

PADDY SECTOR: CHALLENGES AND CHANGES IN 2020



Prof. Ranjith B. Mapa

Paddy Soils: Major Limitations and Management Strategies

The monoculture model developed in western world with large holdings, capital intensive and highly mechanized agriculture may not suit developing countries. Systems of polyculture with rice based farming systems hold more promise in countries as Sri Lanka. For the rice cultivation to be successful in the future decade, it needs expansion in uses of the land. The tanks, channels and bunds which occupies about 1/5th of the holding should not be wasted. Fish can be reared in the tanks while they also can feed on weeds and snails in the rice fields. Ducks can feed on some of the fish while vegetables can be grown on the narrow bunds. In many countries mulberry is grown on broad bunds to feed silkworms while their droppings add nutrients to the soil. After the rice crop, pulses as mung bean or black gram could be grown with residual moisture during the mid season to obtain an additional income.

With regional trade agreements as SAPTA coming into effect in 2001 it may be cheaper to import rice when considering the present cost of production. Therefore our paddy farmers need to be more competitive while the government policies should change towards establishing food security in the staple food, rice, as well as increasing farmer income and satisfying the consumer demands.

Rice is consumed by nearly half of the world population as the staple food, most of whom live in Asia. Sri Lanka is no exception with an average annual per capita consumption of about 100 kg. In 1997 the net harvested area of paddy in Sri Lanka amounted to 618,876 hectares where 64% was cultivated during the wet or Maha season (from October 1996 to February 1997) and 36% cultivated in the dry or Yala season (from April to July 1997) giving a total production of 2,239,370 mt of paddy (Dept. of Census and Statistics, 1998). This consisted of about 30% of the cultivable area contributing 3% to the gross domestic production (GDP) while providing employment for 10% of the population. These statistics illustrates the impotence of the paddy sector to the Sri Lankan economy.

If the consumption pattern remains same with a projected annual population growth of 1.2% per year the annual rice requirement in year 2000 and 2010 will be 2.12 and 2.17 million tons respectively (Herath et al. 1998). In 2020 this will increase to about 2.62 million tons of rice which will account for 4.75 million tons of

paddy approximately. If there is no increase in paddy acreage, this means an increase of annual paddy yields from 3.6 to about 4.8 tons/ha.

The rice production increased considerably from 1968 to 1988 from 0.43 to 2.48 million tons respectively which is mainly attributed to the green revolution taken place during this time. Since 1983 the yields has been stagnating and labour cost which was about Rs. 2190 per hectare in 1980 has risen by about six folds by the year 1997 which had made rice an unattractive crop to grow. With world trade agreements as GATT and regional agreements as SAPTA coming into effect from year 2000 it is questionable whether the government should increase the area under rice production by investing heavily on irrigated agriculture. Therefore, increasing the yield per hectare seems the only solution to meet the increasing requirement of rice. It is the view of the rice breeders of Sri Lanka that one of the major limitations for achieving potential yields from high yielding varieties at present is the soil constraints.



Prof. Ranjith B. Mapa graduated from University of Peradeniya with B.Sc. in Agriculture in 1975 and obtained his Ph.D. in Agronomy & Soil Science from University of Hawaii, USA, in 1984. Presently he serves as the Associate Professor in Soil Science at the Faculty of Agriculture, University of Peradeniya.



In this paper the major soil constraints to increase rice production in the country and management strategies to overcome them are discussed.

Paddy Soils

As rice is the staple food of many tropical countries it is adopted to many different soil conditions. Paddy can be grown in virtually any soil with the correct soil moisture condition. Therefore, paddy soils signifies more a type of land use than a specific soil type. Paddy can be grown in inland valleys with seasonal flooding, in coastal swamps as well as in highlands where water can be supplied by artificial means. Conversion of such highlands to paddy fields is called asweddumizing (Panabokke, 1996). When there are no naturally occurring impervious soil layer a hard pan has to be developed through years of puddling for inundating water in such paddy fields. As maintaining standing water is difficult such lands were called "goda kumbura". The lands at the bottom of the valleys with ill drained conditions where the natural water table is high was called "mada kumbura".

According to soil classification terms most of the paddy in the dry zone is grown in the Low Humic Gley soils which is the ill drained member of Reddish Brown Earth soils. In the most recent Soil Taxonomy these are called wet Alfisols. In the wet zone paddy is grown in many ill drained associations of the great soil groups found in the area reflecting physical, chemical and mineralogical properties

Soil Constraints

The soil constraints which limits paddy yields differ according to the agro-ecological zones. The major constraints in the wet zone where rainfall is high and well distributed are iron toxicity, flooding and acid

sulphate conditions. The paddy production in the dry zone where rainfall is lower showing a bi-modal pattern is effected mainly due to salinity, water shortages and tillage problems associate with the soil consistency where the soils become hard when dry and sticky when moist. In addition all soils are effected by nutrient deficiencies and limitation of root zone due to hard pan formation at shallow depths.

When rice is cultivated under flooded wetland conditions many soil properties change compared to highland conditions. Due to the standing water on the soil, gases as oxygen needed for respiration of plant roots and other soil organisms do not diffuse sufficiently to lower layers. The soil consist of a thin layer at the top which is called the oxidized layer which is red in colour as some oxygen dissolved in water is sufficient to keep it in such conditions. The soil below this few millie meters of oxidized layer is called the reduced zone, as no oxygen penetrates to this layer. This is grey in colour where the composition of soil compounds and organisms vary from oxidized conditions. The Plate no. I shows a cross sectional area through such soils which is called a soil profile.

When rice is cultivated, the nutrients needed in higher quantities, the major nutrients of nitrogen,

potassium and phosphorous are added as fertilizer material. Most of the minor elements as zinc are not applied routinely. Therefore yield reduction in long term paddy cultivation may be due to deficiencies of micro-nutrients. The deficiencies due to micro nutrients must be identified and corrected to overcome this constraint.

The puddling or making a fine mud layer is done in land preparation for the convenience of transplanting paddy. The puddling and repeated tillage operations at the same depth season by season develops a impermeable hard pan below the ploughing depth. The fine clay particles separated during puddling move downwards with water and clog the pores in lower layers. Such a layer is shown by marked pegs in Plate I. This is advantageous in keeping standing water during the growth period specially in irrigated fields. This will also increase the water use efficiency by reducing deep percolation into the soil. Due to limited availability of farm power, farmers are now ploughing at shallower depths causing the formation of hard pan very near to the soil surface. This limits the rooting zone for paddy plants which reduces the nutrient uptake and therefore the dry matter production. Such shallow hard layers are

Plate 1. A cross sectional area (soil profile) showing oxidized and reduced layers, and the hard pan

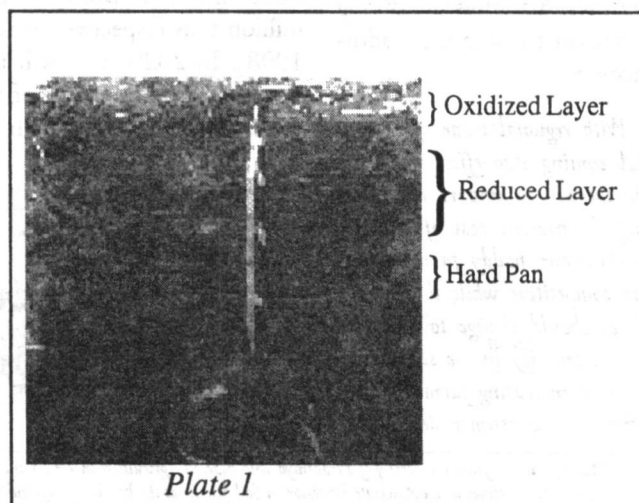


Plate 1

evident in fields which were earlier ploughed using tractors but had to change to animal powered ploughs. There is need to identify these paddy tracts and relocate this hard layers at a sufficiently lower depth for the rice roots to grow and function well.

Major Soil Constraints in the Wet Zone

Iron toxicity is the major soil constrain in the wet zone paddy lands causing an average yield loss of about 43 kg/ha (Herath et al., 1998). Iron toxicity causes bronzing, yellowing or orange colour of the plant and is regarded as a major physiological stress. This is caused by higher solubility of iron compounds after submerging the soil. The standing water in paddy fields deprive the movement of oxygen into the soil where anaerobic conditions occur. These will reduce iron oxides, in scientific terms ferric compounds are reduced to ferrous compounds, making them more soluble.

In soils with high organic matter content this condition may be more severe. According to Ponnampurna (1972) the concentration of water soluble iron is around 20 parts per million (ppm) in a neutral well aerated soil and it may increase by 30 times to about 600 ppm, one to three weeks after submergence in an acid soil with high organic matter content. This higher solubility will result in higher uptake of iron by plants which will cause disorders that reduces the growth.

When the soil is deficient in other nutrients the iron toxicity is aggravated. Therefore, supplying the essential nutrients by fertilizer application, breeding for varieties of well developed root systems and higher oxidizing and nutrient extracting mechanisms has potential for the future. Liming of soils using dolomite to increase other ions as calcium and magnesium in soil solution also can reduce the ill effects of iron toxicity.

Shallow submergence due to occasional flooding also effect paddy production in the internal lowland valleys. With prolonged submergence of soils with high organic matter content make them boggy, deficient in phosphorus as well as make tillage and water management difficult. Better flood protection mechanisms and drainage facilities have to be implemented to overcome the constraints due to flooding.

The problem of acid sulphate conditions in the wet zone paddy soils is not wide spread but limit paddy production in places as Nilwala basin of Matara district. These soils are mainly developed from parent material rich in pyrites. The oxidation of pyrites form sulphuric acid which make the soil strongly acidic. Sulphate contents ranging from about 1800 to 4000 mg/kg has been reported in these soils. If these soils are drained sulphur will be further oxidised to form sulphuric acid which aggravate the condition. The best remediation is to wash the sulphur using good quality drainage water.

Major Soil Constraints in the Dry Zone

Major soil constrains for paddy production in the dry zone is soil salinity and drought conditions. This can be due to natural reasons as sea water intrusion and human induced reasons as improper water management in irrigation schemes. The shadow of salinity hangs on any irrigation project if proper facilities are not available to dispose the drainage water. Due to over irrigation and seepage through irrigation channels the water table rises near to the soil surface. Overuse of water, specially when water is available free of charge, in paddy fields in irrigation systems has remained a norm rather than an exception. Specially during dry seasons as "maha season" the conditions for evaporation in the dry zone is high as 4 to 5 mm/day where this shallow ground water evaporates depositing all the salts on the soil surface. The exact area affected by salinity is not documented but it is prominent in new

irrigation schemes as Mahaweli scheme. As most of the salts wash down along the catenary landscape the lower valleys where paddy is grown show higher salinity levels. However the topographic and rainfall pattern of the country is such that any salinity developed during the dry season get washed off during the rainy season.



As a management strategy for salinity due to sea water intrusion, the sand mining activities and clearing of river catchments should be controlled to avoid low water levels of the rivers. The reduction of human induces salinity can be achieved by proper water management practices, leaching the soil with clean water and breeding varieties resistant to salinity.

Nutrient Deficiencies

Another major soil constraint for paddy production is nutrient deficiencies. To explore the fullest potential of high yielding rice varieties plant nutrients levels has to be maintained in the soil. Fertilizer application is the most common input needed to increase the paddy yields.

In vast studies conducted on use of fertilizer the most crucial is the nitrogen, which should be available in correct quantities at the correct time. Nitrogen supplying ions as nitrates are very mobile and leach readily causing considerable economic losses as well as environmental pollution by contamination of ground and surface waters.

Many ways of reducing the environmental damage by nitrogen fertilizers have been proposed. These include coating nitrogen fertilizers to make it low releasing, applications in split doses and proper incorporation

contd on page 21

contd. from page 5

of these to the reduced zone to decrease de-nitrification and addition of part of the requirement using organic fertilizers.

The other major nutrients where paddy soils are deficient are potassium and phosphorous. These are mainly added as basal fertilizers as these ions are not so mobile as nitrogen and losses are minimal. The Department of Agriculture has shown that the total potassium requirement can be supplied by rice straw.

The strategy for fertilizer use should be geared to soil test based recommendations which may help to add the correct nutrient requirement. The use of Azolla, which is a floating aquatic fern capable of fixing atmospheric nitrogen has great potential of supplying the nitrogen requirement. This fern occurred naturally in rice fields of several regions of Sri Lanka. The limiting factors for natural spread of this fern should be investigated. In addition the ways of using of local materials as rock phosphates should be evaluated while encouraging farmers to recycle rice straw.

Conclusive Remarks

As listed here there are many soil constraints limiting paddy cultivation, which may aggravate by year 2020. With the population pressure some paddy lands has to be released for non agricultural purposes. Regional trade agreements as SAPTA may worsen the situation by making rice available at a cheaper price not warranting the country to invest heavily in building or rehabilitation of tank irrigation systems. In such situations the need for self sufficiency in rice may change to production of agricultural commodities which have a price advantage in the regional markets.

Eventhough this article describes the soil constraints in

increasing paddy production, it is only a part of rice growing ecosystem. To be successful in overcoming the soil limitations it should be coupled with other physical factors in the physical environment as the climate, hydrology and landscape position.

Paddy soils are unique un the context that all toxic materials produced or applied to the upper part of the landscape ultimately get washed down to the lower valleys where paddy is grown. Therefore, the management of these soils in a manner to reduce these ill effects contributed to environmental conservation.

As quoted by Sanchez (1994) the traditional soil fertility paradigm was to overcome soil constraints to fit plant requirements through purchased inputs. The second paradigm for the future is to rely more on biological processes, by adopting germ plasm to adverse soil conditions, enhancing soil biological activity and optimizing nutrient recycling to minimize external inputs.

Further Reading

Department of Census and Statistics, Sri Lanka. 1998. Paddy statistics of Sri Lanka.

Department of Statistics, Ministry of Planning, Sri Lanka.

Herath Banda, R.M., M.P. Dhanapala, G.A.C. de Silva and M. Hossain. 1998. Constraints to increase paddy production in Sri Lanka. Paper presented at the workshop on prioritization of rice research, IRRI, Philippines, 20-22 April 1998.

Panabokke, C.R. 1996. Soils and Agro-Ecological Environments of Sri Lanka. Natural Resource & Energy Authority of Sri Lanka. 220p.

Ponnamperuma, F.N. 1972. The chemistry of submerged soils. *Advances in Agronomy.* (Ed.)