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THE CROP COEFFICIENT OF GINGER (*ZINGIBER OFFICINALE* VAR. *RUBRUM*) DURING VEGETATIVE GROWTH IN EASTERN INDONESIA

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Ginger (*Zingiber officinale* var. *rubrum*) is a rhizome plant that can benefit health, fitness and be used as a spice. The content contained in ginger can prevent and treat various diseases and act as an antioxidant and anti-inflammatory agent. The cultivation of ginger plants requires adequate nutrients and water for development and growth. Crop water requirements are influenced by crop coefficients which vary according to the plant growth stage. The crop coefficient values are needed for irrigation management and increasing irrigation efficiency. The main objective of the current study was to investigate the crop coefficient value of ginger by lysimeter. Lysimeter is a water balance device with the principle of mass conservation, where the input is rainfall and irrigation while the output is percolation and evapotranspiration. The rainfall during the investigated period was 0–62.82 mm·day^{-1}, humidity 70.7–89.4%, and air temperature 23.7–32.9 °C. The crop coefficient of ginger increased during the vegetative growth period, i.e., 0.997 in the seedling stage, 1.072 in the tiller stage, and 1.138 in the advanced vegetative stage. The crop coefficient of red ginger was determined using a lysimeter quite accurately, with a coefficient of determination value (R^2) 0.950 and a significant value of F less than 0.05.

Keywords: crop water requirement; irrigation efficiency; local climate; lysimeter; medicinal plants

Ginger (*Zingiber officinale* var. *rubrum*) is one of the rhizome plants with potential to be developed. The ginger rhizome can benefit health and can be a mixture of spices in cooking (Friska and Daryono, 2017; Hutabarat et al., 2020; Jabborova et al., 2021). As a spice, the nutritional content of ginger can complement nutrients in food and help smooth digestion (Al-Awwadi, 2017). Ginger contains zingiberin, camphor, lemonin, borneol, shogaol, zingiberol, and gingerol, preventing and treating various diseases, and antioxidants and anti-inflammatory agents (Goulart, 1995; Grzanna et al., 2005; Reader's Digest, 2004; Sudewo, 2006; Santoso, 2008).

Ginger plants can be cultivated in the tropics at an altitude of 0–1500 m above sea level (Dhanik et al., 2017), with an optimum altitude of 300–900 m above sea level, and can grow easily in areas with rainfall between 2500 mm·year^{-1} and 4000 mm·year^{-1} with 7–9 wet months and a soil pH of 6.8–7.4 (Rostiana et al., 2016). The optimum temperature for ginger cultivation is 20–25 °C with a humidity of 60–90% (Rukmana, 2000). To increase the productivity of ginger plants, cultivation and water practices and nutrients must be at an adequate level. Water is one of the factors influencing plant growth and development (Alvarenga et al., 2004; Meneghelli et al., 2020). According to Shao et al. (2008), water deficit is the main factor that inhibits plant growth in addition to other environmental factors. The water deficit inhibits metabolic processes in plants, causing plants to become stunted and their development to be disrupted.

Every plant needs water in different amounts, depending on plant type, plant growth stage, and planting schedule (Tahashildar et al., 2015). According to Sofiyuddin et al. (2010), plant water needs depend on crop coefficient (*Kc*), which fluctuates according to the stage of plant growth. Regional-based determination of *Kc* values is needed for crop irrigation management, providing appropriate irrigation applications and increasing irrigation efficiency (Abedinpour, 2015; Babaee et al., 2019; Piccinni et al., 2009).

According to Doorenbos and Pruitt (1977), crop water requirements are the amounts (unit: depth) needed to replace water lost from evapotranspiration. Evapotranspiration is a simultaneous movement of water into the atmosphere through transpiration and evaporation (Allen et al., 1998; Mavi and Tupper, 2004). Evapotranspiration is an essential factor for calculating crop water requirements. It can be determined accurately using lysimeters (Allen et al., 1998; Bryla et al., 2010; Gao et al., 2009). However, the research on water requirements and crop coefficients for ginger plants is still very limited. The main objective of the current study was to calculate ginger's water requirement (*ETc*) and crop coefficient value (*Kc*) in the vegetative growth stage using lysimeters.

Material and methods

The experiment took place in a research farm at Hasanuddin University, Makassar, Indonesia, with the coordinates of 5° 7′ 39.9″ S latitude, 119° 28′ 51.5″ B longitude. The temperature at the research site during July–October was 23.7–32.9 °C. Soil texture in this experiment was clay.

This study uses lysimeters to determine the evapotranspiration of ginger plants. A lysimeter is a container filled with soil that can collect seepage water so that the water at input and output can be measured (Fig. 1). The input water is rainfall and irrigation, while the output water is percolation and evapotranspiration. In this study, three lysimeters were used with a diameter of 1 m and an effective depth of 1 m, with an automatic irrigation system and soil moisture sensor. Two lysimeters were used to determine ginger's crop evapotranspiration (*ETc*). Ginger seeds that have been sown for about 1 month were planted in a lysimeter with a distance of 30×30 cm. The ginger seeds used are red ginger (*Zingiber officinale* var. *rubrum*). One lysimeter was used to measure reference evapotranspiration (*ETo*), planted with grass. The planting medium was a mixture of clay and compost with a 2 : 1 ratio. The properties of the topsoil are listed in Table 1.

Table 1 Some topsoil properties (Chemistry and Soil Fertility Laboratory, Hasanuddin University, Makassar, 2021)

No.	Soil properties	Value
1	soil texture	clay
	clay (%)	58
	silt (%)	30
	sand (%)	12
2	bulk density (g·cm^{-3})	1.2
3	particle density (g·cm^{-3})	2.6
4	soil porosity (%)	53.8

Evapotranspiration was determined from the water balances equation based on the principle of mass conservation (García-Tejero et al., 2018):

$$ETc = I + CH - P \pm ES \quad (1)$$

where: ET – evapotranspiration (mm·day^{-1}); I – irrigation (mm); CH – rainfall (mm); P – depth of percolation water; ES – changes in soil water content (%)

The crop coefficient value (*Kc*) was determined based on the equation by Allen et al. (1998):

$$ETc = ETo \times Kc \quad (2)$$

where: ETo – reference evapotranspiration (mm·day^{-1}); Kc – crop coefficient

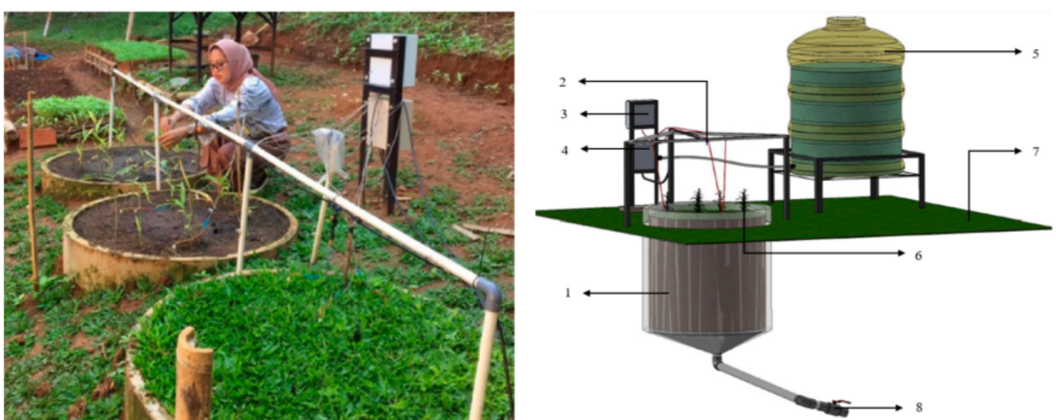
The measurement of rainfall, irrigation, depth of percolation water, and changes in water content was done every day.

The value of *Kc* was also calculated using the equation of Allen et al. (1998):

$$Kc = Kc_{(Tab)} + \left[0.04(U_2 - 2) - 0.004(RH_{min} - 45)\right]\left(\frac{h}{3}\right)^{0.3} \quad (3)$$

where: $Kc_{(TAB)}$ – crop coefficient based on a table; U_2 – value for daily wind speed (m·s^{-1}); RH – value for daily minimum relative air humidity (%); h – plant height (cm)

Two values of *Kc* will be obtained. The first *Kc* value is determined using a lysimeter (Fig. 1), which is called *Kc* lysimeter, and the second *Kc* value is calculated using Eq. (3), which is called *Kc* calculation.



1 – lysimeter, 2 – irrigation nozzle, 3 – soil moisture sensors and pump control panel, 4 – pump, 5 – reservoir, 6 – plant, 7 – soil surface

Fig. 1 The lysimeter system used

The analysis of regression and significant variance *F* were carried out to determine the relationship between *Kc* calculation results and *Kc* lysimeter. The coefficient of determination (R^2) is the percentage value of the independent variable that can be explained by the dependent variable, or a value that describes the accuracy of the model. The value of the coefficient of determination is between 0 and 1. The value of R^2 close to 1 means an almost perfect relationship between the model and the data (Saunders et al., 2012; Zhang, 2017). The value of *F* testing is carried out to determine the effect of all independent variables simultaneously on the dependent variables. The calculation of *F* is compared with the significance level of 5% (Thorfiani and Sakti, 2019).

Results and discussion

Climatic parameters

Daily data, relative humidity, wind speed, solar radiation, and rainfall show fluctuating results (Fig. 2). The average *RH* from July to October 2021 fluctuated between 70.7% and 89.4%. In July, humidity was high and decreased until the end of the study. Fluctuation in solar radiation was 6.74–25.27 MJ·m^2·day^{-1}. Clouds greatly affect the solar radiation that reaches the earth's surface (Qian et al., 2007).

During July–October, wind speed at the research location fluctuated between 0.98 m·s^{-1} and 3.98 m·s^{-1}. According to Choi (1994), rain intensity influences wind speed. Each weather parameter affects the value of evapotranspiration with a different contribution. Daily evapotranspiration results obtained variations between 0.002 mm and 6.523 mm. Solar radiation has an important role in supplying energy for the evapotranspiration process (Allen et al., 1998).

Water requirement and crop coefficients

The growing period of the ginger plant is divided into the stages of seedling, growth and development, rhizome development, and harvest. Li et al. (2010) divided the growth and development stage into the branching/tiller stages (90–110 DAP: day after planting) and an active vegetative stage (110–130 DAP), while the rhizome development stage was 130–160 DAP (Hapsoh et al., 2008). Ginger plants can be harvested early, in the active vegetative growth stage, when the plants are 4–5 months old. Although rhizome has not yet been developed, they can be used to be processed as cooking spices, sweets, and others, because rhizome texture is still soft and the fibre content and spiciness are still low (Jaidka et al., 2018; Sanewski, 2002).

Ginger's average water requirement in the vegetative stage, which begins with the seedling stage, is still quite low at 0.385 mm·day^{-1}. In this stage, the leaf of the ginger plant is narrow, so the largest evapotranspiration comes from soil evaporation. Clay contains an electric charge that can bind water, causing evaporation on the wet soil surface, due to irrigation or rain. According to Asdak (1995), evapotranspiration is influenced by plant physiology and soil elements.

During active vegetative development, water requirements increased at the tiller stage by 0.670 mm·day^{-1} and 1.265 mm·day^{-1} (Fig. 3). The crop development stage is an advanced vegetative stage (90–130 DAP); the increase in water requirement is influenced by soil evaporation and plant transpiration. Water absorption by plant roots increases with plant growth and the number of tillers. The actual crop water requirement depends on climatic factors, crop type, and crop growth stage.

Crop coefficient (*Kc*) is an empirical relationship between evapotranspiration (*ETc*) and reference evapotranspiration (*ETo*) under ideal conditions (Allen et al., 1998). The *Kc* values estimate crop water use and schedule irrigation (Alcaras et al., 2016). Doorenbos and Pruitt (1977) recommended the crop coefficient value at various stages of growth, i.e., early, plant development, mid-season, and ripeness at different conditions of humidity and wind speed.

The results (Table 2) showed that red ginger's crop coefficient (*Kc*) in the seedling stage was 0.997 and increased in the tillering stage to 1.072, and 1.138 in the active vegetative development stage. These values are

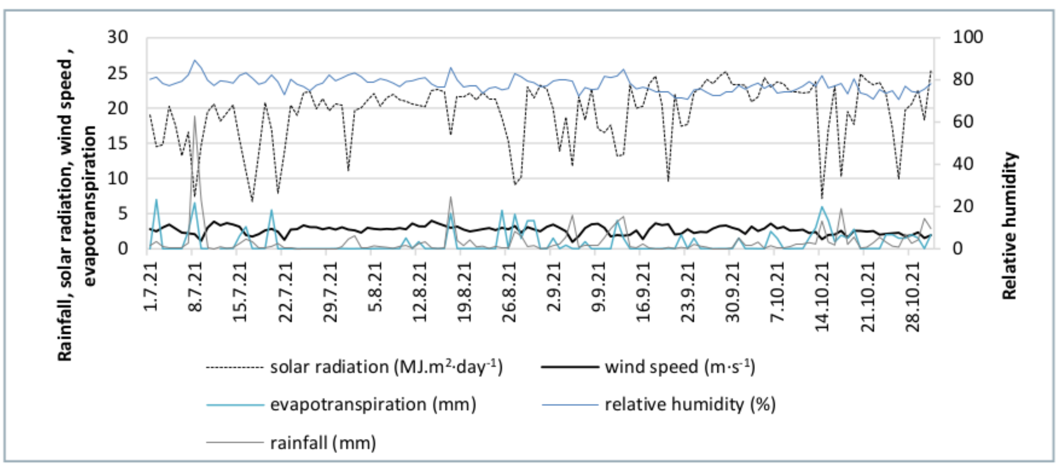


Fig. 2 Daily evapotranspiration, solar radiation, rainfall, wind speed and humidity fluctuations

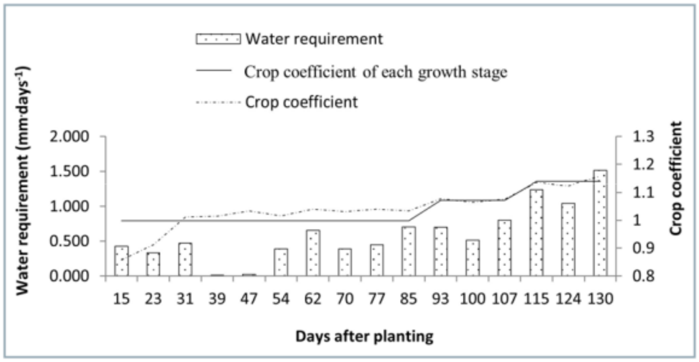


Fig. 3 Water requirement and crop coefficient of ginger

almost similar to the *Kc* value used by Meneghelli et al. (2020) in their research using the *Kc* value of 1.15 for the growth and development stage. The increase in the *Kc* value in this stage is influenced by plant transpiration. At the beginning of plant growth, reference evapotranspiration is higher than the water requirement of ginger plants. This is caused by the fact that the surface area of transpiration on the plants is still small. Water absorption by plant roots increases with the development of plant growth.

Chauhan (2015) in Chitra et al. (2017) suggested a crop factor value of 0.7–0.8 for the advanced vegetative stage of turmeric, a rhizome plant. Crop coefficient values are plant-specific, plant variety-specific, and site-specific. According to Doorenbos and Pruitt (1977), the factors that affect the crop coefficient value (*Kc*) are plant characteristics, planting schedule, plant development rate, the length of the growing season, soil evaporation, and climate. As a result, FAO-56 strongly advises users to get regional *Kc* values for specific plant kinds in accordance with local soil and climatic circumstances (Hong et al., 2017).

Table 2 Crop evapotranspiration and crop coefficient of ginger during July–October in a research farm at farm at Hasanuddin University, Makassar, Indonesia

Date	Rainfall + irrigation (mm)	Percolation (mm)	$ETc_{average}$ (mm)	*Kc*
07 July 2021	0.522	0.020	0.423	0.857
15 July 2021	0.424	0.055	0.332	0.912
23 July 2021	0.489	0.024	0.469	1.011
31 July 2021	0.044	0.031	0.015	1.014
08 August 2021	0.068	0.041	0.028	1.034
15 August 2021	0.425	0.038	0.389	1.016
23 August 2021	0.672	0.039	0.653	1.041
31 August 2021	0.426	0.052	0.387	1.031
07 September 2021	0.490	0.050	0.448	1.040
15 September 2021	0.763	0.067	0.702	1.033
23 September 2021	0.704	0.061	0.696	1.077
30 September 2021	0.564	0.056	0.511	1.064
07 October 2021	0.850	0.078	0.801	1.075
15 October 2021	1.140	0.051	1.240	1.135
24 October 2021	0.981	0.056	1.040	1.123
31 October 2021	1.364	0.048	1.515	1.157

The evaluation of crop coefficient values

Crop coefficient was calculated based on climatic parameters obtained from the nearest weather station. The *Kc* value obtained at the seedling stage was 0.452, at the tiller stage 0.603, and at the active vegetative development stage of ginger 0.955. These values were lower than the results determined using a lysimeter, namely: 0.997, 1.072, and 1.138, respectively (Fig. 4).

This discrepancy in value could be due to the *Kc* equation failing to account for many microclimate factors that affect the evaporation rate. By weighing lysimeters the change of the mass of the soil column can be measured, which equals the change of soil moisture content; therefore, the amount of water consumed through evaporation and transpiration can be determined. The results gained by means of weighing lysimeters are pretty accurate for calculating crop evapotranspiration (Alataway et al., 2019; Babaee et al., 2019; Bryla et al., 2010; Gao et al., 2009; Liu et al., 2017). According to Akanda et al. (2017), the values gained by lysimeter study are more dependable than the values obtained by calibration from the FAO recommended values.

To find out whether there is a one-to-one relationship between *Kc* calculation and *Kc* lysimeter, a regression test was carried out. The coefficient of determination is an indicator that describes how much variation is explained in the model (Chicco et al., 2021; Saunders et al., 2012; Sinambela et al., 2014; Sugiyono, 2011; Zhang, 2017). The coefficient of determination of *Kc* value (R^2) is 0.950, meaning that 95.0% of the independent variables can be explained by the dependent variable (Fig. 5). The value of R^2 close to 1 implies an almost perfect relationship between *Kc* calculation and *Kc* lysimeter.

The value of correlation coefficient was calculated to find out the relationship between variables. The value of correlation coefficient *Kc* is (R) 0.975, which indicates the level of linearization of *Kc* calculation and *Kc* lysimeter. The value of correlation coefficient *Kc* is positive, which means

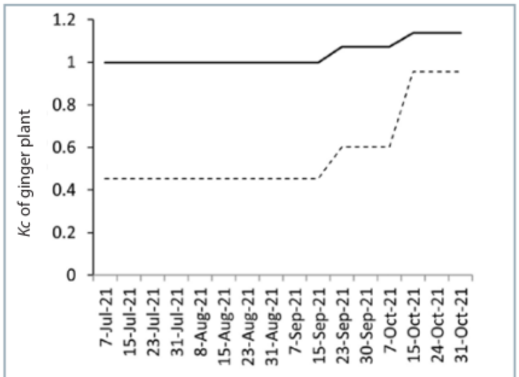


Fig. 4 *Kc* of ginger plant

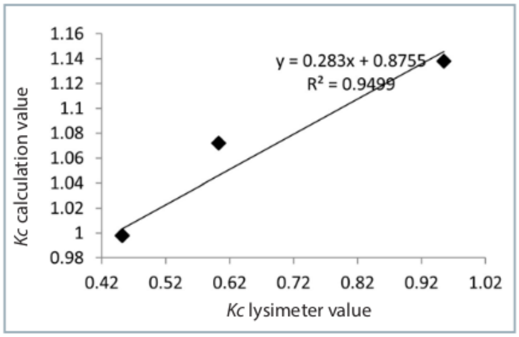


Fig. 5 The correlation of *Kc* values

Table 3 Statistical analysis of *Kc* values

R^2	*R*	SE	Significance *F*
0.950	0.975	0.046	$1.70058\ 10^{-10}$

the increase in the value of *Kc* calculation is positively followed by an increase in the value of *Kc* lysimeter.

F-test is a test of regression coefficient that can assess multiple coefficients simultaneously. This test was conducted to determine the effect of all the independent variables contained in the model together (simultaneously) on the dependent variable (Thorfiani and Sakti, 2019). The significant value of F in the analysis of variance is less than 0.05 (Table 3), which means that the coefficient value in the regression equation is significant or not equal to 0, and the equation can describe the relationship or influence of the independent variable on the dependent variable.

Conclusion

The water requirement and crop coefficients of ginger increased during the vegetative growth period, i.e., each; seedling stage 0.385 and 0.997 mm·day^{-1}; tiller stage 0.670 and 1.072 mm·day^{-1}; and advanced vegetative stage 1.265 and 1.138 mm·day^{-1}. The lysimeter is quite accurate for determining the crop coefficient value of red ginger in the city of Makassar, Eastern Indonesia, with a coefficient of determination (R^2) 0.950 and a significant value of F less than 0.05

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References

ABEDINPOUR, M. 2015. Evaluation of growth-stage-specific crop coefficients of maize using weighing lysimeter. In Soil & Water Research, vol. 10, no. 2, pp. 99–104. DOI: https://doi.org/10.17221/63/2014-SWR

AKANDA, A. R. – RAHMAN, M. S. – ISLAM, M. S. – MILA, A. J. 2017. Crop coefficient of a popular potato variety in Bangladesh. In Bangladesh Journal of Agricultural Research, vol. 42, no. 1, pp. 67–76. DOI: https://doi.org/10.3329/bjar.v42i1.31976

ALATAWAY, A. – AL-GHOBAR, H. – MOHAMMAD, F. – DEWIDAR, A. 2019. Lysimeter-based water use and crop coefficient of drip-irrigated potato in an arid environment. In Agronomy, vol. 9, no. 11, article no. 756. DOI: https://doi.org/10.3390/agronomy9110756

Al-AWWADI, N. A. J. 2017. Potential health benefits and scientific review of ginger. In Journal of Pharmacognosy and Phytotherapy, vol. 9, no. 7, pp. 111–116. DOI: https://doi.org/10.5897/JPP2017.0459

ALCARAS, L. M. A. – ROUSSEAUX, M. C. – SEARLES, P. S. 2016. Responses of several soil and plant indicators to post-harvest regulated deficit irrigation in olive trees and their potential for irrigation scheduling. In Agricultural Water Management, vol. 171, pp. 10–20. DOI: https://doi.org/10.1016/j.agwat.2016.03.006

ALLEN, R. G. – PEREIRA, L. S. – RAES, D. – SMITH, M. 1998. Crop Evapotranspiration: Guidelines for Computing Crop Water Requirements. FAO Irrigation and Drainage Paper no. 56. Rome : Food and Agricultural Organization of the United Nations, 300 pp. ISBN 92-5-104219-5.

ALVARENGA, A. A. – EVARISTO, M. C. – ERICO, C. – LIMA, J. – MARCELO, M. M. 2004. Effect of different light levels on the initial growth and photosynthesis of *Croton urucurana* Baill. in Southeastern Brazil. In R. Árvore, Viçosa-MG, vol. 27, no. 1, pp. 53–57. Available at: http://www.scielo.br/pdf/rarv/v27n1/15921.pdf

ASDAK, C. 1995. Hydrology and Watershed Management. Yogyakarta : Gadjah Mada University Press, 618 pp.

BABAEE, M. – SHOKAT-NAGHADEHB, A. – AHMADPARIA, H. – NABI-JALALI, M. 2019. Comparison of different methods with lysimeter measurements in estimation of rice evapotranspiration in Sari Region. In Revista Ingeniería UC, vol. 26, no. 2, pp. 175–184. Available at: http://servicio.bc.uc.edu.ve/ingenieria/revista/v26n2/art05.pdf

BRYLA, D. R. – TROUT, T. J. – AYARS, J. E. 2010. Weighing lysimeters for developing crop coefficients and efficient irrigation practices for vegetable crops. In Horticultural Science, vol. 45, no. 11, pp. 1597–1604. Available at: https://www.ars.usda.gov/ARSUserFiles/34338/PDF/2010/2010_HortScience_1597_1604.pdf

CHAUHAN, S. 2015 Fertigation management in turmeric (*Curcuma longa* L.) based cropping system. PhD Thesis, The Department of Agronomy, College of Agriculture. Rajendranagar Hyderabad Agriculture University, India.

CHICCO, D. – WARRENS, M. J. – JURMAN, G. 2021. The coefficient of determination R-squared is more informative than SMAPE, MAE, MAPE, MSE and RMSE in regression analysis evaluation. In PeerJ Computer Science, vol. 7, article no. e623. DOI: https://doi.org/10.7717/peerj-cs.623

CHITRA, R. – HAVARADDI, R. M. – SUBRAMANIAN, S. – SURESH, J. 2017. Effect of scheduling of drip irrigation on growth, yield and water use efficiency of turmeric (*Curcuma longa* L.) var. CO 2. In Journal of Spices and Aromatic Crops, vol. 26, no. 1, pp. 8–15. DOI: https://doi.org/10.25081/josac.2017.v26.i1.801

CHOI, E. C. C. 1994. Parameters affecting the intensity of wind-driven rain on the front face of a building. In Journal of Wind Engineering and Industrial Aerodynamics, vol. 53, no. 1–2, pp. 1–17. DOI: https://doi.org/10.1016/0167-6105(94)90015-9

DHANIK, J. – ARYA, N. – NAND, V. 2017. A review on *Zingiber officinale*. In Journal of Pharmacognosy and Phytochemistry, vol. 6, no. 3, pp. 174–184. Available at: https://www.phytojournal.com/archives/2017/vol6issue3/PartC/6-2-17-350.pdf

DOORENBOS, J. – PRUITT, W. O. 1977. Crop Water Requirements. FAO Irrigation and Drainage Paper no. 24. Rome : Food and Agricultural Organization of the United Nations. 144 pp.

FRISKA, M. – DARYONO, B. S. 2017. The phenotype characters of polyploid red ginger (*Zingiber officinale* var. *rubrum*) induced by colchicine. In Al-Kauniyah: Journal of Biology, vol. 10, no. 2, pp. 91–97. Available at: https://media.neliti.com/media/publications/270275-karakter-fenotip-jahe-merah-zingiber-off-547ec71b.pdf

GAO, Y. – DUAN, A. – SUN, J. – LI, F. – LIU, Z. – LIU, H. – LIU, Z. 2009. Crop coefficient and water-use efficiency of winter wheat/spring maize strip intercropping. In Field Crops Research, vol. 111, no. 1–2, pp. 65–73. DOI: https://doi.org/10.1016/j.fcr.2008.10.007

GARCIA-TEJERO, I. F. – LÓPEZ-BORRALLO, D. – MIRANDA, L. – MEDINA, J. J. – ARRIAGA, J. – MURIEL-FERNÁNDEZ, J. L. – MARTÍNEZ-FERRI, E. 2018. Estimating strawberry crop coefficients under plastic tunnels in Southern Spain by using drainage lysimeters. In Scientia Horticulturae, vol. 231, pp. 233–240. DOI: https://doi.org/10.1016/j.scienta.2017.12.020

GOULART, F. S. 1995. Super Healing Foods: Discover the Incredible Healing Power of Natural Foods. Englewood Cliffs, NJ : Prentice Hall Press. 416 pp. ISBN 978-0131088382.

GRZANNA R. – LINDMARK, L. – FRONDOZA, C. G. 2005. Ginger – an herbal medicinal product with broad anti-inflammatory actions. In Journal of Medicinal Food, vol. 8, no. 2, pp. 125–132. DOI: https://doi.org/10.1089/jmf.2005.8.125

HAPSOH, Y. – HASANAH, H. – JULIANTI, E. 2008. Ginger Cultivation and Postharvest Technology. Medan : USU Press, 112 pp. (In Indonesian: Budidaya dan Teknologi Pascapanen Jahe).

HONG, M. – ZENG, W. – MA, T. – LEI, G. – ZHA, Y. – FANG, Y. – WU, J. – HUANG, J. 2017. Determination of growth stage-specific crop coefficients (*Kc*) of sunflowers (*Helianthus annuus* L.) under salt stress. In Water, vol. 9, no. 3, article no. 215. DOI: https://doi.org/10.3390/w9030215

HUTABARAT, N. C. – SUPRIYANA, S. – SUHARTONO, S. 2020. The effect of extract red ginger (*Zingiber officinale* var. *rubrum*) on reducing the blood pressure level among maternal with gestasional hypertension. In International Journal of Nursing and Health Services, vol. 3, no. 4, pp. 479–488. Available at: https://www.ijnhs.net/index.php/ijnhs/article/view/219/167

JABBOROVA, D. – ENAKIEV, Y. – SULAYMANOV, K. – KADIROVA, D. – ALI, A. – ANNAPURNA, K. 2021. Plant growth promoting bacteria *Bacillus subtilis* promote growth and physiological parameters of *Zingiber officinale* Roscoe. In Plant Science Today, vol. 8, no. 1, pp. 66–71. DOI: https://doi.org/10.14719/pst.2021.8.1.997

JAIDKA, M. – KAUR, R. – SEPAT, S. 2018. Scientific cultivation of ginger (*Zingiber officinale*). In Advances in Vegetable Agronomy, pp. 191–197. ISBN 978-93-83168-17-0. Available at: https://www.researchgate.net/publication/327282383

LI, I. – CHEN, F. – YAO, D. – WANG, J. – DING, N. – LIU, X. 2010. Balanced fertilizer for ginger production – why potassium is important. In Better Crops, vol. 94, no. 1, pp. 25–27.

LIU, X. – XU, C. – ZHONG, X. – LI, Y. – YUAN, X. – CAO, J. 2017. Comparison of 16 models for reference crop evapotranspiration against weighing lysimeter measurement. In Agricultural Water Management, vol. 184, pp. 145–155. DOI: https://doi.org/10.1016/j.agwat.2017.01.01727

MAVI, H. S. – TUPPER, G. J. 2004. Agrometeorology Principles and Application of Climate Studies in Agriculture. Boca Raton : CRC Press, 447 pp. ISBN 9780429078378.

MENEGHELLI, C. M. – KRAUSE, M. R. – SCHMIDT, J. – COLOMBO, J. N. – VIEIRA, G. H. S. 2020. Performance of ginger crop under different irrigation depths. In Bioscience Journal, vol. 36, no. 3, pp. 783–791. DOI: https://doi.org/10.14393/BJ-v36n3a2020-47717

PICCINNI, G. – KO, J. – MAREK, T. – HOWELL, T. 2009. Determination of growth-stage-specific crop coefficients (*Kc*) of maize and sorghum. In Agricultural Water Management, vol. 96, no. 12, pp. 1698–1704. DOI: https://doi.org/10.1016/j.agwat.2009.06.024

QIAN, Y. – WANG, W. – LEUNG, L. R. – KAISER, D. P. 2007. Variability of solar radiation under cloud-free skies in China: The role of aerosols. In Geophysical Research Letters, vol. 34, article no. L12804. DOI: https://doi.org/10.1029/2006GL028800

READER'S DIGEST. 2004. Foods that Harm Foods that Heal. New York : The Reader's Digest Association Inc. 400 pp. ISBN 978-0762106059.

ROSTIANA, O. – BERMAWIE, N. – RAHARDJO, M. 2016. Operational Procedure Standard of Ginger, Turmeric, Aromatic Ginger, and Temulawak Cultivation. Bogor : Research Institute for Spices and Medicinal Plants. (In Indonesian: Standar Prosedur Operasional (SOP) budidaya jahe, kencur, kunyit, dan temulawak)

RUKMANA, R. 2000. Ginger Farming, Series Cultivation. Yogyakarta : Kanisius Press. (In Indonesian: Usaha tani jahe, seri budi daya)

SANEWSKI, G. M. 2002. Rhizome and fibre development in early harvest ginger (*Zingiber officinale* Rosc). Brisbane : School of Land, Crop and Food Sciences, The University of Queensland, PhD Thesis, 201 pp.

SANTOSO, H. B. 2008. Variety and Efficacy of Medicinal Plants. Yogyakarta : Agromedia Pustaka Press. (In Indonesian: Ragam dan khasiat tanaman obat)

SAUNDERS, L. – RUSSEL, R. A. – CRABB, D. P. 2012. The coefficient of determination: What determines a useful R^2 statistic? In Investigative Ophthalmology & Visual Science, vol. 53, no. 11, pp. 6830–6832. DOI: https://doi.org/10.1167/iovs.12-10598

SHAO, H. B. – CHU, L. Y. – JALEEL, C. A. – ZHAO, C. X. 2008. Water-deficit stress-induced anatomical changes in higher plant. In Comptes Rendus Biologies, vol. 331, no. 3, pp. 215–225. DOI: https://doi.org/10.1016/j.crvi.2008.01.002

SINAMBELA, S. D. – ARISWOYO, S. D. – SITEPU, H. R. 2014. Determine the determinant coefficient between the estimation of M with Welsch type with least trimmed square in data that has outliers (In Indonesian: Menetukan koefisien determinasi antara estimasi m dengan type welsh dengan least trimmed square dalam data yang mempunyai pencilan). In Saintia Matematika, vol. 2, no. 3, pp. 225–235.

SOFIYUDDIN H. A. – MARTIEF, L. M. – SETIAWAN, B. I. – ARIF, C. 2010. Evaluation of crop coefficients from water consumption in paddy fields. In 6th Asian Regional Conference of the International Commission on Irrigation and Drainage. Yogyakarta : Universitas Gadjah Mada.

SUDEWO, B. 2006. Popular Medicinal Plants. Yogyakarta : Agromedia Pustaka Press. (In Indonesian: Tanaman obat popular)

SUGIYONO. 2011. Quantitative, Qualitative and R&D Research Methodolgy. Bandung, Indonesia : Alpabeta. ISBN 9798433640. (In Indonesian: Metode penelitian kuantitatif kualitatif dan R&D)

TAHASHILDAR, M. – BORA, P. K. – RAY, L. I. P. – THAKURIA, D. 2015. Determination of crop coefficient for capsicum (*Capsicum annumm* L.) in Eastern Himalayan Region through field lysimeter. In Indian Journal of Dryland Agricultural Research and Development, vol. 30, no. 1, pp. 15–23. DOI: https://doi.org/10.5958/2231-6701.2015.00003.2

THORFIANI, D. – SAKTI, T. E. 2019. Application of personal selling product knowledge at the state savings bank Cerebon, Indonesia. In Journal of Business and Marketing, vol. 9, no. 2, pp. 52–62. (In Indonesian: Penerapan personal selling product knowledge pada bank tabungan negar Cirebon, Indonesia)

ZHANG, D. 2017. A coefficient of determination for generalized linear models. In The American Statistician, vol. 71, no. 4, pp. 310–316. DOI: https://doi.org/10.1080/00031305.2016.1256839

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