High Yielding Varieties of Rice and Land/Water Management

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ABSTRACT

Around 90% of 1.8 million metric tons of milled rice consumed by an approximate population of 20 million Sri Lankans are produced from 0.73 million hectares of rice lands scattered in different agro-ecologies of Sri Lanka. The majority of rice lands have assured water supply through major and minor irrigation schemes. The rainfed fluvial lands in the dry and intermediate zones are frequently subjected to moisture stress but the irrigated/phreatic, phreatic and fluxial rice lands in the wet zone are either favorably rainfed or subjected to excess of water. The gain in popularity of semi-dwarf short duration rice varieties during the past three decades indicates the fulfillment of the requirement of more stable, high yielding paddies for water economy. Innovative water saving options like aerobic rice culture are being investigated for water economy in the future. Among other options of economizing water use in rice are soil and water conservation, containing waste and spillage of water, use of alternate weed control strategies for standing water, crop requirement based irrigation, and maximal use of rain water to save irrigation options for supplementary purposes. Future of rice culture depends on culmination of all or many of these options for water economy.

Key words: High yielding varieties, Rice, irrigation water, water economy, sustainability, genetic resources

INTRODUCTION

Rice, the major staple food of nearly 20 m. Sri Lankans is the livelihood of about1.8 m. farm families. Rice is grown in 0.73 m. ha. of land distributed almost in all agro-ecologies of the country. The total rice extent is about 46% of the land area under agriculture in the country. With the two seasonal (Maha, Yala) cultivation pattern, the annual cropping intensity of rice ranges from 108 to 126 %. Globally, we occupy the 18th position based on the rice land extent and produce 2.7m. metric tons of raw rice, which is nearly 0.5 % of the world's annual production of 570 m. metric tons. With the current production, above we meet around 90% of the milled rice requirement of 1.8 m. metric tons based on annual per capita consumption of 104 kg. There is a constant struggle to be self-reliant in rice to assure food security within the country, but the rate of gain in productivity is inadequate to surpass the demand posed by population growth of the country.

In every farmer forum there is a huge cry demanding for irrigation water, quality seed, subsidized inputs, protection from wild animals (wild boar) and a favourable market for raw rice. So it is very timely to discuss at least one of the key issues, relevance of water in rice production, from the perspective of progress in rice research and development of the country.

Historical aspects in irrigation

Prehistoric existence of rice in the country is evident by wild species, weedy types and land races endemic to Sri Lanka. Prominence given to rice cultivation in the ancient kingdoms of Rajarata is reflected in the magnificence of irrigation structures developed around 5th century and the caption that "not a single drop of rain water should leave the land without being used for welfare of human beings" by king Parakramabahu the great. Collapse of Rajarata civilization around 12th century, partially as a result of depopulation due to Malaria, and subsequent foreign invasions would be the major reasons behind the downfall of rice culture in the country. Abolishing forced labor (rajakariya) in 1832 led to general neglect of the irrigation work, and was accompanied by the desuetude of the old customs of communal co-operation (aththam) in the paddy cultivation. Consequently, the annual rice production fell to certainly 5.5 million bushels, if not less, in the 10 year ending with 1856 (Elliot, 1913 b).

The first paddy ordinance passed in 1857 provided voluntary restoration of old systems and as a consequence, efforts were made to expand lands under irrigation. The grain tax was abolished in 1892 as an incentive to increase rice production. The effects of the above steps were felt in the latter half of the 19th century in gradual increase of rice production (Table 1).

Table 1. Rice production statistics reported in the latter half and the turn of the 19th century (Elliot, 1913)

Period (year)	Land extent (acre)	Production (million bu.)	Productivity bu./ac (t/ha)
1856	401,000	5.70	14.2 (0.72)
1892	613,000	10.00	16.3 (0.83)
1893	589,000	10.70	18.2 (0.92)
1902	663,000	11.75	17.7 (0.90)
1903	713,000	13.50	18.9 (0.96)

Elliot (1913a) has highlighted the importance of water by quoting the statement of Mr. Strange, then the Director Irrigation, "the capital will consist of the irrigation works themselves" and equating it to king Dhatu Sena's statement pointing to Kalawewa "these are the treasures I possess" pointing to Kalawewa when he disclosed where his riches were concealed The rate of population growth had increased from 3.7 to 7.3 in districts where irrigation facilities were renovated. Accordingly, provision of irrigation has resulted in abundance of food leading to increased fecundity both in man and beast.

Soil hydrological status in rice cultivation

Productivity of rice, to a large extent, depends on condition of soil and water. The semi aquatic nature of rice plant helps thriving itself in different water regimes in the soil.

In Sri Lanka, an assured supply as well as a good control of water can be anticipated only in irrigated lands under major and minor irrigation schemes in the dry and intermediate zones. The full capacity of these irrigation schemes may be exploited, if at all possible, only during the 'Maha' (major) season. We identify lands under major and minor irrigation schemes with assured supply of water as stable environment for rice production. This sector is about 65% of the total rice land extent. The balance 35%, which are primarily rainfed, include fluvial Manawari lands in the northern and eastern regions, the bunded rainfed rice lands in rest of the dry and intermediate zones, irrigated phreatic or phreatic rice lands of the up and mid country wet zone, phreatic mineral lands of low country wet zone and the low lying fluxial boggy lands of the coastal belt of the wet zone.

Usually, the medium duration rice varieties are grown in irrigable lands in 'Maha' when water is adequate; otherwise short duration varieties are the popularly grown types. During 'Yala' season only short duration varieties are promoted even under irrigation and are usually limited to some segments of the irrigation schemes on rotational basis, leaving room for economical use of water to grow subsidiary food crops.

Rice is cultivated only during the 'Maha' season in Manawari and bunded rainfed lands in the dry and intermediate zones. These lands are drought prone even during the 'Maha' season due to poor distribution of rainfall over the season. Short duration rice varieties not exceeding crop duration of 100 days are best suited for the rainfall pattern experienced in these regions. The wet zone phreatic lands can accommodate varieties of different durations, short (3-3.5 months) or medium (4-4.5 months) to suit the specific ecological conditions of the region. The fluxial boggy lands of wet zone have specific varietal requirements including photoperiod sensitivity with a long vegetative phase and, tolerance to flood and toxic products of soil reduction to overcome location specific stress conditions. Prolong inundation and flash floods are well known major constraints in these regions; not scarcity of water.

One other obsolete form of upland rice cultivation called 'Chena' cultivation, with no emphasis on irrigation, was practiced along with shifting agriculture in the past. 'El wee', a group of specific short duration upland rice varieties that could withstand water stress was used in this form of cultivation. This rice culture has almost reached the stage of extinction or if at all barely seen if at all practiced.

Varietal impact in water economy

Wide agro-ecological variability prevailing within the country may have played an important role in the evolution of genetically diverse, location specific ideotypic land races adapted to different regions. In addition to endemic types, many exotic varieties too have enriched the rice genetic resources in the country. The historical status of traditional varieties was recorded in literature in a couple of events and surveys (Dhanapala, 1996) (Table 2). These varietal types were traditionally maintained and multiplied by the farmers themselves. A cursory botanical analysis would invariably show that a single varietal type actually consists of a number of types (Iliffe, 1922).

Table 2. Status of traditional germplasm recorded in the history of rice cultivation in Sri Lanka

Event / Author	Year	Number of accessions
Agric. Exhibition, Kandy	1902	300
British Empire Exhibition	1920	150
Survey / Molagoda	1924	567
Survey / de Zoysa	1944	600

The earliest recorded attempts towards rice varietal improvement date back to the work of Dr. Lock in 1913 (Dhanapala, 1996). Progress of rice varietal improvement was stepwise with small yield increments within each step but tangible quantum jumps between steps. The major steps in the process were 1. the conventional traditional varieties 2. selection of purelines from traditional land races, 3. development of varieties of cross-bred origin ('H' varieties) and 4. introduction of semi-dwarf high potential cultivars. The third step, semi-dwarf high potential cultivars contributed substantially to the water economy by the provision of short duration cultivars of high productivity. In late 60s, the 'H' varieties (H4, H7, H8, H9, and H10) dominated the varietal distribution in Sri Lanka, occupying over

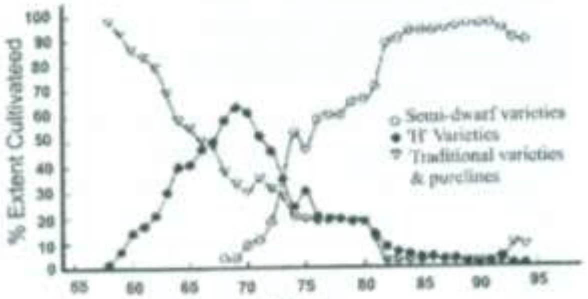

Fig. 1. Spread of Rice Varieties of different era with the progress of varietal improvement

65% of the cultivated extent (Dhanapala, 1999) (Fig. 1). Of these, the most popular medium duration (135 day) variety, H4, occupied more than 50% of the total extent. With the introduction of high yielding

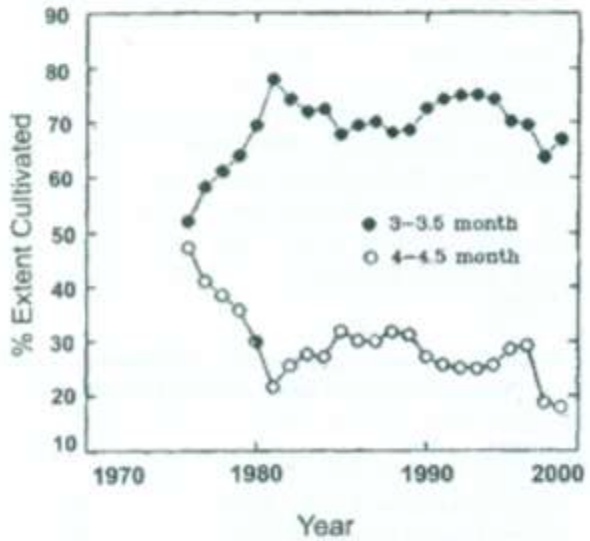

Fig. 2. Predominance of short duration varieties since introduction of semi-dwarf plant type

semi-dwarfs of Bg 34 (90 day) and Bg 94 (105 day) series in early 70s, the predominance of medium duration varieties declined gradually. In two decades time, more than 75% of the annual rice extent were planted to short duration semi-dwarfs (Fig. 2).

The short duration semi-dwarfs were much superior to their counterpart traditional varieties, purelines and H varieties in many attributes, including the yield potential. They are potentially not inferior, if at all not comparable, to their medium duration counterpart semi-dwarfs. With the short growth duration, they have the advantage of saving 1 to 1.5 acre feet of water per acre per season improving duty of water. The short growth duration helps them to escape drought and risk of water shortages, particularly under rainfed conditions, thus improving total production and yield stability while expanding the extent cultivated. The above features made them popular over medium duration types. A wide range of short duration rices varieties of superior grain quality, location specificity as well as wide adaptability are already recommended for cultivation (Annex I). Cultivation of these varieties would eventually help save water to expand the rice extent, while improving yield stability.

Recently, conceptualized aerobic upland rice culture in Brazil and China is one extreme of water economy claiming a potential of saving 70% of irrigation water. Rice with a deep rooting ability is grown on well drained lands with intercultivation operations designed to control weeds and promote deep rooting to tap subsoil layers for water. Supplementary irrigation is provided when needed only. Feasibility and economic viability of this type of culture are still debatable.

Strategic land and water management

Conservation of soil and water is one major basic requirement for sustainability of agriculture. Especially in lowland paddy, the pulverized soil is prone to erosion from the time of land preparation till harvest of the crop, unless water is managed carefully. The most fertile soil fractions, humus and clay, are on the surface when pulverized and erosion of these fractions, particularly with continuous two seasonal cropping, over years is the main reason for declined soil fertility.

In many irrigation schemes, despite having standing water in the field, rice is being cultivated in flowing water. Though not accounted for, the major water losses from the paddy fields are through burrows made by rats and paddy field crabs but not through seepage, percolation and evapotranspiration. Some losses can be attributed to

Annex 1. Semi-dwarf short duration varieties recommended for cultivation since 1970's.

Variety	Year of Release	Age (month)	Special attributes
Bg 34-6	1971	3.5	red rice
Bg 94-1	1975	3.5	high yield
Bg 94-2	1978	3.5	high yield
Bg 350	1986	3.5	red rice, GM-1 resistance
Bg 352	1992	3.5	BPH resistance
Bg 357	1996	3.5	Thrips & GM resistance
Bg 358	1999	3.5	samba, BPH resistance
Bg 359	1999	3.5	GM, BPH resistance
Bg 360	1999	3.5	premium quality samba GM resistance
Bw 266-7	1981	3.5	GM-1 Resistance
Bw 267-3	1981	3.5	Fe tolerance
Bw 351	1986	3.5	red rice, Fe & SB tolerance
Bw 361	2002	3.5	red rice
At 16	1977	3.5	red rice
At 353	1992	3.5	red rice, acid-saline tolerance
At 354	1992	3.5	salinity tolerance
At 362	2002	3.5	red rice
Ld 355	1994	3.5	samba
Ld 356	1996	3.5	red rice, samba
Bg 34-8	1971	3	high yield
Bg 276-5	1979	3	GM-1 tolerance
Bg 300	1987	3	GM-1, BPH resistance
Bg 301	1987	3	red rice, drought tolerance
Bg 304	1993	3	GM resistance
Bw 272-6B	1981	3	red rice,
Bw 302	1987	3	acid-saline tolerance
At 303	1990	3	red rice

GM - 1 gall midge old strain, Fe - iron toxicity, GM - gall midge strains at present, SB - sheath blight, BPH - brown planthopper
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farmer negligence as irrigation water is made available virtually free of charge.

Conservation of water can be attempted by improving water holding capacity of soil through organic manuring. The organic matter complex composed of colloids would then helps water retention as well as nutrients adsorption capacity for slow release.

The practice of transplanting will shorten the length of crop in the field while helping weed management and better stand establishment. Use of standing water to control weeds has to be replaced by the use of alternate methods of weed control.

The actual crop requirement of water is much less than what is being used presently. Reproductive phase and grain filling are the most sensitive stages to water scarcity. Saturated field conditions are important at these two vital stages. Other growth stages are not affected at field capacity provided adequate weed control is achieved.

The most important strategy in water saving is timely cultivation to maximize the use of rainfall in crop establishment and growth. Land preparation should be initiated at least with the onset of rains in heavy soils. If the soils are not heavy, then even semi-dry culture, "Kakulan", can be adopted with adequate weed management. Intuitionally farmers are aware of the fact that crops grow faster and better with rain fall. The irrigation facilities should then be used for supplementary irrigation to overcome drought spells. This is a strong possibility in 'Maha' season in the dry and intermediate zones as the short duration varieties made rice crop more stable in the rainfed environment.

The future of rice cultivation depends on the culmination of some or all the facts stated above for economical use of water.

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