DF-503
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RESEARCH ARTICLE Agricultural Science Digest

Breeding Lines Influence on Growth, Yield and Quality Characteristics of Cutleaf Groundcherry (*Physalis angulata* L.)

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10.18805/ag.DF-503

ABSTRACT

Background: *Physalis angulata* L. or Cutleaf groundcherry is underutilized crop that has not been widely cultivated and is often considered weeds. Cutleaf groundcherry is rich in nutritional and phytochemical contents, which is beneficial for human health. Information on the growth, yield and quality content of cutleaf groundcherry lines is essential for future development. The objective of this experiment was to determine the variation among the lines of cutleaf groundcherry in growth, yield and fruits quality.

Methods: A greenhouse study was conducted in August to December, 2021. Nine lines of cutleaf groundcherry were tested in randomized block design by following the recommended agronomic practcies.

Result: The results show that nine lines of cutleaf groundcherry were varied with significant differences in growth, yield and quality characteristics. The line PA-06 was superior to other lines in vegetative growth and total dry weight, yield characteristics, namely fruit weight fruit^{-1}, fruit diameter and fruit weight plant^{-1}. The nine lines had the same as total soluble solids and ascorbic acid, but differences in β-carotene and antioxidant.

Key words: Cutleaf groundcherry, Ascorbic acid, Growth, Line, Quality characteristics.

INTRODUCTION

Ciplukan or cutleaf groundcherry is the most popular common name for *Physalis angulata* L. and has been known by Indonesian people for generations. *Physalis angulata* is known by different names in region of Indonesia such as Cecendet/Cecenet in West Java (Sundanese), Yoyoran/ Nyurnyuran in Madura, Angket/Kopok-kopokan/Keceplokan/ Angket in Bali, Dededes in Sasak and Bulutuhetomete in Gorontalo (Waluyo *et al*., 2019). It is easy to find in dry lands, yards and even in the understory of forests (Arbiastutie *et al*., 2017). Cutleaf groundcherry has not been widely cultivated and is known as an underutilized crop. Recently, This has gained the interest of researchers due to its phytochemical content and nutritional value (Mirzae *et al*., 2019). Cutleaf groundcherry contains antioxidants, which are known to protect from or limit the spread of diseases such as cancer, cardiovascular disease, diabetes, osteoporosis and degenerative diseases (Bhuyam and Basu, 2018; Bhooshan and Rizvi, 2009). Furthermore, the fruit, leaves and root of cutleaf groundcherry are used in traditional medicine in some Indonesian cultures (Kandowangko *et al*., 2018; Kindscher *et al*., 2012).

Indonesia is known for rich plant diversity including *Physalis* species. However, information on the properties and productivity of different cutleaf groundcherry varieties or lines is limited. Plant breeding is a common approach for genetically improving plants of various lines with the desired characteristics (Frison *et al*., 2011). Genotype evaluation is necessary for selecting the highest yield and best quality varieties. Plant genetics also affect phytochemical contents, so selecting the appropriate lines of cutleaf groundcherry for different cultivation purposes such as fruit and pharmacological compound production (*e.g*. phytochemicals, bioactive compounds), is essential. Golubkina *et al.* (2018) invertigated genotypes of *Pysalis angulata* have growth, yield and phytochemicals contents. Saikia *et al.* (2021) reported genotypes of *Solanum melongena* have different morpho-biochemical characteristics. In this study, we compared and evaluated nine cutleaf groundcherry lines for growth, yield and quality.

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How to cite this article: Yamika, W.S.D., Waluyo, B., Aini, N. and Sebayang, H.T. (2023). Breeding Lines Influence on Growth, Yield and Quality Characteristics of Cutleaf Groundcherry (*Physalis angulata* L.). Agricultural Science Digest. doi: 10.18805/ag.DF-503.

Submitted: 12-08-2022 **Accepted:** 19-01-2023 **Online:** 13-02-2023

MATERIALS AND METHODS

Experimental site and design

The pot experiment was conducted in the Experimental Garden of Faculty of Agriculture, Universitas Brawijaya, located in Lowokwaru district, Malang, East Java, Indonesia, situated at altitude of 440-460 m above sea level, the temperature 23.3°-27.1°C, air humidity 50-80%. In this study was used a randomized block design, consisting of nine lines of cutleaf groundcherry (PA01-PA09) with three replications. Each treatment consisted of 15 polybags, the total was 405 polybags. *P. angulata* lines used were the result of selection where the lines have the potential to be developed as fruit or medicinal plants. The seeds were sown in nursery trays in a 1:1:1 mixture of soil, sand and cow manure. The seedlings were transplanted 21 days after sowing in a polybag mixture of soil and cow manure (with dose 40 t ha^{-1}). Characteristics the planting media were: pH 5.9-6.0; C-organic 1.83%; N-total 0.21%.

Maintenance

Standard agronomic practices were used to grow the cutleaf groundcherry seedlings. Fertilization was carried out at 7 and 21 day after transplanting, with a dose of 150 kg ha^{-1} nitrogen, potassium 100 kg ha^{-1} K_2O and phosphorus 60 kg ha^{-1} P_2O_5. Phosphorus was applied at planting time, Half dose of potassium and nitrogen were applied 3 days after planting and remaining 1/2 doses at 21 days after planting. The plants were watered manually with ± 300 ml of groundwater once a day (morning or afternoon). Manual weeding around the plants was performed every five days. Cutleaf groundcherry fruits were harvested when they turned yellow and the calyx dried up.

Measurements

We measured the growth variable *i.e.* leaf area, total plant dry weight were recorded at 2, 4, 6, 8, 10 WAP (Weeks after planting) and relative growth rate (RGR). RGR was calculated from equation (Price and Munns, 2018):

$$RGR = \frac{\text{Ln W2} - \text{Ln W1}}{t2 - t1}$$

Where,

W= Total dry weight (g $Plant^{-1}$).

T= Time of measurement (week).

Yield variable namely: diameter of fruit, fruit weight $fruits^{-1}$, fruit fresh weight and the number of fruits $plant^{-1}$. The fruit fresh weight $plant^{-1}$ was noted as the accumulated total from the first to the last harvest.

The fruit quality variable consisted of ascorbic acid, total soluble solids (TSS), β-carotene and antioxidant. Measurement of fruit qualities was carried out at harvest time. TSS was measured using a handheld refractometer. β-carotene in the fruit with a UV-Vis spectrophotometer as described by Arnon *et al.* (1949). Ascorbic acid in the fruit was determined with the titration method reported by Sudarmaji *et al.* (1997); antioxidant (DPPH activity) in the fruit by UV-Vis spectrophotometer as given by Gupta *et al.* (2016).

The analysis of variance with F test at 5% error level used to analysed the data and further with HSD a 5%.

RESULTS AND DICUSSION

Plant growth

Variation in growth was observed among cutleaf groundcherry lines (Fig 1). Plant growth pattern of PA 06 and PA 05 was found better than the other lines in terms of total plant dry weight. In the second week to the sixth week, cutleaf groundcherry experienced a rapid growth phase, while at the age of 8 and 10 WAP growth decreased. This is supported by the highest relative growth rate at 2 to 4 WAP and 4 to 6 WAP (Table 1). In the second to fourth week, there was an increase in biomass starting from 6-8 WAP, there was rather the increase however, the decrease was found in biomass and same was recorded at the age of 8 - 10 WAP. The rapid growth of the cutleaf groundcherry lines from the 2-6 WAP was noted so it may be called as grand growth period, it could be due to the variable leaf area. Leaves has role in the photosynthesis process, wider of the leaves causes plants be able to produce more photosynthates, therefore the total dry weight also increased sharply. On the growth variable (total dry weight, leaf area),

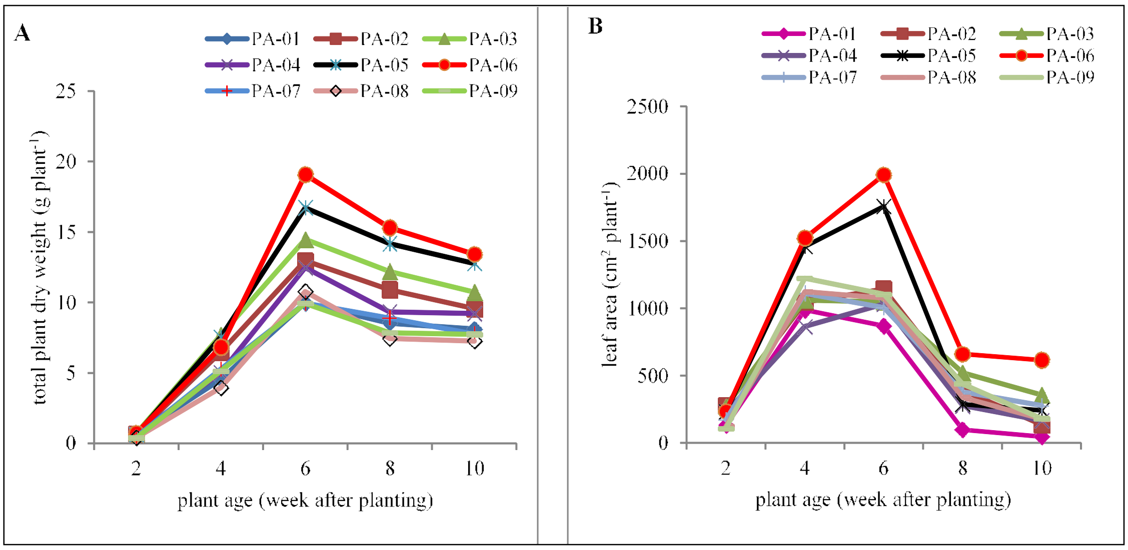

Fig 1: Effect breeding lines on total plant dry weight (A) and leaf area of cutleaf groundcherry (B).

were different in each lines. PA 06 and PA 05 had higher total dry weight and leaf area compared to other lines. Similar was reported by Gulubkina *et al*. (2018) and found growth and yield variable different in cultivar of *Physalis angulata, Phaseolus vulgaris* (Basavaraja *et al*., 2021), *Physalis peruviana* (Sharma *et al.,* 2019), Ipomoea batatas (Reddy *et al*., 2018).

Yield characteristics of cutleaf groundcherry

Each line varied in yield characteristics as number of fruits, fruits diameter and fruits weight (Table 2). The numbers of fruit ranged from 33.92-45.58 were observed in PA 06, PA 03 and PA 07 which were higher than other lines. Compared to similar species, the number of fruits could be categorized as low by Golukina *et al*. (2018) and they reported number of fruits was 47-64 fruits plant^{-1}. The fruit weight of cutleaf grouncherry was 1.32-1.83 g fruit^{-1} however, PA 06 had higher fruit weight and fruit diameter (14.13 mm) more than other lines. Similar reported by Tanam *et al.* (2019) and noted PA 01-PA 09 produced fruit weight plant^{-1} range between 42.22-70.09 g plant^{-1}. Among nine lines, PA 06 had fruit weight (70.09 g plant^{-1}) more than other lines. Similar was reported by Leite *et al*. (2017), fruits weight of *Physalis angulata* was 38-55 g plant^{-1}. However, fruits weight plant^{-1} of *Physalis angulata* very low than *Physalis peruviana* (161.60 g plant^{-1}) (Gocher *et al*., 2017).

Table 1: Effect of breeding lines on relative growth rate of cutleaf groundcherry at 2-6 weeks after planting (WAP).

Lines	Relative growth rate (g g^{-1} d^{-1})	
	2-4	4-6
PA-01	0.141a	0.056ab
PA-02	0.163ab	0.050ab
PA-03	0.172b	0.045a
PA-04	0.148ab	0.065ab
PA-05	0.177b	0.057ab
PA-06	0.162ab	0.073b
PA-07	0.175b	0.045a
PA-08	0.161a	0.072ab
PA-09	0.185b	0.047ab
HSD 5%	0,029	0,030

Note: The different lowercase letters in the same column indicate a significant difference in HSD level of 5%.

Quality characteristics of cutleaf groundcherry

Total soluble solid is defined as sugar and soluble minerals in fruits. Based on the results of measurements, the total soluble sugar content of 7.17-8.200 brix (Table 3). Total soluble solid content was higher than the results of Golubkina *et al*. (2018) as 4.7-7.8°brix. However, it was lower than total soluble solid of *Pysalis pubescens* (9.70 Brix) and strawberry 7-10°Brix (Li *et al*., 2017). β-carotene is the orange pigment in plants such as in fruits, leaves, tubers and flowers (Cseke *et al*., 2006). β-carotene is the most abundant pro-vitamin A carotenoid, which can be converted to Vitamin A (Amengual, 2019). β-carotene content influenced by genetic and environment factors. The result of experiment shows that β-carotene content of nine lines range from 0.056-0.093 mg g^{-1}. When compared β-carotene content in *Physalis angulata* and *Physalis peruviana,* it was high β-carotene in *Physalis peruviana* as 26.62 mg kg^{-1} (Olszanska *et al*., 2017).

Vitamin C or known as ascorbic acid, widely known as potent antioxidant (Bedhiafi *et al*., 2022). The content of ascorbic acid in the PA 01-PA 09 cutleaf grouncherry lines (Table 3). was 44.00-53.68 mg 100 g^{-1}. That was higher than the ascorbic acid in tomato *i.e.* 20-30 mg 100 g^{-1} (Akhtar *et al*., 2010; Ahmad *et al.,* 2015; Du Yu-dan *et al*., 2017). It was high in cutleaf groundcherry than muskmelon 7.74 - 13.32 mg 100 g^{-1} (Lin *et al*., 2004), strawberry 16-27 mg 100 g^{-1} (Li *et al*., 2017) and *Physalis peruviana* 9-19 mg 100 g^{-1} (Ariati *et al.,* 2017; Iwansyah *et al*., 2019). An antioxidant content in PA 01-PA 09 was 56.45-58.70% (Table 3), the consistant results was reported by Yildiz *et al*. (2015), that was recorded 57-59%.

Table 2: Effect of breeding lines on number of fruits, fruit weight fruits^{-1}, diameter of fruits of cutleaf groundcherry at harvest.

Lines	Number of fruits plant^{-1}	Fruit weight fruit^{-1} (g)	Diameter of fruits (mm)	Fruits weight (g plant^{-1})
PA-01	38.83ab	1.41a	12.93ab	51.14ab
PA-02	40.83ab	1.48ab	12.65a	54.50b
PA-03	45.58b	1.58ab	13.56ab	63.96c
PA-04	39.00ab	1.39a	13.12ab	50.14ab
PA-05	39.75ab	1.53ab	13.48ab	55.77b
PA-06	43.92b	1.83b	14.13b	70.09c
PA-07	44.92b	1.37a	12.97ab	56.37b
PA-08	35.83a	1.32a	12.64a	42.22a
PA-09	33.92a	1.47ab	13.11ab	43.10a
HSD 5%	7.78	0.40	1.36	10.04

Note: The different lowercase letters in the same column indicate a significant difference in HSD level of 5%.

Table 3: Effect of breeding lines on Total soluble solid, β-carotene, Ascorbic acid, Antioxidant of cutleaf groundcherry at harvest.

Lines	Total soluble solid (°brix)	β-carotene (mg g^{-1})	Ascorbic acid (mg 100 g^{-1})	Antioxidant (%)
PA-01	7.62	0.091b	44.00	57.05ab
PA-02	8.20	0.071ab	53.68	56.45a
PA-03	7.17	0.056a	49.28	58.00ab
PA-04	7.81	0.093b	48.40	57.40ab
PA-05	7.83	0.083ab	44.88	57.45ab
PA-06	7.56	0.068ab	45.32	58.60ab
PA-07	7.80	0.081ab	47.96	56.50ab
PA-08	8.09	0.090b	47.52	58.70b
PA-09	7.52	0.093b	44.00	58.25ab
HSD 5%	ns	0.035	ns	2.24

Note: The different lowercase letters in the same column indicate a significant difference in HSD level of 5%.

CONCLUSION

The nine lines of cutleaf groundcherry were significantly varied in characteristics of growth, yield and quality. On the basic of observation recorded PA 06 had higher vegetative growth and total dry weight and yield. The nine lines had the same as total soluble solids and ascorbic acid, but differences in b-carotene and antioxidant. Based on the results obtained for growth, yield and quality, it can be used as a basis for consideration of the development of lines, either as fruit crops or medicinal plants.

ACKNOWLEDGEMENT

Indonesian Ministry of Education, Culture, Research and Technology, through BPPDN scholarship was funded this research.

Conflict of Interest: None.

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