

## Rice–wheat cropping system – Food security and sustainability

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During the last four decades of the 20th century the global population doubled itself from 3 to 6 billion and it is estimated that by the year 2020, it will reach the 8 billion mark. Food and nutritional security is therefore a serious global concern. Three international studies/reports<sup>1</sup> have addressed this problem. These are: (i) World Agriculture: Towards 2020 – An FAO study, (ii) Population and Food in Early Twenty-First Century by the International Food Policy Research Institute, and (iii) Full House by the Worldwatch Institute. The projections made by these studies/reports suggest that five populous countries, namely China, India, Indonesia, Brazil and Nigeria would have half of the world population by 2020 and will have serious food deficits. This commentary analyses the situation with respect to India. Despite an increase in its population from 548 million in 1971 to 1027 million in 2000, the per capita net availability of cereals has not decreased due to the Green Revolution that set in the late 1960s; it was 417.6 g/day in 1971 and 422 g/day<sup>2</sup> in 2000.

The Green Revolution in India started with the introduction of dwarf Mexican wheat (Sonora 64 and Lerma Rojo) in 1966; wheat production increased from 10.39 million tonnes (mt) in 1965–66 to 16.54 mt (about 50% increase in a year). It was soon discovered that the dwarf wheat needed lower temperature for good germination and tillering and therefore the wheat sowings in North India had to be delayed from mid-October to mid-November. This provided one additional month for the preceding *kharif* (rainy season crop in the North India). Since high-yielding rice varieties were already available in India, rice cultivation moved to the non-traditional rice belt of north-west India (Punjab, Haryana and western UP). Also the need for delaying wheat sowing to mid-November made it possible to grow wheat after rice in the traditional northeast rice belt (eastern UP, Bihar, West Bengal). This is how the rice–wheat cropping system (RWCS) set in during early 1970s in North India. RWCS now occupies 12.33 million hectares (m ha) of which about 10 m ha is in the Indo-Gangetic plains, where it covers 75% of the total

rice area and 63% of the total wheat area. About one-third of India's cereals are produced in the RWCS belt and it contributes largely to the food grain procurement by the Government of India for its public distribution system<sup>3</sup>.

The district average yield during the period 1985–98 in Ludhiana, Punjab was 5.6 t/ha for rice and 4.3 t/ha for wheat (total 9.9 t/ha for RWCS), while in 24-Parganas in West Bengal, it was 2.8 t/ha for rice and 2.1 t/ha for wheat (total 4.9 t/ha for RWCS)<sup>4</sup>. The predicted potential yields for Ludhiana District are 10.7 t/ha for rice and 7.9 t/ha for wheat (total 18.6 t/ha for RWCS), while those for 24-Parganas are 7.7 t/ha for rice and 5.2 t/ha for wheat (total 12.9 t/ha for RWCS). This shows the tremendous food grain production potential that RWCS has. However, even at the present level of production and the fact that RWCS has been practised in India only during the past 30 years or so, the question of its sustainability has been raised and there are signs of fatigue and decline in yield, specially in States where the level of production is 10 t/ha/yr or more. Also, a decline in factor productivity of fertilizers<sup>5</sup> asking for higher and higher amounts of plant nutrients to obtain the same yield has been reported. This is due to declining soil fertility, specially its content of organic matter. Even at moderate levels of production (6–8 t/ha/yr) RWCS removes 300–400 kg/ha/yr of  $N + P_2O_5 + K_2O$ ; nutrient removal is much higher on farmers fields, where productivity is 10 t/ha/yr or more. In addition, large amounts of secondary and micronutrients are also removed. Widespread Zn and S deficiencies have been reported in the RWCS belt. Farmers generally go on increasing the level of nitrogen application without adequate supply of other plant nutrients and this is mainly responsible for the observed low factor productivity of fertilizers. Adequate and balanced fertilization based on soil-test recommendations is a must for sustained production in the RWCS. Besides declining soil fertility, low wheat yields in RWCS are also obtained due to a short turnover period between rice harvest and delayed wheat sowing due to a number of factors, including delayed rice transplantings resulting in delayed rice

harvests, high soil moisture content after the rice harvest, delay in removal of rice straw (a large part of it is being burned *in situ*, which besides the loss of precious organic C creates environmental and health problems), etc. Incorporation of wheat straw asks for additional nitrogen fertilization to prevent immobilization of native soil N. The manufacture of zero-till machines in the country and their availability at an affordable price is the call of the time.

Another major factor for the low yields of rice and wheat in the RWCS belt is its spread to marginal lands having poor fertility and limited irrigation water. These are also managed by marginal farmers having poor socio-economic status. These lands were used to grow oilseeds and pulses. The area under chickpea in the RWCS belt has declined from 2.33 m ha in 1985 to 1.34 m ha in 1999. Similarly, area under rapeseed–mustard in the RWCS belt declined from 2.94 m ha in 1980–81 to 1.91 m ha in 2000–01.

With increase in area under pulses in the southern states, the production of pulses in India has remained static at  $12 \pm 2$  mt during the last 30 years. The per capita availability of pulses has, however, declined from 60.7 g/day in 1951 to 29.1 g/day in 2001. This is critical for a majority vegetarian nation. The situation in respect of oilseeds is slightly different, where due to the creation of Oilseed Mission, the production<sup>6</sup> of vegetable oils increased from 2.75 mt in 1980–81 to 4.96 mt in 1999–2000. Yet due to increased per capita income, the per capita demand for edible vegetable oil has increased. The per capita availability of edible vegetable oil was 7.9 g/day in 1961–62 and 28.5 g/day in 2000–01. A recent study by the Swaminathan Research Foundation<sup>7</sup> showed that protein-energy deficiency in the rural population is widespread in India. Due to shortage of edible oils and pulses in the country, these are being imported; estimated at 4.32 mt of edible vegetable oil at a value of 6475 crores of rupees and 2.18 mt of pulses at a value of 3160 crores of rupees in 2001–02. This import of the edible vegetable oil and pulses has to be checked.

Although RWCS has been a boon from the food security viewpoint, it being an

intensive cropping system is heavily taxing the two most important natural resources, namely soil and water, which are essential for the survival of human life. Soil fertility depletion due to RWCS has already been discussed. Global availability of water was 3500 m<sup>3</sup>/person/yr in 1950, 1250 m<sup>3</sup>/person/yr in 2003 and is estimated to be 760 m<sup>3</sup>/person/yr in 2050. Rice is a heavy-water consuming crop; about 5000 l are needed to produce 1 kg rice. The cultivation of rice in the non-traditional rice belt (Punjab, Haryana and western UP), where monsoon rains are not as heavy as in the traditional rice belt in the eastern India, forces the farmers to heavily rely on the groundwater through tubewells. This has considerably lowered the water table in this region. Further lowering of water table has to be prevented by adopting alternative cropping systems such as rice-chickpea, pigeonpea-wheat, rice-rape-seed/mustard at least once in a 3–4-year cycle. These cropping systems reduce the demand for groundwater at least in one season and produce much-needed pulses and oilseeds.

RWCS has also adverse effects on the environment, mainly due to the application of high rates of fertilizer nitrogen<sup>8</sup>. About 5–10% of the nitrogen applied to rice may be lost through ammonia volatilization, which contributes to acid-rain. Production of N<sub>2</sub>O due to denitrification is also likely to be more under alternate wetting and drying conditions obtained

under irrigated rice culture. Leaching of nitrates may lead to groundwater pollution with nitrates and some indications of this are already reported from Punjab. Furthermore, burning of rice residue so rampant in the RWCS belt produces large amounts of CO<sub>2</sub>, which adds to the global warming.

To prevent environmental degradation due to fertilizer nitrogen, part of N demand of the RWCS needs to be made by summer (June–July) green manuring or growing of dual purpose summer legumes such as mungbean, use of biofertilizers such as blue-green algae, *Azolla*, *Azospirillum*, etc. and organic manures (FYM, compost, etc.), i.e. to pursue an integrated plant nutrient supply system. Also efficiency of applied nitrogen can be increased by use of fertilizer such as neem-coated urea<sup>9</sup>. Large amount of published literature is available in the country on all these aspects, what is needed is its implementation on a large scale. Furthermore, growing of summer mungbean even on half of the area under the RWCS belt in the north (i.e. 5 m ha) can produce about 2.5 mt of pulses, the amount being currently imported in the country. This is in addition to the contribution of 30–60 kg N/ha to RWCS by the incorporation of mungbean residue after taking one picking<sup>10</sup>.

To sum up, the RWCS has contributed and will continue to contribute largely towards the food security of India. However, well-planned steps are necessary to make it sustainable as well as more pro-

ductive without adverse effects on the natural resources and the environment.

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