

CURRENT STATUS OF AGRICULTURAL WATER MANAGEMENT IN INDONESIA^{1/}

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Abstract

Water demand for agriculture and non agriculture (industrial, households, etc.) activities are more and more increasing in line with the increasing of the population, whereas the water availability from the water sources are more and more decreasing and unpredictable mainly due to (1) decreasing the water holding and the water retention capacity of the watershed, (2) environmental degradation due to overpopulation and escalation of the human activities, and (3) global climate change. In the past the balance between water sources and water demands are still surplus for agriculture, so that the roles of water management is still flexible or not crucial. However, currently and beyond the water deficit will become more and more crucial to agriculture since there will be a big competition among water users, except some measures or efforts are taken. The current status of agriculture water management in lowland rice in Indonesia is still dominated by continuous flooding, although some efforts is to increase water efficiency and productivity such as with controlled intermittent irrigation using perforated PVC tubes. It is combined with low water requirement and short duration crop varieties that may increase yields, save water, and emit less green house gases (GHG). It is suggested that the water management for the future should consider several aspects as follows: (1) to optimized crop planting areas in a region based on water availability and crop demand to avoid drought stress to the crops in the areas; (2) to improve water supply system such as intermittent irrigation, splash irrigation, sprinkler system; (3) to improve crop rotation system with using a crop planting calender, (4) planting more tolerant crop varieties in relation to drought and to submerge and short duration varieties, and (5) prepare water pumps and build water reservoirs and drainage system at the critical land areas to drought and to submerge.

Key words: Water management, food crops, integrated crops and resource management

INTRODUCTION

Agriculture, mainly rice, still play strategic and important roles in Indonesian economy, social and politics. The goals of the agriculture development in Indonesia during 2010-2014 period are as follows: (1) to increase food crop production to suffice food demand for the growing population; (2) food diversification to sustain and to strengthen food security and rice self sufficiency; (3) to increase the added value, competitiveness and export of food crop products; and (4) to increase farmers' income. However, in the future the supply of water tends to decrease due to the watershed capacity to store water is decreasing and due to the other environmental degradation, while the demand tend to increase since the needs for water in industrial, agriculture and human needs are increasing (Hermanto *et al.* 1995).. Therefore the growing issues need to be addressed to achieve the goals, namely (1) water scarcity and drought impact on food crop production; (2) floods and submergence impact on food crops; (3) pest and disease outbreaks in response to the climate change.

Drought. About 1 million ha out of 5.14 ha of land in Java and Sumatera is sensitive to drought. Within 1-2 decades the drought affected areas increases from 0.3-1.4% to 3.1-7.8%. During January to August 2011 water shortage and drought on rice field in East Java occurred in 11 districts/cities and also in Central Java. The “*puso*” areas in 2011 in Tegal district for example was 400.000 ha which is more vast than those in 2010 namely 230.000 ha. The land that usually produces 2 million ton (400.000 ha x 5 ton dry grain/ha) reduce to only 500.000 ton dry grains.

Floods. Within the next two decades the affected areas to flood increases from 0.75-2.68% to 0.97-2.99%, whereas the “*puso*” one increases from 0.24-0.73% to 8.7-13.8%. Sea water rise due to global climate change will affect rice field areas in Java ranges from 113-146 thousand ha, in Sulawesi 14-17 thousand ha, in North Sumatera it is about 1300 ha.

Those indicate that water management for food crops will become very important to reduce crop damages due to submergence or floods and to drought as well. The objectives of this paper are (1) to describe the past and the current status water

management on food crops mainly rice in Indonesia; and (2). to formulate the future needs for water management on food crops to facing global climate change.

Crop water requirement

Before mentioning water management of crops, it is important to consider the water requirement of crops to be grown. Mostly, the requirement of crop on water is determined by (1) the optimum water content of the biomass to meet the optimum physiological processes in the plant tissues; (2) respiration and transpiration rates and usually related to the crop biomass or plant body surfaces; and (3) plant growth duration. The water content and requirement of several varieties of food crops are presented in Table 1.

Table 1. Water requirement of rice, corn, and soybean varieties in different growth duration

Crop	Variety	Growth duration (days)	Crop water requirement (m ³ /ha)	Crop and land preparation water requirement (m ³ /ha)
Rice	Mekongga	125	6,250	7,909-8,519
	Ciherang	120	6,000	7,659-8,269
	Inpari11	105	5,250	6,909-7,519
	Inpari 13	99	4,950	6,609-7,219
Corn	Sukmaraga	105	5,670	
	Bima-4	102	5,508	
	Semar-8	94	5,076	
	Lamuru	90	4,860	
Soybeans	Tanggamus	88	4,224	
	Malabar	87	4,176	
	Menyapa	85	4,080	
	Grobogan	76	3,648	

Rice crop under common practices consume the highest amount of water ranges from 6,609 to 8,519 m³/ha. Corn plant requires water ranges from 4,860 to 5,670 m³/ha, while soybean requires 3,648 to 4,224 m³/ha (Table 1). High water requirement of rice crop is due to land preparation needs extra water to get fine muddy medium unlike in the other two crops. Low water requirement in soybean crop is due to shorter growth duration compared with rice and corn crop. Those water requirement of crops is also dependent on their varieties. Therefore, in agriculture water management selecting

crops in one year rotation is the first step of action, while choosing varieties of the crop is the second one. However, selecting crop and variety in a rotation for optimizing water use, it will also related to the other aspects such as economical values of the crops and farmers' preferences. The third step is field water management for each crop which is dependent on water availability, common agronomical practices, and the specific measures.

Water requirement and management of lowland rice

Water requirements for growing lowland rice is calculated from the amount of water losses due to evaporation, transpiration, percolation, seepage and retained in the biomass of the rice crops and involved in several chemical, physical and physiological processes. The need for water irrigation is the amount of water should be added to the field to suffice the gap between crop water requirement and rainfall as formulated as follows:

$$IR = E + T + S + D + P - Re, \text{ where}$$

IR: water irrigation requirement (mm); E: Evaporation (mm); T: Transpiration (mm); S: soil saturation (mm); D: flooding (mm); P: Percolation (mm); Re: Effective rainfall (mm)

Water requirements for growing lowland rice if practicing continuous flow during whole rice grow periods as reported by Balai Irigasi (2008) is 1.4 lt/sec/ha in average. However, there are variation of water requirement among soils; heavy clay soils require 0.7-1 lt/sec/ha, while the light porous sandy texture soils require about 6 lt/sec/ha.

In the field level, farmers manage water inflows to rice fields is to reduce the nonproductive outflows by seepage, percolation, or evaporation, while maintaining transpiration flows as these contribute to crop growth. This can be done at land preparation, crop establishment, and during the actual crop growth period.

Land preparation

Land preparation is the first important practice for good water management, consist of field channels, land leveling, and tillage operations (puddling, bund preparation and maintenance). Field channels in many irrigation systems like in

Indonesia, there are no field channels (or 'tertiary' irrigation or drainage channels) and water flows from one field into the other through breaches in the bunds. This is called "plot-to-plot" irrigation. The amounts of water flowing in and out of a rice field can not be controlled and field-specific water management is not possible. This means that farmers may not be able to drain their fields before harvest because water keeps flowing in from other fields. Also, they may not be able to have water flowing in if upstream farmers retain water in their fields or let their fields dry out to prepare for harvest. Consequently, the water that continuously flows through the paddies may remove valuable (fertilizer) nutrients.

Land leveling. A well-leveled field is a prerequisite for good crop. When field are not level, water may stagnate in the depressions whereas higher parts may fall dry. This results in uneven crop emergence and uneven early growth, uneven fertilizer distribution, and maybe extra weed problems.

Tillage. Large amounts of water can be lost during soaking prior to puddling when large and deep cracks are present that favor rapid "by-pass flow" to below the root zone. Cabangon and Tuong (2000) showed the beneficial effects of additional shallow soil tillage before land soaking to close the cracks: the amount of water used in wet land preparation was reduced from about 350 mm to about 250 mm (Cabangon and Tuong, 2000).

Bund preparation and maintenance. Good bunds are a prerequisite to limit seepage flows. To limit seepage losses, bunds should be well compacted and any cracks or rat holes should be plastered with mud at the beginning of the crop season. Farmers make bunds high enough (at least 20 cm) to avoid over-bund flow during heavy rainfall. Small levees of 5-10 cm height in the bunds can be used to keep the submerge water depth at that height. If more water needs to be stored, it is relatively simple to close these levees. Plastic sheets in bunds sometimes used in the field experiments to reduce seepage losses.

Crop establishment

Minimizing the turn-around time between land soaking for wet land preparation and transplanting reduces the period that no crop is present and that the outflows of

water from the field do not contribute to production. Especially in large-scale irrigation systems with plot-to-plot irrigation, the water losses during the turn-around time can be very high.

Alternate wetting and drying. In alternate wetting and drying (AWD), irrigation water is applied to obtain flooded conditions after a certain number of days have passed after the disappearance of pond water. The number of days of non-flooded soil in AWD before irrigation is applied can vary from 1 day to more than 10 days. AWD is also the water management practice of the System of Rice Intensification (Stoop *et al.*, 2002). Figure 1 is a schematic of AWD comparing with continuous flow that was conducted in Sukamandi, West Java, Indonesia. Alternately wet-dry irrigation (AWD) in lowland rice areas with heavy soils texture and shallow ground water tables in Sukamandi reduced total water inputs (irrigation and rainfall) by around 16-20% and without a significant impact on yield (Abdulrachman *et al.*, 2009).

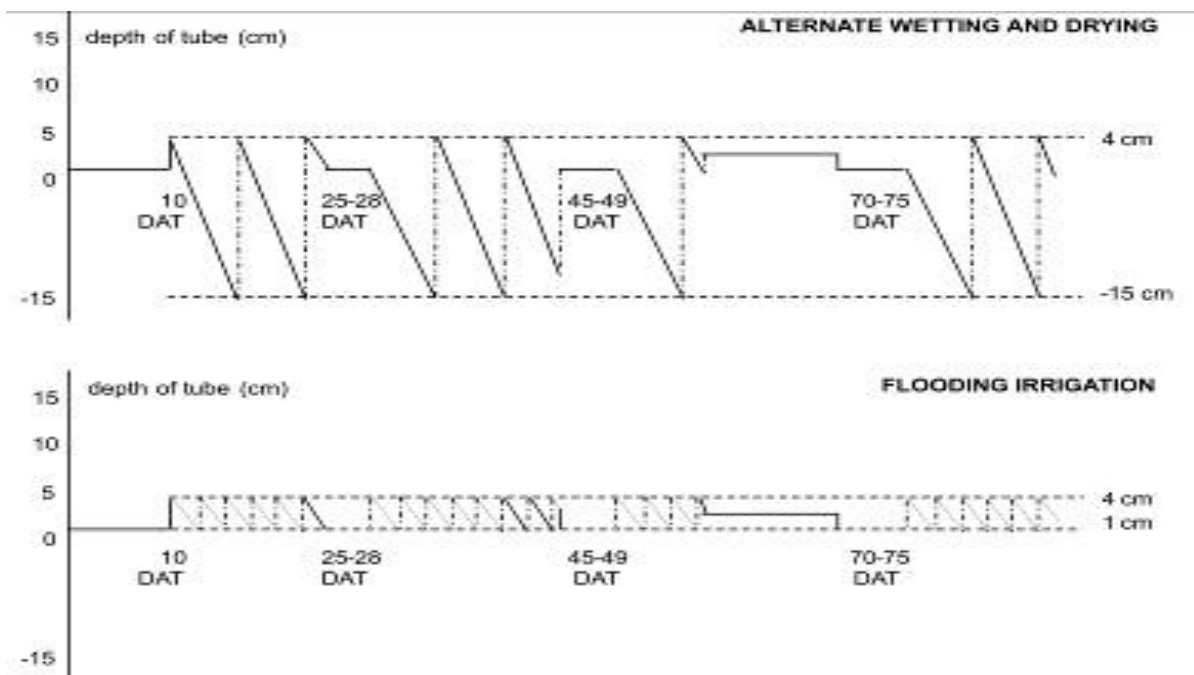


Figure 1. Water depth in porous tube during rice crop growth under Alternate Wetting and Drying (AWD) compared with continuous flooding irrigation practices

Experimenting with AWD in lowland rice areas with heavy soils and shallow ground water tables in Sukamandi reported that total (irrigation and rainfall) water inputs were reduced by around 16-20% without a significant impact on yield (Abdulrachman et al, 2009).

Water use efficiency and productivity

Efficiency of water use on lowland rice (m^3/kg grains) is defined as the ratio between water consumption to grow rice crop (m^3/ha) and the rice yield produced (kg/ha). It indicates the amount of water used to produce each kg of rice grain. Therefore, the higher the ratio, the lower the efficiency of water uses. Another term being used in this paper is water productivity to express the affectivity of each m^3 of water usage to produce rice grains (kg). Therefore, the higher the ratio the more effective in using water. There are three strategies or conditions in water use efficiency or water productivity as follows: (1) maintaining rice yield at the same level while reduces water consumption; (2) increases rice yield without increases of water consumption; and (3) increases rice yield and reduces water consumptions. Highly efficiently in irrigation system is reached whenever the mean of rice yield increases and the water consumption decreases, while the excessive water is used to irrigate the other areas. Therefore, the efficiency of water use is more important during the dry season of rice crop or under limited water condition in the areas (Setiobudi and Fagi 2008).

Continuous flow of irrigation system which is commonly practiced in irrigated rice field with the supply efficiency as much as 80% required $12,000 \text{ m}^3/\text{ha}/\text{season}$. Meanwhile, the splash irrigation with four day intervals in alluvial soils of the North coastal areas of West Java spent as much as $8,000\text{-}9,000 \text{ m}^3/\text{ha}/\text{season}$. This system, however, requires highly committed of the all irrigation water users (Baharsyah and Fagi 2008).

Effects of soil tillage on rice yield and water consumption

Improvement of water use efficiency and productivity in rice culture can be achieved in selected practices such as (1) soil tillage; (2) direct seeding; (3) planting drought tolerance rice variety and short growth duration variety; (4) the method of water supply; and (5) application of organic and inorganic fertilizers. Without soil tillage during

the dry season, rice crop at Subang district on the clay soil required 280 mm, whereas the complete soil tillage required 340 mm (Setiobudi 1999). However, the rice yield of the without tillage practice after the fifth season decreased to 5,0 t/ha from 6.0 t/ha in the first season, due to soil compaction, root growth restriction and so reduce N uptake. Effects of soil tillage on the water requirement of rice culture is presented in Table 2. Complete tillage required 846 mm water/season, whereas the minimum and without tillage required 555 and 573 mm water/season, respectively. Higher water requirement of the complete tillage than the other tillage is due to land preparation for the CT requires 305 mm/season, while MT and WT are not. Therefore, MT and WT save water 34 and 32% compared with the CT.

Table 2. Water requirement of rice crop at different soil tillage

Water requirement (mm/season)	Complete tillage (CT)	Minimum tillage (MT)	Without tillage (WT)
Land preparation	305	0	0
Water flooding	0	47	46
Evapo-transpiration	185	340	346
Percolation and leaking	185	168	181
Total	846	555	573

Source: Setiobudi and Ruskandar (2010)

Effects of water irrigation system on yield, water consumption and GHG emission

In a 2008 dry season the average water consumption of rice at alternate dry-wet system is 7,460 m³/ha/season with the production efficiency between 1.07 kg grain/m³ water. The practice of 2 cm depth of continuously flooding consumes water as much as 8,740 m³/ha/season or equal to the production efficiency between 0.95 kg grain/m³ water (Table 3). As comparison at the same experiment in a 2008/2009 wet season the average water consumption of rice at alternate dry-wet system is 3,379 m³/ha/season with the production efficiency is 1.96 kg grain/m³ water. The practice of 2 cm depth of continuously flooding consumes water as much as 5,551 m³/ha/season or equal to the production efficiency of 1.20 kg grain/m³ water. The results indicate that the water

requirement of rice crop in the dry season is almost double than that in the rainy season. However it is more related to the higher yield of rice in the dry season compared with the rainy season. Alternate wet-dry irrigation practice, however, consistently lower than that of continuously flooding.

Table 3. Water consumption, production and use efficiency and grain yield as affected water irrigation system. Sukamandi, 2008 dry season and 2008/2009 rainy season

Treatment	Grain yield 14% (kg/ha)	Water consumption (m ³ /ha)	Production efficiency (kg grain/m ³)	Water use efficiency (m ³ /kg grain)
2008 Dry season				
Continuous flooding	8294	8740	0.95	1.05
Alternate wet-dry	8009	7460	1.07	0.93
2008/2009 Rainy season				
Continuous flooding	6679	5551	1.20	0.83
Alternate wet-dry	6612	3379	1.96	0.51
Average Dry and wet season				
Continuous flooding	7487	7146	1.08	0.63
Alternate wet-dry	7311	5420	1.52	0.72

Source: Setiobudi and Ruskandar (2010)

The effects of water irrigation system and crop establishment on methane emission, yield and biomass production on Aeris Eutropept soils at Jaken, Pati District in 2007 have been reported by Setyanto and Kartikawati (2008) as presented in Table 4. Intermittent irrigation emits less methane (58-78 kg CH₄/ha/season) than continuous flooding (283-347 kg CH₄/ha/season) either in farmers' practice (FP), in Integrated Crop and Resource management (ICM) or under System of Rice Intensification (SRI), full organic manure (15 ton/ha) without chemical fertilizers, young seedling (15 das), 30 cm x 30 cm plant spacing and intermittently irrigated. However, biomass and yield production of intermittent treatments is slightly lower (or not significant) than the continuous irrigation ones, except in SRI. Biomass and yield of rice crop is very low in SRI treatment due to the soil nutrient content is very low while the organic manure

application is not sufficient to supply rice crop. This experiment concludes that intermittent irrigation reduces water consumption and methane emission,

Table 4. Rice yield, biomass and methane emission of three cultural practices and water management. Jaken, Pati 2007

Treatment	Total biomass (t/ha)	Grain yield (14% mc) (ton/ha)	Methane emission (kg CH ₄ /ha/season)
FP-continuous flooding	8.70 ± 0.82	6.72 ± 0.19	283 ± 36
FP-intermittent	7.18 ± 0.63	6.49 ± 1.15	58 ± 7
ICM-continuous flooding	8.81 ± 1.03	7.10 ± 0.08	347 ± 0.82
ICM-intermittent	8.80 ± 1.62	6.76 ± 0.14	78 ± 42
System of Rice Intensification (SRI)	2.50 ± 0.31	2.41 ± 0.34	61 ± 9

Source: Setyanto and Kartikawati (2007)

Effects of rice variety, plant population and fertilizer application on yield, water consumption and GHG emission

Rice varieties (hybrid, New Rice Plant Type and the common variety) with similar length of growth duration consume relatively the same amount of water. Besides that, the plant population or spacing and N fertilizer application method (SSNM 1 and 2) need the similar amount of water (Table5 and 6).

Table 5. Rice grain yield, water consumption, efficiency and production efficiency at different rice variety, plant spacing, and N fertilizer application under alternate wet-dry irrigation. Sukamandi, 2008 dry season

Treatment	Grain yield 14% (kg/ha)	Water consumption (m ³ /ha)	Production efficiency (kg grain/m ³ water)	Water use efficiency (m ³ /kg grain)
Variety				
Rokan (hybrid)	8,157	7,736	1.08	0.95
BP360 (Rice New Plant Type or NPT)	8,169	7,082	1.19	0.87
Ciherang (inbred)	7,701	7,563	1.07	0.98
Plant spacing				
20 cm x 20 cm	8,071	7,323	1.13	0.91
25 cm x 25 cm	7,947	7,597	1.10	0.96
N fertilizer application				
SSNM-1	8,126	7,999	1.07	0.98
SSNM-2	7,892	6,922	1.16	0.88

Note: SSNM-1 based on SSNM; SSNM-2 high rate of basal N and low rate of top dress
Source: Setobudi and Ruskandar (2010)

Those indicate that the demand for water of the rice crop is mostly dependent on crop growth duration. In this experiment with the alternate wet-dry practice the production efficiency ranged from 1.07 to 1.19 kg grains/m³ water or the water use efficiency from 0.87 to 0.98 m³ water/ kg grain. Hybrid rice (Rokan variety) and NPT (BP360) produce 8.16 and 8.17 ton/ha while the inbred (Ciherang) 7.70 ton/ha.

Table 6. Rice grain yield, water consumption, efficiency and production efficiency of the different rice varieties, plant spacing, and N fertilizer application under continuous flooding irrigation. Sukamandi, 2008/2009 wet season

Treatment	Grain yield 14% (kg/ha)	Water consumption (m ³ /ha)	Production efficiency (kg grain/m ³)	Water use efficiency (m ³ /kg grain)
Variety				
Rokan (hybrid)	8489	8409	1.01	0.99
BP360 (Rice New Plant Type or NPT)	8501	9109	0.93	1.07
Ciherang (inbred)	7892	8702	0.91	1.10
Plant spacing				
20 cm x 20 cm	8327	8786	0.95	1.06
25 cm x 25 cm	8261	8694	0.95	1.05
Nfertilizer application				
SSNM-1	8197	8929	0.92	1.09
SSNM-2	8391	8551	0.98	1.02

Note: SSNM-1 based on SSNM; SSNM-2 high rate of basal N and low rate of top dress
Source: Setobudi and Ruskandar (2010)

Further study in 2010 indicated that Integrated crop and resource management (ICM) which integrate a rice variety of low GHG emission and stress tolerant (Ciherang, IR64, Way Apoburu), intermittent irrigation, and organic+inorganic fertilizer based on site specific nutrient management produce 6.8 t/ha lower than that of the conventional flooding practices, but emit half GHG emission i.e. 5.696 kg CO₂e/ha.

Strategy to overcome water shortage and drought

There are two main strategies of improvement water management in food crop agriculture to anticipate global climate change, namely (1) improve crop varieties in relation to drought; (2) improve water supply system; (3) cultivation system and crop

rotation; and (4) optimized crop planting areas in a region based on water availability to avoid water stress to the whole areas.

Rice crop.

Drought and water deficit to crops may reduce yield up to zero or “puso” (crop failure). The possible measures to overcome those problems are (1) planting short duration varieties to avoid the crop imposed directly to water shortage; (2) tolerate to drought in which the crop can stand alive and produce yields; and (3) optimize the planting areas of different crops in order to the crops are survive to drought.

Planting adaptable rice variety. This strategy depend on crop varieties which have characteristics as follows: (1) short growth duration to avoid the crop imposed directly to water shortage; (2) tolerate to drought in which the crop can survive and produce yields. Upland rice variety and lines such as Inpago-5, TB409-TB14-3, B1249E-MR-1, TB368-TB-25-MR-2 tolerate to drought stress and to blast disease. Inpago-5 has potential yield 6 ton/ha. Inpari-10 is a new lowland rice variety tolerate to drought with the yield potential 7 ton/ha. It has strong stem, resistant to lodging and moderately tolerant to brown plant hopper (BPH) and bacterial leaf blight (BLB) strain III. Several lowland rice lines have also prepared to be released as drought tolerant rice varieties which have also very short growth duration: OM2395, OM5240, OM1490 (introduced from Vietnam), B10970C-MR-4-2-1-1-1-Si-3-2-4-1. Besides those varieties, Inpari-1, Inpari-11, Inpari-12 and Inpari-13 has very short growth duration which may escape from water shortage period in the field.

Water management. Intermittent irrigation or wet-dry irrigation system in lowland rice field may reduce the water requirement of the lowland rice as much as 30% compared with the continuously flooding without decreasing rice yield and reduces methane emission. The land should be irrigated whenever the depth of water surface in the perforated tubes is more than 15 cm below the soil surface. This method also reduces methane emission as much as 30-50% from the rice field.

Strategies to overcome submergence and flood

Global climate change may increase the flood affected areas under rice and other crops. Splash floods to rice crop may decrease rice yield up to the zero yield (crop failure). Recently there are promising rice varieties and lines which are more tolerant to submerged condition than the present varieties. Inpara-4 and Inpara-5 are the varieties which can stand to the submergence condition for 14 days. Ciherang sub-1 is also submergence tolerant varieties which is derived from the original Ciherang with addition of sub-1 gen. The other rice lines tolerant to submergence: IPB 1R Dadahup, dan IPB 2R Batola. Application of briquette urea (including carbon coated urea and SCU) and optimize plant spacing may reduce yield losses due to submergence (Ikhwan and Makarim 2010).

Current water management in rainfed lowland rice

Water management in rainfed lowland is “passive”, means the crop rotation pattern is adjusted to the water condition or availability. The example is rainfed lowland around Pati district, Central Java farmers planting two rice crops in a year. The first rice called “*Gogo rancah*”, while the second one called “*walik jerami*”. The third crop if water still available is *palawija* (peanut or mungbean).

Gogo rancah rice.

Land preparation is usually conducted at the end of the dry season or at the beginning of rainy season, where the land has already moist to cultivate. As indicator, the amount of rainfall has reach 60 mm/10 days. Rice seeds are planted using a dibbled stick like in upland rice. The difference with the dry land or upland rice, the land for *gogo rancah* rice surrounded by bunds like in a lowland, so that since the middle of rice growth until the harvest time the land is flooding with rain water. The benefit of this system is (1) if the water from rain is not sufficient, the crop is still like upland rice; (2) if the rainfall is high during the plant age of 30 to 60 days old, so that the flood depth 30 - 50 cm, the rice crops are still able to stand.

Walik jerami.

On the second rice crop (*walik jerami*) rice seedling is planted 10-15 days after harvesting *gogorancah* rice, while the nursery is prepared two weeks before the first rice

(gogorancah) harvest. On *walik jerami* rice transplanting is done when the land is usually wet or slightly flood and it coincides with the peak of the rainy season or high rainfall. Harvest time, however, usually conducted during the dry period of the season. If the water is still available either from the rainfall or from the small ponds (“*embung*”) the third crop is usually planted to *palawija* (non-rice food crop).

Corn crop

Corn cultivation in Indonesia until now depends on the rainfall. Therefore, water management should be optimized to support corn area development, planting intensity, and corn productivity. Water shortage due to less rainfall should be anticipated by providing water pumps. Corn plant required water during whole growth ranges from 400-500 mm (FAO 2001). Determining crop rotation pattern based on water availability which includes corn are grouped as follows:

1. Dry land dry climate: corn – fellow – fellow; or corn – corn – fellow
2. Dry land wet climate: corn – corn – corn; or corn – corn – fellow
3. Rainfed lowland : rice – corn – fellow;
4. Irrigated lowland : rice – rice– corn; or rice – corn – corn

Group 1 with the crop rotation corn – corn – fellow can be implemented if the additional water is guaranteed from shallow water table. Land drainage is required to accelerate corn planting time after rice harvest. Crop rotation rice – corn - corn on rainfed lowland besides drainage, additional irrigation from shallow water table or surface water is required (Prabowo et al. 1996).

Planting adaptable corn variety. Corn varieties tolerate to drought have been released by Balitsereal among others: Bima-4 hybrid corn and Lamuru composite corn with the respective potential yields of 11.7 and 7.6 t/ha. The other composite lines have also bred with the yields range from 9.1-9.7 t/ha and the growth period less than 90 days.

Bima-7, Bima-8 (hybrid corn) and Gumarang (composite corn) have crop growth duration 89, 88, and 82 days, respectively. Two lines (ST201054 and ST201043) have less than 80 days with the yield potential 9.4-10.7 ton/ha. The presence of short growth duration (80-90 days) and very short growth duration (70-80 days) corn varieties

through breeding make possible to grow corn twice a year or even to grow 3-4 times a year (PI 300-400) by relay cropping techniques

Soybean crop.

Balitkabi (Indonesian Research Institute of Legumes and Tuber Crops) has released short growth duration soybean varieties and tolerate to drought, namely Argomulyo (82 days) and Grobogan (76 days) with the respective potential yields as high as 3.3 and 3.4 ton/ha. In anticipating flood due to climate change, two soybean varieties namely Grobogan and Kawi are tolerant to submergence/anaerobic soil condition with the respective yields of 3.4 and 2.8 ton/ha; and growth duration of 76 and 83 days (ICFORD 2011).

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