METHODS OF CULTIVATION FOR RICE DOUBLE CROPPING IN INDONESIA

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ABSTRACT

Irrigated and rainfed lowland rice occupies about 76% of 8.2 millions hectares of the land area devoted to rice production in Indonesia. A rice production increase program has been implemented in irrigated and rainfed lowland areas by using early-maturing high-yielding varieties and improved cultural management since 1969. Increasing grain yield per unit land area and cropping intensity are two major efforts to step up rice production. In fully irrigated areas rice can be grown twice a year in the dry and wet season using ordinary transplanting methods. In rainfed lowland and in partially irrigated areas rice double cropping can be accomplished by either dry seeding of rice, called "gogo rancah rice", followed by ordinary transplanting of rice, or lowland rice followed by a second crop of rice grown without land preparation called "walik jerami rice". The "gogo rancah" method promotes early planting while the "walik jerami" method reduces the interval between two rice crops.

Introduction

Out of 8.2 million ha of land devoted to rice production in Indonesia in 1980 irrigated lowland rice occupied the largest area (50%), followed by rainfed lowland (26%), upland rice (14%) while deep water rice and tidal swamp rice together comprised 10% (CRIFC, 1985).

Since 1969 the government has initiated a special program to increase rice production, especially on lowland irrigated areas by using high-yielding varieties, improved fertilizer use, modern cultural practices, integrated control measures for pests and diseases and improved irrigation water management.

Rice cultural practices in irrigated lowland areas are the most advanced compared to other types of rice culture. Seedlings grown in nursery beds and transplanted in paddy fields is the most common practice in lowland rice culture. Irrigated lowland rice and rainfed lowland rice differ due to the source of irrigation water. However the cultural management, is identical.

As Indonesia is a tropical country the wet and the dry seasons determine the availability of water in irrigated and in rainfed lowland areas. Using early-maturing non-photoperiod-sensitive varieties farmers can grow both wet and dry season rice crops.

A modified rice culture practice using a dry seeding technique in flooded bunded lowland rice, called "gogo rancah rice", is practiced by farmers in rainfed areas. In limited areas, in order to shorten the interval between two rice crops, the second rice crop is transplanted without land preparation, locally called "walik jerami rice".

Cultural management

In areas where irrigation water is available throughout the year farmers grow wet and dry season crops of rice. This intensive rice cropping is possible because climatic factors (especially temperature) do not limit rice growth.

Transplanting seedlings to the paddy field is the most common practice in rainfed and partially irrigated areas; however, some modified cultural practices are also used. The series of field operations may consist of: land preparation, nursery management and planting, irrigation

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and water management, fertilizer application, pest control, harvesting, drying and storage.

I Lowland rice

1 Varietal choice

Rice varieties widely grown by farmers in Indonesia have several improved characteristics: early-maturing, potentially high-yielding, responsive to fertilizer application, resistant to major pests and diseases and good eating quality.

Recent developments indicate that farmers are becoming more and more commercially and market-oriented. Therefore, consumer preference may one day dictate the varieties to be grown.

Table 1 shows some improved lowland rice varieties released by the Central Research Institute for Agriculture. Among these varieties IR36 is the most popular and widely grown, due to its early maturity and high yield potential and resistance to the brown planthopper - the most threatening insect pest. Good eating quality rices such as Cisadane and Krueng Aceh are also widely grown.

Table 1 Several lowland rice varieties released by Bogor Research Institute for Food Crops

Variety and year of release		Maturity (day)	Eating quality	Resistant to
Bengawan (1943)		155	good	Tungro virus*)
Sigadis (1953)		145	good	BB
Syntha (1963)		145	good	BB
Pelita I-1 (1971)		135	good	BB
Pelita I-2 (1971)		135	good	BB
Cisadane (1980)		140	good	BPH-1 and 3
Krueng Aceh (1981)		125	good	BPH-1, 2 and 3
Cisokan		120	good	BPH-1, 2 and 3
Batang Pane		120	good	BPH-1, 2
Introduced varieties				
IR5 (PB5)	1967	145	-	-
IR8 (PB8)	1967	130	-	BB
IR26	1975	125	-	BPH-1, GLH, Tungro
IR36	1978	115	-	BPH-1, 2, GLH, BB, BLS, GSV
IR42	1980	135	-	BPH-1, 2; BB, Tungro, GSV, Blast
IR50	1981	105		BPH-1, 2, 3; Tungro
IR56	1983	125		GPH-1, 2, 3; BPH-NS

*) BB: bacterial blight; BPH-1: brown planthopper biotype 1; GLH: green leafhopper, BLS: bacterial leaf streak; GSV: grassy stunt virus; BPH-NS: brown planthopper, North Sumatra-biotype

Source: AARD, 1986.

2 Land preparation

Land preparation is an important operation in growing lowland rice. Land preparation consists of a series of activities to achieve a certain quality of field condition which is even, muddy and soft, to facilitate transplanting of young rice seedlings and also to eliminate weeds. These ideal conditions can be obtained by careful plowing and harrowing with good water management.

In many parts of Indonesia plowing is done by using traditional plows of different shapes for preparing the paddy field, mostly under wet conditions. Plowing is followed by flooding of the field. Puddling and harrowing are usually performed by using a tooth harrow driven by animals.

Rice stubbles and weeds will be incorporated by plowing and harrowing and they will decompose in time. Well-prepared land will be kept under flooded conditions until the time of transplanting. The time required for land preparation depends upon the local conditions.

3 Seedling nursery

The majority of Indonesian rice farmers use the wet bed method for raising seedlings, which is common in irrigated areas. The dry bed system is being adopted in areas where the water supply is limited.

In the wet bed method during the first few days after sowing, the beds should be saturated with water. Shallow irrigation should be practiced continously afterwards. Young rice seedlings in the nursery bed are protected from rat and insect pests. Different insecticides and rodenticides are used to protect rice plant. Basudin, Diazinon and Furadan are commonly used by farmers to control insect pests.

Nursery beds must be well-puddled. Raised beds about 10 cm high and about 1 m wide are constructed. Furrows between raised beds are intended to irrigate the seedlings. Inorganic N-P-K fertilizers are applied to promote the growth of healthy rice seedlings.

Pregerminated rice seeds are sown in raised beds, with a density of approximately 75 g - 100 g/m^2 of seed. About 500 m^2 of seedbed is prepared for 20-25 kg of seeds in order to obtain a sufficient number of seedlings to plant a hectare of land.

Seedlings should be grown until a certain age in the nursery bed before being transplanted to the field. Experimental results shown in Fig. 1 and 2 indicate that 25 day old seedlings

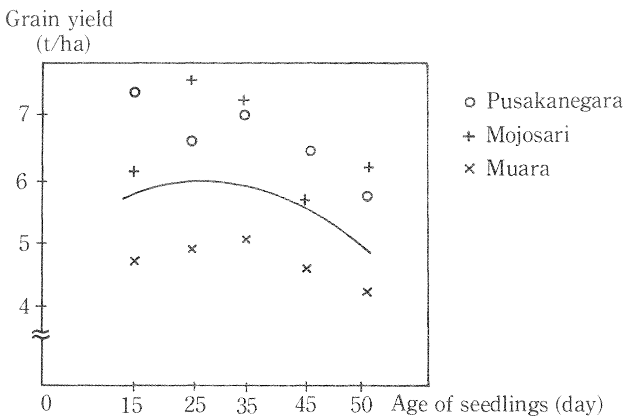


Fig. 1 Effect of age of seedlings on the grain yields of early-maturing varieties (average of three varieties) at 3 locations (dry season, 1972).
Source: PARTOHARDJONO *et al.*, 1983.

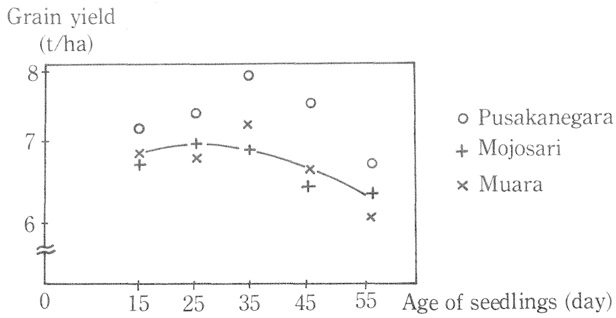


Fig. 2 Effect of age of seedlings on the grain yield of medium-maturing varieties (average of three varieties) at 3 locations (dry season, 1972).
Source: PARTOHARDJONO *et al.*, 1983.

produced the highest grain yield, both for early- and medium-maturing varieties. Too old seedlings reduced rice yields. The general recommendation is that seedlings should be transplanted at the age of three weeks.

4 Transplanting and plant spacing

Seedlings 21 days old are transplanted at a depth of 2.5 cm, with 3 seedlings per hill. Flooded rice fields should be drained prior to transplanting of seedlings. Basal fertilizers (mostly phosphate and a portion of nitrogen) are applied before planting the seedlings.

Plant spacing is an important aspect in growing rice in order to obtain an optimum number of panicles per unit area and spikelets per panicle to get high rice yield.

With improved varieties (medium height, high tillering, early and medium maturity), a spacing of 20 × 20 cm is recommended, as indicated by the experimental results in Table 2.

Uniform plant spacing can be obtained by using markers. In areas where water cannot be controlled properly a rope marked at certain intervals is usually used.

Table 2 Effect of spacing on the grain yields of different rice varieties (Muara, dry season 1976)

Variety	Spacing (cm)			Average grain yield (t/ha)
	25 × 25	20 × 20	25 × 12.5	
IR26	3.9	4.3	4.2	4.1
IR28	4.3	5.2	4.2	4.6
IR30	4.9	5.4	5.0	5.1
IR32	4.7	4.7	4.4	4.6
IR34	4.8	5.0	5.0	4.9
IR36	5.2	5.9	5.5	5.5
Pelita T-1	3.9	4.6	4.4	4.3
Adil	4.3	5.0	4.9	4.7
Makmur	4.3	5.5	4.7	4.9
Gemar	4.6	4.7	4.6	4.6
Average	4.5	5.0	4.7	

Source: PARTOHARDJONO *et al.*, 1983.

5 Water management

In order to obtain high rice yields water should be made available to the rice plants throughout the growing period. In lowland rice culture, flooding is important to compensate the loss due to evapotranspiration as well as to suppress weeds. Flooding will eliminate water stress at any stage. Water stress (drought) occurring during the generative phase will reduce rice yield (Table 3).

Water may be drained in paddy fields during weeding and top dressing with fertilizers. Where water is scarce, the paddy may receive water on a rotational basis. This practice is usually followed in the dry season.

Experimental results indicated that the interval of irrigation in the rotational system depends upon the soil characteristics and climatic factors, especially rainfall (Table 4). In heavy clay soils (Grumusols) a longer interval (10 days) was not detrimental to the growth of the rice

Table 3 Effect of soil drying on growth and yield of early-maturing rice varieties (Mojosari, dry season 1974)

Treatment	Plant height (cm)	Panicle/ hill	Filled grain/ panicle	Empty grain/ panicle	Weight of 1000 grain (g)	Grain/ straw ratio	Grain yield (t/ha)
Continuous flooding	90.2	11.3	77.0	20.8	23.0	1.1	4.6
Drying 7 DAT*)-PI	84.1	11.1	67.8	23.9	22.3	1.1	3.0
Drying PI-FL	84.1	11.3	73.8	24.3	22.0	0.8	3.7
Drying PI-MT	77.0	11.3	51.5	45.9	20.6	0.5	1.5

*) DAT: days after transplanting; PI: panicle initiation stage
FL: Flowering; MT: maturity

Source: PARTOHARDJONO *et al.*, 1983.

Table 4 Effect of water management on grain yield of IR5 in different locations (dry season, 1973)

Location	Water management			
	A	B	C	D*)
	t/ha			
Muara (Latosol)	4.4	4.3	4.1	4.2
Pusakanegar (Alluvial)	3.8	3.9	3.9	3.5
Ngale (Grumusol)	4.8	5.0	4.4	4.5
Mojosari (Regosol)	5.4	5.2	4.5	4.5

*) A = Continuous irrigation
B = Rotational irrigation, interval 5 days
C = Rotational irrigation, interval 10 days
D = Intermitent irrigation

Source: PARTOHARDJONO and FITTS, 1974.

plant; but in coarse-textured soils with fast drainage, delayed irrigation caused severe drought stress and reduced yields.

Table 5 shows that in areas of alluvial low-lying plain, in the dry season, a 17 day interval of irrigation (13-stress day) reduced rice yield significantly.

To optimize water use and to obtain high rice yield a shallow continuous flooding of 5 cm depth is recommended. Drainage of water should be performed about 10 days before maturity of the grain to obtain uniform ripening and to facilitate the harvesting operation.

Table 5 Effect of "stress day" period on the average of grain yields of three lowland rice varieties (Sukamandi, dry season 1982)

Irrigation interval ("stress day" period)	Grain yield
Continuous flooding	5.3[b*)]
5 day (1-stress day)	5.4[b]
9 day (5-stress day)	5.3[b]
13 day (9-stress day)	5.0[ab]
17 day (13-stress day)	4.6[a]
21 day (17-stress day)	4.4[a]

*) Any two means followed by the same letter are not significantly different at 5% level by DMRT.

Source: Fagi and Sanusi, 1983.

6 Weed control

Weeds in paddy fields will directly reduce rice yields by competing with the rice plants for nutrients, sunlight and space. Indirectly, weeds reduce rice yields by serving as hosts for insects and diseases which eventually infest the crops. Weed seeds may also lower the quality of the harvested rice grain.

Lowland paddy weeds can be grouped as grasses, sedges and broad-leaved species. Control measures will depend upon the type of weeds as well as the growth stage. Weeds can be eradicated mechanically by better land preparation, or by rotary weeder or by hand pulling. Hand weeding is quite time-consuming and therefore becoming more expensive, depending upon the rate of weed growth, it might require 25 to 50 man days/ha.

Chemical herbicides can effectively control weeds. The use of herbicides may become more popular among rice farmers if the price of these materials is low enough in comparison with the cost of hand weeding. Table 6 shows some promising herbicides for lowland rice.

Rice grain yield reduction caused by weeds depends upon the weed population (degree of competition) and the period of competition. Basically, weeds should be pulled as early as possible.

Hand weeding or the use of a rotary weeder is the most common practice by farmers in many areas. Usually weeding is carried out before the first and the second top dressing of N-fertilizer. During the weeding operation irrigation water should be drained and the rice top-dressed by fertilizers.

Table 6 Some promising herbicides for lowland rice

Formulation	Active ingredient	Rate kg (1)/ha	Time of application (DAT)*)	Target weeds
Rilof H 500 EC	2, 4-0 ester isopropanil + piperafos	1 - 2	10 - 21	*C. difformis, S. juncoides M. vaginalis M. crenata*
Ronstar 25 EC	oksadiazon	2 -4	4	As above + *J. repens*
Satunil 60 EC	benthiokarb + propanil	7 - 10	13 - 21	As above + *F. littoralis*
Herbazol	2, 4-D amine	0.5 - 1.5	21	*M. vaginalis, S. juncoides C. difformis, F. littoralis*
Londax 0.26	sulfonil urea	15 - 22	4	*M. vaginalis, S. juncoides*
Saturn-D	benthiokarb + 2.4D IPE	20 - 30	1 - 4	*M. vaginalis, S. zeylanica E. crus-galli, S. lateriflo-rous, C. difformis*
Fernimine 720 AS	2, 4-D amine	0.5 - 2	21	*M. vaginalis, J. repens F. littoralis*
Rhodiamine 72	2, 4-D amine	1 - 2	21	As above

*) DAT: days after transplanting

7 Fertilizer application

Improved varieties and fertilizer use are undoubtedly the two major components for increasing rice production beyond the present level. The response of rice crops to individual nutrients from fertilizers depends on many factors, i.e. varietal type, season, soil characteristics, time and method of application, and other cultural practices.

At present there are general recommendations for fertilizer use for various rice-producing areas in terms of kinds of fertilizers to be applied, the application rate, and timing and method of application. Guidelines, for fertilizer use are made available at the sub-district (*kecamatan*) level, throughout the country. Fertilizer recommendations have been improved from time to time over the past 15 years since the beginning of the intensification of rice production programs.

1) N-fertilizer

Urea is the most widely used N-fertilizer by farmers. Ammonium sulfate is only used in areas deficient in sulfur. Nitrogen fertilizer use and amounts depend on the rice varieties and growing season. In the dry season the rate of N would be higher compared to the wet season. HYVs need higher fertilizer rates compared to local varieties.

Nitrogen fertilizers (such as urea) are applied in three split applications: 1/3 as a basal dressing, 1/3 at the active tillering, and 1/3 at the panicle initiation stages (PARTOHARDJONO *et al.*, 1982). The total rate varies between 60 to 135 kg N/ha. In areas deficient in sulfur, ammonium sulfate (AS) should be applied as a basal dressing at the rate of 50–100 kg AS/ha. The fertilizers are broadcast and incorporated into the muddy soil (MAMARIL *et al.*, 1976).

In many cases the efficiency of N-fertilizer is low due to the massive losses through leaching, denitrification and volatilization.

Research on improving the efficiency of N fertilizer uses is continuing through the integrated efforts, including the use of green manures. Experimental results reported by PARTOHARDJONO *et al.* (1983) indicate that deep placement of urea super granules (urea briquet) gave higher yields than urea split application. Combining inorganic and organic materials can further improve rice yield.

2) *Phosphate*

Readily soluble phosphate fertilizer, such as triple super phosphate (TSP), has been used as a source of P for lowland rice for many years. TSP has been used in areas with soils with a low P content such as Ultisols. The rate of phosphate application may vary from 30 to 45 kg P_2O_5/ha and this fertilizer should be applied as a basal dressing.

Other sources of P have been studied in lowland rice. In areas where P fertilizer should be added (with pH = 4.8 and available P = 2.8 mg/100 g), it was found that TSP is superior compared to rock phosphate (MURSIDI *et al.,* 1975).

Sometimes the fertilizers are delivered too late to the farmers. An experiment was conducted in relation to the time of phosphate application. The results indicated that P should be applied not later than 3 weeks after transplanting to get the highest benefit from the P application (PARTOHARDJONO *et al.,* 1983).

3) *Potassium*

Potassium, as muriate of potash (KCl), is applied in areas deficient in potassium (K). In most cases a quantity of 30 to 50 kg K_2O/ha is sufficient to supply K to paddy fields with K problems.

Until recently the recommendation for potassium fertilizer application was a basal dressing. Recent experimental findings, however, indicate that potassium application at the active tillering stage, and in a split application, gave higher yields compared to basal dressing alone (ISMUNADJI and PARTOHARDJONO, 1980). Application of potassium fertilizer at the active tillering stage very likely reduced potassium losses. The rapid uptake of this nutrient by the roots, which develop quickly at this stage, prevents leaching losses.

4) *Sulfur*

The importance of sulfur for lowland rice in Indonesia has only been recently realized. Dramatic responses to sulfur were reported in field demonstration plots in South Sulawesi (MAMARIL *et al.,* 1976). Experiments conducted throughout Java showed that 46% of 41 sites were responsive to sulfur.

Ammonium sulfate seems to be the most effective source of sulfur compared to elemental sulfur.

8 Organic matter utilization

In lowland rice organic manures play an important role in maintaining and increasing the fertility of the paddy field. It is a common practice for farmers to plow under rice straw, compost and stable manure.

Straw incorporation is done at least 3-4 weeks before transplanting. Yield increases due to straw incorporation have been reported by many scientists. The research results show that absorption of plant nutrients and nutrient content of the plant tissues increase with straw application, especially for potassium. Long term application of straw increased organic-C, organic-N, phosphorus and potassium in the soil.

Incorporation of legume leaves (*Sesbania* sp.), animal manure, and compost alone or in combination with inorganic fertilizer will increase rice yields (PARTOHARDJONO *et al.,* 1983).

9 Harvesting, drying and storage

To facilitate the harvesting operation, about 10 days before harvest time, water should be drained from the rice field. The drainage may also induce uniform ripening of the grain.

The traditional method of harvesting is single stem utilizing a special knife called locally "ani-ani". The harvest operation can be speeded up by using a sickle. Mechanized harvesting has a limited use and is restricted to large scale rice estates.

The indica rice variety will be threshed right after harvest. In rural areas, farmers beat the rice panicles on a special implement made of bamboo. Winnowing is done by using wind force or other means. Some farmers, however, use small threshing machines combined with winnowing.

Fully ripened grain, containing about 20% moisture, should be dried in order to reduce the moisture content down to 14%. This level of moisture content is considered suitable for the storage of the grain.

Drying processes may be accomplished by using a drier with or without supplemental heat or simply by sun-drying.

II "Gogo Rancah Rice"

In rainfed areas, or in areas with partial irrigation, farmers grow "gogo rancah rice" which is direct-seeded under dry conditions at the beginning of the rainy season. When rainfall becomes high or when irrigation water becomes available, the rice field will be inundated as in the case of ordinary lowland rice.

"Gogo rancah rice" can be planted earlier in the rainy season, therefore, minimizing the risk of flood and drought. Early planting and early harvest of "gogo rancah rice" promotes the cultivation of the following crops. Depending upon the availability of water, either lowland rice or upland crops can be grown after "gogo rancah rice".

III "Walik Jerami Rice"

Another means to increase the rice cropping intensity in lowland areas is by minimizing the interval between two rice crops. In the northern coastal plain of West Java farmers have been using a traditional method of lowland rice cultivation called "walik jerami rice", which consists of directly transplanting seedlings in unprepared paddy, following the first rice crop.

"Walik jerami rice" and "gogo rancah rice" cultivation methods have been improved by providing early-maturing lowland rice varieties to the farmers. Improved weed control is also being introduced.

Rice cropping can be intensified by combining transplanted lowland rice, "gogo rancah rice" and "walik jerami rice", depending upon the local conditions - mainly water availability.

Rice cropping pattern in lowland areas

Weather and climatic conditions in the rice-growing areas in many parts of Indonesia are determined by the intertropical convergence zone as affected by *passat* and monsoon Asian winds. There are two seasons in the year; the wet season is characterized by high humidity and high rainfall, which occurs from September until March, while the dry season is characterized by less rainfall which lasts from April to August.

Rice production increase programs are implemented through better water distribution systems to farmers' fields. Irrigation systems are classified into technical (full) irrigation, semi-technical (partial) irrigation and non-technical (simple) irrigation. In fully irrigated areas rice can be cropped twice a year (wet season and dry season crop) very easily. This is the common and recommended practice of the farmers. One upland crop (corn or legumes) can be planted after a second rice crop.

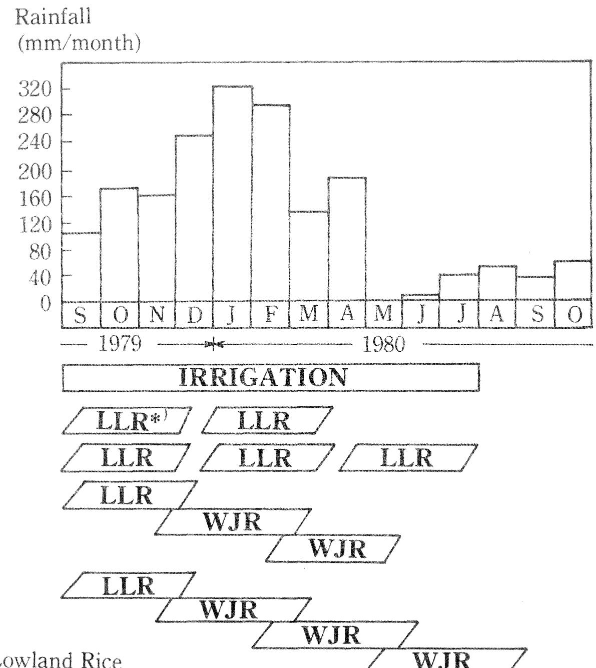
Potentially more than two crops of rice can be grown each year if water is available, as shown by the experimental data in Table 7 and Fig. 3. This experimentation was done by combining ordinary transplanted lowland rice with "walik jerami rice" using older seedlings (35

Table 7 Effect of different cropping intensity on grain yields of IR36 (Sukamandi, dry season 1979 and wet season 1979 - 1980)

Rice cropping	Grain yield per crop (t/ha)				Total grain yields	
	I	II	III	IV	(t/ha/year)	(Index)
LLR - LLR*)	4.4	4.9	-	-	9.3	(100)
LLR - LLR - LLR	5.1	4.8	4.8	-	14.7	(159)
LLR - WJR - WJR	5.3	4.5	4.5	-	14.3	(154)
LLR - WJR - WJR - WJR	4.7	4.5	4.4	4.4	18.0	(193)

*) LLR: Lowland Rice
WJR: "Walik Jerami Rice"

Source: PIRNGADI *et al.*, 1983.



*) LLR: Lowland Rice
WJR: "Walik Jerami Rice"

Fig. 3 Rainfall, irrigation availability and rice cropping pattern (Sukamandi, WS 1979-80 and DS 1980).
Source: PIRNGADI *et al.*, 1983.

days old). The findings cannot be recommended, however, due to the possible disease and pest development and the decline of soil fertility.

Hydrological features of the rice environment, as determined by the physiography of the land, which is represented by the slope, soil texture and water table are the measure of land suitability for growing crops, including the rice plant (O' TOOLE and CHANG, 1978). Rice double cropping, by using early maturing varieties, is possible in certain areas with more than 6 consecutive wet months (zones A, B_1, and B_2) (D.G. Food Crops, 1978).

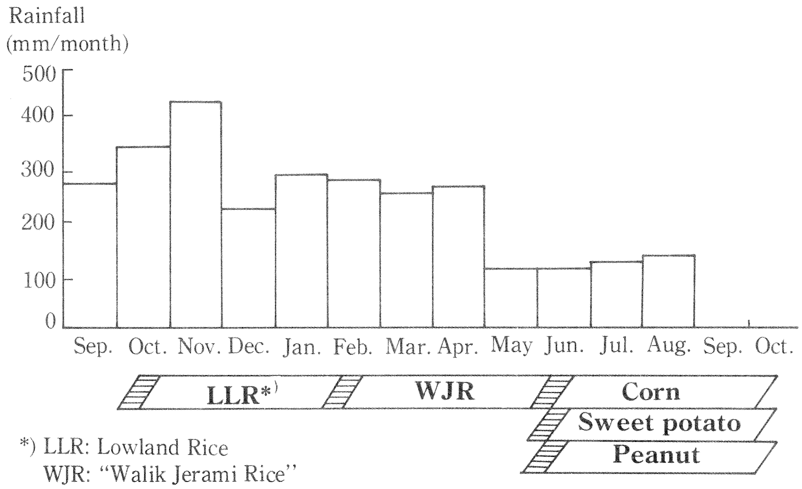


Fig. 4 Rainfall and cropping pattern in rainfed lowland area in Zone "A" in Java and Madura.
Source: D.G. Food Crops, 1981.

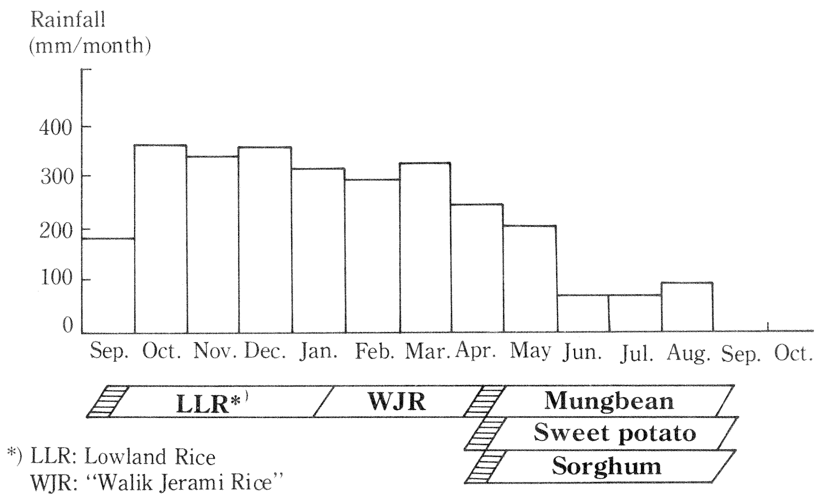


Fig. 5 Rainfall and cropping pattern in rainfed lowland area in Zone "B_1" in Java and Madura.
Source: D.G. Food Crops, 1981.

In zone A, with 8 consecutive wet months (Fig. 4), wet season rice crops can be planted from the month of October till February followed by a second rice crop planted in February till May. A third, upland crop (corn, sweet potato, and legume), can be grown after the second rice crop.

In zone B_1 (7 consecutive wet months) and in zone B_2 (6 consecutive wet months) rice may also be double-cropped (Fig. 5 and 6). In these cases the second rice crop will be planted right after the harvest of the first rice crop in mid - January without land preparation ("walik jerami rice"). Upland crops such as mungbean, sweet potato and sorghum can be planted after "walik jerami rice".

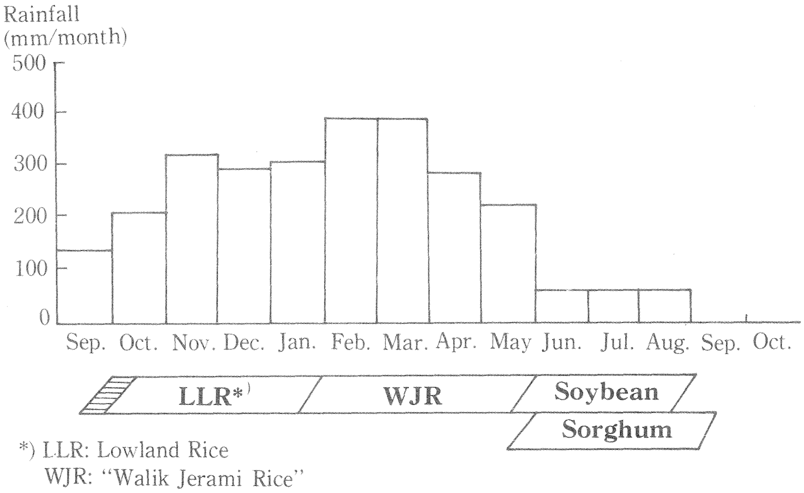


Fig. 6 Rainfall and cropping pattern in rainfed lowland area in Zone "B_2" in Java and Madura.
Source: D.G. Food Crops, 1981.

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