Utilization of lowland rice in increasing maize production in Indonesia

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Abstract. To meet the maize demand, maize area is expanded to new agricultural land. Besides this, maize cropping is also shifted to lowlands, where water is not adequate to support the growth of rice. Almost all lowland rice area in Indonesia is located in Java, Sumatera, Bali, Nusa Tenggara, Kalimantan and Sulawesi islands. On those islands, lowlands cover 7,391,384 ha, comprising 2,361,792 ha of technical irrigation, 1,119,615 ha semi technical irrigation, 1,758,280 ha non-technical irrigation, and 2,151,697 ha of rainfed lowland. Cropping intensity of rice in lowlands is tending to decrease, which indicates that there is an opportunity to increase cropping intensity in the lowlands by planting maize. Rice and maize in lowlands can be planted as rice-rice-maize, rice-maize-maize, or rice-maize-fallow cropping patterns. Lowland areas planting rice twice per year were 4,558,568 ha, located 2,327,647 ha in Java, 1,162,130 ha in Sumatera, 232,687 ha in Bali and Nusa Tenggara, 133,502 ha in Kalimantan, and 702,602 ha in Sulawesi islands. Lowland areas planted with rice once per year were 2,832,816 ha, scattered 995,871 ha in Java, 779,756 ha in Sumatera, 200,652 ha in Bali and Nusa Tenggara, 476,747 ha in Kalimantan, and 379,880 ha in Sulawesi islands. Planting maize after rice provided high profit because maize prices increased to their highest level. High yield obtained by planting hybrid varieties, along with high prices are resulting in expansion of maize area in the lowlands, which is increasing every year.

Key words: Lowland production, rice, maize

Introduction

Maize is an important food crop in Indonesia, and is also important as feed and industrial raw material for various industries. The demand for maize, especially for feed, has been steadily increasing over the years. Maize demand for feed has exceeded 50% of the national requirement (Suryana *et al*., 2008). This demand is larger than production, and has forced the government to import maize. In 2005, Indonesia imported 1.80 million tons of maize and in 2010 it is projected that imports will reach 2.71 million tons (Swastika, 2007). Therefore, national production must be pushed significantly to meet domestic requirements.

In 2007, the national maize harvested area was around 3.63 million hectares, with productivity of 3.66 t/ha (Deptan, 2008). In efforts to increase maize production, besides increasing productivity, the maize planting area was extended by using available land. Lowlands are agricultural lands that are compartmentalized and have small dikes to resist water, with rice typically as their main crop. The planting of maize on lowland areas usually happens in the dry season, and is a strategic step that can reduce the maize production deficit and help meet the demand. The grain quality produced in the dry season is much higher, and its price usually increases to its highest level.

One million hectares of lowland is usually neglected and left fallow after rice harvest. Those lowlands can be used to expand the maize growing area. Maize can be grown on lowlands more than once, especially for green maize. Thus, increased maize production on lowlands can be achieved through proper cropping systems and increasing cropping intensity.

A part of the irrigated lowlands can not be planted with rice because there is insufficient water for irrigation due to climate change, less water held in soil as a result of deforestration, and damage to some irrigation facilities. Irrigation water has become a main problem faced in rainfed lowlands. The irrigation water problem can be solved by use of surface water and underground water. The availability of engined pumps is very useful for utilization of water for maize irrigation. Maize grown on lowland can be damaged by unpredictable rains, resulting in water logging that can kill the maize crop. To anticipate that problem, drainage must be prepared.

Lowland area available

Lowlands are devided into irrigated and rainfed lowlands. The two lowland systems are identified based on the degree of water control. Irrigated lowlands have permanent irrigation infrastructure, and rainfed lowlands are irregularly flooded by rainfall runoff. Irrigated lowlands

Table 1. Irrigation systems of lowland area in Indonesia

Island	Lowland area (ha)			
	Technical irrigation	Semi-technical irrigation	Non-technical irrigation	Rainfed irrigation
Java	1,528,625	408,025	606,368	780,410
Sumatera	357,942	335,385	595,706	652,853
Bali and Nusa Tenggara	100,973	185,030	76,382	70,954
Kalimantan	24,569	33,748	194,303	357,629
Sulawesi	349,683	157,427	285,521	289,851
Total	2,361,792	1,119,615	1,758,280	2,151,697

BPS (2004)

are more uniform and generally have higher productivity. Meanwhile, large parts of the rainfed lowlands have low productivity potential.

Technical irrigated lowland is a rice field where the input drainage is separated from the output drainage to enable controlled water usage. Generally this type of irrigation consists of main drainage, secondary drainage and tertiary drainage. The main and secondary levels are completely controlled by the government.

Semi-technical irrigation lowland is a rice field where the input or output drainage are not controlled by the government. Non-technical irrigated lowland is a rice field with simple irrigation built by farmers. Rainfed lowland is a rice field where the irrigation depends upon the rainfall.

In efforts to meet the maize demand, maize cropping can be shifted to lowlands, where water in lowlands is not adequate to support the growth of rice. Almost all lowland rice area in Indonesia is located in Java, Sumatera, Bali, Nusa Tenggara, Kalimantan and Sulawesi islands. On those islands, lowlands cover 7,391,384 ha, consisting of 2,361,792 ha technical irrigation, 1,119,615 ha semi-technical irrigation, 1,758,280 ha non-technical irrigation, and 2,151,697 ha of rainfed lowlands (Table 1).

Lowland areas planted with rice twice per year were 4,558,568 ha, located 2,327,647 ha in Java, 1,162,130 ha in Sumatera, 232,687 ha in Bali and Nusa Tenggara, 133,502 ha in Kalimantan, and 702,602 ha on Sulawesi islands. Lowland areas planted with rice once per year were 2,832,816 ha, scattered 995,871 ha in Java, 779,756 ha in Sumatera, 200,652 ha in Bali and Nusa Tenggara, 476,747 ha in Kalimantan, and 379,880 ha in Sulawesi islands (Table 2).

These data indicate that vast lowland areas are available to be utilized for maize cropping. Since rice is a main crop for the lowlands, cropping systems must be arranged accordingly.

Table 2. Rice cropping and cropping index in lowland area in Indonesia

Island	Lowland area (ha)		Cropping index 2006*
	Rice cropping intensity		
	Once	Twice	
Java	995,781	2,327,647	1.7
Sumatera	779,756	1,162,130	1.6
Bali and Nusa Tenggara	200,652	232,687	1.54
Kalimantan	476,747	133,502	1.22
Sulawesi	379,880	702,602	1.65

BPS (2004)
*BPS (2006)

Cropping system

The rice cropping intensity in the lowlands has been tending to decrease (BPS, 2006), which indicates that there is an opportunity to increase cropping intensity on lowlands by planting maize. Rice and maize in lowlands can be planted as rice-rice-maize, rice-maize-maize, or rice-maize-fallow cropping patterns. Extremely, on irrigated lowlands in Baranti village and rainfed lowlands in Kulo village, Sidenreng Rappang district, farmers did not plant rice on irrigated lowlands due to lack of irrigation water. Farmers in those villages grow maize as maize-maize-maize cropping pattern (Fadhly *et al*., 2008).

The degree of water control and availability determines whether maize is grown once or twice in this lowland system. Flooding for rice is assured only in the first season for much of Malang and Kediri, where the rice crop is followed by two maize seasons. Where better water control permits two rice harvests, only one maize crop is grown. It is not unusual to find a dry-season maize crop on lowlands that are technically irrigated (with full water control), which could grow three rice crops a year. In system with technical irrigation, the Department of Agriculture often reduces

water supplies to farmers in the dry season to permit canal maintenance and to control pest build-up through enforced breaks in continuous rice cultivation. Residual moisture and limited irrigation supply in certain areas are sufficient for maize (Mink, Dorosh and Perry, 1987). On irrigated lowlands, farmers grow maize for one or two crops. The introduction of short duration rice varieties made this possible. The choice of rice variety determines the time available for the other two crop seasons. After choosing a short-duration rice variety, farmers usually grow two hybrid maize crops. It will be used at least for the first maize crop following rice. These cropping patterns are still practiced in those areas, and even have been developed in many provinces such as Lampung, North Sumatera, South Sulawesi and West Nusa Tenggara.

This cropping pattern is also found on a limited basis in South Sulawesi, primarily on the inland plain around Lake Tempe. Lack of irrigation on rainfed lowland and otherwise fertile soils, limits rice to one crop per year, during the time of peak rainfall, which floods the level, bounded plains. Rains during the first and third crop seasons are insufficient to grow flooded rice, but they permit growing maize on either end of the main rice crop. Hence two maize crops per year are possible in this area (Mink, Dorosh and Perry, 1987; Bahtiar *et al*., 2006).

In terms of better management technologies, production recommendations should include practices such as hybrid varieties, adjusting population densities, no tillage or minimum tillage, using animal manure and inorganic fertilizers, ridging systems to reduce run-off, planting with the onset of the first good rains, dry planting, and controlling weeds early in plant development. Planting maize after rice provides high profit because at that time maize prices tend to increase to their highest level. High yield obtained by planting hybrid varieties along with high prices are resulting in expansion of maize area in the lowlands, increasing every year.

Irrigation

Water is the main limitation to maize production in the lowlands. In general, maize needs a least 500-700 mm of well-distributed rainfall during the growing season. Drought during the crop establishment stage can kill young plants, reducing the plant density. The main effect of drought in the vegetative period is to reduce leaf growth, so the crop intercepts less sunlight. Around flowering, from about two weeks before silking to two weeks after silking, maize is very sensitive to moisture stress. Grain yield can be seriously affected if drought occurs during this period. During the grain-filling period, the main effect of drought is to reduce kernel number and size (Lafitte, 1994).

If the soil profile is at field capacity at the time of planting, 350 to 400 mm of well-distributed rain throughout the growing cycle is sufficient to produce a good crop. For optimum growth, soil moisture content should be at about 60 to 70 percent of the field capacity. Good deep soil, permitting the roots to grow down to 1.5 m, may have a moisture capacity of 1 cm of water per 6 cm of soil, i.e. about 250 mm of water. The main water source for the maize crop may be moisture stored in the soil before planting, from rainfall during the crop season, from irrigation and, in much lower amounts, from dew condensed on the leaves that is funneled by the leaf blades and stems to the base of the plants. In certain areas, water from rainfall and its distribution throughout the year is adequate for more than one maize crop per year (Violic, 2000).

There were 4,558,568 ha of lowlands planted with rice twice per year, and almost half of those were technically irrigated lowlands. Lowland area planted with rice once per year was 2,832,816 ha, and more than half of that were rainfed lowlands (Table 3).

Generally maize crops are grown early or during the dry season. The majority of maize crops planted in the dry season require irrigation water; although expensive but very important. If water is available, high input levels can be used with low risk, especially fertilizers, which are very effective when moisture is sufficient. In conditions of high natural soil fertility, water availability throughout the growing cycle permits the exploitation of this natural advantage.

Irrigation is an important factor in maize farming on lowlands. Various water sources for irrigation can be used, such as coverage rivers, dikes, dams, irrigation canals, and wells. Generally, farmers use drilled wells as a water source and irrigate their maize crops by using engined pumps. Farmers drill wells by themselves and they only purchase

Table 3. Rice cropping intensity in lowland areas by irrigation system

Irrigation system	Lowland area (ha)	
	Rice cropping intensity	
	Once	Twice
Technical	352,673	2,009,119
Semi technical	271,188	848,427
Non-technical	614,034	1,144,246
Rainfed	1,594,921	556,776

BPS (2004)

pipes, pipe glue and other necessary materials. Usually one drilled well is used for one hectare.

Drainage

Maize is very sensitive to excess soil moisture conditions; hence it is important that fields where this crop is grown be well drained. If the water-table is high, the development of the crop will be considerably hampered, and the crop will suffer due to the inability of the root system to adsorb adequate amounts of moisture. Maize is particularly sensitive to excess moisture at the seedling stage, when the growing point is below ground level, and will show a reduction in plant stand and retarded growth with consequent final yield reduction. At the knee-high stage of growth, an excess of moisture for three to six days may cause a yield reduction of up to 30 to 50 percent, but if this excess moisture occurs at he flowering stage, yield reduction will be less. In many cases, surface drainage may help reduce the excess of water (Violic, 2000).

To avoid excessive water due to unpredictable rain, drainage must be prepared. Drainage ditches are made all around and every 10-20 m across and/or lengthwise of area planted, depending on rainfall. The drainage ditches are prepared before planting.

Conclusions

Overall there were 7,391,384 hectares of lowlands consisting of 2,361,792 hectares with technical irrigation, 1,119,615 with semi-technical irrigation, 1,758,280 hectares with non-technical irrigation, and 2,151,697 rainfed hectares. Lowland area planted with rice twice per year was 4,555,568 hectares and planted with rice once per year was 2,832,816 hectares.

In efforts to increase maize production, maize cropping systems could be shifted to lowlands by promoting increased cropping intensity using rice-rice-maize, rice-maize-maize, or rice-maize-fallow cropping patterns.

Irrigation is an important factor in maize farming on lowlands. Various water sources for irrigation can be used, but farmers generally use drilled wells and irrigate their maize crops by using engined pumps. To avoid excess water due to unpredictable rains, drainage must be prepared.

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