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Research Article

Growth and yield performance of three peanut cultivars on different watering intervals

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ABSTRACT

Many peanut planting fields have limited water resources, therefore farmers must use water efficiently. A study aimed to obtain appropriate watering intervals and adaptive peanut cultivars at limited water conditions. The greenhouse study was conducted at Central Bengkulu Regency, Indonesia, from December 2019 to March 2020. Three varieties of peanut (Takar 2, Talam 1, and Kancil) and four watering intervals (1, 3, 6, and 9-day intervals) were arranged using a split-plot design and replicated three times. Results showed that the three varieties evaluated had similar agronomic performance (P≥0.05). The Takar 2 and Kancil had similar growth and yield components to the dry land adaptive variety Talam 1. It indicates that Takar 2 and Kancil cultivars are suitable for cultivation in a water-limited field. Watering every 6 days reduced peanut growth and insignificantly differed from watering every 9 days. Daily watering produced the highest growth and yield of peanut, irrespective of genotypes. Nevertheless, in areas with limited water availability, watering every 3 days was sufficient with yield reduction by about 25.55% of watering daily.

Keywords: drought, irrigation, peanut production

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INTRODUCTION

Peanut (*Arachis hypogaea* L.) is one of the essential food crops in Indonesia. About 70% of peanut cultivation exists on dry land (Harsono, 2015). Some farmers cultivate peanut in wetlands of paddy fields during the dry season (± 30% of the total harvested peanut area). In this case, farmers cultivate peanut as the second crop after rice or the third crop after maize resulting in a high probability of water shortage (Buge et al., 2017). Nevertheless, the evaluation of water shortage on peanut growth and yield performance is rarely studied in Indonesia.

According to Harsono (2015), a peanut crop requires around 250-800 mm daily depending on the climate and cultivation pattern. Monoculture peanut requires 372 mm per day while intercropping peanut requires 700 mm of water per day (Harsono, 2015). Limited water availability suppresses peanut growth and yield. Therefore, water management to provide optimal quantity and sequence of watering to achieve maximum yield is essential. The application of water on a regular basis or watering intervals is a kind of water management to increase water efficiency.

Although irrigation scheduling has been extensively studied in many crops (Hidayatullah et al., 2020; Awoke & Alem, 2021; Irmadamayanti et al., 2021; Sezen et al., 2021), watering interval in peanut genotypes is still an interesting topic. It is known that specific genotypes could respond differently to different soil moisture.

Genotype selection is one way to increase peanut yields. The phenotypic performance is a result of genetics, environment, and GxE interaction (Nurhidayah et al., 2017). Plant breeders create varieties with unique characteristics (Diwyanto et al., 2012; Guang-Hui et al., 2014; Zulchi, 2016; Nurhidayah et al., 2017), including drought-resistant genotypes. In such cases, agronomic evaluation in the field is important before adopting by farmers on a commercial scale.

Here, peanut genotypes are evaluated under different watering intervals to obtain varieties superior to a particular environmental condition from the existing cultivars. Considering the importance of adequate water supply and the limited water availability in several cultivation locations, it is necessary to search for water-limited-resistant varieties and water supply intervals that still provide good growth with high peanut seed yields. This study aimed to obtain appropriate watering intervals and adaptive peanut cultivars at limited water conditions.

MATERIALS AND METHODS

Location and experimental design

This research was conducted at Talang Boseng Village, Pondok Kelapa District, Central Bengkulu Regency, from December 2019 to March 2020. The planting media was placed into polybags containing 5 kg, and the pots were arranged in a plastic house to ensure that the water was only sourced from the applied treatment. The planting medium consisted of a mixture of soil and manure in a 1:1 ratio.

The experimental units were arranged randomly following the split-plot design. Three peanut cultivars were placed in the main plot, and four watering intervals were placed in the subplot. The three Takar 2, Talam 1, and Kancil peanut genotypes were evaluated. Daily (as a control), 3, 6, and 9-day intervals were the four watering intervals. Three replications of the experiment were performed. Two peanut seeds were planted in each pot to a depth of approximately 2 cm and thinned out at two weeks of age, leaving only one plant per pot.

Plants were watered daily for the first three weeks. Then, the watering was applied following the interval watering treatment. Watering was done two times in a day, i.e., morning and evening, with the volume of the water being 370 mL each application time. Under normal irrigation conditions, the addition of 370 mL of water has reached field capacity for media in polybags weighing 5 kg.

Measurement

The responses of each peanut cultivar to the watering interval were observed on plant height (cm), number of leaves, leaf area (cm^2), number of branches, the greenness of leaves (SPAD units), stomatal density ($stomata.mm^{-2}$), plant dry weight (g), number of pods (pods), and the weight of 100 grains (g).

Leaf area was measured using an image processing software, ImageJ version 1.53v. All samples of leaves were scanned and transferred into a computer.

Stomata printed using the imprint technique were photographed under a 0.19625 mm^2 field of view microscope lens with 40 x magnification. The number of stomata in the photo file was counted using ImageJ. The formula determined that stomatal density (D):

$$D = \frac{Number\ of\ stomata\ in\ the\ field\ of\ view\ of\ a\ microscope}{Field\ of\ view\ of\ a\ microscope}$$

The plant height parameter was also presented as plant height increased. The relative growth rate (RGR) was calculated by dividing the difference between the natural logarithm (ln) of two dry weight data (W2 and W1) by the time of observation (T2 and T1) from the age of observation 21 and 40 days after planting (Isah et al., 2014):

$$RGR = \frac{\ln W_2 - \ln W_1}{T_2 - T_1}$$

Data analysis

The data analyzed statistically were the average of 5 samples in each experimental unit. Homogeneity and normality tests were performed on all peanut growth and yield data prior to the analysis of variance. Fisher's test (F test) was used to analyze the variance of each data at the 5% level.

Data showing a significant effect on the F test were analyzed using the Duncan Multiple Range Test (DMRT) to compare the mean values of each treatment at the 5% level. Data were analyzed using IBM® SPSS® Statistics Version 26 and Microsoft Excel software.

RESULTS AND DISCUSSION

The three peanut varieties evaluated in this experiment had no significant differences in the growth and yield component (P≥0.05) except for the number of branches at the age of 4 and 5 weeks after planting (P<0.05). The interaction between cultivars and watering intervals had no significant effect on all observed variables. However, all observed variables were significantly affected by watering intervals (P<0.05) (Table 1).

Table 1. Probability values (p-value) of the variance of all variables.

Parameter	P-value		
	Cultivar	Watering interval	Cultivar × watering interaction
Plant height at 4 WAP	0.676ns	0.004**	0.767ns
Plant height at 5 WAP	0.654ns	0.0001**	0.755ns
Plant height at 6 WAP	0.612ns	0.00002**	0.719ns
Plant height at 7 WAP	0.656ns	0.0002**	0.892ns
Plant height at 8 WAP	0.444ns	0.00003**	0.916ns
Plant height at 9 WAP	0.358ns	0.0001**	0.589ns
Plant height at 10 WAP	0.268ns	0.00005**	0.396ns
Leaf area at 6 WAP	0.940ns	0.00003**	0.815ns
Leaf greenness	0.144ns	0.028*	0.523ns
Stomatal density	0.671ns	0.216ns	0.866ns
Branches number at 4 WAP	0.011*	0.000003**	0.813ns
Branches number at 5 WAP	0.042*	0.00004**	0.720ns
Branches number at 6 WAP	0.105ns	0.00003**	0.967ns
Branches number at 7 WAP	0.109ns	0.0001**	0.846ns
Branches number at 8 WAP	0.077ns	0.001**	0.930ns
Branches number at 9 WAP	0.131ns	0.001**	0.861ns
Branches number at 10 WAP	0.168ns	0.0004**	0.870ns
Plant dry weight at 4 WAP	0.072ns	0.0001**	0.330ns
Plant dry weight at 6 WAP	0.497ns	0.0001**	0.946ns
Relative growth rate	0.842ns	0.0001**	0.961ns
Pods number	0.404ns	0.0001**	0.182ns
Weight of 100 seeds	0.235ns	0.0004**	0.460ns

Note: ** significant at P<0.01, * significant at P<0.05, ns not significant, WAP = weeks after planting.

The only significant difference between the three varieties was the number of branches at 4 and 5 weeks after planting (WAP). The number of branches from 6 to 10 WAP and other traits were similar among varieties. The growth and yield of all peanut varieties were similar. Whereas according to previous studies, all varieties differed in their superiority. Takar 2 is resistant to leaf spots and rust diseases; Kancil is an early maturing variety; and Talam 1 adapts to dry, acid soils and is tolerant to Aspergillus disease (Kasno, 2010; Diwyanto et al., 2012; Puspitasari et al., 2019). This study found that Takar 2 and Kancil varieties perform similarly to Talam 1, which adapts to dry land with low soil moisture.

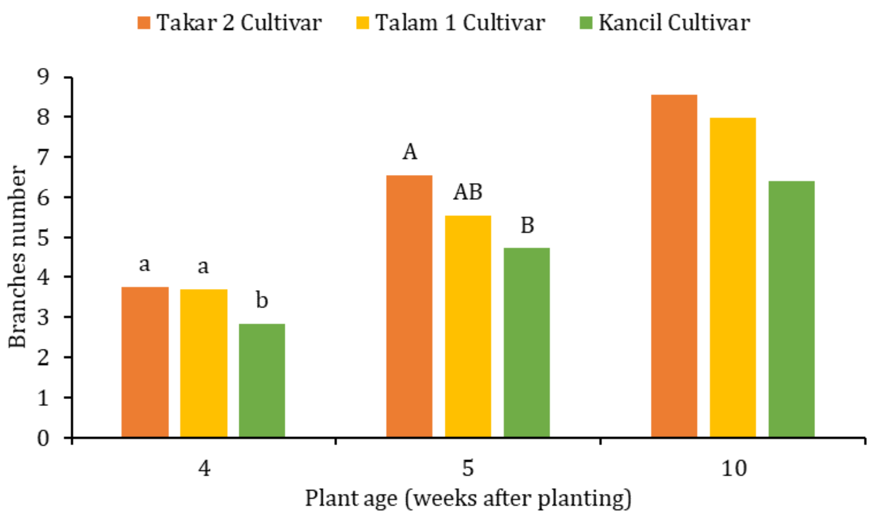

Figure 1. The number of branches of three peanut cultivars at 4, 5, and 10 WAP. The same letter at the top of the bar at the same age indicates an insignificant difference according to Duncan's Multiple Range Test at the level of 5%.

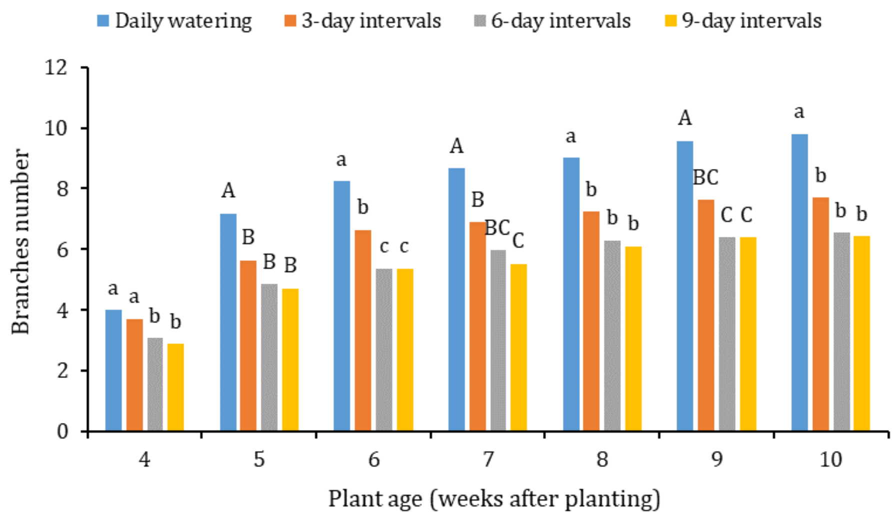

Figure 2. The number of branches at 4 to 10 WAP. The same letter at the top of the bar at the same age indicates an insignificant difference according to Duncan's Multiple Range Test at the level of 5%.

The present study showed that watering is important for the growth of peanut plants. Watering at different intervals causes diverse growth and yield components of peanut plants. All observed variables, which are the growth and components of the yield of peanut plants, show different behavior between watering interval treatments.

The number of branches caused by the watering interval reached an average of 9.8 branches in the 10th week for daily watering. Whereas, the number of branches caused by genetics between varieties only reached an average of 8.56 branches in the Takar 2 cultivar (Figures 1 and 2).

The tallest canopy arises from plants treated by everyday watering (Figure 3). After applying the watering intervals from the third week, the plants immediately responded with a different speed of height growth starting from the fourth week of observation. The plants watered every three days were still insignificantly different from those watered daily. However, the plants' height at 6- and 9-day intervals significantly differed from the plants watered daily. A linear regression illustrates the trend of height growth (R^2 = 0.9751 – 0.9936). With an exact intercept value (5.0878), the linear regression slope of the daily watering data was higher than every three, six, and nine days. Coincident linear lines between 6- and 9-day intervals indicate that watering every six days had disrupted plant growth. Adequate soil moisture will ensure well metabolic processes to support rapid cell division and elongation (Sankar et al., 2014; Kalarani et al., 2018).

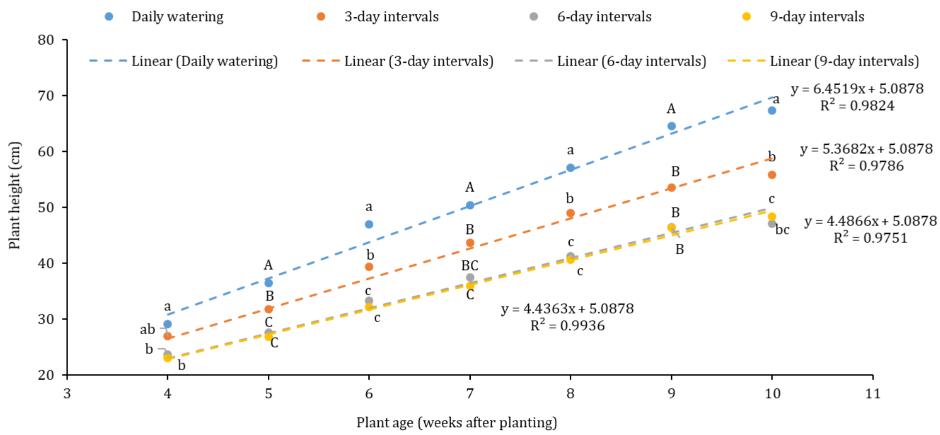

Figure 3. Plant height and the trend of plant height growth by linear regression. The same letter next to the point at the same age indicates an insignificant difference according to Duncan's Multiple Range Test at the level of 5%.

Table 2. Leaf area, greenness, and stomatal density of peanut plants with different watering intervals.

Watering interval	Leaf area (cm^2)	Leaf greenness	Stomata per mm^2
Everyday	11.17a	43.28a	133.67
3-day intervals	10.22ab	42.81a	130.89
6-day intervals	8.33b	41.71ab	130.78
9-day intervals	4.96c	41.03b	121.89

Note: Values followed by the same letter in the same column indicate an insignificant difference according to Duncan's Multiple Range Test at the level of 5%.

Less frequent watering did not significantly reduce stomatal density (Table 2). Stomatal density in relation to water-use efficiency could be modified genetically (Franks et al., 2015; Bertolino et al., 2019). Watering interval caused leaf greenness and area to differ significantly between treatments (Table 2). The greenness of the leaves significantly decreased by decreasing soil moisture, and the leaves of the peanut plants which were rarely watered were significantly narrower than the plants which were watered every day.

The relative growth rate using the dry weight of biomass reflected plant growth. Plants watered daily significantly have the highest relative growth rate (Figure 4). This finding is in line with Pratiwi (2011).

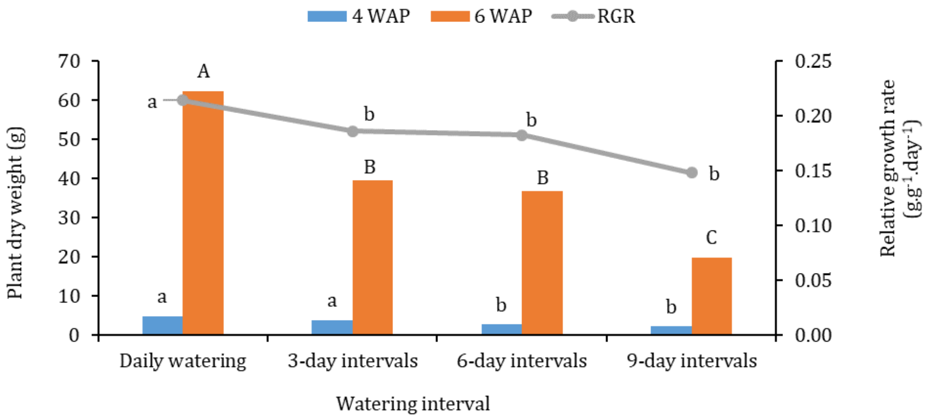

Figure 4. Plant dry weight at 4 and 6 WAP and relative growth rate (RGR). The same letter at the top of the bar and next to the point at the same watering interval indicates an insignificant difference according to Duncan's Multiple Range Test at the level of 5%.

Table 3. Yield component of peanut plants with different watering intervals.

Watering interval	Pods number per plant	Weight of 100 seeds (g)
Everyday	24.07a	90.00a
3-day intervals	17.92b	77.22a
6-day intervals	11.73c	49.22b
9-day intervals	10.44c	46.78b

Note: Values followed by the same letter in the same column indicate an insignificant difference according to Duncan's Multiple Range Test at the level of 5%.

Water is essential for plants because it dissolves nutrients (Koryati et al., 2021). Water also plays a role in maintaining the humidity and temperature of plant (Osakabe et al., 2014; Hatfield & Dold, 2019). Water is a major plant constituent by about 70-90% of total fresh weight (Koryati et al., 2021). Thus, a lack of water causes cell damage and disruption of their metabolic processes, which eventually causes poor plant growth and production (Osakabe et al., 2014).

The number of peanut pods per plant from less frequent watering was lower than those of more frequent ones. Although the number of peanut pods watered daily differed from the number of peanut pods watered every three days, the seed size of both watering treatments was not significantly different, as indicated by the weight of 100 peanut seeds (Table 3). Such a similar pattern between yield components and growth of tested varieties expressed a strong relationship between vegetative and reproductive phases; it is affected by photosynthesis (Guang-Hui et al., 2014; Harun et al., 2022; Novrika et al., 2016; Thangthong et al., 2018; Zulchi, 2016). This result is also supported by Figure 4, which explains the effectiveness of biomass accumulation.

CONCLUSIONS

Watering intervals significantly affected the growth performance and yield components of peanut. Plants produced more pods in 3-day watering intervals than those in 6- and 9-day intervals. Although the pod number of plants from 3-day watering intervals was lower than that of every day, the seed size as reflected by the 100 seeds index of both treatments was insignificantly different. Therefore, watering could be done in 3-day intervals in limited water availability, irrespective of varieties. Under limited water conditions, Takar 2 and Kancil varieties had similar growth performance and yield components with Talam 1 as an adaptive variety to dry land.

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