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Application Of Organic Matter To Increase Growth And Yield Of Cowpea (Vigna Unguiculata L.) Under Drought Stress Conditions

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ABSTRACT

Cowpea (Vigna unguiculata) or better known as tolo bean is a plant that can be developed, because it contains high nutrition, especially protein, this causes cowpea as a substitute for soybeans.The research that will be carried out aims to: 1) obtain cowpea cultivation technology under drought stress conditions with selected organic matter 2) obtain the best combination of drought stress and types of organic matter that can increase the growth and yield of cowpea. The research method was carried out by experimenting in a green house, the study was carried out in August – November 2020. The experiment was treated with a Randomized Block Design (RBD) with two factors. The first factor is organic matter and consists of three kinds, namely: Control (without organic matter) (CO), Manure (PK), Rice husk biochar (BC).The second factor is drought stress which consists of 3 types, namely: 50% field capacity (K1), 75% field capacity (K2) and 100% field capacity (K3). From the treatment, 9 experimental combinations were obtained and each experiment was repeated 3 times so that 27 units of treatment combinations were obtained. The results showed that the application of organic matter in the form of cow manure and 75% field capacity ould be used in cowpea cultivation under drought stress conditions. Giving 75% field capacity was still able to maintain the growth and yield of cowpea on the number of leaves, leaf area, number of filled pods, number of seeds and seed weight. Cow manure was able to increase the growth and yield of cowpea under drought stress conditions with 75% field capacity which was indicated by the interaction on the total dry weight parameter of the plant.The proline content of cowpea leaves increases as the field capacity decreases.

Keywords: stress, drought, cowpea, organic matter

INTRODUCTION

Cowpea (Vigna unguiculata) is a plant that has the potential to be developed. Because it contains high nutrition, particularly protein, cowpea is used as a substitute for soybeans. Soybean is one of the processed food products that has the potential to be developed in order to reduce soybean consumption and support food diversification. Cowpeas without mixed soybeans can produce high-quality tempe. Cowpeas have a high nutritional value after being processed into tempeh. Cowpea tempeh contains 34 g protein, 3 g fat, 53 g carbohydrates, 3 g fiber, and 1 g ash per 100 g. Cowpeas have roughly the same amount of essential amino acids (amino acids that the body cannot synthesize) as soybeans (Haliza et al., 2010). Furthermore, cowpea is able to adapt widely in the tropics and subtropics with dry to slightly dry conditions. Karsono, 1998; Hall et al., 2003; Kumar & Narain 2005; Kébé et al., 2016; Singh, 2016).

The potential yield of cowpea seeds ranges from 1.5 to 2.0 t ha-1 depending on the variety, location and growing season as well as the cultivation applied (Adisarwanto et al., 1998). One of the processed food products that has the opportunity to be developed to reduce soybean consumption and support food diversification is non-soybean. Currently, cowpea varieties are limited to only 9 varieties, including KT-1, KT-2, KT-3, KT-4, KT-5, KT-6, KT-8 and KT-9, and several local accessions of peanuts. dadap, white tolo beans, and red tolo beans (Setyowati and Sutoro, 2010).

One of the advantages of cowpea is that it can thrive in dry environments and this makes it the crop of choice in the semi-arid/arid zones of West and Central Africa. Cowpea is Africa's most versatile crop because it can be used as human food, fodder for livestock and because of its ability to fix nitrogen which increases soil fertility, helping to increase cereal yields when grown in rotation and contributing to the sustainability of cropping systems. The mechanism by which cowpeas are able to witDAPand vegetative-level drought may be related to the limited decrease in leaf water potential even under extreme drought. The lowest leaf water potential recorded for cowpea was -18 bar (-1.8 MPa) (Blade et al., 1997; Mortimoreet al., 1997; Kristjanson, 2005;Asiwe, 2009;Agbicodo et al., 2011; Moray,2014; Carvalho et al.,2017;Gerrano et al., 2017;Muñoz-Amatriaín et al., 2017;).

Drought-resistant cowpea varieties are found to be quite good, but their production is still relatively low, according to the findings of Sing and Matsui, (2002), Slabbert and colleagues (2004); Jaleel and colleagues (2008); Goufo and colleagues (2017); Karuwal and colleagues (2018). Drought-tolerant plants that can boost cowpea production must be treated. In addition to providing organic materials, there are other benefits. Adding organic matter can improve soil quality and make it more suitable for drought-stricken areas in addition to providing nutrients. The chemical, physical, and biological fertility of soil can be improved by adding organic matter. Soil porosity can be improved by adding more organic matter to the mix (through increased activity of soil fauna).

A soil's water-holding capacity can be increased by adding organic matter to the soil. By either "sticking" together soil particles or by providing ideal conditions for soil life, organic matter in the soil increases soil micropore and macropore numbers (Bot and Benites, 2005). Soil chemical properties in Entisol soils are significantly improved by organic matter, which increases available P, total N, available K, carbon content, humic acid, sulfuric acid, and maintains soil pH stability (Utami and Handayani, 2003; Tahir et al., 2011;Shaaban & Abou-Shanab, 2013). In order to boost biological fertility, manure can increase the population of Azotobacter bacteria by 0.02 % and Azospirillum bacteria by 0.46 % (Handayan to and Hairiah, 2007).

According to Zandroto's (2017) research, organic matter can boost cowpea growth and yield on lowland land. From 0.70 to 1.32 t ha-1, cowpea seeds were harvested. The number of flowers per bunch at 7 WAP, the number of pods per plant, the weight of dry pods per plant, the weight of 100 seeds, and the harvest index were all associated with increased dry seed weight in cowpea plants. Indole acetic acid (IAA) in cowpea can increase plant height, fresh and dry weight, number of branches, number of leaves per plant, and yield components when combined with organic fertilizers. For example, by increasing the accumulation of organic solutes like sugar and proline and inorganic solutes such as potassium sodium calcium magnesium zinc ferrochelatin in the leaves and seeds (El Bassiouny and Shukry 2001), it is possible to trigger drought defense mechanisms.

Due to the low rainfall and low temperatures that cowpeas grow in after rice, the crop yields are usually less than ideal. Cowpeas, on the other hand, are grown on dry land. Organic matter, aimed at providing nutrients and increasing water holding capacity, must be added to help combat this. Research into drought-tolerant varieties and the application of organic matter to the response of Indonesian cowpea varieties to various drought stress conditions is required in this regard.

MATERIALS AND METHODS

The research was conducted using polybags in a green house at the Experimental Garden of the Faculty of Agriculture, Universitas Brawijaya, Jatimulyo, Malang, East Java. Located at an altitude of 460 meters above sea level, with temperatures ranging from 20-28°C with Andosol soil types. The research will be carried out in August - November 2020.

The treatment design used in this study was a factorial randomized block design (RAK) with 2 factors. The first factor is organic matter and consists of three kinds, namely: control (without organic matter) (CO), cow manure (PK) and rice husk biochar (BC). While the second factor is drought stress (K) and consists of 2 types, namely: 50% field capacity (field capacity) (K1), 75% field capacity (K2) and 100% field capacity (K3). From these treatments, 9 treatment combinations were obtained, each treatment combination was repeated 3 times, so that 27 units of treatment combinations were obtained and each treatment combination consisted of 8 sample plants, so that the total sample reached 216 samples.The tools used include: polybag, centrifuge, spectrophotometer, vortex, water heater, oven, measuring cup, Leaf Area Meter (LAM), digital scale, erlenmeyer, micropipette, petridish and ruler. The organic materials used are cow manure and rice husk biochar. The seeds used in this study were cowpea varieties (Vigna unguiculata L. Walp.) issued by the Research Institute for Legumes and Sweet Potatoes (BALITKABI), namely the KT6 variety. Urea, SP36 and KCL fertilizers. Some chemicals for physiological analysis are ninhydrin acid, glacial acetic acid, phosphoric acid, 3% sulfosalicylic acid, toluene, 80% acetone and distilled water.

Observations made include: Observation of growth components, namely: number of leaves, leaf area (cm2). Physiological components, namely: the content of proline. Observations of plant yield components were: number of filled pods, number of seeds, seed weight and total dry weight of the plant.

Growth Observation Results

a. Number of leaves

Organic matter treatment had no effect on the number of leaves in the field at any stage of observation between 28 and 56 days after planting. At 42-56 days after planting, however, field capacity treatment had a significant impact. Table 1 shows the average number of cowpea leaves per treatment.

Table 1. Number of Leaves of Cowpea Plants due to Treatment of Organic Matter and Field Capacityat All Observation Ages

Treatment	Number of Leaves (strands) at Observation Age (DAP)				
	28	**35**	**42**	**49**	**56**
Organic Matter					
No Organic Matter	4,36	8,31	12,98	15,11	14,93
Cow Manure	4,62	9,16	13,69	17,02	16,76
Rice Husk Biochar	4,53	9,04	13,11	16,27	15,11
LSD 5%	**ns**	**ns**	**Ns**	**ns**	**ns**
Field capacity					
50% Field capacity	4,18	7,40	9,89 a	11,62 a	11,76 a
75% Field capacity	5,07	9,78	14,20 b	17,16 b	15,82 b
100% Field capacity	4,27	9,33	15,69 b	19,62 c	19,22 c
LSD 5%	**ns**	**ns**	**2,17**	**1,89**	**4,83**
CV (%)	**12,90**	**17,09**	**16,42**	**11,72**	**17,90**

Notes: Numbers accompanied by the same letter in each of the same columns indicate a non-significant difference in the LSD test (Least Significant Difference) with a level of 5%. DAP: Days After Planting, ns:not Significant

One of the roles of water is as a solvent for nutrients contained in the soil, so that it can be taken up by plants easily through the roots and lifted to parts of plants that need it, such as the process of photosynthesis through the xylem. Leaves are the site of the photosynthesis process in plants, so the leaf area greatly determines the plant's capacity to produce assimilate. The number and area of leaves is one of the parameters for measuring growth. The results showed that there was no interaction between organic matter treatment and field capacity, but separately the capacity treatment had a significant effect on leaf number and leaf area (Tables 1 and 2). In general, the decrease in to field capacityresulted in a decrease in the number of leaves and leaf area of cowpea. This condition causes the supply of nutrients in the soil to decrease because the availability of water functions to absorb nutrients from the soil through the roots so that plants are not able to produce optimal number of leaves and leaf area. Cowpea plants had fewer leaves after the field capacity treatment. At 42DAP, the treatment with 50% field capacity produced the fewest leaves, while treatments with 75% and 100% field capacity did not differ significantly. At the observation 49 - 56 DAP, the 100% field capacity treatment produced the highest number of leaves and was significantly different from the 50% field capacity treatment and 75% field capacity treatment.This is because the condition of sufficient water availability will be able to absorb nutrients optimally so as to produce an optimal number of leaves and leaf area. Lack of water will inhibit plant growth so that it affects the number of leaves and plant leaf area. Gardner et al., (1991) stated that when plants experience drought stress during the vegetative phase, it affects the development of smaller leaves which can reduce LAI values at maturity and result in reduced light absorption by plants. Supported by research from Widiatmoko et al., (2012) that, in soybean plants that were given a drought stress of 50% to field capacitycaused a decrease in the number of leaves. This decrease is thought to aim to reduce transpiration and maintain water potential in plants. Nugraha (2014) stated that in soybean plants on the observation variable the number of leaves, the combination of treatment 0-75 days according to to field capacityresulted in more leaves than other treatments. This is as a result of the sufficient level of water availability for plants. The large number of leaves is accompanied by an increase in leaf area.

b. Leaf area

Analysis of the variety of cowpea leaf area showed that there was no interaction between the treatment of organic matter and field capacity at the age of observation 28 to 56 days following planting. The organic matter treatment had no effect on leaf area at any of the observed ages, whereas the field capacity treatment did. Table 5 shows data on plant leaf area in field capacity treatments. Table 2 shows the average leaf area of cowpeas for each treatment.

Table 2. Leaf Area of Cowpea due to Treatment of Organic Matter and field capacityat All Observation Ages

Treatment	**Leaf Area (cm2 plant^{-1}) at Observation Age (DAP)**				
	28	35	42	49	56
Organic Matter					
No Organic Matter	666,2	1271	1985	2311	2284
Cow Manure	707,0	1400	2027	2603	2562
Rice Husk Biochar	693,2	1383	2005	2488	2297
LSD 5%	**ns**	**ns**	**Ns**	**ns**	**ns**
Field capacity					
50% Field capacity	638,8 a	1131 a	1512 a	1777 a	1798 a
75% Field capacity	775,0 b	1495 b	2172 b	2624 b	2420 b
100% Field capacity	652,6 a	1427 b	2333 b	3001 b	2926 c
LSD 5%	**77,21**	**174,06**	**335,43**	**289,15**	**438,66**
CV (%)	**11,21**	**12,88**	**16,73**	**11,72**	**18,43**

Notes: Numbers accompanied by the same letter in each of the same columns indicate a non-significant difference in the LSD test (Least Significant Difference) with a level of 5%. DAP: Days After Planting, ns:not Significant

At the age of 28 days after observation, the 75% field capacity treatment produced the highest leaf area compared to the 50% field capacity treatment and 75% field capacity treatment. At the age of 35-49 DAP, the 50% field capacity treatment produced the lowest number of leaves, while the 75% field capacity and 100% field capacity treatments were not significantly different. At the age of 56 days after planting, the 100% field capacity treatment produced the highest leaf area compared to the 50% field capacity and 75% field capacity treatment. One type of plant morphological response to drought stress is to reduce the transpiration rate, resulting in a reduction in leaf area. Leaf stomatal water loss accounts for nearly 90% of plant water loss, so plants reduce leaf surface area, tilt leaves nearly perpendicular to the direction of light's arrival, and keep leaf temperature near quicfield capacity to reduce canopy water loss (Efendi, 2009).Purwanto and Agustono (2010) added, in soybean plants, the average leaf area decreased by 35.7% in soybean plants under drought stress with a moisture content of 60% to field capacityand an initial population of 5 bulbs per polybag compared to field capacity without weeds. Leaf area continued to decrease with increasing levels of drought stress and initial population of puzzle weeds.

c. Total dry weight of plants

There was a correlation between organic matter treatment and field capacity based on the dry weight of cowpeas. As a result of the interaction between organic matter and available field capacity, Table 3 shows the mean total dry weight of plants.

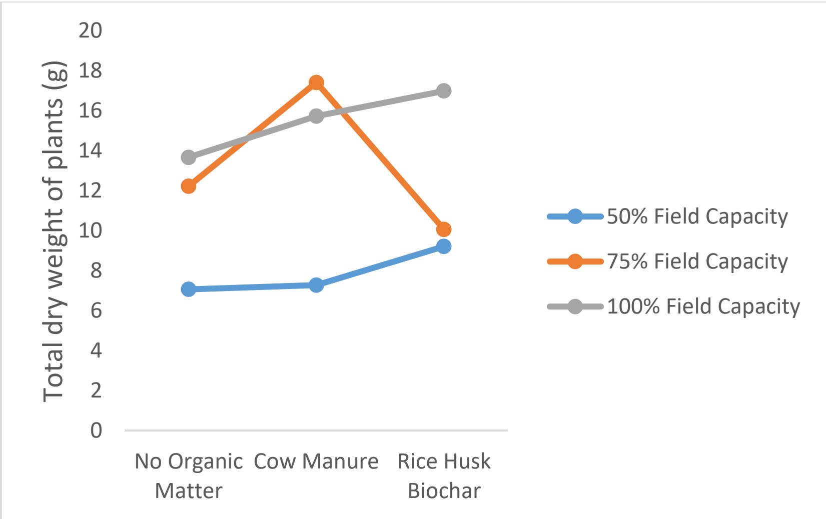
Table 3. Total dry weight of cowpea plants due to the interaction of organic matter treatment and field capacity.

Organic Matter	**Total Plant Dry Weight(g plant^{-1})**		
	Field capacity		
	50% Field capacity	75% Field capacity	100% Field capacity
No Organic Matter	7,06 a	12,22 bc	13,67 cd
Cow Manure	7,28 a	17,42 e	15,73 de
Rice Husk Biochar	9,21 ab	10,06 ab	16,99 e
LSD 5%		**3,16**	
CV (%)		**14,99**	

Note: Numbers accompanied by the same letter in the same column and row show no significant difference based on the 5% LSD test

Suparno (2011) stated that plant vegetative growth had an effect on the dry weight of the plant. Vegetative growth is influenced by the availability of nutrients, water and sunlight. The results of observations on the total dry weight of cowpea plants showed an interaction between organic matter and field capacity. The combination of cow manure treatment with 75% to field capacity had a higher dry weight of stover but was not significantly different from the treatment of rice husk biochar with 100% to field capacity and cow manure with 100% field capacity, while the treatment without organic matter with 50% to field capacity gave the weight value. Dry stover was smaller than other treatments, while the treatment of cow manure with 50% to field capacity and rice husk biochar treatment with 50% to field capacity was not significantly different. Table 2 shows that drought stress treatment reduces leaf area and indirectly affects the total dry weight of plants that have decreased due to drought stress. In subsequent developments, severe water shortages can lead to stomata closure, which will reduce CO2 uptake and dry weight production (Gardner et al., 1991). In accordance with research from Hartatik and Widowati (2010), it was found that cow manure has advantages over other manures, namely it has high fiber content such as cellulose, provides macro and micro nutrients for plants, and improves water absorption in the soil. Soybean plants that are subjected to high levels of drought stress will show lower total dry weight yields (Suryaningrum, 2016). The addition of organic matter in the soil can improve the physical properties of the soil by increasing the micro and macro pore spaces so as to create a living environment for microorganisms in the soil. In accordance with the results of Verdiana's research (2016) which states that biochar has micro pores that can be used as a habitat for microorganisms which results in reduced competition between microorganisms so that it can increase soil biological activity.

Figure 1. Diagram of the average total dry weight of plants due to the interaction between organic matter treatment and drought stress in cowpea



Physiological Observations

Proline Content

The results of the analysis of variance in cowpea's proline content showed an interaction between organic matter and field capacity (Table 4).

Table 4. Proline Content of Cowpea due to Interaction between Organic Matter Treatment and Field Capacity

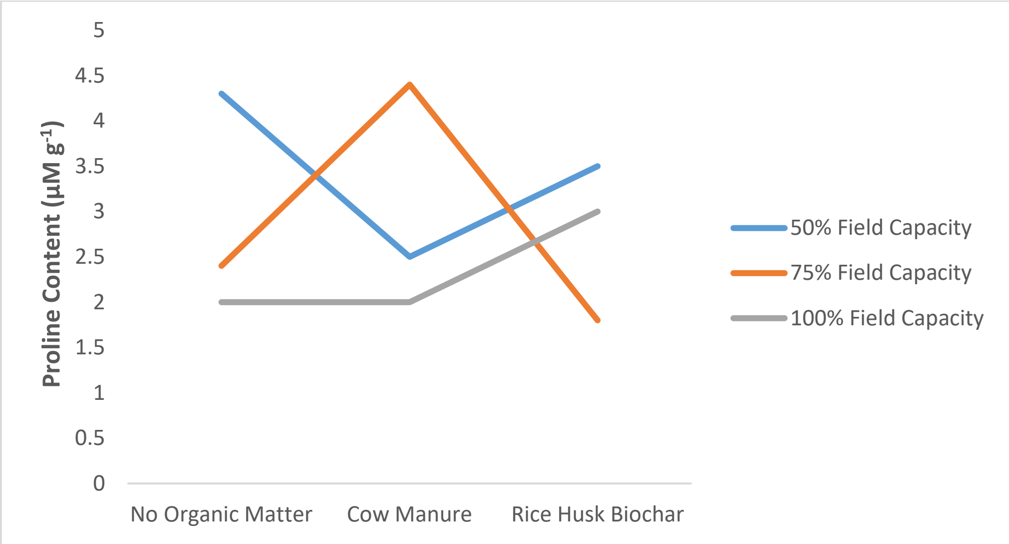
Organic Matter	**Proline Content (µM g^{-1})**		
	Field Capacity		
	50% Field capacity	75% Field capacity	100% Field capacity
Organic Matter	0,25 f	0,23 de	0,20 b
Cow Manure	0,23 e	0,22 d	0,19 a
Rice Husk Biochar	0,25 f	0,22 d	0,21 c
LSD 5%	**0,006**		
CV (%)	**1,56**		

Note: Numbers accompanied by the same letter in the same column and row show no significant difference based on the 5% LSD test

Proline is a secondary metabolite released by plants under stressed conditions. This proline increased when cowpea plants were given drought stress treatment so that they were able to produce proline. This shows that the proline content in cowpea plants which is increasingly experiencing drought stress, the higher the proline content value.The results of the study on the proline content of cowpea leaves that were given rice husk biochar with 50% field capacity and without organic matter with 50% field capacity resulted in a proline content that was not significantly different, namely 0.25 M g-1. The proline content was 24.00% higher than cowpea plants which were applied to cow manure with 100% field capacity (0.19). According to Hamim (2004); Bhaskara &Verslues(2015); Per et al. (2017); Zegaoui et al. (2017). Plants under drought stress will synthesize and accumulate proline in various plant tissues, especially in leaves, plants that accumulate proline under stressed conditions generally have a better morphological appearance and have higher survival rates than plants. which does not accumulate. With reduced water potential, plant hormone concentrations also change in concentration, for example abscisic acid (ABA) increases in leaves and fruit, ABA accumulation stimulates stomata closure, resulting in reduced CO2 assimilation (Gardner et al., 1991). Hasanah and Rahmawati (2014) stated that soybean plants at a soil moisture content of 40% to field capacitytend to increase leaf proline content. The increase in leaf proline content in soybeans with higher drought stress is closely related to the large role of proline as an osmoregulator. Excessive production of these compounds can result in increased tolerance to drought stress in plants.

The mechanism of drought tolerance in addition to reduced density and stomatal opening to minimize water loss under conditions of excessive light is by accumulating proline compounds that function to regulate cell osmotic pressure (osmotic adjustment). Accumulation of proline can reduce the osmotic potential, thereby reducing the water potential in cells without limiting enzyme function and maintaining cell turgor (Tuasamu, 2009). Rosawanti (2016) added that in soybeans there was a response pattern of proline content which tends to increase along with the occurrence of drought stress, almost all genotypes showed the same response, namely by increasing the accumulation of proline in the leaves to maintain the balance of osmotic potential in plants. Proline accumulation is the result of an increase in free amino acids when plants are in a stressful environment. The content of proline produced by plants can be used as an indicator of how much tolerance level to stress. Proline accumulates in the meristem tissue which is part of the plant that is actively dividing in plants under stress.

Figure 2. Diagram of the average proline content due to the interaction between organic matter treatment and drought stress in cowpea



Observation Results

Number of pods, number of seeds and seed weight.

Organic matter and field capacity appear to have little effect on cowpea pods' number of filled pods, seeds sown, or seed weight per plant. Field capacity treatment, on the other hand, had a substantial impact on the parameters of filled pods, seeds planted, and the weight of seeds planted for a single factor analysis (Table 5).

Table 5. Number of Filled Pods, Number of Seeds and Seed Weight of Cowpea Plants due to Treatment of Organic Matter and field capacity

Treatment	**Number of Filled Pods (plant^{-1})**	**Number of Seeds(plant^{-1})**	**Seed Weight (gplant^{-1})**
Organic Matter			
No Organic Matter	9,73	99,71	10,30
Cow Manure	9,64	108,38	11,16
Rice Husk Biochar	9,29	94,33	9,66
LSD 5%	**ns**	**ns**	**ns**
Field capacity			
50% Field capacity	7,58 a	73,47 a	8,37 a
75% Field capacity	9,69 ab	105,6b	10,64 b
100% Field capacity	11,40 b	123,2 b	12,10 b
LSD 5%	**2,17**	**21,89**	**1,49**
CV (%)	**22,76**	**21,72**	**14,45**

Notes: Numbers accompanied by the same letter in each of the same columns indicate a non-significant difference in the LSD test (Least Significant Difference) with a level of 5%. DAP: Days After Planting, ns:not Significant

The yield component most affected by water shortages during flowering is the number of pods planted (Gardner, 1991). Provision of to field capacity water into the soil affects the formation of the number of filled pods. Lack of water during flowering can affect the number of pods per plant. The 100 % field capacity treatment resulted in a higher score of 11.40 for the number of filled pods. In comparison to the 50% field capacity treatment, the number of pods that were filled was 33,51% greater (7,58). Similarly, Mahdalena (2020) found that a 30% increase of water dryness in cowpea crops reduced the number of pods filled significantly. In the late stages of pod growth and in the middle stages of seed filling, water deficit is most noticeable. Pod loss, poor pod development, and impaired photosynthesis continue to occur in the last phases of pod formation due to a shortage of water. Although the number of pods planted and the number of seeds per pod had minimal impact, the most significant effect was on the weight per seed (Diepenbrock, 2000; Boutraa & Sanders, 2001; Brevedan & Egli, 2003; Gan et al., 2004; Gardner, 1991; Kaur et al., 2008; Ahmadi & Bahrani 2009).Cowpea plants after being given drought treatment by 57% in the greenhouse and 64% in the field can reduce the number of pods and the number of seeds when compared to plants without stress (Agbicodo et al., 2009). Widiatmoko et al. (2012) added that 50% drought stress treatment for soybeans given 25 days after planting decreased the number of pods per plant, the number of filled pods, and increased the percentage of empty pods. While the stress treatment given before the pod filling phase did not have a significant effect on the number of pods per plant and the number of filled pods.

The main generative organ of cowpea plants is the flower part which then becomes a pod then the process of filling the seeds occurs, the number of seeds planted is one of the predictor indicators of cowpea crop yields. The decrease in the number of filled pods had an effect on the decrease in the number of seeds in cowpea plantations (Table 5). The results showed that there was no interaction between the treatment of organic matter and to field capacityon the parameters of the number of seeds planted, but separately the field capacitytreatment had an effect on the number of seeds planted. The decrease in field capacityhas an impact on the decrease in the number of seeds planted.The number of seeds per plant increased by 123.2 in the 100% field capacity treatment. At 50% field capacity, there were 40.37 % more seeds than cowpea (73.47).The need for water is high and the importance of water, plants need a constant source of water to grow and develop. Whenever water becomes limited, growth is reduced and usually crop yields are reduced. This result is in line with Suparno (2011) who explained that when environmental stress occurs, it can affect the process of seed formation in plants.

Drought stress is one of the environmental stressors, so that if it occurs before and during the flowering process, it will determine seed production. Soybean plants in the treatment (0-75 DAP; according to field capacity) produced the highest number of seeds, while the lowest number of seeds was found in the treatment (0-20 DAP; 2 weeks) which reduced the number of seeds by 61% (Nugraha, 2014). Provision of field capacitywater can improve the physical properties of the soil so that plant growth can be optimal. In addition, water also functions as a solvent for the results of photosynthesis to be further distributed throughout the plant through the phloem and the photosynthate will be used by plants for the growth process and plant yields. Rukmini (2017) adds that soil porosity is a measure that shows the part of the soil that is not filled with solid soil material, because the solid soil is filled with water and air. Soil itself has three pores, namely macro pores, meso pores and micro pores. Micro pores are often known as capillary pores, meso pores are often referred to as slow drainage pores and macro pores are fast drainage pores. The pores in the soil determine the water and air content in the soil and the ratio of good air and water management.

The formation of high dry weight is an indication that photosynthetic activities and assimilate accumulation in plants are going well. In cowpea plants, the most important assimilate accumulation is the protein contained in the seeds that are harvested when they show symptoms of physiological maturity (90% of the pods have turned brown, the leaves turn yellow and fall off). The results showed that the higher the field capacitygiven the weight of the seeds also increased. The increase in dryness caused a decrease in the dry seed weight of the plant, the dry seed weight was more sensitive to the level of drought, because it immediately decreased significantly, which was 44.56%. Mahdalena (2020) stated that in cowpea, an increase in dryness caused a decrease in the dry seed weight of the plant, the dry seed weight was more sensitive to the level of drought, because it immediately decreased significantly, this is presumably because an increase in water dryness resulted in a lack of CO2 entering the leaf mesophyll. caused by the closing of the stomata, so that less photosynthate is produced for filling the seeds.

The decrease in field capacitycauses a decrease in the availability of water in the soil which functions to absorb nutrients through the roots so that the absorption of nutrients to support the growth of plant generative organs will decrease due to low nutrient availability in the soil. Widiatmoko et al. (2012) explained that soybean plants under drought stress given 25 days after planting reduced seed weight per plant compared to the production of plants that grew without stress, among others by 52.34% (L/S: B6- G1); 16.47% (L/S:B6-G3); 45.11% (Grobogan); 47.00% (Borangrang); and 37.12% (Argomulyo). While the stress given since 50 days after planting did not have a significant effect with the treatment without stress. In mung bean, drought stress treatment of 100% field capacitygave the highest dry weight of 1.64 g, while the lowest was at 40% field capacityof 1.19 g. This shows that optimally providing water increases plant productivity. At high levels of drought stress, mung bean plants are still able to grow and adapt well, but their production is low (Sianipar et al., 2013).

CONCLUSION

Provision of organic material in the form of cow manure and 75% field capacitycan be used for cowpea cultivation.Giving 75% field capacitywas still able to maintain growth and yield of cowpea on number of leaves, leaf area, number of filled pods, number of seeds and seed weight. The proline content of cowpea leaves increased with the decrease in field capacity. The proline content of cowpea leaves increases as the field capacity decreases.Cow manure was able to increase the growth and yield of cowpea under drought stress conditions with 75% field capacitywhich was characterized by interactions with proline content and total plant dry weight.

REFERENCES

Agbicodo, E. M., Fatokun, C. A., Muranaka, S., & Visser, R. G. (2009). Breeding drought tolerant cowpea: constraints, accomplishments, and future prospects. Euphytica, 167(3), 353-370.

Ahmadi, M., & Bahrani, M. J. (2009). Yield and yield components of rapeseed as influenced by water stress at different growth stages and nitrogen levels. American-Eurasian Journal of Agricultural and Environmental Sciences, 5(6), 755-761.

Asiwe, J. A. N. (2009). Needs assessment of cowpea production practices, constraints and utilization in South Africa. African Journal of Biotechnology, 8(20).

Bhaskara, G. B., Yang, T. H., & Verslues, P. E. (2015). Dynamic proline metabolism: importance and regulation in water limited environments. Frontiers in Plant Science, 6, 484.

Blade, S. F., Shetty, S. V. R., Terao, T., & Singh, B. B. (1997). Recent developments in cowpea cropping systems research. Advances in cowpea research, 114-128.

Brevedan, R. E., & Egli, D. B. (2003). Short periods of water stress during seed filling, leaf senescence, and yield of soybean. Crop Science, 43(6), 2083-2088.

Bot, A., & Benites, J. (2005). The importance of soil organic matter: Key to drought-resistant soil and sustained food production (No. 80). Food & Agriculture Org..

Boutraa, T., & Sanders, F. E. (2001). Influence of water stress on grain yield and vegetative growth of two cultivars of bean (Phaseolus vulgaris L.). Journal of Agronomy and Crop Science, 187(4), 251-257.

Carvalho, M., Lino-Neto, T., Rosa, E., & Carnide, V. (2017). Cowpea: a legume crop for a challenging environment. Journal of the Science of Food and Agriculture, 97(13), 4273-4284.

Diepenbrock, W. (2000). Yield analysis of winter oilseed rape (Brassica napus L.): a review. Field crops research, 67(1), 35-49.

Efendi, R. (2009). Tanggap genotipe jagung toleran dan peka terhadap cekaman kekeringan pada fase perkecambahan. In Prosiding Seminar Nasional Serealia. ISBN (pp. 978-979).

El-Bassiouny, H. M., & Shukry, W. M. (2001). Cowpea growth pattern, metabolism and yield in response to IAA and biofertilizers under drought conditions. Egyptian Journal of Biology, 3, 117-129.

Gan, Y., Angadi, S. V., Cutforth, H., Potts, D., Angadi, V. V., & McDonald, C. L. (2004). Canola and mustard response to short periods of temperature and water stress at different developmental stages. Canadian journal of plant science, 84(3), 697-704.

Gardner, F. P., Pearce, R. B., & Mitchell, R. L. (1991). Fisiologi tanaman budidaya.

Gerrano, A. S., van Rensburg, W. S. J., & Adebola, P. O. (2017). Nutritional composition of immature pods in selected cowpea ['Vigna unguiculata'(L.) Walp.] genotypes in South Africa. Australian Journal of Crop Science, 11(2), 134-141.

Goufo, P., Moutinho-Pereira, J. M., Jorge, T. F., Correia, C. M., Oliveira, M. R., Rosa, E. A., ... & Trindade, H. (2017). Cowpea (Vigna unguiculata L. Walp.) metabolomics: osmoprotection as a physiological strategy for drought stress resistance and improved yield. Frontiers in plant science, 8, 586.

Hamim. (2004). Underlaying Drought Stress Effect on Plant: Inhibition of Photosynthesis. Journal of Biosciences. 11 (4): 164 – 169.

Haliza, W., Purwani, E. Y., & Thahir, R. (2010). Pemanfaatan kacang-kacangan lokal mendukung diversifikasi pangan. Pengembangan Inovasi Pertanian, 3(3), 238-245.

Hall, A. E., Cisse, N., Thiaw, S., Elawad, H. O., Ehlers, J. D., Ismail, A. M., ... & McWatters, K. H. (2003). Development of cowpea cultivars and germplasm by the Bean/Cowpea CRSP. Field Crops Research, 82(2-3), 103-134.

Handayanto, E., & Hairiah, K. (2007). Biologi Tanah Landasan Pengelolaan Tanah Sehat. Pustaka Adipura. Yogyakarta, 16-90.

Hartatik, W., & Widowati, L. R. (2010). Pupuk Kandang.(on-line) http://www. balittanahlitbang. deptan. g o. id.

Hasanah, Y., & Rahmawati, N. (2014). Produksi dan fisiologi kedelai pada kondisi cekaman kekeringan dengan aplikasi Bradyrhizobium japonicum yang diberi penginduksi genistein. Jurnal Agronomi Indonesia (Indonesian Journal of Agronomy), 42(2).

Jaleel, C. A., Gopi, R., Sankar, B., Gomathinayagam, M., & Panneerselvam, R. (2008). Differential responses in water use efficiency in two varieties of Catharanthus roseus under drought stress. Comptes Rendus Biologies, 331(1), 42-47.

Kaur, G., Kumar, S., Nayyar, H., & Upadhyaya, H. D. (2008). Cold stress injury during the pod-filling phase in chickpea (Cicer arietinum L.): Effects on quantitative and qualitative components of seeds. Journal of agronomy and crop science, 194(6), 457-464.

Karuwal, R. L., Suharsono, S., Tjahjoleksono, A., & Hanif, N. (2018). Identification of drought-tolerant local cowpea varieties of Southwest Maluku (Indonesia). Makara Journal of Science, 22(4), 5.

Karsono, S. (1998). Ekologi dan Daerah Pengembangan Kacang Tunggak di Indonesia. Balai Penelitian Tanaman Kacang-kacangan dan Ubi-ubian, Malang. Hal, 59-72.

Kébé, K., Alvarez, N., Espíndola, A., Justy, F., Olivieri, I., & Sembène, M. (2016). Insights into the genetic structure of the cowpea pest Callosobruchus maculatus in Africa. Journal of pest science, 89(2), 449-458.

Kristjanson, P., Okike, I., Tarawali, S., Singh, B. B., & Manyong, V. M. (2005). Farmers' perceptions of benefits and factors affecting the adoption of improved dual-purpose cowpea in the dry savannas of Nigeria. Agricultural Economics, 32(2), 195-210.

Kumar, D., & Narain, P. (2005). Production technology for cowpea.

Mahdalena, Z. (2020). PENGARUH TINGKAT KEKERINGAN TERHADAP PERTUMBUHAN GENERATIF KULTIVAR KACANG TUNGGAK (Vigna unguiculata L). ZIRAA'AH MAJALAH ILMIAH PERTANIAN, 45(3), 347-353.

Moray, C., Game, E. T., & Maxted, N. (2014). Prioritising in situ conservation of crop resources: a case study of African cowpea (Vigna unguiculata). Scientific reports, 4(1), 1-5.

Muñoz-Amatriaín, M., Mirebrahim, H., Xu, P., Wanamaker, S. I., Luo, M., Alhakami, H., ... & Close, T. J. (2017). Genome resources for climate-resilient cowpea, an essential crop for food security. The Plant Journal, 89(5), 1042-1054.

Nugraha, Y. S., Sumarni, T., & Soelistyono, R. (2014). Pengaruh interval waktu dan tingkat pemberian air terhadap pertumbuhan dan hasil tanaman kedelai (Glycine max (L) Merril.). Jurnal Produksi Tanaman, 2(7).

Per, T. S., Khan, N. A., Reddy, P. S., Masood, A., Hasanuzzaman, M., Khan, M. I. R., & Anjum, N. A. (2017). Approaches in modulating proline metabolism in plants for salt and drought stress tolerance: Phytohormones, mineral nutrients and transgenics. Plant physiology and biochemistry, 115, 126-140.

Purwanto, P., & Agustono, T. (2010). Kajian Fisiologi Tanaman Kedelai Pada Berbagai Kepadatan Gulma Teki Dalam Kondisi Cekaman Kekeringan. Agroland: Jurnal Ilmu-ilmu Pertanian, 17(2).

Rukmini, A. (2017). Pengaruh dosis pupuk kandang Sapi terhadap pertumbuhan Kacang Hijau (Vigna radiata L.) pada kondisi kadar air tanah yang berbeda (Doctoral dissertation, Universitas Islam Negeri Maulana Malik Ibrahim).

Rosawanti, P. (2016). Pengaruh Cekaman Kekeringan Terhadap Kandungan Klorofil dan Prolin Daun Kedelai. Anterior Jurnal, 15(2), 172-179.

Shaaban, M., Abid, M., & Abou-Shanab, R. A. I. (2013). Amelioration of salt affected soils in rice paddy system by application of organic and inorganic amendments. Plant, Soil and Environment, 59(5), 227-233.

Setyowati, M., & Sutoro, S. (2010). Evaluasi plasma nutfah kacang tunggak (Vigna unguiculata L.) di lahan masam. Buletin Plasma Nutfah, 16(1), 44-48.

Sianipar, J., Putri, L. A. P., & Ilyas, S. (2013). Pengaruh Radiasi Sinar Gamma Terhadap Tanaman Kacang Hijau (Vigna radiata L.) pada Kondisi Kekeringan. Jurnal Agroekoteknologi Universitas Sumatera Utara, 1(2), 94364.

Singh, B. B., & Matsui, T. (2002). Cowpea varieties for drought tolerance. Challenges and opportunities for enhancing sustainable cowpea production, 287-300.

Singh, B. B. (2016). Genetic enhancement for yield and nutritional quality in cowpea [Vigna unguiculata (L.) Walp.]. Indian J Genet Plant Breed, 76(4), 568-582.

Slabbert, R., Spreeth, M., Krüger, G. H. J., & Bornman, C. H. (2004). Drought tolerance, traditional crops and biotechnology: breeding towards sustainable development. South African Journal of Botany, 70(1), 116-123.

Suparno, S. (2011). Usaha Induksi Pembungaan Kacang Tunggak (Vigna Unguiculata L.) Di Luar Musim Dengan Variasi Pengurangan Panjang Hari.

Suryaningrum, R., Purwanto, E., & Sumiyati, S. (2016). Analisis Pertumbuhan Beberapa Varietas Kedelai pada Perbedaan Intensitas Cekaman Kekeringan. Agrosains: Jurnal Penelitian Agronomi, 18(2), 33-37.

Tahir, M. M., Khurshid, M., Khan, M. Z., Abbasi, M. K., & Kazmi, M. H. (2011). Lignite-derived humic acid effect on growth of wheat plants in different soils. Pedosphere, 21(1), 124-131.

Tuasamu, Y. (2009). Toleransi hotong (Setaria italica l. Beauv) pada berbagai cekaman kekeringan: pendekatan anatomi dan fisiologi. Tesis. Sekolah Pascasarjana. Institut Pertanian Bogor. Bogor.

Utami, S. N. H., & Handayani, S. (2003). Sifat kimia entisol pada sistem pertanian organik chemical properties in organic and conventional farming system. Ilmu Pertanian, 10(2), 63-69.

Verdiana, M. A., Sebayang, H. T., & Sumarni, T. (2017). Pengaruh Berbagai Dosis Biochar Sekam Padi dan Pupuk NPK terhadap Pertumbuhan dan Hasil Tanaman Jagung (Zea mays L.). Jurnal Produksi Tanaman, 4(8).

Widiatmoko, T., Agustono, T., & Imania, M. (2012). Pertumbuhan Dan Hasil Beberapa Genotip Kedelai Berbiji Besar Pada Cekaman Kekeringan Di Berbagai Stadia Pertumbuhan. Agrin, 16(1).

Zandroto, F. V. (2017).Evaluasi Produksi Beberapa Varietas Kacang Tunggak (Vigna unguiculata (L.) Walp.) di Dataran Rendah.

Zegaoui, Z., Planchais, S., Cabassa, C., Djebbar, R., Belbachir, O. A., & Carol, P. (2017). Variation in relative water content, proline accumulation and stress gene expression in two cowpea landraces under drought. Journal of Plant Physiology, 218, 26-34.