ECODEV ECODEVELOPMENT JOURNAL
Ecodevelopment Journal
Vol. 2 No. 2 (59-62)
https://jurnal.unpad.ac.id/ecodev
cess.unpad.ac.id

EFFECT OF WATER LEVEL MANAGEMENT ON YIELD OF LOWLAND RICE IN SOBARI SYSTEM

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ABSTRACT

Research aimed to study effect of water level management on yield of lowland rice in System of Organic - Based on Controlled Aerobic Rice Intensification (SOBARI) had been conducted in lowland Group Farmers Sadang Mukti, Sadang Sari Baleendah, Bandung West Java with altitude of 668 m above sea level. The experiment was conducted since April 2013 until July 2013. Research used experimental methods, with Randomized Block design with three replications. The water level management treatment consisting of four water level managements, namely : A = moldy where re-filled when the soil water level had dropped to -15 cm below the soil surface, B = moldy where irrigation re-filled when the soil water level had dropped to -10 cm below the soil surface, C = moldy where irrigation re-filled when the soil water level had dropped to -5 cm below the soil surface, D = flooded water management 3-5 cm above the soil surface (conventional). The results showed that: to mitigate CH4 from rice field and increase the number of grain per panicle and yield of rice plants, the planting can be done with a water level management moldy, where irrigation re-filled when the soil water level had dropped to -5 cm below the soil surface.

Keywords: SOBARI System, Water level management, Yield of rice

INTRODUCTION

Naturally rice crops can grow well in a wide range of water levels until saturated conditions. Paddy rice growth best occurs at the level of stagnant water with 2-25 cm height, due to the water continuous conditions, rice plants have two advantages, namely a maximum rice growth and depressed types of grass weeds and *Cyperus rotundus,* although other types of weeds broadleaf not so depressed (Taslim and Fagi, 1988). According to Moody and De Datta (1982) continuous flow in rice field is the most effective way to control weeds. At the level of the water surface about 15 cm rice plants are able to grow better because it has aerenkhim vessels that supply O2 while the weeds do not have the vessels (Kusanagi, 1981). High water levels create anaerobic conditions that interfere with the absorption of nutrients and weed root respiration. Inundation of water causes interfere the process of gas exchange between the air and ground.

Managing proper water level will give a positive impact on the growth and yield of rice plants, because water level management that creates a more aerobic soil conditions can make the plant roots get more oxygen, so that the growth becomes better, and in turn the plants will grow more well and provide optimal results (Berkelaar, 2001). Aerobic conditions also allow soil microbes to get more oxygen thus maintain their survival, and can assist in the process of decomposition of organic materials into materials that can be utilized by the rice plant, so that the growth and yield of rice plants can be increased. There are several techniques that can create water aerobic conditions i.e. saturated water conditions and intermittent techniques.

Regulation of water techniques effects on rice yield and generates a lot of methane gas emissions. Condition of flooded rice is the largest contributor of methane gas into the atmosphere. Globally, it is estimated to be around 18 to 280 Gt of CH4 per year released into the atmosphere by lowland rice farming. This happens due to the waterlogged conditions are ideal conditions for methanogenic bacteria in the metabolic activity to produce CH4. (Lindau et al., 1990).

Apart from being a waste, the use of water resources by flooding caused soil pH become neutral, so that the decomposition of organic matter can take place and lead to the formation of CH_4 (Suparyono et al, 1994). Continuous inundation of rice fields, especially in the tropics, will increase the soil temperature and the temperature of the water in paddy fields during the day with a range of 30 °C - 40 °C, most of methanogenic bacteria that play a role in the process of formation of CH_4 is very active at the optimum temperature of 30°C - 40°C (Notohadiprawiro, 1992).

According Setyanto (1997) lowland rice plants play an important role in CH_4 emissions. Allegedly CH4 released into the atmosphere from paddy fields emitted by the plant, and the rest through stagnant water bubbles.

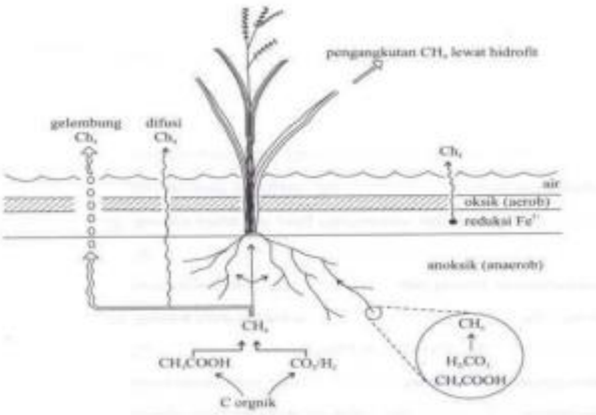

Figure 1. Chart Methane formation in paddy soil and release into the atmosphere according to Takai and Wada (1990) in Notohadiprawiro (1992).

The condition of water resources increasingly limited at this time so that necessary several dealings to overcome them, including water management in paddy rice farming, one of the technologies that can be applied is the approach of in System of Organic Based on Controlled Aerobic Rice Intensification (SOBARI), this is rice production system integrated with a holistic-based local input (straw compost, bio fertilizers, and other inputs) with the concept of LEISA (low external input sustainable agriculture) and water system management, also fertilizer plants to harness the power of biological plant (root system and the potential number of productive tillers) and strength biological soil or soil

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biological power (the abundance of beneficial soil organisms) based technology design and management input to achieve the production target (input- oriented management) in a planned manner (by design) Simarmata (2008).

In the SOBARI system, water demand is only half to one- third compared with a conventional way, with saturated condition or without inundated. This will save water usage up to 30%, however, this condition will lead more of weed growth and development than the flooded rice fields (Simarmata and Yuwariah, 2008).

Water level used in SOBARI method is saturated conditions. Thus the rice plants and rice rhizosphere activity in the area have opportunity to be in alternating aerobic conditions with anaerobic conditions. This will give the roots a chance to get some air so it can grow deeper, prevent iron toxicity, prevent the accumulation of organic acids and H_2S gases which inhibit root development (Ihsan, 2011), can also mitigate the formation of CH_4 from paddy fields.

The purpose of this research is to study the effect of different water level managements on rice yield in SOBARI System.

MATERIALS AND METHODS

The study used an experimental method, with a randomized block design with three replications. Treatment consisted of various water level managements namely: saturated water level management where irrigation refilled when the water level decreased between -15, -10,-5 cm below the soil surface, and inundated management of water level 3-5 cm above the soil surface during plant growth. Each plot had an area of 4 m x 5 m, with a spacing of 35 cm x 35 cm.

Seeds were transferred to the field after had reached the age of 10-15 days after sowing, using twin seedlings planting system , there were 2 seeds for each planting hole within 5 cm on saturated water level conditions. Water level management was carried out by saturated water level (0 cm water level) at first, then the water supply was stopped then water level allowed falling naturally. Provision of irrigation water to a height of 0 cm of water, then refilled when the ground water level had gone down and reach the specified depth limit on treatment (-5, -10, and -15 cm from the ground).

Measurement of the depth of ground water level was done by using the pipe 4 inches long with a diameter of 35 cm (the pipe 4 inches diameter with length of 35 cm) and a diameter of perforated with holes with a distance of 1 cm x 2 cm placed in the fields. Installation of the pipe was done by immersing 20 cm of length of PVC into the ground, and let the rest above the soil surface. Water level management was conducted since the plants were 7-10 days until the plant reached maximum vegetative phase (half way to generative phase), when the release of the panicle phase (7 days before the flowering period of 100% up to 7 days after flowering) all treatment were continuous flooded to prevent water deficiency in plants.

At the ripe stage until harvest time, the plants were not watered for the entire treatments. Weeding was done manually at 20 days after planting (DAP) and 40 DAP. Pest and disease control was done mechanically, physically or using pesticides according to the target.

Straw compost application was given one week before planting at a dose of 2.5 tons ha^{-1}. Nutritional were given by inorganic fertilizer, namely Urea 250 kg ha^{-1}, NPK 100 kg ha^{-1} KCL 50 Kg ha^{-1}. Urea and NPK fertilizer application was done 3 times; at planting time, 28 DAP and 50 DAP, whereas KCl was applied one time, at 50 DAP.

Harvesting was done using a sickle after physiological maturity of plants marked by yellowing grain threshing evenly performed and the yield were weighed to obtain the dry weight of the grain harvest. Variable response observed were component of weeds and yield components of rice plants including: dry weight of weed, length of panicle, number of panicle, number of grains per panicle, filled grain percentage and weight of dry grain harvest.

RESULTS AND DISCUSSION

1. Dry Weight of Weed

The analysis results of total weed dry weight at 90 DAP showed that among water level management treatments indicated different weed dry weight (Table 1). At the age of 90 DAP, the highest weed dry weight was in treatment A, this happened due to the treatment of the land was relatively open and not flooded for longer time than the other treatments so that the weeds grew more than other treatments.

Table 1. Effect of Water Level Management Treatments on Dry Weight of Weeds At 90 days after planting

Water Level Management Treatment	Dry Weight of Weeds At 90 DAP
A = moldy where irrigation re-filled when the soil water level had dropped to -15 cm below the soil surface	61.77 a
B = moldy where irrigation re-filled when the soil water level had dropped to -10 cm below the soil surface	17.18 b
C = moldy where irrigation re-filled when the soil water level had dropped to -5 cm below the soil surface	14.12 c
D = flooded water management 3-5 cm above the soil surface (conventional)	0.20 d

Remarks : The average number followed by the same letter in the same column are not significantly different according to Duncan's Multiple Range Test at the 5% level.

2. Yield Components

Study results of yield components consisting of panicle length, number of panicles, and filled grains percentage in Table 2, did not show significant differences between all treatments tested, these happened because plant growth was limited by the availability of ground water level whether low or very high. According to Hakim *et.al* (1986) the availability of water is required for the synthesis of carbohydrates and act as a carrier in the process of translocation of nutrients used for crop growth, and the whole treatments gave relatively equal levels of water availability, therefore, yield components (length of panicle, number of panicle and filled grain percentage) caused by all treatments there be not significantly different, according to the opinion of Munarso (2011) which stated that the provision of water to dry wet alternation with a safety limit of 10 cm and 15 cm did not lower plant height, number of tillers per hill, grain yield, yield components and whole.

The results in Table 2 also shows that the treatment management of water levels A, B and C (SOBARI) showed the same effect on the number of grains per panicle compared with conventional treatment (flooded), this occured because in the SOBARI system, water demand is only half to one-third compared with a conventional way, with saturated condition or without inundated, so that the soil aeration become good, it is directly related to the increasing of soil biodiversity (beneficial organisms in soil) under aerobic conditions, so that the ecosystem to be healthy and fertile soil, the root zone become widespread thus the nutrients available in the soil will be optimally absorbed and used by plants when sufficient available water in the soil. Blum (1993) explained that the low levels of water availability in the soil, in addition to result in reduced absorption of water, also causes low nutrients that can be absorbed by plants. This causes biochemical processes in the plant body, especially the synthesis of carbohydrates and proteins can not walk properly, so that the plant becomes stunted growth.

Increasing water availability in the soil according to Harjadi (1986) will increase the plant's photosynthesis process, thus resulting carbohydrates more that can be used to improve plant growth. On soil conditions in a field capacity state, the maximum growth rate approaching the plant, because in these conditions is available in a state of sufficient oxygen and followed by absorption of water and nutrients rapidly. But the increase in soil water content until saturated condition may result in less favorable due to the influence of soil aeration which is interrupted, so that the plant roots do not get enough oxygen and excess carbon dioxide interfere with root respiration. These conditions lead to disruption of water absorption and absorption of nutrient elements by plant roots, so plant growth is decreased.

Watering by means of wet-dry alternation in the area of technical irrigation with ground water level shallow depth (<50 cm) is an effective strategy in the efficient use of irrigation water especially when water availability is limited (dry season) or irrigated areas prone to drought. This method has been developed or widely adopted by farmers in several countries such as China, the Philippines, India, Vietnam, and Bangladesh (Zhi, 2001 in Munarso, 2011).

Application of alternation irrigation system in China turned out to produce an average grain yield of hybrid rice ranged from 6.4-7.2 tons ha^{-1} (Kato et al., 2009). Meanwhile testing of the hybrid rice Rokan Sukamandi in the dry season of 2007 showed that the irrigation system to dry wet alternation with a safety limit of 15 cm from the soil surface did not decrease grain yield when compared with continuous irrigation system with 3 cm high water level. This method also proved to be capable of producing 8.7 tons of grain ha^{-1}, with a saving of irrigation water use between 13-16% (Setiobudi, 2008).

Panicle is a result parameter that is sensitive to the dominance of weeds. Panicle growth is determined at the time of tillering, so the dominance of weeds during tillering will determine the number of tillers and panicles that are formed. Nitrogen deficiency during tillering to panicle initiation inhibiting and lower grain weight per panicle (Kusanagi, 1981) as well as determining the emptiness of grain.

These conditions will deteriorate due to an increase abscisic acid. Nutrient deficiency before the flowering period will cause the seeds that are formed so easily fall into grain production declines as a result of an increase in abscisic acid levels caused by a decrease in C02 xation as a result of stomatal closure (Marschner, 1989).

Table 2. Effect of Water Level Management Treatments on Yield Components of Rice Crop

Water Level Management Treatment	Yield Components of Rice Crop			
	Lenght Of Panicle	Number of Panicle	Number of grain per panicle	Filled grain precentage
A = moldy where irrigation re-filled when the soil water level had dropped to -15 cm below the soil surface	21.970 a	30.000 a	89.15 ab	76.927 a
B = moldy where irrigation re-filled when the soil water level had dropped to -10 cm below the soil surface	21.833 a	32.333 a	124.65 a	78.400 a
C = where irrigation re-filled when the soil water level had dropped to -5 cm below the soil surface	21.760 a	34.333 a	98.55 ab	82.030 a
D = flooded water manjemen 3-5 cm above the soil surface (conventional)	21.253 a	32.667 a	82.67 b	82.520 a

Remarks : The average number followed by the same letter in the same column are not significantly different according to Duncan's Multiple Range Test at the 5% level.

The level of soil water availability is as much as 3/5 of field capacity in the period when planting time to 4 weeks after planting is tolerated for the initial growth of upland rice crop.

Grain yield was determined by other yield components such number of plants per unit area, number of panicles per clump, number of grains per panicle, and grain weight per panicle (Manurung and Ismunadji, 1988). The components of rice crop are essentially influenced by genetic factors, but the management of plant and environmental factors will control the crop. The number of panicles per hill is the number of productive tillers in the clump. The number of panicles in clumps directly related to crop yield. The number of panicles in clumps is a reflection of productive tillers. The number of tillers formed in the vegetative phase will be closely linked to the panicle is formed. This is due to different nutrient supply, whereas in conventional land full dose of inorganic fertilizer that supplies nutrients faster and more available to plants.

Empty grains are seeds that failed to be fertilized or any time of anthesis denaturation takes place at the start of grain filling. The large number of empty grains in conventional land compared to pure organic land; part of organic or alleged to be caused by an imbalance of nutrients in plants. The high N fertilization without balancing other elements including micro elements suspected of causing a higher number of empty grains. The combination of inorganic fertilizers with organic can be complementary. Organic fertilizer is a complete fertilizer that contains elements despite low levels, as it also contains micro elements. In addition, the number of empty grains is also caused by environmental and biological factors. Pests in field trials in the flowering phase can affect whether the control has been done biologically and chemically.

In Table 1 shows that the treatment C resulted lower dry weight of weeds lower than the other treatments, indicating fewer weed competition with crops on C treatment, so that rice plants can utilize nutrients more during tillering which would eventually lead to the formation of panicle and increase the weight of grains per panicle (Kusanagi, 1981) as well as affecting number of empty grain. Nutrient deficiency due to competition with weeds that occur before the flowering period will cause the seeds formed so easily fall into a depressed grain production as a result of an increase in abscisic acid levels caused by a decrease in C02 fixation as a result of stomatal closure (Marschner, 1989).

3. Yield of Rice

The analysis results on weight of dry grain harvest in Table 2 shows that the highest weight was achieved by treatment C, this happened because the rice yield per hectare was determined by the outcome components (panicle length, number of panicles, number of grains per panicle, and percentage of grain content). Vegetative phase of plant growth from the beginning to the generative and ripening will determine the level of grain yield. On optimal soil nutrient availability conditions, nutrient uptake will be increased so that the needs for optimal growth and production levels will also be high. Increase on growth components and yield components will be followed by an increase in the production of dry grain per hectare.

Table 3. Effect of Water Level Management Treatments on Weight of Dry Grain Harvest

Water Level Management treatments	Weight of Dry Grain Harvest (Kg/ha)
A = moldy where irrigation re-filled when the soil water level had dropped to -15 cm below the soil surface	5896.667 ab
B = where irrigation re-filled when the soil water level had dropped to -10 cm below the soil surface	2198.333 b
C = where irrigation re-filled when the soil water level had dropped to -5 cm below the soil surface	9818.333 a
D = flooded water management 3-5 cm above the soil surface (conventional)	5568.333 b

Remarks : The average number followed by the same letter in the same column are not significantly different according to Duncan's Multiple Range Test at the 5% level.

Major effect of water stress on vegetative and generative growth of the rice plant can especially affect low yield, the occurrence of water stress during the growth generally inhibits growth process and seen in impaired photosynthesis. Since water is an essential element for the production, the efficiency of its use should give high production. (Turner, 1979), Drought is an environmental stresses that cause crop shortages of water, resulting in disruption of plant physiological processes that can be shown to decrease the organs themselves (Moment, et a1., 1979) and the subsequent effect on the results.

Furthermore, it occurs when water stress during flowering and grain filling, it can affect a lot of empty grain due to water shortages, droughts initially lowered cell turgor, subsequently causing stomatal closure and reduce cell growth. Thereby, it will reduce leaf surface area and the rate of photosynthesis per unit leaf area. Rice plants experience water stress at flowering phases and lead to reduce grain filling components results (Chang, et al., 1982).

According to Turner (1979), plants can avoid drought by maintaining water uptake. This mechanism is supported by a root system that is capable of absorbing water in par (Chang, *et* al, 1982).

CONCLUSION

Based on the experiment results, it can be concluded that to mitigate CH_4 from paddy fields and increase the number of grain per panicle and yield of rice plants grown can be done with a water level management moldy, where irrigation re-filled when the soil water level had dropped to -5 cm below the soil surface.

ACKNOWLEDGMENT

Thanks to the Advisor, Post Graduate Program, Padjadjaran University, Director General of Higher Education. West Java Provincial Departments of Education, Chairman Gapoktan Sadang Mukti and The Village Agricultural Extension District Andir Baleendah Bandung regency, which has supported this research activity. This article is part of Merry Antralina's dissertation with guidance of second and third author.

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