Jurnal Lahan Suboptimal : Journal of Suboptimal Lands
ISSN: 2252-6188 (Print), ISSN: 2302-3015 (Online, www.jlsuboptimal.unsri.ac.id)
Vol. 11. No.1: 104-111 April 2022
DOI: 10.36706/JLSO.11.1.2022.566

Improving Drought Tolerance in Chili Pepper by the Application of Local Microorganisms (LMo)

Meningkatkan Toleransi terhadap Cekaman Kekeringan pada Tanaman Cabai dengan Pemberian Mikroorganisme Lokal (*MoL*)

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(Received: 13 November 2021, Accepted: 9 February 2022)

Citation: Eliyanti E, Zulkarnain Z, Ichwan B, Novita T, Sihotang J. 2022. Improving drought tolerance in chili pepper by the application of local microorganisms (LMo). *Jurnal Lahan Suboptimal : Journal of Suboptimal Lands* 11 (1): 104-111. DOI: 10.36706/JLSO.11.1.2022.566.

ABSTRAK

Penelitian ini bertujuan untuk mengetahui pengaruh interval penyemprotan mikroorganisme lokal (MoL) keong mas terhadap toleransi tanaman cabai pada kondisi ketersediaan air terbatas. Penelitian dilaksanakan di rumah kaca dan Laboratorium Proteksi Tanaman Fakultas Pertanian Universitas Jambi selama 6 bulan. Penelitian menggunakan Rancangan Acak Kelompok (RAK) dengan 2 faktor dan 3 ulangan. Faktor pertama yakni varietas tanaman cabai yang terdiri atas 3 Vitra, Lado dan Laris. Sedangkan faktor ke-2 adalah interval waktu penyemprotan MoL keong mas, yang terdiri atas air tanah 100% kapasitas lapang dan tanpa keong mas, air tanah 75% kapasitas lapang dengan interval penyemprotan keong mas seminggu sekali, dan air tanah 75% kapasitas lapang dengan interval penyemprotan keong mas dua minggu sekali. Hasil penelitian menunjukkan bahwa penyemprotan MoL keong mas dengan interval 1 hingga 2 minggu sekali dapat meningkatkan toleransi terhadap cekaman kekeringan pada tiga varietas cabai yang ditanam pada kondisi air tanah 75% kapasitas lapang. Respon pertumbuhan dan produksi tanaman pada kondisi 75% kapasitas lapang sama dengan tanaman dalam kondisi optimum, penyemprotan MoL pada varietas Vitra dapat meningkatkan bobot buah per tanaman hingga 32% melebihi bobot buah tanaman dalam kondisi optimum.

Kata kunci: cekaman abiotik, *Capsicum*, keong mas

ABSTRACT

This study aimed at determining the effect of spraying intervals of local microorganism (MoL) golden apple snails on the improvement of drought tolerance of chili grown under limited water availability. The trial was carried out at greenhouse and Plant Protection Laboratory, Faculty of Agriculture, University of Jambi for 6 months. The study used a Randomized Block Design with 2 factors and 3 replications. The first factor was the chili cultivar consisted of Vitra, Lado and Laris. While the second factor was the spraying interval of MoL golden apple snail consisted of 100% field capacity of soil water without MoL application, 75% field capacity of soil water and spraying intervals once a week, and 75% field capacity of soil water and spraying intervals every two weeks. The results

showed that spraying MoL golden apple snail at intervals of either once in 1 or 2 weeks could increase tolerance to drought stress in three chili cutivars grown under 75% field capacity of soil water. Plant growth and yield at 75% field capacity of soil water was the same as that of plants grown under optimum conditions (100 % field capacity of soil water), MoL spray on the cv. Vitra could increase fruit weight per plant by up to 32% over fruit weight of those plants grown under optimum conditions.

Keywords: abiotic stress, *Capsicum*, golden apple snail

INTRODUCTION

Jambi Province is one of the national chili development areas based on the Decree of the Minister of Agriculture No.472/Kpts/Rc.040/6/2018 with the first priority areas covering the Tanjung Jabung Barat, Tanjung Jabung Timur and Muaro Jambi Regency. Overall, this priority development area faced the problem of marginal land in the form of peat land and Ultisol dry land (Jambi Regional Development Planning Agency, 2013). In addition to the marginal land issues, it turns out that the development of chili in Jambi and other development areas have several problems, such as low average productivity (around 7-10 tons/ha) compared to its potential production which can exceed 25 tons/ha (IAARD, 2019), the demand for chili continues to increase both from within and outside the country that it becomes one of the contributors to the national inflation rate (Statistics of Jambi Province, 2021), as well as the global market demand for healthy agricultural products without being contaminated with harmful chemicals.

Previous studies have proven that the use of natural/organic materials in the form of solid (compost) or liquid (LOF, biological pesticides and various LMo) could be multifunctional, namely not only serving as a nutrient provider, growth stimulant, and protection/protection from various pest attacks, but also as an environmentally friendly and sustainable soil ameliorant (Prasetya, 2014; Baharuddin, 2016; Hapsoh et al., 2017; Asroh & Novriani, 2019; Ichwan et al., 2021a; Ichwan et al., 2021b).
Limited water conditions on agricultural land are a major threat to the sustainability of plant growth because most of the physiological processes of plants depend on sufficient water (dos Santos et al., 2018; Roeswitawati et al., 2018; Yuliana, 2021).

Previously Supriyanto (2013) reported that planting media with drought stress condition of 60% - 70% field capacity (FC) cause the local upland rice plants of guava cultivars to be unable to continue growth to the generative phase. Furthermore, Ichwan et al. (2017) reported that red chili planted in soil with conditions of 50% - 75% FC showed stunted growth, the number of productive branches and number of fruits and total fruit weight per plant were also low. The study by Purwanto et al. (2019) stated that 50% FC drought stress on mung bean cause a significant decrease in leaf area and dry seed weight.

The LMo of golden apple snail, apart from containing macro and micro nutrients, growth regulators, contain various beneficial microorganisms both in the process of land amelioration and as plant protectors through the activity of antagonistic microorganisms (Suhastyo et al., 2013; Yudi et al., 2013; Salma & Purnomo, 2015).

Several research results related to the use of LMo of golden apple snails have also been reported and show a positive response to the growth and yield of various food crops and horticulture (Purwasasmita & Kurnia, 2009; Suhastyo et al., 2013; Yuliani, 2016; Kurniawan et al., 2020). However, it is also necessary to study the effective and efficient time interval for spraying the LMo of golden apple snail, especially for the development of chili plants on marginal land with limited water condition. This study aimed to test the application of LMo of golden apple snail and the effective spraying interval in

inducing red chili plant resistance under the condition of limited water availability (75% FC condition).

MATERIALS AND METHODS

The research was conducted at the greenhouse Faculty of Agriculture, University of Jambi, Desa Mendalo Indah, Muaro Jambi Regency. The study site was at an altitude of 35 m above sea level. The research was carried out for 6 months. The tools in this study used digital scales, measuring cup, hoe, machete, gembor (watering could), hand sprayer, bucket, stationery, polybag (size 30 x 40 cm), plastic, label and camera. The materials used were chili seeds of 3 cultivars (Lado, Laris and Vitra), golden apple snail, brown sugar, coconut water, NPK fertilizer (16:16:16), cow manure and top soil.

The method of preparing LMo golden apple snail and the recommended concentration of use (10%) on plants referred to the Technical Instructions for Preparing LMo (Salma & Purnomo, 2015). The drought stress was applied when the plants were transplanted to polybags or at 0 week after transplantation (WAT). The drought stress/limited water condition was 75% FC. The calculation of the soil moisture content of FC was carried out gravimetrically (Ichwan et al., 2017).

The study used a Randomized Block Design with 2 factors and 3 replications. The first factor was chili cultivars: Vitra, Lado and Laris. The second factor was the interval of spraying the golden apple snail LMo: no LMo at 100% FC, LMo spray once a week at 75% FC and LMo spray every 2 weeks at 75% FC. There were total 27 treatment plots, each plot consisting of 10 plants (in polybags), and 4 plants were taken as samples for each plot.

The variables observed were plant height, main stem height, flowering time, number of flowers per plant, number of fruits per plant, and fruit weight per plant (each of these generative variables was calculated in one flowering period), as well as analysis of the relative leaf water content of leaves (RLWC value) measured by the leaf turgidity method (Lugojan & Ciulca, 2011). All the data were tested for Variant Analysis and continued with Duncan's Multiple Range Test (DMRT) at $\alpha = 5\%$.

RESULTS

The average plant height as affected by spraying of LMo golden apple snails on plants grown on media with 100% FC (control) and 75% FC of soil water was presented in Table 1. Table 1 showed that the LMo spraying treatment on the three cultivars resulted in different growth responses. Two cultivars (Lado and Laris) which were sprayed with LMo at intervals of every week and every 2 weeks at 75% FC conditions, gave the same response as control plants (100% FC) in the form of plant height. Meanwhile, the same spray interval applied on Vitra resulted in a greater growth response than that of the control plants.

Table 1. The effect of different interval of LMo sprays and different soil water conditions (field capacity) on the average height (cm) of three chili cultivars

Cultivars	Control (100% FC)	Lmo Once a Week (75% FC)	LMo Twice a Week (75% FC)
Vitra	64.59 B c	79.4 A b	82.34 A b
Lado	98.49 A a	92.94 A a	97.15 A a
Laris	87.80 A b	85.85 A ab	79.71 A b

Note: Numbers followed by the same uppercase in the same row and the same lowercase in the same column showed non significant difference in the DMRT test at $\alpha = 5\%$.

Main Stem Height

The average height of main stem of plants grown on media conditions of 100% FC (control) and 75% FC as affected by LMo spray was shown in Table 2. The LMo spraying treatment on the three cultivars produced different responses on the main stem height. Table 2 also showed that the three cultivars that were sprayed with LMo once a week and grown under limited water condition (75% FC) show the same main stem height as the control (100% FC). Even the Vitra cultivar that was sprayed with LMo every 2 weeks show a higher main stem height than those of the control plants.

Flowering Time

The average flowering time of three chili cultivars that were treated with LMo golden apple snail and grown on media with 100% FC (control) and 75% FC was presented in Table 3. Two cultivars (Lado and Laris) sprayed every 2 weeks interval and grown under 75% FC of soil water conditions showed the same flowering time response as that of those plants grown under 100% FC of soil water (control). Meanwhile, the same LMo interval treatment on chili cv. Vitra resulted in a faster flowering time than those of the control plants

Number of Flowers per Plant

The average number of flowers per plant as the result of LMo golden apple snail sprays at different intervals on chili plants grown on media with 100% FC of soil water (control) and 75% FC of soil water was presented in Table 4. Table 4 showed that the LMo golden apple snail spraying resulted in different effect on the three cultivars in term of number of flowers per plant.

The two cultivars (Vitra and Laris) which were sprayed with LMo at intervals of 1 and 2 weeks at 75% FC soil water condition produced the same response as those of control plants (100% FC). However, in cultivar Lado, the LMo sprays at the same intervals resulted in less number of flower than those of the control plants.

Number of Fruits per Plant

The average number of fruits per plant in one flowering period of chili plants treated with LMo golden apple snail sprays and grown on media condition with 100% FC of soil water (control) and 75% FC of soil water was presented in Table 5. Table 5 reveals that the LMo spraying on the three varieties produced different responses in term of number of fruits per plant. In cultivar Vitra, LMo spraying at intervals of 1 and 2 weeks at 75% FC condition gave the same response to the number of fruits per plant as that of control plants (100% FC). Meanwhile, in Lado and Laris cultivars, the LMo spray at 2-week interval provided the same response to the number of fruits per plant as those of the control plants.

Fruit Weight per Plant

The effect of different interval of LMo golden apple snail sprays (once or twice a week) and different soil water conditions (100% and 75% of field capacity) on fruit weight per individual plant of the three chili cultivars was presented in Table 6. Table 6 indicates that the LMo spraying treatment on the three cultivars grown on different water field capacity resulted in different responses in the form of average fruit weight per plant. In cultivar Vitra, the LMo spraying at intervals of 1-week and 2-weeks at 75% FC condition produced greater fruit weight per plant than those of the control plants (100% FC). Meanwhile, on cultivar Lado and cultivar Laris, the LMo treatment at 2-week intervals produced the same fruit weights per plant as those of the control plants.

Relative Leaf Water Content

The average relative leaf water content (RLWC) of chili plants sprayed with LMo golden apple snails and grown on media with water condition of 100% FC (control) and 75% FC was presented in Table 7. Table 7 reveals that the LMo spraying at intervals of 1-week and 2-week on the three

cultivars grown under limited water condition produce the average RLWC value exceeding the RWC value of the control plants. The higher RLWC value in the three cultivars was an indicator of a high tolerance of the plants to limited water availability or drought stress condition.

Table 2. The effect of different interval of LMo sprays and different soil water conditions (field capacity) on average main stem height (cm) of three chili cultivars

Cultivars	Control (100% FC)	LMo Once a Week (75% FC)	LMo Twice a Week (75% FC)
Vitra	28.81 B b	32.36 AB B	33.93 A b
Lado	43.31 A a	41.99 A A	44.55 A a
Laris	44.10 A a	44.80 A A	35.97 B b

Note: Numbers followed by the same uppercase in the same row and the same lowercase in the same column showed non significant difference in the DMRT test at $\alpha = 5\%$.

Table 3. The effect of different interval of LMo sprays and different soil water conditions (field capacity) on average flowering time (days after planting) of three chili cultivars

Cultivars	Control (100% Fc)	LMo Once a Week (75% Fc)	LMo Twice a Week (75% Fc)
Vitra	32.36 A a	31.06 AB a	28.83 B a
Lado	26.33 A b	27.75 A a	24.44 A b
Laris	25.67 B b	30.25 A a	25.94 B ab

Note: Numbers followed by the same uppercase in the same row and the same lowercase in the same column showed non significant difference in the DMRT test at $\alpha = 5\%$.

Table 4. The effect of different interval of LMo sprays and different soil water conditions (field capacity) on average number of flower of three chili cultivars

Cultivars	Control (100% FC)	LMo Once a Week (75% FC)	LMo Twice a Week (75% FC)
Vitra	49.33 A b	57.94 A a	52.31 A b
Lado	83.61 A a	63.83 B a	67.58 B a
Laris	54.44 A b	61.25 A a	63.67 A a

Note: Numbers followed by the same uppercase in the same row and the same lowercase in the same column showed non significant difference in the DMRT test at $\alpha = 5\%$.

Table 5. The effect of different interval of LMo sprays and different soil water conditions (field capacity) on average number of fruit of three chili cultivars

Cultivars	Control (100% FC)	LMo Once a Week (75% FC)	LMo Twice a Week (75% FC)
Vitra	22.00 A b	27.89 A b	26.69 A c
Lado	54.56 A a	40.67 B a	48.92 AB a
Laris	29.78 B b	39.22 A a	36.17 AB b

Note: Numbers followed by the same uppercase in the same row and the same lowercase in the same column showed non significant difference in the DMRT test at $\alpha = 5\%$.

Table 6. The effect of different interval of LMo sprays and different soil water conditions (field capacity) on fruit weight per plant (g) of three chili cultivars

Cultivars	Control (100% FC)	LMo Once a Week (75% FC)	Lmo Twice aWeek (75% FC)
Vitra	77.73 B b	101.62 A ab	102.64 A b
Lado	141.16 A a	118.13 B a	143.21 A a
Laris	74.56 A b	81.76 A b	78.23 A c

Note: Numbers followed by the same uppercase in the same row and the same lowercase in the same column showed non significant difference in the DMRT test at $\alpha = 5\%$.

Table 7. The effect of different interval of LMo sprays and different soil water conditions (field capacity) on leaf relative water content of three chili cultivars

Cultivars	Control (100% FC)	LMo Once a Week (75% FC)	LMo Twice a Week (75% FC)
Vitra	62.97	71.81	67.91
Lado	63.32	79.17	72.02
Laris	77.20	86.44	84.23

DISCUSSION

The spraying of LMo at intervals of 1 week or every 2 weeks on the three chili cultivars (Vitra, Lado and Laris) grown under limited water condition (75% FC) shows different responses in growth and yields. However, the overall spraying of LMo golden apple snail at both spraying intervals is able to support optimal plant growth and yield, and increase the tolerance of the three cultivars to limited water conditions. Even the cultivar Vitra sprayed with LMo at 2-week interval shows better plant growth and development, in which the average fruit weight per plant is 32% higher than those of plant grown under optimum condition (100% FC). It is believed that the spray of LMo golden apple snail at 1-week or 2-week intervals is able to induce tolerance to limited water conditions in the three chili cultivars by optimizing the function of plant leaves. This is due to the LMo golden apple snail contains various beneficial microorganisms that support plant growth and development such as *Aspergillus niger, Azotobacter, Azospirillium, Pseudomonas* and *Staphylococcus* sp. in addition to plant growth regulators as well as macro and micro nutrients (N, P, K, Ca, Mg, Cu, Zn, Mn, and Fe) (Purwasasmita & Kurnia, 2009; Suhastyo et al., 2013).

Further, Related to this, according to Alshaal and El-Ramady (2017), in the condition of environmental abiotic stress such as drought, it turns out that some essential nutrients often cannot be absorbed by plants through roots so that the provision of nutrients through spraying on leaves can support nutrient needs for plants. Mandić et al. (2015) reported that the impact of drought stress on soybean plants can be reduced by the application of nutrient solution through leaves. Yuliani (2016) added that in addition to containing macro and micro nutrients needed by plants, the LMo golden apple snail also contained various types of amino acids (arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine) and various antagonistic microorganisms that play an important role in inducing plant tolerance to biotic and abiotic stresses including drought. According to Suhastyo et al. (2013), the amino acid tryptophan which is also contained in the LMo golden apple snail is a precursor forming the growth regulator of Indole Acetic Acid which plays an important role in inducing growth through the elongation of plant cells,

especially during the vegetative phase. Spraying of LMo golden apple snail at 1-week or 2-weeks intervals on chili cultivar Vitra, Lado and Laris grown under limited water conditions resulted in average RLWC values exceeding the RLWC value of control plants. This is also an indicator that the spraying of LMo golden apple snail at 1-week or 2-week intervals can induce drought tolerance of chili plants so that the three cultivars can grow and develop normally just like those plants under optimum condition. According to Lugojan and Ciulca (2011), the high value of RLWC in limited water condition related to rapid response of plant in suppressing the impact of environmental stress. This value is also an indicator of balance between water supply to leaf tissue and rate of transpiration so that all plant physiological processes can take place optimally.

CONCLUSSION

The LMo golden apple snail sprays at 1week or 2 week intervals can improve drought tolerance of three chili cultivars (Vitra, Lado and Laris). The three cultivars shows the same growth response as those plants grown under optimum condition. Spraying of LMo golden apple snail on the cultivar Vitra can increase average fruit weight per plant by 32% higher than average fruit weight per plant under the optimum condition.

ACKNOWLEDGEMENTS

Authors would like to thank you Rector, Head of Research and Community Service Institute, and Head of Doctoral Program in Agricultural Sciences University of Jambi for approval and financial support to carry out this research in 2021 fiscal year.

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