J. Appl. Environ. Biol. Sci., 7(6)76-80, 2017
© 2017, TextRoad Publication

ISSN: 2090-4274
Journal of Applied Environmental and Biological Sciences
www.textroad.com

The Effect of Water Stress on Growth and Capsaicin Content of Cayenne Pepper (*Capcisum frutences L.*)

Arum Pratiwi[1], Seto Sugianto P.R[2]

[1]Departement of Agriculture, Agriculture of Extension College Malang, Indonesia
[2]Departement of Aquaculture, University of Brawijaya Malang, Indonesia

Received: January 16, 2017
Accepted: March 26, 2017

ABSTRACT

Cayenne pepper is a vegetable fruit very popular with the public in Indonesia. Chillies contain many essential oils that gives a spicy flavor and heat. The spicy flavor caused by the content capsaicin ($C_{18}H_{27}NO_3$) is very high. Pepper fruit contains a lot of Vitamin A and C. Problems crop irrigation chili among other things that still rely on rain-fed. So the efficiency of irrigation based on crop water needs to be considered to increase the national production of cayenne pepper. The purpose of this research is to know the effect of water stress on growth and capsaicin content of cayenne pepper. The experiment was installed as a completely randomized design, with one treatment and 5 replicates. The drought condition was be indicated with capacity field of media on 4 level, that was 40% field capacity; 60% field capacity, 80% field capacity, and 100% field capacity (waterlogged). The result of the research indicated that the growth of Cayenne pepper was be inhibited by drought condition. The higher of water stress had impacted on the lower of growth parameters (dry weight, water use efficiency, relative growth rate), but oppositely, the higher of water stress, the higher of capsaicin content. The drought condition (40% field capacity) had been resulted the highest capsaicin content. The waterlogged condition (100% field capacity) had been resulted the lowest capsaicin contents. As consideration for chili cultivation techniques, it is advisable to use a water availability level between 40-60% to obtain high levels of capsaicin. If the dry weight of the plant became the purpose of cultivation, the level of water availability of 80% will produce the best dry weight accumulation.

KEYWORDS - *water stress, field capacity, capsaicin, cayenne pepper, drought condition*

INTRODUCTION

Cayenne Pepper is one vegetable crop with the potential to develop its use in Indonesia, the plant is known by the name of cabai rawit. This plant has been cultivated extensively both for farmers and companies in Indonesia, but the problems that often occur this plant has a different sense of spiciness during the dry season and the rainy season.[2]

Cayenne pepper is a vegetable fruit very popular with the public in Indonesia. Chillies contain many essential oils that gives a spicy flavor and heat. The spicy flavor caused by the content capcaisin ($C_{18}H_{27}NO_3$) very high. Chili fruit contains a lot of Vitamin A and C. Problems crop irrigation chili among other things that still rely on rain-fed. So the efficiency of irrigation based on crop water needs to be considered to increase the national production of cayenne pepper . Proline is of secondary metabolites, which are generally formed as a response to the drought and salinity in the environment. [7]. To anticipate the growing need continuously and has a quality as raw material fitofarmaka, then efforts need proper cultivation [2]. The water needs of plants vary, depending on the type of plant and its growth phase. In the dry season, the plants often get water stress (water stress) due to insufficient supply of water in the root zone and evapotranspiration rate that exceeds the rate of absorption of water by plants [7]. In contrast to the rainy season, plants often suffer water saturated conditions.

Plant roots grow into the soil moist and draw water until the water reached critical potential in the soil. The water can be absorbed from the soil by plant roots is called the available water. The water provided is the difference between the amount of water in soil at field capacity and the amount of water in soil at permanent wilting percentage. Water at field capacity is the water that remains in the soil does not flow downward due to gravity; while the percentage of water in the permanent wilting when the soil moisture is the plants that grow on it will wilt and will not be refreshed in an atmosphere with a relative humidity of 100% [4].

Water often limits plant growth and development of aquaculture. The response of plants to water shortage can be seen in metabolic activities, the morphology, growth rate, or productivity. Cell growth is a function of the plants most sensitive to water shortages. Lack of water will affect the cell turgor so that will reduce the development of cells, protein synthesis and cell wall synthesis [4]. Effect of lack of water during the vegetative level is the development of the leaves are smaller in size, which can reduce the absorption of light.

***Corresponding Author:** Arum Pratiwi, Departement of Agriculture, Agriculture of Extension College Malang, Indonesia.

Lack of water also reduces the synthesis of chlorophyll and reduce the activity of some enzymes (eg. nitat reductase). Lack of water actually increases the activity of enzymes hydrolysis (eg. amylase) [6].

Drought stress can lower the level of productivity (biomass) plants, because of the declining primary metabolism, depreciation leaf area and photosynthetic activity. The decline in biomass accumulation due to water stress for each type of plant is not the same magnitude. It is influenced by the respective response type of plant. Decrease in accumulated biomasaa types of medicinal plants Centella (*Centella asiatica L.*) reached 48.9% in drought stress 50% of field capacity and unable to grow at 40% of water stress KL (Rahardjo. 2009). The decline in plant biomass accumulation tempuyung (*Sonchus arvensis L.*) reached 52.8% in water stress by 50% compared with the KL water stress tempuyung 80. Plants grown under dry conditions with full light intensity, the level of flavonoids is higher than the plants grown on a wet climatic regions and under naungan.Tanaman tempuyung receiving water stress equal to 60% of field capacity, the level of flavonoids than doubled compared with plants that are not exposed to stress [10]. Based on genetic factors, the adaptability of plants to environmental stress vary [2], reported that Vicia faba treated drought stress will show a physiological response that leaf stomata to close, decreasing the number and leaf area. The physiological responses of the root (root dry weight, number and effectiveness of root nodules) decreases rapidly with increasing drought stress. In the soybean plants, plant resistance to stress drought is characterized by a better root system, and the ability of osmotic adjustment and increased proline content in the leaves [5]. At the plant periwinkle (Vinca rosea L.) drought stress 40% and 60% of field capacity, reducing growth and biomass plants significantly [13]. Plant secondary metabolites have long been known to have many benefits for plants such as medicine or pharmaceutical, food dyes, pesticides and fragrances [5]. As for his own plant secondary metabolites are often instrumental to the survival of a species in the face of other species [8].

Capsaicin is a secondary metabolite belonged terpene glycosides [6]. Capsaicin is a powerful surface active compounds, which cause foam when shaken in water, soluble in alcohol, and can menghemolisis animal blood. Given the importance of the cayenne pepper plant is on the content of the active ingredient, it is necessary to investigate the active ingredient (secondary metabolites) of these plants on soil water availability conditions were different. This research is expected to obtain information about the accumulation of secondary metabolites cayenne on drought conditions and water saturated condition so it can be used as reference in cultivation techniques.

The purpose of this study was to determine the growth and content of capsaicin cayenne pepper (*Cayenne pepper L.*) under conditions of water stress. The benefits of this research is to obtain information about the growth response of cayenne pepper to the availability of different water so it can be used as reference in cultivation techniques.

RESEARCH METHODS

The experiments were performed in the greenhouse Laboratory Brawijaya University, starting in July to November 2016. The analysis carried out in the Lab capsaicin content. Biochemistry Faculty of Agricultural Technology Brawijaya University.

Seed cayenne pepper (Cayenne pepper L.) were used as research material obtained from local stone. Disenai seed. Results nursery aged 3 Week used for planting and as research material.

Media planting using soil type of the area is Andisol. Dried and sieved soil. After being weighed each weighing 250 g, the land put into polybags-polybags. Soil is then calculated lapangnya capacity by gravimetric methods (weighing). Basic fertilizer urea used is 12.5 mg, 37.5 mg SP36, and 37.5 mg of KCl. Routine maintenance was conducted on the watering (according to treatment), weeding (manually), and pest and disease control (if required).

The study design experiment using a completely randomized design with one factor is the level of water supply (40%, 60%, 80%, and 100% of field capacity), with five replications. Treatment was given for 12 weeks (3 months), starting when the plant was three weeks after planting. To maintain the treatment conditions, the addition of water in accordance with the availability of water is determined by weighing method. Plants were harvested at 16 weeks (four months) after treatment. Plants that have been harvested put into paper bags for the oven (temperature 70-800C) for 4-5 days until a constant weight is reached.

The parameters observed were plant dry weight, relative growth rate, canopy-root ratio, water use efficiency, bulbs capsaicin levels, and the levels of capsaicin total. Dried tubers as much as 0.1 g crushed by mortal up into a fine powder. Fine powder which has been incorporated into a test tube and then extracted with ethanol 70% on top of the water heater at 800 for 15 minutes. Results ekstraks its absorbance was measured using a UV-VIS spectrophotometer at a wavelength of 365 nm. Levels of capsaicin and capsaicin Merc calculated using as a comparison [11].

Plants were harvested at 16 weeks (4 months) days after the treatment. The parameters observed were plant dry weight, canopy-root ratio, relative growth rate, water use efficiency, bulbs capsaicin levels, and the

levels of capsaicin total. Data were analyzed by analysis of variance followed by Duncan Multiple Range Test level 1%, 5%, or 10% [12].

RESULT AND DISCUSSION

The availability of water will affect the growth and development of plants. The growth of a plant can be measured by dry weight and relative growth rate. The dry weight of the total biomass of plants that form, is seen as a manifestation of metabolic processes occurring in the plant body. Biomass plants include the results of photosynthesis, uptake of nutrients and water. Dry weight can indicate plant productivity because 90% of photosynthesis are in the form of dry weight [4]. From the data it is known that the growth parameters of soil moisture treatment difference (40.60, 80, and 100% of field capacity) will reduce the accumulation of plant dry weight of cayenne pepper.

The process of enlargement and cell expansion, in addition influenced by hormonal factors, are also affected by cell turgor. The availability of water is low (40 and 60% of field capacity) will degrade cell turgor pressure. Cell turgor is low will reduce the ability of cells to be stretched, so it will affect growth and development. The effect of different water availability to dry weight of plants can be seen in Table 1 the availability of water to 40% of field capacity generating plant dry weight is lower than that of 80% of water availability. Availability of water equal to 80% of field capacity is known to be the optimum level of water availability, because the level of water availability is higher (ie. 100%) the accumulation of dry weight it is smaller.

Availability of water 100% of field capacity caused ground cayenne pepper grown into a place saturated by water and is thought this will only complicate the absorption of water and nutrients by the plant roots for the creation of anaerobic conditions approaching.

Table 1. The Effect of water availability in the dry weight of plant

Field Capacity	Age of Plant				
(Water Avaibility)	21 dap	35 dap	49 dap	63 dap	80 dap
40%	0,139[a]	0,286[a]	0,307[a]	0,457[a]	0,556[a]
60%	0,123[a]	0,453[b]	0,479[ab]	0,689[b]	0,789[a]
80%	0,183[a]	0,571[b]	0,912[c]	1,202[c]	1,352[b]
100%	0,198[a]	0,568[b]	0,794[bc]	0,994[b]	1,134[b]
* dap : days after planting					

The effect of different water availability to the canopy-root ratio can be seen in Table 2. The allometry of growth canopy and root growth (usually expressed as the ratio of the canopy-root) has a physiological interest. Header-root ‘ratio can describe one type of tolerance to drought. Header-root ratio is controlled by genetic factors and environmental factors [4]. Basically growth is a balance between the acquisition of carbon in photosynthesis and respiration expenditure. In drought stress (eg. drought), the balance will undergo changes that can leadinterference with the growth [1]. Header-root ratio may indicate the growth is related to the availability of water and unsurhara especially nitrogen in the soil. Lack of water which inhibit the growth of the canopy and roots, have a relatively larger impact on the growth of the canopy [4].

Table 2. The effect of water availability to the header-root ratio

Field Capacity	Age of Plant				
(Water Avaibility)	21 dap	35 dap	49 dap	63 dap	80 dap
40%	1,29	3,01	3,08	4,31	5,95
60%	1,13	2,98	3,04	4,58	6,32
80%	1,14	2,21	2,46	3,86	5,64
100%	1,26	2,12	2,49	3,97	5,58
* dap : days after planting					

Table 3. The effect of water availability to the relative growth rate of plants

Field Capacity	Age of Plant				
(Water Avaibility)	21 dap	35 dap	49 dap	63 dap	80 dap
40%	0,035	0,047	0,052	0,059	0,062
60%	0,036	0,047	0,054	0,061	0,068
80%	0,039	0,054	0,062	0,066	0,078
100%	0,037	0,057	0,065	0,068	0,073
* dap : days after planting					

The effect of different water availability to the relative growth rate of plants can be seen in Table 3. Availability of water to 40% of field capacity generating plant relative growth rate smaller than that of 80% in

water availability. The process of enlargement and cell expansion, in addition influenced by hormonal factors, are also affected by cell turgor. Relative growth rate showed an increase in weight of biomass crops within an interval of time compared to the weight of the initial plant [4]. Relative growth rate is generally based on the measurement of the dry weight of the plant. From Table 3 it is known that the provision of water availability of different causes relative growth rate of cayenne pepper plant is different.

Tabel 4. The effect of different water availability to water use efficiency

Field Capacity	Age of Plant				
(Water Avaibility)	21 dap	35 dap	49 dap	63 dap	80 dap
40%	0,41	0,49	0,52	0,61	0,68
60%	0,71	0,75	0,78	0,93	0,98
80%	0,97	1,08	1,12	1,43	1,52
100%	0,88	0,92	0,96	1,23	1,32
*** dap : days after planting**					

Growth is concentrated header when available nitrogen (N) and water; whereas root growth is encouraged when factors nitrogen and water is limited. This will affect the header-root ratio. Header-root ratio is used to determine the ability of plants to maintain a functional balance in environments experiencing stress. Header-root ratio is plastic; its value will increase in the conditions of supply of water, nitrogen, oxygen, and low temperatures [3]. This happens because in plants that experienced stress will allocate most of their photosynthetic production to storage organs.

On the availability of water 80 and 100% of field capacity, relative growth rate of cayenne pepper plant is higher than plants growing on the availability of water 40 and 60% of field capacity. This is thought to occur because of the availability of high water will affect the cell turgor; cell turgor will affect the expansion of cells that will determine the rate of growth (biomass accumulation / dry weight). The effect of different water availability to water use efficiency can be seen in Table 4. Differences in water availability does not affect the efficiency of water use cayenne pepper tested. Water use efficiency (WUE water-use efficiency) related to the amount of water used to produce crops (biomass). Generally sought from research on WUE is a tall plants WUE its value while maintaining high productivity.

Table 5. The effect of different water Avaibility to produce levels of capsaicin/fruits

Field Capacity	Harvest to		
(Water Avaibility)	1	2	3
40%	22,57	23,21	23,18
60%	16,67	16,33	16,73
80%	13,11	14,23	13,98
100%	10,76	11,17	11,23

Table 6. The effect of different water Avaibility to produce levels of capsaicin/plant

Field Capacity	Harvest to		
(Water Avaibility)	1	2	3
40%	38,21	38,82	38,77
60%	30,98	31,12	30,96
80%	28,44	28,88	28,33
100%	27,21	28,12	28,11

The availability of different water will produce different levels of capsaicin. The availability of water is low (40%) provide the highest levels of capsaici. The higher the level of availability of water, the levels of capsaicin to be decreased. Similarly to the levels of capsaicin total. Capsaicin is one of secondary metabolites. Secondary metabolites in general will increase its accumulation in the body of plants when plants undergo environmental stresses (including drought) [6]. In general, the higher the level of water availability will decrease the accumulation of plant dry weight, but instead will increase the active ingredient is capsaicin cayenne pepper plants. As a medicinal plant, which will usefulness into consideration is the content of the active ingredients, so as to cultivate chili plants should be considered in terms of the quality of the drug substance (high content of active ingredient) ata in terms of quantity (higher plant dry weight).

CONCLUSION

Availability of water (40, 60, 80, and 100%) affecting the dry weight, growth rate relative, efficient use of water, fruit capsaicin levels, and the levels of total capsaicin cayenne pepper plant (*Capsicum frutences L.*). Availability of water does not affect header-root ratio. In general, the higher the level of availability of water, the accumulation of plant dry weight will decrease, whereas the levels of capsaicin will increase. As

consideration for chili cultivation techniques, it is advisable to use a water availability level between 40-60% to obtain high levels of capsaicin. If the dry weight of the plant became the purpose of cultivation, the level of water availability of 80% will produce the best dry weight accumulation.

REFERENCES

[1] Amthor, J.S. 2004. Plant respiratory responses to the environment ang their effects on the carbon balance. *In:* Wilkinson, R.E. *Plant Environment Interactions*. New York: Marcell Dekker, Inc.

[2] Darwati, I., M. Rahardjo, S.M.D., dan Rosita. 2010. Produktivitas cabai (*Capcisum Annum L.)* pada beberapa komposisi bahan organik. *Jurnal Littri* 6 (1): 1-4.

[3] Fitter, A.H. dan R.K.M. Hay. 2008. *Fisiologi Lingkungan Tanaman*. Yogyakarta: Gadjah Mada University Press.

[4] Gardner, F.P., Perace, R.B., dan Mitchell, R.L. 2001. *Fisiologi Tanaman Budidaya*. Penerjemah: Susilo, H. Jakarta: UI Press.

[5] Heble, M.R. 2006. Production of secondary metabolie through tissue culture and its prospects for commercial use. *In:* Islam, A.S. (ed.) *Plant Tissue Culture.* New Delhi: Science Publisher, Inc.

[6] Hopkins, W.G. 2009. *Introduction to Plant Physiology*. Toronto: John Wiley and Sons, Inc.

[7] Levitt, J. 2008. *Responses of Plant to Environmental Stresses, Volume II: Water, Radiation, Salt, and Other Stresses.* New York: Academic Press.

[8] Manitto, P. 2012. *Biosintesis Produk Alami*. Semarang: IKIP Semarang Press.

[9] Mead, R., R.N. Curnow, and A.M. Hasted. 2003. *Statistical Methods in Agriculture and Experimental Biology*. London: Chapman and Hall.

[10] Rahardjo, M. dan I. Darwati. 2009. Pengaruh cekaman air terhadap produksi dan mutu simplisia Tempuyung (*Sonchus arvensisL.*). *Jurnal Littri* 6 (3): 73-79.

[11] Stahl, E. 2009. *Analisis Obat Secara Kromatografi dan Mikroskopi.* Penerjemah: Padmawinata, K. dan I. Sudiro. Bandung: ITB.

[12] Steel, R.G.D. and J.H. Torrie, 2009. *Prinsip dan Prosedur Statistika, Suatu Pendekatan Biometrik*. Jakarta: Penerbit PT. Gramedia.

[13] Sukarman, I. Darwati, dan D. Rusmin. 2000. Karakter morfologi dan fisiologi tapak dara (Vinca rosea L.) pada beberapa cekaman air. *Jurnal Littri* 6 (2): 50-54.