Varietal improvement studies of rainfed rice at Maha Illuppallama

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Rainfed rice is grown in the Maha season under upland chena, or manawari conditions in the unirrigable lowlands that are prepared and seeded under dry conditions, and depend only on rainfall for moisture.

In the dry zone the intensity and duration of the Maha rains show minor but significant regional variations. Occasional deficiency of rainfall is also experienced towards the latter part of the Maha season. The soils in these regions have a narrow range of available soil moisture, and they cannot supply moisture to a shallow rooted rice crop without frequent replenishment by rainfall. The unirrigable lowlands in these regions where the water table rises above the surface of the soil during certain periods of the Maha season, are ideally suited for the cultivation of dry rice (Abeyratne 1956).

Work on the improvement of rainfed rice varieties was carried out at the Agricultural Research Station, Maha Illuppallama. Initially the local germ plasms were screened for adaptability under rainfed cultivation. This resulted in the release of the pure line selection Dikwee - 328 in 1963. The variety H 4 which was released in 1958 for lowland cultivation was also cultivated under rainfed manawari conditions. Both these varieties, of 4 to 4½ months growth duration, were widely grown in the regions where the rainfall is of a longer duration. However varieties of shorter growth duration were found to be better suited for cultivation in a major portion of the rainfed rice tracts especially where the Maha rains are of shorter duration. Later in 1967 a hybrid selection MI-329 of 3½ months growth duration, and an introduction Pinulot-330 of 4 months duration were released as replacements for Dikwee-328 and H 4 for rainfed cultivation. Studies made under rainfed conditions at Maha Illuppallama on H 4, Dikwee-328 and Pinulot-330 indicated a high level of dry matter production in Pinulot-330 (Ponnuthurai 1975). These varieties are of traditional indica type, which are preferred to suit the management conditions of local farmers. The improved indica introductions like IR-8, IR-5, and Taichung (native) 1 however did not perform well under

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experimental conditions even in the seasons of favourable rainfall, and suffered frequently from blast and helminthosporium leaf spots.

Shorter duration varieties introduced from India (eg. CR 42) performed well under Maha Illuppallama conditions, but were not released to farmers as they could not combat weeds owing to their shorter height. The variety 62-355, also of shorter duration, gained popularity among farmers in the northern and north-central regions because of its taller growth habit, and reasonably high grain yields under normal Maha seasons. Although this variety is widely cultivated it is susceptible to blast, lodging and moisture stress, and needs improvement.

The grain yield performances of the important rice varieties, tested under rainfed experimental conditions at Maha Illuppallama over a number of Maha seasons, showed that a wide variation in the yield of upland rice ranging from outright crop failure to 4.800 kg/ha could be obtained (Fernando 1974). It is observed that this yield is positively correlated with rainfall (r = .778 **). The ability of CR-42 to maintain stable high yields in the past when the other recommended varieties failed, suggests the superiority of this variety under the rainfed conditions at Maha Illuppallama (Table 1).

At Maha Illuppallama failure of the crop has always resulted from a deficiency of rainfall after about the 3rd week of December, and this has occurred with a frequency of approximately 4 years out of 10 (Panabokke and Walgama 1974). This period coincides with the panicle development and flowering stages of the 3½ to 4 months age varieties, for which moisture requirements are very critical. Sivanayagam (1973) observed that the consumptive use of water varied during the different stages of growth of rice. Moisture stress during the period 15 days before heading to 15 days after heading severely affects the rice yields (Murakami and Vignarajah 1966). When the crop undergoes severe stress during this period it leads to considerable crop loss.

Using 1:1 confidence limits of expected rainfall for a number of dry zone stations, their soil moisture characteristics, and the consumptive use of water for cereal crops Panabokke and Walgama (1974) indicated that a shorter duration rainfed rice variety of approximately 95 to 100 days would be more suitable for the Anuradhapura and adjacent regions, which represent a major part of the dry zone. The past yield performances of rainfed rice at Maha Illuppallama confirm this observation, and suggest that shorter duration varieties with drought tolerance properties are required under these conditions. The varieties of 3 to 3½ months growth duration have a better chance of survival than the 4 to 4½ months age classes in the major portion of the rainfed rice area. However they observed that in the Amparai and Batticaloa regions the rainfall alone could satisfy the crop-water requirement for a 120 day upland rice crop, and suggested that the ideal sowing dates for the greater part of the dry zone is around the first week of October, since selection of proper sowing dates is essential for optimum use of the rainfall resource.

Objectives of Breeding

The breeding objectives for rainfed rice is aimed at raising the yield potential of the varieties under local rainfed culture, considering the climatic, edaphic, biotic and cultural conditions of the production areas. Varieties with wide adaptability to variations in seasonal patterns, and stability of yields under adverse conditions are preferred for upland rice areas. The following plant characteristics are considered at Maha Illuppallama, for the rainfed rice breeding programme to achieve these objectives:

1. Early seedling vigour to establish the root system and crop as quickly as possible and to combat weed growth; a more open habit with open tillering and moderately long and slightly drooping leaves to facilitate good ground cover.

2. Growth duration of the variety to be 3 to 3½ months and its crop water requirement to suit the normal local rainfall pattern.

3. Moderate number of tillers with a high tiller-to-panicle ratio, a high harvest index and a good grain quality; late tillering and grain shattering to be avoided.

4. Plant height of about 100 to 120 cm with stiff and non-lodging culms, and high fertilizer response at low to moderate fertilizer levels.

5. Adequate tolerance to drought and quick recovery from drought; ability to develop deep and thick roots to compensate for the reduction of moisture supply near the soil surface.

6. Plant responses to drought such as leaf drying and tiller mortality and fully exerted panicles with reduced spikelet sterility.

7. Resistance to major diseases and insect pests.

Field Screening for Drought Resistance

Under field tests the ratio of the yield under dry conditions to the yield under optimal conditions of water supply is considered as a valuable criterion of this concept of drought resistance (Levitt 1951). However this criterion of drought can be misleading in practice, as observed in experiments at Maha Illuppallama.

Many techniques are available for measuring drought stress in plants, but none of them are suitable for mass field screening. For the screening of rice germplasm for drought resistance Chang *et al* (1975) advocated dry season planting in the upland fields and controlling the soil moisture by applying a known increment of water to observe the water stress symptoms among the screening materials. The relative performance of the varieties under upland and flooded culture was taken to assess the variety's yield capacity. The drought resistant entries from the above screening had to be retested in the following wet season in a rainfed upland field to observe agronomic features.

Although the drought tolerant qualities of the test materials could be assessed in this method, the test materials might show a different response in the Yala season (Sri Lanka) due to the increased day length, solar radiation, wind velocity, open pan evaporation etc., and as such the results may not be directly applicable to a Maha crop. Further, the unpredictable nature of the Maha rains might affect the subsequent test of the materials in the Maha season. Although an initial drought screening is undertaken in the Yala season, the final screening of all the test materials should be carried out in the Maha season under the natural drought conditions.

Alternatively the method of replicated planting of the test materials at different seeding dates in the wet season as suggested by Chang *et al.* (1974) will be applicable under Maha Illuppallama environment only in a favourable Maha seasons. Table 1 and the findings of Panabokke and Walgama confirm that any date selected after the optimum date of sowing will have to risk crop failure. Further the intensity of rainfall received after the initial showers in Maha is normally so great that the second date of planting will have to be often postponed. Past experiences at Maha Illuppallama have indicated that even under normal Maha conditions most of the late planted materials failed to grow beyond the tillering to booting stages, and only their reaction to drought during the vegetative growth phase could be assessed. However, different dates of plantings could be carried out for the test materials of 3 to 3½ months duration in the Eastern regions if the crop stand is established. Under these circumstances supplementary irrigation at the tail end of the Maha season will permit the screening of varieties with two or more seeding dates at Maha Illuppallama. Screening of 120 day old varieties could be also undertaken at Maha Illuppallama for cultivation in the Amparai and Batticaloa Districts with such supplementary irrigations. Screening the test materials at a number of locations for a number of seasons will identify the most adaptable genotypes with relatively stable responses across the different environments.

The unpredictable nature of Maha rains with erratic showers and the limited moisture retention capacity of the soil has necessitated the selection of upland rice varieties with definite age groups for adaptability under wider seasonal variability. Although a Yala crop could be raised and testing for yield performance should be undertaken in the Maha each year with controlled irrigation under upland condition, selection season, as a result of which progress in breeding will be slower in the upland rainfed areas than in the irrigated rices.

Selections made under a favourable Maha season which meets the entire crop-water requirement of the rainfed rice has always resulted in selecting drought escaping genotypes. On the other hand selections made under a major drought period such as the one experienced during Maha 74/75 should reasonably perform well over a range of Maha environments. Hurd (1971) pointed out that in breeding for drought resistance it is more important to breed for maximum yield in the most adverse year rather than highest yield in a good year, and that breeding for high yield in semi-arid climates would largely require many genes to be assembled, each having a small effect.

Some of the upland rice varieties grown under local rainfed conditions in Sri Lanka have moderate drought tolerant qualities, short to medium growth duration, desirable panicle and grain features, resistance to major diseases, but their base yields under major drought seasons need to be improved.

Methods of Breeding

Where the parents were adapted to upland conditions, and with different genotypic backgrounds, straight crosses were made. Three way or double crosses were made when a parent had moderate drought tolerance. Back-crossing method was followed to incorporate disease resistance.

On the several introductions screened for drought resistance at Maha Illuppallama, the following lines appear promising and are used in the breeding programme: SML 140-142-1-25, IR 3880-16, IR 3880-29, ARC 10372, Salumpikit, IR 5, B44B-50-2-2-5-2-1.

The shorter duration varieties of 3 months age as Ai-nan-Tsolo, IET-3226, CR42, MI-42-1, MI-42-2, SE-322B-19, SE302G, IET-15860, RP-1188-111-1, IRAT-109, IRAT-110, IRAT-111 usually escapes the drought period at Maha Illuppallama. Some of the hybrid selections involving CR-42 and H 4 gave appreciably high yields under upland conditions and were resistant to blast. These hybrids have also given stable high yields over a range of soil moisture regimes tested at Maha Illuppallama in Yala 76 (Ganashan 1977). The varieties showed reduction in grain yield with reduction in soil moisture regimes. Although 62-355 has produced the highest mean yield, greatest yield reduction with soil moisture depletion was noticed in this variety. The stability analysis for grain yield gave a high regression coefficient for this variety, indicating that it has low yielding stability with changes in soil moisture regimes (Fig. 1). The selections 75-150 and 75-160 have a high base yield. They have average stability as their parent CR-42, but their grain yields are better.

In general with reduction in soil moisture regimes the varieties took a longer time to flower, and showed reduction in lengths of culm and panicle, panicle number, and 1000 grain weight, but the spikelet sterility showed a reverse trend. Several promising rainfed rice selections evolved from these programmes are being tested at Maha Illuppallama and in farmers' fields to determine the yielding stability.

When releasing rice varieties for upland conditions with unpredictable rainfall, higher base yield with drought tolerant qualities should be considered. Current breeding programme for rainfed rice at Maha Illuppallama is directed towards this end.

Greater awareness of the physiological and genetical aspects involved in drought resistance and other related fields, and exploring genotype by environmental interactions will accelerate the progress in rainfed rice breeding.

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Table 1—Grain Yield (kg/ha) below & Rainfall (inches) above

SEASON		1963/64	64/65	65/66	66/67	67/68	68/69	69/70	70/71	71/72	72/73	73/74	7475
CR 42	RF (in)								16.8		25.0	39.8	13.9
	YIELD kg/ha... ...								1593		3015	3406	80
Bg 34-8	... ...							40.6	16.8				
	... ...							2713	2407				
MI 329	... ...	53.6	19.5	48.9	36.1	33.6	21.0	42.8	21.9	39.0	25.0	39.3	13.9
		4034	887	4515	4381	2442	0	3789	2894	1111	246	0	0
DIKWEE	... ...	56.0	20.7	51.2	36.5	35.4	23.3	46.0	29.8		25.2		
		4741	135	4441	3878	2079	0	4300	0		0		
PINULOT	... ...		20.7	51.2	36.5	35.4	23.3	46.0	29.8	40.0	25.2	39.4	
			244	4823	4798	1888	0	4417	3620	1708	0	0	
H 4	... ...	56.0	20.7	51.2	36.5	35.4	23.3	46.0	29.8	40.0	25.2	39.4	
		4496	334	4501	4244	1643	0	3165	1994	0	0	0	
Bg 11-11	... ...								29.8				
									1805				

FIGURE 1.

REGRESSION LINES SHOWING GRAIN YIELD PERFORMANCES OF SOME RICE VARIETIES WITH VARYING SOIL MOISTURE REGIMES