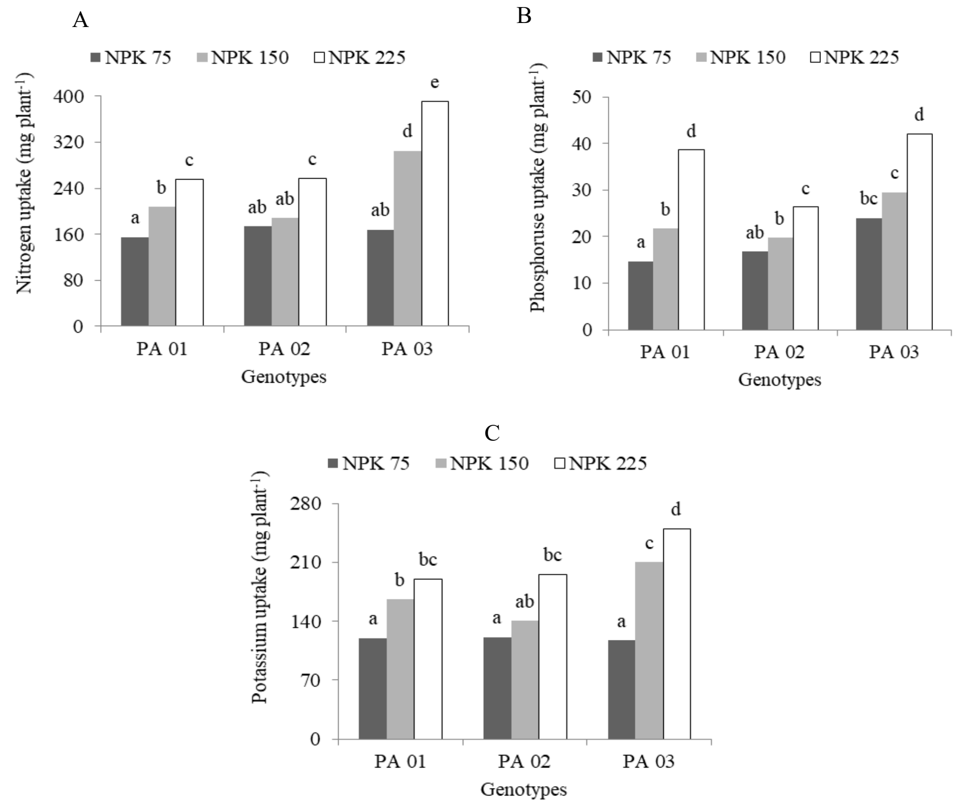

Fig 2: Effect NPK fertilizer on nitrogen uptake (A), phosphorus uptake (B) and potassium uptake (C) of genotypes.

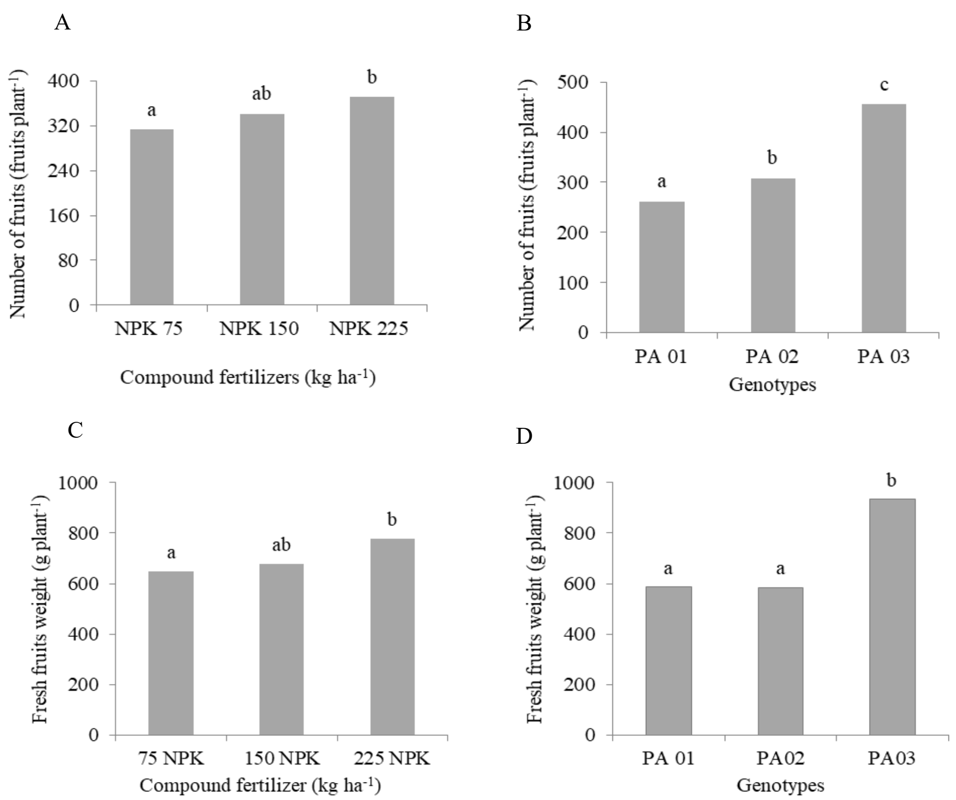

Fig 3: Effect NPK fertilizer on number of fruits (A), fresh weight of fruit (C) and the effect genotypes on yield, number of fruits (B), fresh weight of fruit (D).

doses of 75 kg ha^{-1} was lower than 150 kg ha^{-1} and 225 kg ha^{-1} (Fig 2C). The potassium uptake in PA 01, PA 02 and PA 03 genotypes at a dose of 225 kg ha^{-1} were higher than dose of 150 kg ha^{-1}. This result similar was reported by Adekiya and Agbede (2009) and Varma *et al.* (2017) application of NPK fertilizer show significant increased NPK content and uptake in shoot of tomato and mungbean.

Fertilizer plays an important role for increasing growth, yield and quality of plant (Zou *et al*., 2009). An NPK fertilizer (16:16:16) fertilizer can increase the biomass accumulated by plants. High plant growth result from fertilizer application, which leads to higher dry mass production. Nitrogen functions in the vegetative growth of plant, as a nutrient essential for cell division and cell elongation. Nitrogen is a constituent of protoplasm, which is widely found in plant tissue such as in growth points (Van Averbeke *et al*., 2007). Plant dry weight depends on photosynthesis and growth rate. Qadri *et al*. (2015) reported that nitrogen, phosphorus and potassium are part of essential nutrient and required for production of meristematic and physiological activities such as leaf, roots, shoots, dry matter, which leads to efficient translocation of water, nutrient, interception of solar radiation and fixation carbon dioxide. Adekiya and Agbede (2009); Hussein and Alva (2014) added that nitrogen, phosphorus play important role in increasing dry matter due to their function of developing wider root zone, allowing plant to absorb water and nutrient more deeply. Increasing phosphorus usage can increase the dry weight of leaf and stems in plants.

Yield and quality

Based on analysis of variance, there was no interaction between cutleaf groundcherry genotypes and NPK fertilizer doses on the number of fruits and fruit weight. Each cutlleaf groundcherry genotypes resulted in different number of fruits. The application of NPK fertilizer at a dose 150 kg ha^{-1} and 225 kg ha^{-1} was proven to increase the number of fruits (Fig 3A). In PA 03 genotype produced the highest number of fruits (455.83) followed by PA 02 (308.06) and PA 01

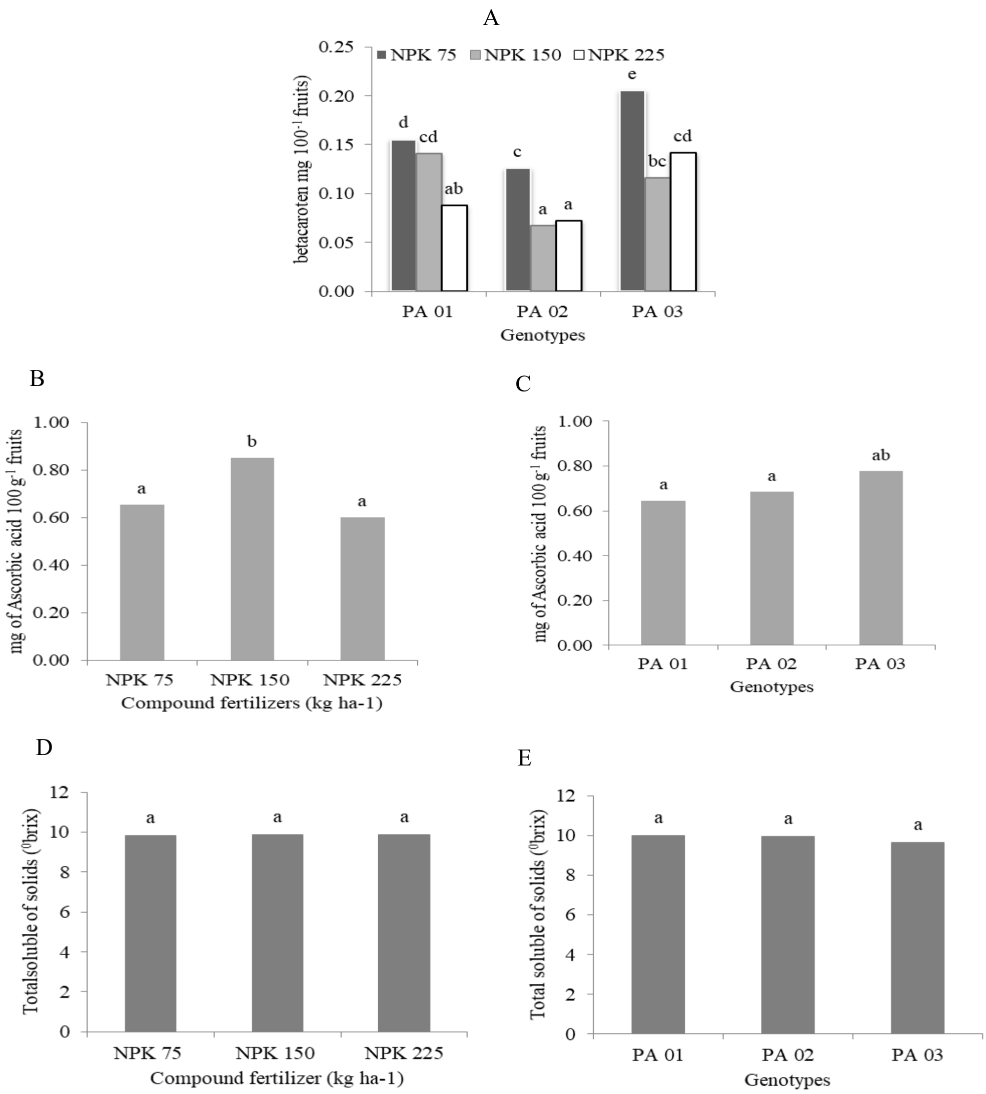

Fig 4: Effect NPK fertilizer on beta-carotene (A), ascorbic acid (B and C) and total soluble sugar (D and E) of genotypes.

(313.00) genotypes (Fig 3B). Same as the number of fruit, the fruit weight of cutleaf groundcherry increased with the application of NPK fertilizer with doses of 150 kg ha^{-1} and 225 kg ha^{-1} (Fig 3C). PA 03 also had the highest fresh weight of fruit per plant (933.21 g), while PA 02 and PA 03 were not significantly different of fresh weight of fruit (Fig 3D). The application of NPK 225 kg ha^{-1} resulted in both higher number of fruits and fresh weight of fruits compared to NPK 75 kg ha^{-1} and NPK 150 kg ha^{-1}. Rosa *et al*. (2016); Varma *et al*. (2017); Woldemariam *et al*. (2018); Sachan and Krishna (2020) also reported that the availability of sufficient nitrogen, phosphorus and potassium would increased metabolism processes in plants as a result the plant yields more higher.

Genotypes varied among themselves with respect to growth and yield of cutleaf groundcherry. Isah *et al*. (2014) also reported significant difference in the total fruit yield of tomatoes among different varieties. According to Adekiya and Agbede (2009), the differences of the growth and yield of each variety generally depend on the physiological processes in plants, which were controlled by plant genetics and the environmental conditions. Golubkina *et al*. (2018) also reported that each variety shows a different response to nutrition in relation to the genetic material of each individual plant and the physiological processes in the plant.

NPK fertilizer with doses 75 kg ha^{-1} showed a higher beta-carotene content in cutleaf groundcherry. In PA 01 genotype, NPK fertilizer at dose of 75 kg ha^{-1} produced the higher betacarotene (0.16 mg 100 g^{-1}) than an application NPK fertilizer at dose 225 kg ha^{-1}. The same response in PA 02 and PA 03 ganotypes the highest betacarotene (0.13 mg 100 g^{-1} and 0.21 mg 100 g^{-1}) was found in the application of NPK 75 kg ha^{-1} (Fig 4A). From three genotype, PA 03 showed a higher beta-carotene content than PA 01 and PA 02. Similar was reported by Leite *et al*. (2018) and Petropoulos *et al.* (2020) that low fertilization producer of phytochemical compounds higher than high fertilization in cutleat groundcherry and potato.

Observation of ascorbic acid showed that the application of fertilizer at a dose of 150 kg ha^{-1} had the higher of ascorbic acid (0.85 mg 100 g^{-1}) than at a dose of 225 kg ha^{-1} (0.60 mg 100 g^{-1}) (Fig 4B). The genotype of PA 03 had the ascorbic acid content higher (0.78 mg 100 g^{-1}) than PA01 (0.65 mg 100 g^{-1}) and PA 02 (0.68 mg 100 g^{-1}) (Fig 4C). Similar was reported by Cintya *et al.* (2018), higher dose inorganic fertilizer cause decreased ascorbic acid content in lettuce, spinach, bok choy and mustard. The NPK doses and genotypes were not significantly different the total soluble of solid (Fig 4D, 4E).

CONCLUSION

Each genotype has different growth responded with different doses of NPK fertilizer. The increasing doses of NPK fertilizer increased of the nutrient uptake and yield of cutleaf groundcherry, but decreased beta-carotene. Meanwhile ascorbic acid content increased with a dose of 150 kg ha^{-1} NPK, but decreased with increased NPK fertilizer rates. The genotype of PA 03 was yielded higher with and better quality than PA 01 and PA 02.

ACKNOWLEDGEMENT

This research was funded by the Indonesian Ministry of Research, Technology and Higher Education in cooperation with Community Service Research Institute (LPPM) of University of Brawijaya with contract number: 330.34 / UN10.C10 / PN / 2019.

REFERENCES

Adekiya, A.O. and Agbede, T.M. (2009). Growth and yield of tomato (*Lycopersicon esculentum* Mill) as influenced by poultry manure and NPK fertilizer. Emirates Journal of Food and Agriculture. 21(1): 10-20.

Adeli, A., Sistani, K.R., Rowe, D.E. and Tewolde, H. (2005). Effect of broiler litter on soybean production and soil nitrogen and phosphorus concentrations. Agronomy Journal. 97: 314-321.

Albayrak, B., Sonmez, İ. and Biyikli, M. (2014). The determination of nitrogen demand of Physalis (*Physalis peruviana* L.) in Yalova/Turkey. Turkish Journal of Agricultural and Natural Sciences. 1(2): 1425-1428.

Ali, A. and Singh, B.P. (2017). Effect of plant spacing and fertility level on leaf area variation at different phenological stages of cape gooseberry (*Physalis peruviana* L.) grown in sodic soil. Journal of Applied and Natural Science. 9(1): 274-279.

Arnon, D.I. (1949). Copper enzymes in isolated chloroplasts. Polyphenoloxidase in *Beta vulgaris*. Plant Physiology. 24(1): 1-15.

Bastos, G.N.T., Silveira, A.J.A., Salgado, C.G., Picanc, D.L.W. and Do Nascimento, J.L.M. (2008). *Physalis angulata* extract exerts anti-inflammatory effects in rats by inhibiting different pathways. Journal of Ethnopharmacology. 118: 246-251.

Bonela, G.D., Dos Santos, W.P., Sobrinho, E.A. and Gomes, E.J.C. (2017). Produtividade e qualidade de raízes de rabanete cultivadas sob diferentes fontes residuais de matéria orgânica. Revista Brasileira de Agropecuária Sustentável. 7(2): 66-74.

Chrysargyris, A., Nikolaidou, E., Stamatakis, A. and Tzortzakis, N. (2017). Vegetative, physiological, nutritional and antioxidant behavior of spearmint (*Mentha spicata* L.) in response to different nitrogen supply in hydroponics. Journal of Applied Research on Medicinal and Aromatic Plants. 6: 52-61.

Cintya, H., Silalahi, J., Putra, E.D.L. and Siburian, R. (2018). The influence of fertilizer on nitrate, nitrite and vitamin C contents in vegetables. Oriental Journal of Chemistry. 34(5): 2614-2621.

Dalai, S., Evoor, S., Mastiholi, A.B., Hanchinamani, C.N., Mulge, R., Kukanoor, L. and Kantharaju, V. (2021). Studies on growth, yield and quality of edible poded dolichos bean as affected by NPK fertilization. Legume Research. 44(6): 699-705.

El-kenawy, A.E., Elshama, S.S. and Hussein, H. (2015). Effects of *Physalis peruviana* L. on toxicity and lung cancer induction by nicotine derived nitrosamine ketone in rats. Asian Pacific Journal of Cancer Prevention. 16: 5863-5868.

El-Tohamy, W.A., El-Abagy, H.M., Abou-Hussein, S.D. and Gruda, N. (2009). Response of cape gooseberry (*Physalis peruviana* L.) to nitrogen application under sandy soil conditions. Gesunde Pflanze. 61: 123-127. .

Erturk, Ö., Çol Ayvaz, M., Can, Z., Karaman, Ü. and Korkmaz, K. (2017). Antioxidant, antimicrobial activities and phenolic and chemical contents of *Physalis peruviana* L. from Trabzon, Turkey. Indian Journal of Pharmaceutical Education and Research. 51(3): S213-S216.

Fitria, M., Armandari, I., Septhea, D.B., Ikawati, A.H.M. and Meiyanto, E. (2011). Effect of ethanolic extract of ciplukan herbs (*Physalis angulata* L.) on cytotoxic and apoptosis induction in mcf-7 breast cancer cell lines. Bionatura. 13(2): 101-107.

Geisseler, D., Aegerter, B.J., Miyao, E.M., Turini, T. and Cahn, M.D. (2020). Nitrogen in soil and subsurface drip-irrigated processing tomato plants (*Solanum lycopersicum* L.) as affected by fertilization level. Scientia Horticulturae. 261(3): 1-8.

Golubkina, N.A., Kekina, H.G., Engalichev, M.R., Antoshkina, M.S., Nadezhkin, S.M., and Caruso, G. (2018). Yield, quality, antioxidants and mineral nutrients of *Physalis angulata* L. and *Physalis pubescens* L. fruits as affected by genotype under organic management. Advances in Horticultural Science. 2(4): 541-548.

Hseu, Y., Wu, C., Chang, H., Kumar, K.J.S., Lin, M., Chen, C., Cho, H., Huang, C., Huang, C., Lee, H., Hsieh, W., Chung, J., Wang, H. and Yang, H. (2011). Inhibitory effects of *Physalis angulata* on tumor metastasis and angiogenesis. Journal of Ethnopharmacology. 135: 762-771.

Hussein, M.M. and Alva, A.K. (2014). Growth, yield and water use effeciency of forage sorghum as affected by NPK fertilizer and deficit irrigation. American Journal of Plant Sciences. 5: 2134-2140.

Isah, A.S., Amans, E.B., Odion, E.C. and Yusuf, A.A. (2014). Growth rate and yield of two tomato varieties (*Lycopersicon esculentum* Mill.) under green manure and NPK fertilizer rate Samaru Northern Guinea Savanna. International Journal of Agronomy. https://doi.org/10.1155/2014/932759.

Leite, R. da S., Hernandéz-navarro, S., Nascimento, M.N. do, Potosme, R.N.M., Carrión-prieto, P. and Souza, E. dos S. (2018). Nitrogen fertilization affects fourier transform infrared spectra (FTIR) in *Physalis* L. species. Computer and Eluctronics in Agriculture. 150: 411-417.

Marschner, H. (2003). Mineral Nutrition of Higher Plants (second edi.). Academic Press.

Nur, M. and Jumin, H.B. (2016). Ceplukan (*Physalis angulata* L.) growth on soil contaminated by bleach waste with remediation of manure. Jurnal Dinamika Pertanian. 32(1): 35-50.

Petropoulos, S. A., Fernandes, A., Polyzis, N., Antoniadis, V., Barros, L. and Ferreira, I.C.F.R. (2020). The impact of fertilization regime on the crop performance and chemical composition of potato (*Solanum tuberosum* L.) cultivated in Central Greece. Agronomy. 10: 1-18.

Qadri, R.W.K., Khan, I., Jahangir, M.M., Ashraf, U., Samin, G. Anwer, A., Adnan, M. and Bashir, M. (2015). Phosphorous and foliar applied nitrogen improved productivity and quality of potato. American Journal of Plant Sciences. 6: 144-149.

Rivera, D.E., Ocampo, Y.C., Castro, J.P., Barrios, L., Diaz, F. and Franco, L.A. (2019). A screening of plants used in Colombian traditional medicine revealed the anti-inflammatory potential of *Physalis angulata* calyces. Saudi Journal of Biological Science. 26(7): 1758-1766.

Rosa, M., Longo, C., Lupini, A., Miller, A.J., Araniti, F., Mercati, F., Princi, M.P. and Sunseri, F. (2016). Phenotyping two tomato genotypes with different nitrogen use efficiency. Plant Physiology and Biochemistry. 107: 21-32.

Sachan, H.K. and Krishna, D. (2020). Effect of organic and inorganic fertilization on growth and yield of french bean (*Phaseolus vulgaris* L.) in Fiji. Legume Research. DOI: 10.18805/LR-4376.

Sarfraz, M., Hussain, K., Nawaz, K., Yasin, G., Geng, Z., Sajjad, M. and Parveen, S. (2021). Determination of effective method of NPK fertilization in pea (*Pisum sativum* L.) cultivars grown in Pakistan. Legume Research. 44(4): 431-438.

Siddiq, S., Anayat, A., Sattar, A., Ali, M.A. and Yassen, M. (2011). Response of different rice (*Oryza sativa* L.) cultivars to different NPK levels in the central cropping zone of Punjab. Agricultural Science Digest. 31(1): 156-160.

Sudarmadji, S., Suhardi and Haryono, B. (1984). Analisa bahan makanan dan pertanian. Liberty.

Tuan-Anh, H.Le, Thao, T.Do, Dung, D.T., Kiem, P.Van, Quang, T.H., Yen, P.T.H., Tuan, D.T., Cuong, P.V., Cuonga, L.C.V. and Hung, T.M. (2018). Phytochemical constituents and cytotoxic activity of *Physalis angulata* L. growing in Vietnam. Phytochemistry Letters. 27: 193-196.

Van Averbeke, W., Juma, K.A. and Tshikalange, T.E. (2007). Yield response of African leafy vegetables to nitrogen, phosphorus and potassium: The case of *Brassica rapa* L. subsp. chinensis and *Solanum retroflexum* Dun. Water SA. 33(3): 355-362.

Varma, D., Meena, R.S., Kumar, S. and Kumari, E. (2017). Response of mungbean to NPK and lime under the conditions of Vindhyan region of Uttar Pradesh. Legume Research. 40(3): 542-545.

Woldemariam, S.H., Lal, S., Zelelew, D.Z. and Solomon, M.T. (2018). Effect of potassium levels on productivity and fruit quality of tomato (*Lycopersicon esculentum* L.). Journal of Agricultural Studies. 6(1): 104-117.

Yang, Y., Xie, S., Xu, W., Nian, Y., Liu, X., Peng, X., Ding, Z. and Qiu, M. (2016). Six new physalins from *Physalis alkekengi* var. *franchetii* and their cytotoxicity and antibacterial activity. Fitoterapia. 112: 144-152.

Zhang, Q., Hu, X.F., Xin, M.M., Liu, H.B., Sun, L.J., Morris-Natschke, S.L., Chen, Y. and Lee, K.H. (2018). Antidiabetic potential of the ethyl acetate extract of *Physalis alkekengi* and chemical constituents identified by HPLC-ESI-QTOF-MS. Journal of Ethnopharmacology. 225: 202-210.

Zou, J., Lu, J.W., Chen, F. and Li, Y.S. (2009). Increasing yield and profit of rapeseed under combined fertilization of nitrogen, phosphorus, potassium, and boron in Yangtze River Basin. Acta Agronomica Sinica. 35(1): 87-92.