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Frequency and water supply on inerie kidney bean production in dry lowland of East Nusa Tenggara, Indonesia

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ABSTRACT

The purpose of this study was to examine the frequency and amount of water supply that provided the best production potential of Inerie kidney bean seed variety that were cultivated in the dry lowlands of East Nusa Tenggara (NTT). The variables observed were number of filled and empty pods, number and weight of seeds and weight of 100 seeds. The results of the study informed that the frequency of giving water every day gave the highest number of filled pods per plant which was 17.10 pods, the lowest number of empty pods per plant was 0.263 pods, the highest number of seeds per plant was 62.113 g, and the weight of the 100 best seeds was 44.668 g. The amount of water given twice each frequency of water gave the highest number of seeds, which was 54.708 grains, and the weight of the 100 best seeds was 43.487 g. There was a correlation between frequency and amount of watering for seed weight per plant which was 20,800 g. The results of this study informed that the Inerie variety has the potential to be developed in drylands of lowlands.

Key words : *Kidney bean, Water supply, Lowlands, Dry lands*

Introduction

Dry land is a suboptimal form of land that is very potential and should receive attention, because it is the main source of poverty and food insecurity, especially in East Nusa Tenggara (NTT). Dry land is characterized by relatively low annual rainfall, which is less than 2,000 mm/year. Rain is shed in a short period of time (3-5 months), and so is the planting period (Abdurachman *et al.,* 2008). Beside of that, the rain is also very eratic, so it is very difficult to arrange the right planting pattern.

Kidney beans are a horticultural plant that is widely consumed by the public. One of the national varieties of kidney beans from East Nusa Tenggara is the Inerie variety (Hosang *et al.,* 2006). This variety is consumed by many people because it is a type of vegetable seeds that has a protein content of 18.1780% - 18.7692%, fat content of 0.7737% - 0.8835% (Lewar *et al.,* January 1, 2018a) (Lewar, *et al.,* 2018a), and carbohydrate content of 60.32% - 61.55% (Lewar *et al.,* 2018b). Kidney bean plants in East Nusa Tenggara are generally cultivated in the highlands, even though the area in NTT is dominated by very broad lowlands with dry climate conditions. Kidney beans are suitable for planting in areas that have a wet climate with varying heights. The height of the suitable place is 1000-1500 masl. But apparently kidney beans can also be planted in dry land and rice fields in the lowlands around 50-300 meters above sea level which yields 370 kg/ha with a number of pods per plant around 12-21 pods per plant (Silverius *et al.,* 2007). (Lewar *et al.,* 2018b) through their research stated that kidney bean plants have the potential to be developed in the lowlands with modified micro climate utilizing organic mulch and companion plants. Furthermore, (Lewar, Hasan, 2019) stated that the utilization of coconut shell biochar and rice husk as well as giving water supply of 85 ETc was able to produce Inerie kidney bean seed variety with the best physiological quality. This illustrates that there are opportunities for the development and improvement of the potential production of kidney beans in the lowlands. With such limited highlands in NTT, efforts to develop kidney bean plants in the lowlands need to be done. However, its development is constrained by the height of the place in accordance with the growth and production of kidney beans. The difference in altitude affects the difference in climate, both temperature, humidity and light intensity. Therefore, we need a touch of technology that can modify the micro climate of plants.

The microclimate is very influential on plant growth which directly influences the physiological process of plants because it is related to the atmosphere in the plant environment from roots to crown tops. The elements that have strong influence are mainly solar radiation, air temperature, soil temperature, humidity, wind speed, precipitation and evapotranspiration. The micro climate of the plant is the condition around the plant from the deepest roots to the top of the plant (Indrawan *et al.*, 2017). Kidney bean plants have the potential to be developed in the lowlands but technology is needed that can modify the microclimate such as the amount of watering.

Water is an essential element for plant growth. All the water available to plants is not necessarily so easily absorbed by plants. The more the humidity level approaches the withering point, the harder the competition between the soil and plant roots. Water content that is easily absorbed ranges from 50% - 85% of available capacity (Hardjowigeno, 2003), this is important to know in determining the planting time and the amount of watering. If the availability of water cannot meet the needs of plants so that the use of ground water is lower than the water requirements will cause the plants to suffer from water stress. Water stress on plants is damage and disturbance in plants induced by lack of water availability in the body of the plant. This deficiency can occur due to lack of availability of water in the soil or the rate of transpiration exceeds the rate of absorption by plant roots (Laukamang, 2000). Plants that are experiencing water shortages will be stunted or visibly suffering accompanied by tissue damage. This disruption occurs because water plays an important role in the process of water transportation and nutrient translocation between cells and between tissues, in cell division and enlargement and its role in the physiological and metabolic processes of plants. Furthermore, water stress will cause plant roots to form slightly, small size with relatively narrow distribution area which results in decreased water and nutrient absorption followed by disruption of carbohydrate, protein, body regulating and nutrient translocation metabolism, causing plants to grow stunted and leaves formed are not perfectly developed (Laukamang, 2000). Plant water requirements are defined as the amount of water evaporated by plants during their lifetime. Water given to meet the needs of plant evapotranspiration so that it can grow normally will be efficient if given at intervals of time and volume of water with the use of appropriate irrigation technology (Merit, Narka, 2007).

This study is aimed at examining the effect of frequency and amount of water supply on the production of Inerie red bean seed variety planted in the dry lowlands of East Nusa Tenggara. The study was conducted from March to July 2019 in the farmers' land of Baumata Village, Taebenu District, Kupang Regency, East Nusa Tenggara Province - Indonesia. The location is in the dry lowlands with an altitude of 105 meters above sea level.

Materials and Methods

Research Design

This research applied Factorial Block Randomized Design: Watering frequency (F) composed of: F_1 : daily; F_2 : twice a day; F_3 : three times a day, and amount of water supply (J) composed of : J_1 : water supplied once; J_2 : water supplied twice. Result data were then analyzed using analysis of Variance followed by Duncan's Multiple Range test ($\alpha = 0.05$).

Research Materials

Materials used were Inerie variety of kidney bean seeds, manure, biochar from rice husk, Urea, NPK and pesticide.

Research Procedure

Fertilizing; was done at 1 and 3 weeks after planting (MST) using Urea 200 kg/ha, NPK 300 kg/ha. Urea was given 2 twice, namely 1 MST of 100 kg/ha and age 3 MST of 100 kg/ha. NPK was given once at 1 MST.

Water supply: water supply was carried out in accordance to the treatment that had been designed. Water was supplied by watering using a bucket with a volume of 14 liters of water/plot.

Control of plant-disturbing organisms; weeding was done mechanically using machetes, while pest and disease control used chemical pesticides: Alika and Sidametrin.

Harvest and postharvest; it was done when the leaves and pods of kidney beans had turned yellowish brown. The pods were then dried in the sun for 3 days followed by spawning and cleaning of the remaining dirt. Prospective seeds were then dried until the water content reached 10%.

Results

1. Number of Filled Pods

Analysis of variance informed that the frequency of water supply had a very significant effect while the amount of water giving had no significant effect on the average number of filled pods. The average number of pods containing Inerie kidney bean variety per plant based on the Duncan test of 5% is presented in Table 1.

Table 1 informed that the supply of water daily had a better effect than giving water every 2 and 3 days to the number of filled pods, which was as many as 17,100 crop filled pods. This showed that the element of water is an essential for plants, especially for the growth of Inerie kidney bean plant variety in lowlands of dry land and dry climate.

2. Number of Empty Pods

Analysis of variance informed that the frequency of water supply had a very significant effect while the amount of water given had no significant effect on the average number of empty pods. The average number of empty pods in Inerie kidney bean variety per plant based on the Duncan 5% test is presented in Table 2.

Table 2 informed that the treatment of the frequency of water every day was able to suppress the formation of empty pods in kidney bean plants that was 0.263 of empty pods, while other treatments reached 0.588 and 0.600 of empty pods. This was influenced by the water that was given more than the frequency of water given every 2 and 3 days.

3. Number of Seeds

Variance analysis informed us that the frequency and amount of water supplied has a very significant effect on the average number of seeds. The average number of Inerie kidney bean seed variety per plant based on the Duncan test of 5% is presented in Table 3.

Table 1. The Average Number of Pods Containing Inerie Variety of Kidney Beans per Plant (Pod)

Frequency of water supply	Amount of water supply		Average
	Once for each frequency	Twice for each frequency	
Daily	14.650	19.550	17.100 a
Twice daily	11.450	13.000	12.225 b
Thrice daily	12.475	11.600	12.038 b
Average	12.038	14.717	(-)

Note: Figures followed by the same letters in the same column and treatment show no significant difference in the 5% DMRT. The sign (-) indicates there was no interaction between the two treatments.

Table 2. Average Amount of Empty Pods of Inerie Kidney Bean Seeds per Plant (Pods)

Frequency of water supply	Amount of water supply		Average
	Once for each frequency	Once for each frequency	
Daily	0.350	0.175	0.263 b
Twice daily	0.625	0.550	0.588 a
Thrice daily	0.650	0.550	0.600 a
Average	0.542	0.425	(-)

Note: Figures followed by the same letters in the same column and treatment show no significant difference in the 5% DMRT. The sign (-) indicates there was no interaction between the two treatments.

Table 3. Average Amount of Inerie Kidney Bean Seeds per Plant (seeds)

Frequency of water supply	Amount of water supply		Average
	Once for each frequency	Once for each frequency	
Daily	51.525	72.700	62.113 a
Twice daily	40.775	48.325	44.550 b
Thrice daily	42.625	43.100	42.863 b
Average	44.975 b	54.708 a	(-)

Note: Figures followed by the same letters in the same column and treatment show no significant difference in the 5% DMRT. The sign (-) indicates there was no interaction between the two treatments.

Table 3 informed that the treatment of the frequency of water every day gave the highest number of Inerie kidney bean seed variety (62,113 seed) when compared to other treatments which only reached 42,863 seeds and 44,550 seed. This was influenced by the number of filled pods, the more number of filled pods the more seeds were produced. In addition, the number of seeds was influenced by the number of seeds per pod.

4. Weight of Seeds

Analysis of variance informed that the frequency and amount of water giving had a very significant effect on the average seed weight. There was an interaction between the frequency of water supply with the amount of water given to the average weight of Inerie kidney bean seeds variety per plant. The average number of Inerie kidney bean seed variety per plant based on the Duncan test of 5% is presented in Table 4.

Table 4 shows that the frequency of treatment and the amount of water given twice every day during the morning and the afternoon, gave the highest seed weight of Inerie variety (20,800 g) when compared to other treatments. This was influenced by the number of seeds per plant produced, the more the number of seeds, the higher the weight of the seeds produced.

5. Weight of 100 Seeds

Analysis of variance informed that the frequency and amount of water supply had a very significant effect on the average weight of 100 seeds. The mean weight of 100 seeds of Inerie kidney bean per plant based on Duncan's test (α= 0.05) is presented in Table 5.

Table 5 informs that the treatment of the frequency of water daily gave the highest weight of 100 grains of kidney bean seeds (44,685 g) compared to other treatments that only reached 40,242 g and

Table 4. Average Weight of Inerie Kidney Bean Seeds per Plant (g)

Frequency of water supply	Amount of water supply		Average
	Once for each frequency	Once for each frequency	
Daily	15.713 b	20.800 a	18.256 a
Twice daily	13.075 b	14.950 b	14.013 b
Thrice daily	13.825 b	13.275 b	13.550 b
Average	14.204 b	16.342 a	(+)

Note: Figures followed by the same letters in the same column and treatment show no significant difference in the 5% DMRT. The sign (-) indicates there was no interaction between the two treatments.

Table 5. Average Weight of 100 Seeds of Inerie Kidney Bean Seeds (g)

Frequency of water supply	Amount of water supply		Average
	Once for each frequency	Once for each frequency	
Daily	44.273	45.098	44.685 a
Twice daily	41.205	43.573	42.388 b
Thrice daily	38.720	41.765	40.242 c
Average	41.399 b	43.478 a	(-)

Note: Figures followed by the same letters in the same column and treatment show no significant difference in the 5% DMRT. The sign (-) indicates there was no interaction between the two treatments.

42,388 g. The weight of 100 seeds was also influenced by the amount of water given which was water supply given twice daily, in the morning and the afternoon, was able to give the highest weight of 100 seeds (43.487 g) when compared to just once daily (41.399 g). This was influenced by seed size and chemical content of seeds such as protein, fat and carbohydrate. However, the weight of 100 seeds produced was still low when compared with production at the highlands. Weight of 100 grains of kidney beans produced in the highlands was 45.71 g.

Discussion

Water is one of the main components making up the plant body. Water has basic functions, among others, as a raw material in the process of photosynthesis, the constituent of protoplasm which at the same time maintains cell turgor, as a medium in the process of transpiration, as a nutrient solvent, and as a media for translocation of nutrients, both in the soil and in body tissues of plants (Sugito, 1999).

Plants have different water needs in each phase of growth. In the vegetative growth phase, water is used by plants to carry out the process of cell division and enlargement. Treatment of water every 2 and 3 days in general results in the lowest average number of filled pods compared to giving water every day. Water supply with a frequency of 2 and 3 days is not able to meet the water needs of plants so that plant growth and development is hampered. (Jumin, 1992) stated that water deficit conditions can reduce plant cell turgidity. Decreased plant cell turgidity can result in inhibition of multiplication and enlargement of plant cells.

Water as a mean of nutrient transportation from the soil to plants is needed in the process of plant metabolism, such as the process of photosynthesis, plant transpiration and solvents of organic matter for plants. The role of water for the process of photosynthesis, obviously as one of the basic ingredients for the formation of complex compounds in the form of carbohydrates, proteins and fats in plants. Water also functions as a plant temperature stabilizer. At a certain temperature, the process of photosynthesis will run optimally. The optimal temperature for photosynthesis in C_3 plants including kidney beans is in the range of 24-27 ^{0}C (Soepardi, 1983). The air temperature around the research location during the research activities ranged from 28 - 33,87 ^{0}C. This had an impact on evapotranspiration. Evaporation is increasing not only due to air temperature but also the condition of the study soil which has sandy clay texture. The frequency of water supplied every 2 and 3 days hindered plant growth, due to insufficient water essential for plant growth. To be able to optimize the accumulation of photosynthesis process, an adequate intake of organic matter and water for plants is needed. Frequency of water given daily is very good for the growth of Inerie variety kidney bean plants in lowlands of arid dry climate. Inerie kidney bean plant variety has a native habitat in the highlands that requires temperatures between 20-25 ^{0}C and humidity of 55% (Hosang *et al.,* 2006). While the research location in the lowlands has an air temperature of 28–33 ^{0}C and a humidity of 55 - 70%, therefore the microclimate around the kidney bean plantations needs to be managed properly, one of which is the regulation of watering. Inerie kidney bean plant variety has the potential to be developed in the lowlands of dry climate, but in its development, it needs water element. Good water management will be able to create a micro climate (temperature and humidity of the air and soil) which is also good for plant growth. (Hosang *et al.,* 2006) stated that the number of pods that can be produced by the Inerie variety in the highlands was 17-20 pods per plant. In this study, the mean value of filled pods was as many as 17.10 pods per plant, which still met the minimum number of pods in the highlands.

It is also influenced by the maximum temperature of the air around the plant at the pod filling stage which was quite high at 33.87 ^{0}C where the energy produced was used more for transpiration than photosynthesis for photosynthate accumulation during the pod filling stage so that empty pods are formed. Taufiq, Wijanarko, (2007) stated that the critical phase of legume plants for seed production is during germination, early vegetative growth, when flowering, and when filling pods and seeds. Therefore, efforts should be made so that plants are not gripped by drought during these phases. Water demand increases and reaches a maximum when the phase starts filling pods. Lack of water during the generative phase (from flowering to ripening pods) reduces yield by 34% - 46%.

Provision ofs watering supplied daily could help the development of pods formed so that they are capable of producing seeds to the fullest. If during the pod filling phase the water are available in sufficient quantities then the pod filling will also take place maximally (Taufiq, Wijanarko, 2007) stated that the phase of pod filling is a critical phase of plants for water and therefore water supply must be optimally available.

The amount of water given as much as twice for each frequency of water supply was better than just being given once. This affects both the weight of the seeds and the weight of 100 seeds. In the phase of filling seeds or grain filling plants need water in sufficient quantities. An adequate amount of water helps plants to accumulate photosynthates in the seeds. Flowering, fertilization and seed filling will fail if the plant experiences water stress. Daytime air temperature is quite high when the plant is in the phase of pod filling (33.87 ^{0}C) has an impact on evapotranspiration which is also high, so giving twice each frequency of water is very helpful to replace the evapotraspired water. Water stress triggered by high temperatures will slow down the appearance of flowers which will shorten the seed filling period, thereby increasing the water content of the seeds during harvest. Exposure to high temperatures in a short time during seed filling will induce senescence, reduce seed formation, seed weight and reduce crop yield. Plants will use photosynthate to deal with high temperature stress, so only a limited amount of photosynthate is available for the reproductive development of plants. Legume plants are very sensitive to high temperature stress in the flowering phase, only in a few days experiencing stress temperatures of 30-35 ^{0}C can cause large yield losses due to flower fall, pod abortion, and pods not filled (Las *et al.,* 2018).

Plant water status is a very important variable in changes in ambient temperature of the environment. In general, plants tend to maintain their water status without being affected by changes in temperature when humidity is sufficient, but in high temperature conditions it is not possible at all because water availability is very limited. In field conditions, high temperature stress is often associated with decreased water availability. In general, at midday the increase in transpiration causes a deficit of water in plants, which induces a decrease in water potential which causes disruption to some physiological processes (Wahid *et al.,* 2007).

Conclusion

The frequency of water supply had a significant effect on the number of filled pods, number of empty pods, number of seeds, and weight of 100 seeds. The amount of water given had a very significant effect on the number of seeds and weight of 100 seeds.

The frequency of giving water daily gave the highest number of filled pods per plant which was 17.10 pods, the lowest number of empty pods per plant was 0.263 pods, the highest number of seeds per plant was 62.113 g and the weight of the best 100 seeds was 44.668 g. The amount of water given twice a day for each frequency of water supply gave the highest number of seeds, which was 54.708 seeds, and the weight of 100 best seeds was 43.487 g.

There was an interaction between frequency and amount of water supply for seed weight per plant which was 20,800 g.

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References

Abdurachman, A., Dariah, A. and Mulyani, A. 2008. Strategy and technology of dryland management supporting the national food procurement. *Jurnal Penelitian dan Pengembangan Pertanian.* 27: 43–49. (in Indonesian)

Hardjowigeno, S. 2003. *Soil Science.* Akademika Pressindo, Jakarta. (in Indonesian)

Hosang, E.Y., Samapaty, M.R., Bhuja, P. and Arsa, I.G.B.A. 2006. Release of kidney bean seeds as a superior variety at the national seed agency. Badan Bimas Ketahanan Pangan Kabupaten Ngada, Balai Pengkajian Teknologi Pertanian NTT dan Universitas Nusa Cendana, Jakarta. (in Indonesian)

Indrawan, R.R., Suryanto, A. and Soeslistyono, R. 2017. Study of microclimate to various cropping system and population of sweet corn (*Zea mays* saccharata Sturt.). *Jurnal Produksi Tanaman.* 5: 92–99. (in Indonesian)

Jumin, H.B. 1992. *Plant ecology: A Physiological Approach. Rajawali Press,* Jakarta. (in Indonesian)

Las, I., Istiqlal, A., Hermanto, Syahbuddin, H. and Apriyana, Y. 2018. *Handbook of Indonesian Agricultural Climate.* IAARD Press, Jakarta. (in Indonesian)

Laukamang, L.S. 2000. Effect of rate of water provision on growth and yield of cowpea crops. Faperta-

UNDANA. (in Indonesian)

Lewar, Y., Hasan, A., Hasan, M. and Pandjaitan, C.T.Br 2018b. The potential of production and quality of kidney bean seed of inerie Ngada variety in dry lowlands with dry climate. Politeknik Pertanian Negeri Kupang, Kupang. (in Indonesian)

Lewar, Y. and Hasan, M. 2019. Potential seed production of red bean varieties inerie ngada in the lowlands dry land: studies application type bio char and volume giving water against viability and viogur of seeds. *Ecology, Environment and Conservation.* 25: 52–57.

Lewar, Y., Hasan, M. and Lehar, L. 2018a. Effect of biochar types and sprinkling water volume on seed production and seed protein and fat content of red bean under lowlands dry climates. *Bioscience Research.* 15: 2848–2853.

Merit, I.N. and Narka, I.W. 2007. Effect of water provision intervals through drip irrigation and mineral plus fertilizer on the wine production in dryland at Gerokgak district, Buleleng regency | AGRITROP. 26: 24–32. (in Indonesian)

Silverius, L., Arsa, I.G.B.A., Kaunang, S., Gandut, Y.R., Markus, J.E.R. and Kleden, P. 2007. Research and development activity of kidney bean cultivation (*Phaseolus vulgaris* L.) in Ngada regency. Badan Bimas Ketahanan Pangan dan Penyuluhan Pertanian Kabupaten Ngada dengan Puslitbang Umbi-Umbian dan Kacang-Kacangan Universitas Nusa Cendana, Kupang. (in Indonesian)

Soepardi, G. 1983. *The Nature and Characteristics of Soils.* S.N., Bogor. (in Indonesian)

Sugito, Y. 1999. Plant ecology. UB Press, Malang. (in Indonesian)

Taufiq, A. and Wijanarko, A. 2007. Technology of soybean seed production summary introduction. Balai Penelitian Tanaman Aneka Kacang dan Umbi. (in Indonesian)

Wahid, A., Gelani, S., Ashraf, M., Foolad, M.R. 2007. Heat tolerance in plants: An overview. *Environmental and Experimental Botany.* 61: 199–223. doi:10.1016/j.envexpbot.2007.05.011.