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The effect of interaction between salicylic acid and drought stress on growth and photosynthetic rate of *Basella alba* and *B. rubra*

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Abstract. *Ayuningtias AW, Solichatun, Pangastuti A. 2023. The effect of interaction between salicylic acid and drought stress on growth and photosynthetic rate of* Basella alba *and* B. rubra*. Asian J Agric 7: 108-115. Basella alba* L and *B. rubra* L are two species of potential drugs and have very potential to develop because of the secondary metabolic content. The change of climate, which is uncertain and prolongs the dry season, is a problem in the cultivation of these plants. Drought stress affects the aspect in growth and photosynthesis rate. The application of salicylic acid tolerated plants due to drought stress and gave a physiologically different response from both plants. This study aimed to determine the interaction effect of Salicylic Acid (SA) on growth and photosynthesis rate in *B. alba* and *B. rubra*. A completely random design was used. Two factors of this study were salicylic acid and drought stress. The dosage of salicylic acid were 0 mM, 2 mM, 4 mM, and 6 mM, and field capacities were set by 100%, 75%, 50%, and 25%. Observed data in this study include plant height, leaf area, photosynthesis rate, stomata conductance, and transpiration rate at *B. alba* and *B. rubra*. The result showed in *B. alba* KL 50% and SA 4 mM (50.1 cm^2), in *B. rubra* KL 25% and SA 4 mM (52.9 cm^2) were the best treatment in plant high. The highest values of leaf area in *B. alba* are KL 75% and SA 2mM (91.72 cm^2), and in *B. rubra,* are KL 50% and SA 4 mM (122.67 cm^2). The treatment KL 50% and SA 6 mM on *B. alba* showed the highest result in photosynthesis rate, stomata conductance, and transpiration rate (0.8663 µmol m^{-2} s^{-1}; 0.9468 µmol m^{-2} s^{-1}; 0.1890 µmol m^{-2} s^{-1}), in *B. rubra* the highest value are KL 75% and SA 6mM (0.9202 µmol m^{-2} s^{-1}; 0.9468 µmol m^{-2} s^{-1}; 0,105 µmol m^{-2} s^{-1}). This study concludes that the interaction between salicylic acid and field capacity significantly affects growth and photosynthesis rate.

Keywords: *Basella*, drought stress, growth, photosynthesis, salicylic acid

INTRODUCTION

The pharmaceutical Indonesia industry can export 90% of domestic medicinal products, but almost 95% of production depends on imported raw materials (BPPT 2021). Imported raw materials cause a deficit and affect the whole of Indonesia's economy. Indonesia's high number of raw materials and drug additives encouraged researchers to research the production of pharmaceutical-grade active compounds with existing natural resources.

Basella is a genus of potential drugs to develop because of its secondary metabolic content. There are two species, *Basella alba* L, and *B. rubra* L. In recent decades, the public has been interested in secondary metabolites of medicinal plants because of their therapeutic compounds. The secondary metabolites in plants are varied. The *B. alba* contains acacetin, rutin, betacyanin, saponins, kaempferol, and ferulic acid. The *B. rubra* contains tannins, alkaloids, saponins, steroids, and flavonoids. Secondary metabolic production by direct extraction must be accompanied by proper cultivation to prevent over-exploitation. Therefore, to avoid over-exploitation, the cultivation must use the right method to increase the yield and quality of production.

Water is an important environmental factor that affects crop productivity. Physiologically, Reactive Oxygen Species (ROS) produced by plants under stress conditions often cause oxidative stress. Serious drought stress conditions result in stunted plant growth, low production yields, and poor dry matter accumulation. Therefore, water must be used wisely to maintain sustainable crop productivity. Red and white gondolas are plants that are easy to grow in both highland and lowland areas. But, NASA (2022) said that the earth's temperature in 2021 increased by 0.85% compared to the average temperature in 1951-1980's. The uncertain climate change and prolonged dry season were the problems for cultivating these plants. Extreme climate change causes plants to experience abiotic stress. Fresh water will be scarce if global changes are not controlled. Water is a molecule key in plant physiological activity; it helps transport metabolites and nutrients to all plant parts. In the long term, severe drought stress results in stunted plant growth, low yields, and decreased productivity. The bad impact is decreased plant size, leaf area, and yield. The other bad impact is stomata closing to reduce CO_2 binding, thus inhibiting photosynthesis. Cultivation of plants to optimize secondary metabolite levels can be carried out with various treatments, such as giving hormones and stress relievers (Ahmad et al. 2017; Movahedi et al. 2021; Simbeye et al. 2023)

The application of growth regulators plays an important role in the plant's response to stress. Plant hormones must be right so that gene activity and plant regulation in their life cycle are also good. Both plants, *B. alba* and *B. rubra* have different responses in dealing with stress. Applying phytohormones is an effort to increase plant growth due to drought stress. The salicylic acid hormone increases plant tolerance when dry stress occurs because it's effective for target cells even though produced in small amounts. In addition, salicylic acid plays an important role in increasing physiological processes, stomata conductance, photosynthetic rate, and chlorophyll content under stress. Salicylic acid activates the gene expression that responds to abiotic stress and induces enzyme expression and protein biosynthesis. The exogenous application of salicylic acid hormone upregulates dehydrin-like protein synthesis, chlorophyll content, and rubisco (Li et al. 2013; Nazar et al. 2015; Wiraatmaja 2017). Najafabadi and Ehsanzadeh (2016) stated that applying salicylic acid to the leaves increased the photosynthesis rate in sesame under drought stress. This study aimed to determine the effect of interaction between salicylic acid and drought stress on growth and photosynthetic rate of *B. alba* and B. *Rubra* cultivated in Assalaam Islamic Modern Boarding School green house (used polybag), Pabelan, Kartasura, Sukoharjo, Central Java, Indonesia.

MATERIALS AND METHODS

Study area

This study was conducted from December 2022 to April 2023 and located in Assalaam Islamic Modern Boarding School green house, Pabelan, Kartasura, Sukoharjo, Central Java, Indonesia (7º3'11"S 110º 46'15"E). The temperature was captured between 23 to 31ºC, and the humidity was around 64%. The ratio of media-fertilizer used per polybag is 2:1.

Procedures

Collection of seeds and preparation of seedlings

The *B. alba* and *B. rubra* seeds were bought from traditional markets with the *Ninu Farm* brand. Seeds are selected based on size, color and contain embryos. Then put the seeds in the seedling container and cover it with planting media mixed with manure. Regularly water every morning until the seeds are 8 weeks, then choose seeds of the same height.

Planting and maintenance

Seedlings were planted in polybags with 2 factors and 3 replications in a greenhouse. The first factor was Salicylic Acid (SA) doses of 0 mM (control), 2 mM, 4 mM, and 6 mM, and the second factor was field capacity (FC) 100% FC (control), 75% FC, 50% FC and 25% FC. Control treatment is the treatment that is not given salicylic acid and dry stress. There were 45 *B. rubra* and 45 *B. alba* with 15 treatment combinations, each repeated thrice.

Salicylic acid treatment was given using the method by Sayyari et al. (2013). It is sprayed on plants that already have 3-6 true leaves, spraying salicylic with slight modifications every two days with an interval of 2 weeks for 2 months. Drought stress based on Field Capacity was given to plants 3 days after the first spraying of salicylic acid. The plant's watering was done every day with a watering quantity of 100% field capacity. After the age of the plants 60 days after planting, the watering volume was changed based on Field Capacity (FC) treatment (100, 75, 50, 25%). The initial process for determining Field Capacity (FC) was that polybags with 3 kg of planting media were doused with water and waited for the first drops to come out. Next, pour water until the first drop was 1,000 mL as a field capacity; then, calculate the groundwater level by taking 10 grams soil sample, letting it stand for 24 hours, and drying the sample in the oven at 60°C for 24 hours. The oven-dried soil samples were dried, and calculations were made for water concentrations; the formula for calculating soil water content by Saputra (2015). The weight of the soil obtained after baking is 6 g with 3 repetitions, then soil water content is determined by the following formula. Treatment of drought stress by looking at the condition, the amount of watering is adjusted to the level of water loss in treatment. Hence, the polybag conditions are within field capacity. The harvesting stage of *B. alba* and *B. rubra* was carried out when the plants were 90 days after planting or 4 weeks after treatment.

$$GWL\ (\%) = \frac{A-B}{A} \times 100\%$$

Where:
A : Initial weight of soil sample before drying (g)
B : Final soil weight after drying (g)

Observation

Plant height, leaf number, and leaf area were observed when the plants were 12 weeks after transplanting in the greenhouse. Photosynthesis measurements were carried out directly on the third leaf from the shoot. Photosynthesis and transpiration rate also stomatal conductance were observed with natural light 8.30 am-11.30 am with Plant Photosynthetic Meter NY-1020 (Zhengzhou Nanbei Instrument Equipment Co., Ltd.) measured on the leaf of *B. alba* dan *B. rubra*.

The leaf area measurement was done by the constant method. The leaves have fully opened, and the data is presented in cm^2 units. Measurement of leaf surface using millimeter paper with approximation, measured the length with (LA= L x W x K). Constant value on *B. alba* is 0.8934 and constan value on *B. rubra* is 0.9736

Data analysis

Normality and homogeneity tests were carried out at the beginning and then continued with a two-way Analysis of Variance (ANOVA) and continued with Duncan's multiple range test at a 5% level. DMRT test aims to determine the real effect of every treatment. If there is a significantly different effect with p-value < 0.05 or F count > F table, then H0 is rejected.

The statistical test used the Pearson matrix correlation to measure the linear relationship between variables.

Pearson's correlation coefficients range from -1 (perfect negative correlation) to +1 (perfect positive correlation), with 0 indicating no correlation. The data were analyzed with SPSS 26.0 software.

RESULTS AND DISCUSSION

From 48 plants of *B. alba* and 48 plants of *B. rubra*, the growth rate parameters are height, leaf number, and leaf surface area (Table 1). The photosynthetic rate parameters are photosynthetic, transpiration, and stomata conductance (Table 2). The morphological appearance of *B. alba* and *B. rubra* plants can be seen in Figures 1 and 2.

Growth parameters

Plant height

Plant height is a variable that determines the effect between plant and plant growth parameters. The plant height measurement can determine the physiological function of plants. The DMRT test at the 5% level showed that the interaction of SA and DS had a slightly significant effect on *B. alba* and B. *rubra* (Table 1). The treatment between SA 6mM and FC 25% was the highest result in *B. alba* (52.90 cm), and between SA 4mM and FC 25% was the highest in *B. rubra* (52.70 cm).

Leaf area

Plant leaf area is a parameter directly related to photosynthesis and transpiration. The result showed (Table 1) that the treatment between SA 2 mM and FC 75% was the highest result in *B. alba* (91.72 cm^2), and treatment between SA 4 mM and FC 50% was the highest result in *B. rubra* (122.67 cm^2). The lowest plant leaf area is in plants that were exposed to severe drought stress (25% FC), both *B. alba* (57.55 cm^2) and *B. rubra* (57.59 cm^2).

Leaves number

The result showed that the treatment between SA and FC did not affect the number of leaves of *B. alba* and *B. rubra*. Table 1 shows that the DMRT test at a 5% level in *B. alba* had the highest yield, namely 18 leaves in the treatment (25% FC and 2 mM SA) compared to the control, which totaled 11 leaves. In *B. rubra*, the highest yield interaction was in the 50% FC treatment and 6 mM SA with 23 leaves compared to the control, which totaled 12 leaves. The values between treatments in the graph are not different enough. The lowest number of leaves of *B. alba* is in several interactions (100% FC, 2 mM SA; 100% FC, 6 mM SA; 75% FC, 2 mM SA; 50% FC, 0 mM SA; and 25% FC, 0 mM SA) that is 10 leaves, in *B. rubra* the lowest number of leaves in several interactions (50% FC, 0 mM SA; 25% FC, 6 mM SA; and 25% FC, 0 mM SA) with 11 leaves.

Photosynthetic parameters

Photosynthetic rate

The result indicates (Table 2) the treatment between SA 6mM and FC 50% was the highest result in *B. alba* (0.8663 µmol m^{-2} s^{-1}), while the lowest value is the interaction between FC 25% and SA 0 mM (0.1144 µmol m^{-2} s^{-1}). Treatment between SA 6mM and FC 75% was the lowest result in *B. rubra* (0.9202 µmol m^{-2} s^{-1}), and the highest is FC 25% and 0 mM SA (0.1406 µmol m^{-2} s^{-1}).

Table 1. The effect of interaction between Salicylic Acid (SA) and Drought Stress (DS) on *Basella alba* and *B. rubra* growth

Treatment	Height		Leaf area		Leaves number	
	B. alba	*B. rubra*	*B. alba*	*B. rubra*	*B. alba*	*B. rubra*
SA 0 Mm x FC 100%	48,20±2.27 D a	48.80±1.75 C ab	65.85±0.22 A a	58.75±0.23 A a	11±1.0 A a	12±2.51 A b
SA 2 Mm x FC 100%	35.13±4.35 D a	44.30±4.71 C a	65.11±0.77 A b	67.95±0.88 A d	10±1.73 A ab	15±3.51 A b
SA 4 Mm x FC 100%	43.16±1.79 D a	51.43±3.49 C a	66.63±0.48 A d	81.98±0.28 A c	12±2.51 A bc	12±4.35 A b
SA 6 Mm x FC 100%	27.90±1.35 D b	26.20±2.08 C b	74.86±0.78 A c	83.18±0.49 A b	10±1.0 A c	14±2.64 A b
SA 0 Mm x FC 75%	41.73±3.81 B a	51.93±4.16 B ab	74.61±0.43 D a	78.88±0.15 C a	8±2.08 B a	12±1.73 B b
SA 2 Mm x FC 75%	39.06±2.95 B a	33.23±2.66 B a	91.72±0.65 D b	87.45±0.07 C d	10±2.0 B ab	14±1.73 B b
SA 4 Mm x FC 75%	42.33±5.96 B a	49.50±1.05 B a	71.00±0.85 D d	122.67±0.23 C c	15±4.35 B bc	18±2.51 B b
SA 6 Mm x FC 75%	28.60±1.84 B b	25.56±5.12 B b	64.89±0.87 D c	66.67±0.33C b	16±5.03 B c	21±3.78 B b
SA 0 Mm x FC 50%	44.13±5.25 C a	48.63±6.76 C ab	74.58± 1.00 C a	76.90±0.87 D a	10±0.01 B a	11±1.00 BC b
SA 2 Mm x FC 50%	39.56±0.61 C a	42.20±4.45 C a	81.20±1.31 C b	68.76±0.64 D d	14±2.08 B ab	16±2.51 BC b
SA 4 Mm x FC 50%	50.16±2.65 C a	47.80±3.72 C a	82.8±1.18 C d	122.67±0.32 D c	16±5.03 B bc	17±4.35 BC b
SA 6 Mm x FC 50%	26.73±1.85 C b	25.56±1.96 C b	70.82±0.57 C c	74.64±0.48 D b	15±2.51 B c	23±3.78 BC b
SA 0 Mm x FC 25%	26.72±5.25 A a	44.06±10.79 A ab	57.55±0.24 B a	57.59±0.62 B a	10±0.57 B a	11±5.50 C b
SA 2 Mm x FC 25%	47.86±5.40 A a	50.50±2.69 A ab	91.67±0.85 B b	110.23±0.81 B d	18±2.0 B ab	12±3.24 C b
SA 4 Mm x FC 25%	47.86±2.02 A a	52.70±3.25 A ab	91.71±±0.43 B d	68.100± 1.11 B c	16±3.51 B bc	12±3.21 C b
SA 6 Mm x FC 25%	52.90±1.20 A b	32.43±1.91 A b	64.50±0.39 B c	58.75±0.43 B b	16±2.08 Bc	11±5.03C b

Note: Different capital letters mean SA and DS levels, with each SA level marked in upper case letters significantly different, and DS marked in lower case based on the DMRT test at 5% level

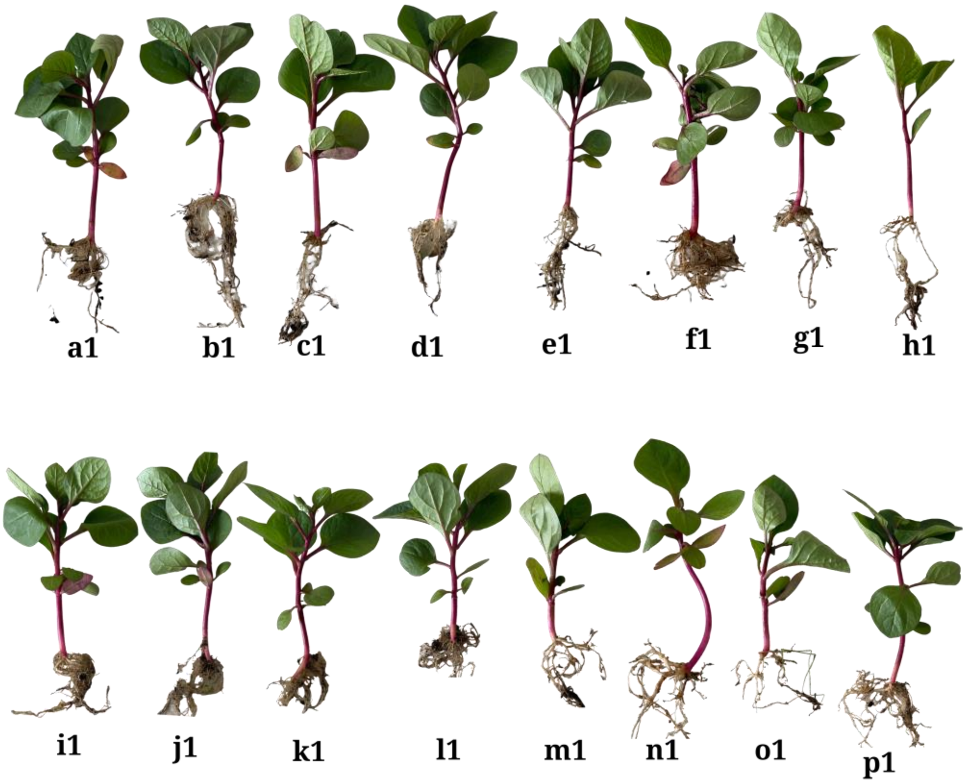

Figure 1. All parts of *Basella rubra* plant. Note: a1. Control (not given stress and salicylic acid), b1. SA 0mM+FC 75%, c1. SA 0mM+FC50%, d1. SA 0mM+FC 25%, e1.SA 2mM+FC 50%, f1. SA 4mM+ FC 50%, g1. SA 6mM+FC 50%, h1. SA 2mM+FC 100%, i1. SA 4mM+FC 100%, j1. SA 6mM+FC 100%, k1. SA 2mM+FC 75%, l1. SA 4mM+ FC 75%, m1.SA 6mM+FC 75%, n1. SA 2 mM+FC 25%, o1. SA 4mM+FC 25%, p1. SA 2mM+FC 25%

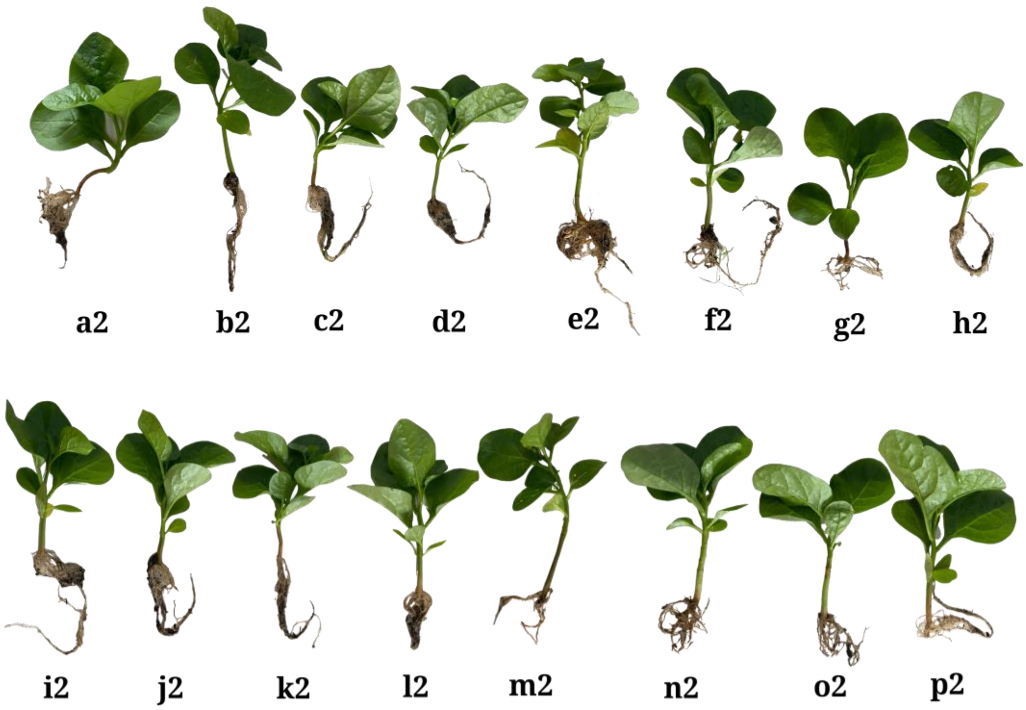

Figure 2. All parts of *Basella alba* plant. Note: a2. Control (not given stress and salicylic acid), b2. SA 0mM+FC 75%, c2. SA 0mM+FC50%, d2. SA 0mM+FC 25%, e2.SA 2mM+FC 50%, f2. SA 4mM+ FC 50%, g2. SA 6mM+FC 50%, h2. SA 2mM+FC 100%, i2. SA 4mM+FC 100%, j2. SA 6mM+FC 100%, k2. SA 2mM+FC 75%, l2. SA 4mM+ FC 75%, m2.SA 6mM+FC 75%, n2. SA 2 mM+FC 25%, o2. SA 4mM+FC 25%, p2. SA 2mM+FC 25%

Table 2. The effect of interaction between salicylic acid and drought stress on *Basella alba* and *B. rubra* photosynthesis rate

Treatment	Transpiration rate		Photosynthesis rate		Stomata conductance	
	B. alba	***B. rubra***	***B. alba***	***B. rubra***	***B. alba***	***B. rubra***
SA 0 Mm x FC 100%	0.012±0.0001 A c	0.0465±0.06 A a	0.2674±0.0001 B a	0.2133±0.0001 B a	0.1888±0.0001 B a	0.1615±0.004 A a
SA 2 Mm x FC 100%	0.0291±0.006 A a	0.0169±0.0002 A b	0.1084±0.002 B b	0.2424±0.002 B b	0.1084±0.002 B b	0.1885±0.0017 A b
SA 4 Mm x FC 100%	0.037± 0.002 Ad	0.018±0.001 A a	0.2636±0.002 B c	0.2423±0.002 B c	0.2636±0.002 B c	0.3869±0.004 A c
SA 6 Mm x FC 100%	0.0501±0.002 A b	0.0189±0.0001 A a	0.3962±0.0005 B d	0.1341±0.0005 B d	0.3962±0.0005 B d	0.1965±0.004 A d
SA 0 Mm x FC 75%	0.0197±0.0003 C c	0.0155±0.001 A a	0.1144±0.002 A a	0.2442±0.002 D a	0.1144±0.002 A a	0.326±0.006 C a
SA 2 Mm x FC 75%	0.0191±0.0002 C a	0.0425±0.0001 A b	0.2145±0.003 A b	0.5059±0.003 D b	0.2145±0.003 A b	0.1857±0.001 C b
SA 4 Mm x FC 75%	0.0108±0.0002 C d	0.0196±0.001 A a	0.5852±0.001 A c	0.2944±0.001 D c	0.5852±0.001 A c	0.5865±0.002 C c
SA 6 Mm x FC 75%	0.0643±0.0001 C b	0.0475±0.003 A a	0.6367±0.003 A d	0.9202±0.003 D d	0.6367±0.003 A d	0.9736±0.0005 C d
SA 0 Mm x FC 50%	0.0104±0.0007 B c	0.0105±0.0009 A a	0.3735±0.001 D a	0.464±0.001 A a	0.3735±0.001 D a	0.3368±0.004 D a
SA 2 Mm x FC 50%	0.0108±0.001 B a	0.0196±0.0006 A b	0.2446±0.003 D b	0.7448±0.003 A b	0.2446±0.003 D b	0.7258±0.003 D b
SA 4 Mm x FC 50%	0.0128± 0.0003 B d	0.024±0.0007 A a	0.8365±0.004 D c	0.8828±0.004 A c	0.8365±0.004 D c	0.9552±0.003 D c
SA 6 Mm x FC 50%	0.189±0.007 B b	0.0386±0.0008 A a	0.8663±0.002 D d	0.507±0.002 A d	0.9468±0.002 D d	0.8934±0.0007 D d
SA 0 Mm x FC 25%	0.0097± 0.001 D c	0.0121±0.002 B a	0.1144±0.007 C a	0.1406±0.0007 C a	0.1889±0.0007 C a	0.1857±0.001 B a
SA 2 Mm x FC 25%	0.0643±0.001 D a	0.0137±0.0004 B b	0.8044±0.002 C b	0.9075±0.002 C b	0.8044±0.002 C b	0.9546±0.003 B b
SA 4 Mm x FC 25%	0.0195±0.0001 D d	0.0192±0.004 B a	0.6716±0.003 C c	0.3773±0.003 C c	0.6716±0.003 C c	0.9736±0.005 B c
SA 6 Mm x FC 25%	0.011±0.001 D b	0.0285±0.0007 B a	0.2375±0.002 C d	0.5366±0.002 C d	0.2375±0.002 C d	0.3842±0.0005 B d

Note: Different capital letters mean SA and DS levels, with each SA level marked in upper case letters significantly different, and DS marked in lower case based on the DMRT test at 5% level

Transpiration rate

The results showed (Table 2) the highest value of *B. alba* plants at 50% FC and 6 mM salicylic acid (0.1890 µmol m^{-2} s^{-1}) compared to the control (0.012 µmol m^{-2} s^{-1}), while the lowest value was in the FC treatment 25% and 0 mM salicylic acid (0.0097 µmol m^{-2} s^{-1}). In *B. rubra*, the highest value was 75% FC and 6 mM salicylic acid (0.0475 µmol m^{-2} s^{-1}) compared to control (0.0465 µmol m^{-2} s^{-1}), the lowest value was 25% FC, 0 mM salicylic acid (0.0121 µmol m^{-2} s^{-1}).

Stomata conductance

The highest stomatal conductance (Table 2) of *B. alba* was at 50% FC and 6 mM salicylic acid (0.9468 µmol m^{-2} s^{-1}) compared to control (0.1888 µmol µmol m^{-2} s^{-1}), while the lowest value was in the FC 25% and 0 mM salicylic acid (0.1889 µmol m^{-2} s^{-1}). In B. *rubra,* the highest value was at 75% FC and 6 mM salicylic acid (0.9736 µmol m^{-2} s^{-1}) compared to the control (0.1615 µmol m^{-2} s^{-1}), the lowest value was at 25% FC and 0 mM salicylic acid (0.1857 µmol m^{-2} s^{-1})

Correlation between growth parameters and photosynthesis

The value of the correlation coefficient between parameters in *Basella* plants is shown in Table 3. Significant correlations were obtained between several growth parameters and the photosynthetic rate of *B. alba*. This shows that several growth parameters significantly contribute to the rate of photosynthesis and vice versa for the plants studied. As shown in Table 3 there is a positive linear correlation between height and leaf area (r^2=0.247*), number of leaves and photosynthetic rate (r^2=0.370**) and transpiration rate (r^2=0.258*). Furthermore, leaf area is positively correlated with photosynthetic rate (r^2=0.258*), photosynthetic rate is positively correlated with transpiration rate (r^2=0.203*). For parameters that have a negative correlation only between plant height and transpiration rate ($r^{2=}$-0.344**).

Discussion

Interaction effect between DS and SA on growth and photosynthesis rate

Drought stress greatly affects plant’s physiological and biochemical activities, including photosynthesis, respiration, transpiration, hormone metabolism, and enzyme activity. ROS increases during drought stress, causing plant toxicity due to reduced electron transport activity. Excessive ROS Destroys Nucleic Acids (DNA), proteins, photosynthetic pigments, and membrane lipids and causes inactivation of enzymes involved in metabolism. Salicylic acid in plants experiencing drought stress inhibits catalase (CAT) activity; hence H_20_2 increases. Furthermore, H_20_2 helps increase the activity of entioxidant enzymes to increase resistance in activating ROS. Plant responses to drought stress are varied, involving various mechanisms such as defense or modification of physiology, morphology, anatomy, and biochemistry, as well as adaptation processes related to short-term and long-term development and growth (Kordi and Fardin 2013; Hossain et al. 2015; Okunlola et al. 2017; Abobatta 2019; Hasanuzzaman et al. 2020; Zulfiqar and Ashraf 2021;)

Plants at 100% field capacity are in optimal growth conditions; water availability below field capacities inhibits plant metabolism. Under drought stress, plants are generally smaller because their vegetative growth is stunted. Salicylic acid and its derivatives sprayed on the leaves increased drought tolerance in Basella experiencing dry stress. Research shows that the application of salicylic acid (Morovvat et al. 2021) reported treatment of potatoes showed a significant effect on the water supply status of the plants; the effect of salicylic acid on irrigation treatment 60 and 80% showed an increase in potato yields under severe drought stress conditions. The best yield treatment was salicylic acid treatment with 100% irrigation. The reduction in length and weight caused by drought stress can be tolerated by applying Salicylic Acid (SA), which helps maintain internal water balance and protein synthesis during drought stress. Therefore, reducing leaf area during drought stress is an adaptation to reduce water loss through transpiration. Some plants can't maintain growth from drought stress when the field capacity is 100-50%. The turgor pressure of plants cannot be maintained if drought stress is severe (Yang et al. 2022).

Plants at various growth phases recognize drought stress and depend on the sensitivity or variety of the plant. For example, in this study, the two types of Basella showed that the growth percentage was not significantly different (Table 1). That shows Basella plants are not too sensitive to dry stress ranging from mild to severe intensity during the vegetative stage (growth of roots, stems, and leaves). This can be related to the synthesis of carbohydrates for cell division and growth due to the closure of stomata and considered to be repaired. Dry stress during the vegetative phase causes plant degeneration and poor and late germination, which affects plants' proper development; the responses of these two form *Basella* plants to drought through a tolerance mechanism. Drought avoidance describes the capacity of plants to maintain high water levels even with adequate humidity. This drought tolerance is the plant's ability to maintain a relatively high tissue water potential (Barnabás et al. 2008; Kumar et al. 2017; Yang et al. 2019)

Table 3. Pearson correlation matrix between growth parameters and photosynthesis

Parameters	Height	Leaves number	Leaf area	Photosynthesis	Transpiration	Stomata
Height	1					
Leaves number	-0,136	1				
Leaf area	.247*	0,190	1			
Photosynthesis	0.038	.370**	.258*	1		
Transpiration	-.344**	.258*	0,044	.203*	1	
N	96	96	96	96	96	96

Note: * Correlation is significant at the 0.05 (2-tailed), **Correlation is significant at the 0.01 level (2-tailed)

Photosynthesis is the main metabolic process that regulates plant growth and yield; this process is strongly influenced by water availability and nutrients in the soil. In dry stress, closing stomata reduces the amount of carbon dioxide reaching the leaves, causing the formation of ROS. Phytohormones such as salicylic acid are important in physiological and biochemical changes. A very important role of SA physiological response changes leading to plant adaptations to unfavorable environments has been reported. Although water shortages are harmful, plants can respond to varying degrees of water shortages; avoidance and tolerance mechanisms exist. The ability of plants to adapt to dry stress affects their biochemistry, physiology, and growth, especially photosynthesis (Nazar et al. 2015; Mishra et al. 2018; Sharma et al. 2022).

Drought stress (abiotic stress) decreases the photosynthesis rate (A), but applying salicylic acid sprayed on the leaves can reduce the impact. Dry stress with a 25% FC concentration is a severe condition for plants; a very low water deficit affects the photosynthetic rate, transpiration, and stomatal conductance (Table 2). During dry stress, stomata close progressively, followed by a decrease in photosynthesis. Closing of stomata significantly reduces the rate of photosynthesis and transpiration and negatively impacts plant growth and productivity. During drought stress, stomata limit gas exchange by closing stomata, which affects photosynthesis due to the limited CO_2 absorbed from the air. The stomata are closed to prevent excessive water loss from transpiration. Closing of stomata results in reduced NADPH during the Calvin cycle, so electron transport during photosynthesis decreases. During dry stress, photosynthetic activity is disrupted due to the energy balance between absorption capacity and energy uses. The rate of transpiration is greatly reduced under conditions of severe dry stress, but salicylic acid presumably can fix it (Pinheiro and Chaves 2011; Pirasteh-Anosheh et al. 2016; Liang et al. 2020; Rehschuh et al. 2020; Khalvandi et al. 2021; Alam et al. 2023).

This process begins by accumulating Abscisic Acid (ABA), closing stomata, and forming ROS. Furthermore, there was a decrease in the activity of carboxylase/oxygenase (Rubisco), NADP-malic enzyme, ribulose-1, 5-biphosphate, phosphoenolpyruvate carboxylase, pyruvate orthophosphate dikinase (PPDK) and fructose-1, 6-biphosphate (FEBase). Then the activity of rubisco is inhibited, causing downregulation of non-cyclic electron transfer, thereby inhibiting energy biosynthesis (ATP) and then a decrease in the rate of photosynthesis (Farooq et al. 2009). This study observed that the exogenous application of SA enhanced growth and photosynthesis and reduced the harmful caused by dry stress. SA-induced increase in photosynthesis, transpiration, and stomatal conductance during drought stress is caused by changes in physiological and biochemical processes due to SA induction. In our experiment, the photosynthesis rate increased significantly in drought-treated two species of *Basella* plant, and SA application enhanced the rate levels in these plants. The results of our research are SA can increase the rate of photosynthesis in plants experiencing drought following research by Khalvandi et al. (2021) that the rate of photosynthesis increased by 28%, 48%, and 25% in winter-wheat given control and dry stress treatments.

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