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The Improvement of Red Rice Paddy Growth by Population Arrangement and Organic Fertilizer in Dry Land

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Abstract
The requirement of red rice always increases periodically but the availability of its at wetland has been recessive by land use change and rice cultivation in general. Alternative solution is directed to dry land and be the opportunity of red rice paddy area expansion that based on appropriate technology. In fact, red rice paddy has cultivated on the dry land in scatter plot system and the production is relatively low (1.5-2.5 ton.ha^{-1}). Scatter plot system causes the high competition between plants and gives directly impact on production. There are many wide areas of dry land in Indonesia and still not productive, so the good cultivation method has to be created through the arrangement of plant population and organic fertilizer as good agricultural practices manifestation. The goal of research is to increase production of red rice with high quality continuously and to improve the potency of dry land and also to increase the capability of dry land as a planting area. The research is conducted by experiment method by Randomized Completed Bock Design with plant population (scatter plot, 2, 4, 6 seeds per hole) as first factor and dose of manure (10, 3, 5, 7 ton.ha^{-1}) as the second factor (there are 16 combination treatments). Each of combination treatments is replicated three times. The result shows that combinations of 6 seeds per hole with 3 ton.ha^{-1} of manure give the highest amount of productive tiller and dry weight of grain (1.3 gram per clump and it is equal with 3.25 ton.ha^{-1}).
Keywords: Red rice paddy, population arrangement, organic fertilizer, dry land

1. Introduction

Paddy is the main food crop in Indonesia and almost all of the people need it for daily food. It means the rice production must be available continuously. Actually, rice production in Indonesia is not sufficient and for ad equating domestic demand, the government makes decision to import rice from foreign country such as Thailand. Those are caused by reducing of plant area especially in wetland or land field that completed with irrigation channel (caused by land use change) and the high price of production facilities. The wise effort should be done immediately such as cultivation on non irrigation technique land field which is directed on a dry land or rain fed land either on agro forestry system or monoculture with appropriate paddy. The development of paddy cultivation technology on dry land should be the first priority effort for preserving food availability and especially to reach food security.

The kind of paddy which is cultivated on dry land usually be called Gogo paddy. Those are the kind of paddy that can be planted on the limited water condition, unfortunately the productivity of Gogo paddy is still low either production or the quality, because the protein content just less than 6.8 gram per 100 gram. For recovering the production and quality of gogo paddy is needed cultivation technology through development of specific local commodity for improving high production. The potential of local dry land paddy that can be improved intensively is the kind of paddy which produces red rice or brown rice. Red rice is fulfill of vitamin and fiber that useful for maintaining human health, so it is worthy to increase production of red rice paddy on dry land that based on good agricultural practices.

Generally paddy cultivation is done on wet land which is begun by nursery and after 21 days be moved on wet land (sawah), one seed per hole with specific plant spacing. While Gogo paddy does not need nursery process, so the way for planting just scattered without plant spacing. That method causes high competition either on vegetative or generative phase and finally influences rice production. The cultivation technique for reducing water, nutrition and light competition can be closed with arrangement of plant population such as determination of amount of seed per hole on certainly area.

The high production of red rice paddy is determined by the amount of tiller on vegetative phase and then finally be a productive tiller. The productive tiller is determined by flower primordial formation of every tiller until seed formation. Thus vegetative growth is determined by the intensity of competition on growing phase and the formation of flower and seed are determined by the fulfillment of water and nutrition. So the growth requirement should be prepared from vegetative until generative phase. Unfortunately it is not easy to do because of dry land condition that always has minimal nutrition and water.

Paddy cultivation on wet land (sawah) usually plant 3-7 seeds per hole and it causes competition on water, nutrition, root and tiller development and it affect red rice production (Uphoff, 2001 *cit*. Hasrizart, 2008). Paddy cultivation still develops and finally some of the experts find a method namely SRI (*The System Of Rice Intensification*) which based on plant method that is one seed per hole and it can increase nitrogen fixation by free bacteria and microbe that live a round of paddy root and it makes nitrogen availability for the plant (Barkelaar, 2001 dalam Hasrizart, 2008).

One seed per hole supports plant opportunity for stabilizing growth process and produce the maximum tiller. When primary tiller grows well so it can be confirmed the second and thrid tiller will grow well too, and then there will be formed the big clump (Vallois *et al*., 2000 *cit*. Hasrizart, 2008). Furthermore, the amount of seed per hole influence growth rate of clump, because of the competition between plants on clump. The recommendation of paddy planting in Indonesia is 2 until 3 seeds per hole and it can produce 4.5 ton per ha of paddy. In China, Madagascar and Philippines just plant one seed per hole and can produce about 10.5-16 ton per ha (Hui and Jun, 2003 *cit*. Gasparillo *et al*., 2003).

Beside the arrangement of plant population, it is necessary to make attention on fertilizer, especially to apply organic substances such as dung as a basic fertilizer with appropriate dose. This point is an important strategic for increasing capability of dry land as an optimal land production. The application of organic fertilizer is especially used for repairing soil fertility and structure, because of nutrition content such as nitrogen, phosphor, potassium, and also micro nutrition that is needed for plant growing and also to increase the function of soil improvement (Sutanto, 2002 *cit.* Minardi, 2009).

Low production of red rice paddy should be approached by appropriate technology especially on dry land. The intensive effort for improving dry land condition through population arrangement and fertilizer must be done by this research. The high level of production is approached by population arrangement (the amount of plant per unit area) for evaluating the competitive condition and furthermore can be decided the optimum amount of plant. Besides, paddy cultivation must be supported by organic fertilizer application, and the appropriate dose of it should be found for determining the level plant productions succeed.

2. Research Method

Research has done on the beginning of rainy season from March until July 2012 at Tawangsari village, Teras sub-district, Boyolali district, (between 7°30'39.25" South Latitude and 110°39'40.49" East Longitude), on 215 meters above sea level with Entisol soil. The research is conducted by experiment method by Randomized Completed Bock Design with plant population (scatter plot, 2, 4, 6 seeds per hole) as the first factor and dose of manure (10, 3, 5, 7 ton.ha^{-1}) as the second (there are 16 combination treatments). Each of combination treatments is replicated three times. Soil and manure are analyzed before planting to get the content of nitrogen, phosphor, potassium, pH (level of acidity), organic compound and organic carbon.

First of all, field experiment is prepared by hoe and then is arranged as experiment plot which sized 160 x160 x 30 cm and the spacing between plots is 40 cm. Organic fertilizer is applied according to the treatment and mixed with soil. Then plant hole is made with 20 x 20 cm spacing for planting the red rice seed. Before planting, seed should be soaked on salty solution for choosing the good seed. Selected seed ready to be planted according to treatment.

After planting it has to be completed with weeding, watering, and pest controlling. Weeding to be implemented by mechanical treatment and begin at the second week until the eight week. Whereas watering is implemented twice a week every evening. The harvesting is signed by yellowish tassel and if red rice begins to dry.

The research variable are vegetative and generative growth such as the amount of tiller, the amount of productive tiller, the length of tassel, the amount of seed per tiller, the weight of 100 seeds per plot and biomass. Data is analyzed by analysis of variance and be continued by 0.05 and 0.01 level of F test, if there is a significant different be continued by Duncan Multiple Range Test (DMRT).

3. Discussion

3.1 Vegetative Growth

Leaves are the main plant organ that have big role for plant growing. Leaf area is one of character indicator which reflects the plant capability to catch the light and can be mentioned as Leaf Area Index (LAI). Leaf Area Index can be decrypted as a relatively covering of canopy on the land where plant growing. In the maximum growing of paddy (65 days), leaf area index of paddy will be maximum too, and the way of planting (scattered, 2, 4, and 6 seed per hole, at 20 x 20 cm spacing) influences leaf area. Leaf area index on scattered, 2, 4 and 6 seed per hole are 8.3, 4.75, 7.53, and 10.94 respectively. Those are the high of LAI because the ideal LAI usually reach around 3 until 5 (Sitompul and Guritno, 1995).

The high of LAI level can be mentioned through clump condition which is formed from the relatively big tiller. The amount of tiller on the maximum growth either on the scattered method or amount of seed per hole (2, 4, 6

seeds) are 14.80, 9.30, 10.70, and 12.30 respectively. The correlation (r) between LAI and the amount of tiller is 0.60 (quite closed) and it makes sense to explain why this plant has a big of LAI. The development of clump is determined by tiller formation; the first tiller grows from main plant (parent plant) and be followed by the second that grows from first tiller and so on. The amount of tiller on red rice paddy is almost the same with paddy on wet land; it is around 12 until 15 per clump (Purnomo *et al*., 2011).

The greater of Leaf Area Index causes mutual shading and finally decreases the rate of photosynthetic. Those phenomenon can be seen on Leaf Unit Value which has no significant different between treatment (scatter and the amount of seed per hole) and the value of leaf unit value are around 0.11 until 0.35 g cm^{-2}. The part of photosynthetic product is used as an energy for plant growing and another part is distributed in the form of biomass which is reflected on the weight of biomass (Taiz and Zieger, 2006; Purnomo *et al*., 2010).

There is no significant different on photosynthetic per leaf area unit, but it is found that there is differences between number of tiller and it causes the weight of biomass which is similar with the increasing of leaf area index. The weight of biomass all of treatments (scatter, 2, 4, 6 seeds per hole) are 11.30, 10.68, 14.80, and 15.12 g per clump, and the weight of biomass from scatter seems lower than from plant population treatment (4 and 6 seeds per hole). The closed correlation is found between leaf area index and weight of biomass (r = 0.70), however there is a competition between tillers so the number of tiller is limiting factor. That condition is reported on another research which is written on the conclusion that the low of biomass can be connected with the number of tiller (Purnomo, 2012). It can be reported that biomass of red rice paddy is lower than wet land paddy (30.85-32.66 is compared with 10.68-15.12 gram per clump) (Purnomo *et al*., 2011).

3.2 Generative Growth

3.2.1 The Productive Tiller

Unit of clump consists of some of tillers that come from the initial plant. The part of tiller becomes tassel namely productive tiller and it becomes an indicator of generative growth initially. The formation of number of productive tillers is about 30 until 45% of totally tillers. The number of tillers have closed relation with biomass (r = 0.99) and it shows that the formation of tiller need a lot of energy. A lot of energy need to confirm a tassel and the high biomass influences the amount of energy that needed for forming a tassel. Not all of tassels are followed by grain formation, because there is a competition between tillers on a unit clump, the bigger clump the bigger competition between tillers. The competition between tillers can be explained through the condition of another productive component such as length of tassel, the number of tassel and grains production. The difference of number of tiller influences paddy production because grains formation on tassel is determined by number of tiller (Karyawati and Prayogo, 2003).

3.2.2 The Weight of Grain

The grain of paddy can be found in tassel on the productive tiller, therefore the length of tassel determines grain productions. The length of tassel in this research is about 14-17 cm and it is not significant different between treatments (scatter, 2, 4, and 6 seed per hole), but the weight of grain is significant different. The weight of grain comes from net assimilate remobilization process which is accumulated as a biomass, thus leaf area index determines biomass and weight of grain (Hendrix, 2002) (Figure 1). The weight of grain per clump on scatter and all of number of seed per hole are 0.85, 0.60, 0.98, and 1.30 respectively and it is similar with 2.5, 1.5, 2.45, and 3.25 ton ha^{-1}. Paddy on scatter planting can produce 2.5 ha^{-1} of grains because of multiply plant number. In this research multiply plant number is not support with good grain, because there is a lot empty grain. Generally, the production per hectare is the same with the paddy production on a dry land (3 ton ha^{-1}). Production on a dry land always lower than on a wet land, likewise production in tropic is lower than sub tropic. Some researchers report that the production in sub tropic can reach 10-12 ton ha^{-1} and in India red rice paddy just reaches 4-7.8 ton ha^{-1} (Suardi, 2005).

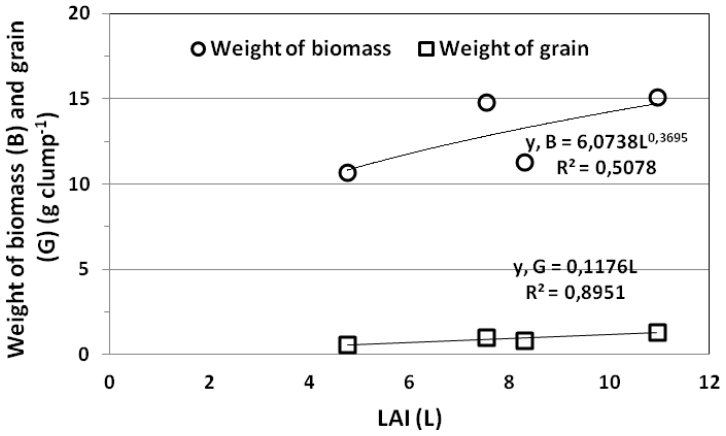

Figure 1. Leaf Area Index (LAI=L) determines The weight of biomass (B) and the weight of grain (G)

The low production of paddy on dry land in Indonesia is caused by:

- The limited of water availability
- The high temperature (>35°C), and it is not good for paddy (the best temperature for paddy is 68-100°F or 25-35°C) (Williams and Joseph, 1976).

The ideal temperature for photosynthetic processing is about 30°C for C3 and more than 30°C for C4 plant (Hall and Rao, 1999). Below 30°C, rate of photosynthesis of plant relatively low and the rate of respiration are low too. On thus condition, the net photosynthetic becomes high (Purnomo *et al*., 2010; Hall and Rao, 1999; Taize and Zieger, 2006 and 2010). The high of red rice paddy production comes from 6 seed per hole treatment, shows that there is grain filling success on tassel, and it can be connected with the lowest productive tiller percentage (32% be compared with 42-45% in another treatment). According to the theory, low of productive tiller cannot be expected as a good producer of grain. It is logic, although the productive tiller is low while supported by the best grain filling, have effect on grain production. Grain filling is determined by many factors such as temperature, soil moisture and nutritional adequacy (Taize and Zieger, 2010). For increasing the production, cultivation technology of red rice paddy on dry land should be done through many tests for the best result.

4. Conclusion

The conclusions of this research are:

- The high of red rice paddy production comes from 6 seed per hole, because of grain filling success on tassel
- Dose of organic manure does not become the important thing for red rice growing, and the lower dose (3 ton ha^{-1}) can be recommended as a dose of planting
- Combinations of 6 seeds per hole with 3 ton ha^{-1} of manure give the highest amount of productive tiller and dry weight of grain (1.3 gram per clump and it is equal with 3.25 ton.ha^{-1})

Organic farming can be applied on red rice paddy cultivation specially on dry land for improving soil structure and fertility

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References

Hall, D.O. & K.K. Rao. (1999). "Photosynthesis". 6th ed. Cambridge University Press. 214 pp.

Hendrix, J.E. (2002). "Production Related Assimilate Transport and Partitioning". In *Handbook of Plant and Crop Physiology* (M. Pessarakit, edt). Marcel Dekker Inc. New York. 972 pp.

Purnomo, D., A.T. Sakya, M. Rahayu. (2010). "Fisiologi Tumbuhan. Dasar Ilmu Pertanian". UNS Press. Surakarta.

Purnomo, D., A.Yunus, & S. Budiastuti. (2011). "Budidaya Padi Berwawasan Lingkungan Dengan Metod System Rice Intensification dan Penggunaan Pupuk Organik Cair". *Ekosains. Jurnal Ilmiah Lingkunga Hidup*. 3 (1), 25-31.

Purnomo, D., S. Adi, & S. Poncoraharjo. (2012). "Budidaya Padi Menggunakan *System Of Rice Intensification* (Sri) Dan Penggunaan Pupuk Organik". *Agrosains* 15(1), 24-31.

Taiz, L. & E. Zeiger. (2006). "Plant Physiology". The Benyamin/Cunmings Pub. Co. California.
Taiz, L. & E. Zeiger. (2010). "Plant Physiology" online. 4th ed. Created by Sinauer Associates Inc.
Williams, C.N. & K.T. Joseph. (1976). "Climate, Soil, and Crop Production in The Humid Tropics". Revised ed. Oxford University Press. Kuala Lumpur. 177 pp.
Karyawati. A. S. & C. Prayogo. (2003). "Respon Tanaman Padi Gogo yang Ditanam pada Penetrasi Pencahayaan Rendah Terhadap Penyerapan Hara Nitrogen". *Jurnal Ilmu Hayati.* 15 (2), 204-209.
Suardi, D. (2005). "Potensi Beras Merah Untuk Peningkatan Mutu Pangan". *Jurnal Litbang Pertanian.* 24 (3). 15-21.