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Review Article

Sustainability issues on rice–wheat cropping system

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ABSTRACT

Rice–wheat cropping system (RWCS) of the South Asia is labour-, water-, capital- and energy-intensive, and become less profitable as the availability of these resources diminished. This could be further aggravated with deterioration of soil structure, declining underground water and lesser land and water productivity which ultimately are threat in front of sustainable and profitable RWCS in the region. For improving the profits, production and sustainability of this sequence - a paradigm shift is required. Scientists recommended different resource-conserving technologies (RCTs) viz. zero tillage, laser levelling, irrigation based on soil matric potential, bed planting, direct seeding, mechanical transplanting of rice and crop diversification for this purpose. These technologies are site specific and before selecting any particular RCT for a particular region, soil texture and agro-climatic conditions must be considered. A solitary approach/RCT might not be effective to solve the upcoming issue of producing more food grains with inadequate available water and land. Therefore, an integrated approach is required. But before implementing any approach, different issues relating to RWCS must be discovered, considered and addressed in a holistic manner.

In this review, an attempt was made to highlight different issues resulted from the practise of intensive rice–wheat cropping sequence of the region, which must be considered while framing and implementing any integrated approach/project such as *conservation agriculture* for improving the productions, profits and sustainability of RWCS in the region.

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1. Introduction

Rice–wheat cropping sequence (RWCS) is the world's largest agricultural production system occupying around 12.3 M ha in India, 0.5 M ha in Nepal, 2.2 M ha in Pakistan and 0.8 M ha in Bangladesh and around 85 percent of this area falls in Indo-Gangetic plains (IGP) (Ladha et al., 2003; Timsina & Connor 2001). The IGP region of India has RWCS spread over a vast area spanning from Punjab in the Northwest to East up to West Bengal (Singh, Jat & Sharma, 2005). Sustainability of RWCS system has been questioned with yield stagnation (Ladha et al., 2003; Busari, Kukal, Kaur, Bhatt & Dulazi, 2015), declining underground water table (Humphreys et al., 2010; Hira, Jalota & Arora, 2004), unattended intervening periods (Bhatt and Kukal 2014a,b; Bhatt and Kukal 2015a,b,c), soil degradation (Bhandari et al., 2002) and atmospheric pollution (Bijay, Shah, Beebout, Yadvinder & Buresh, 2008).

Conventionally, rice in the region is established by repeated wet tillage (Puddling) followed by transplanting of the seedlings in the puddled soil while wheat established (in rice residue burned fields) by broadcasting/drilling seed after disking, tilling and planking operations (Bhatt, 2015). Seed bed preparation operations oxidises the once hidden organic matter, break the macro-aggregates into the micro-aggregates which adversely affect the soil properties (Roper, Ward, Keulen & Hill, 2013; Das et al., 2014). Furthermore, soil perturbation by conventional tillage makes the soil to serve as a source rather than a sink of atmospheric pollutants and thus is not sustainable and environment friendly (Busari et al., 2015). Improve productivity of RWCS should be a major concern to increase to keep up with population growth in India, which is predicted to swell from 1.12 billion in 2008 to 1.35 billion by 2025 (UNEP, 2008). But the conventional practices adopted for establishing wheat and rice by the farmers as per their indigenous knowledge are water-, capital- and energy-intensive and leads to many issues which are a serious threat to the sustainable agriculture. This publication seeks to highlight almost all the sustainability issues originated due to intensive cultivation of RWCS in such a manner so as to save the region without deteriorating the God gifted resources viz. soil and water.

2. Rice–wheat cropping system issues

Indigenous conventional system of rice–wheat cropping system leads to the following issues.

Considering these issues as a threat to sustainable and profitable agriculture attempt is being made to discuss of them under the following headings so that scientists might discover, test and recommend some alternative wheat and rice establishing techniques/RCTs in the region.

2.1. Ecological issues

2.1.1. Declining underground water table

India- The prime groundwater user on the planet ($230\ km^3\ yr^{-1}$), more than a quarter of the total global water use (Tyagi, Datta & Singh, 2012) is being used here. Instead of a major consumer of water, agricultural sector has been seems to lose its share as water allocated for irrigation is likely to decrease in the coming years (Singh, Kundu & Bandyopadhyay, 2010). Already, per capita water availability is decreasing in the major rice growing countries of the Asia (Table 1) (Gardner-Outlaw & Engelman, 1997). Irrigation is the basic need for the agriculture sector but its un-judicious use results in large consumption of green and blue water required for this sector (Rost et al., 2008; Döll et al., 2012). From historic point of view, before 150 years, water comes from the mountains and directly goes into the sea without much infiltrating much into the ground. However from 100 years ago (1859–1960) with development of multi-development river project, six head works were framed and water supplied to the agricultural field for irrigation (Table 2).

At present, 1.45 lakh km long network, 1100 canals assured irrigation to 15.6 lakh ha of the Punjab, India. Before introduction of the canal system, the underground water levels are more than 40 m deep while with canals the water levels arose to 3 m deep below the ground surface. Nationally, the area under GW irrigation has increased by 6-times over the last six decades (1950–51 to 2005–06) in contrast to the declined share of water in agriculture because of increased demand of non-agricultural sectors (Tyagi et al., 2012). The gravity mapping satellite of NAAS "GRACE" showed a sharp decline of underground water ($1\ ft\ year^{-1}$) in northern India in an area of about $440{,}000\ km^2$ which further resulted in the loss $18\ km^3\ year^{-1}$ (Soni, 2012). In South-Asia, the primary freshwater resources are presented in Table 3 where almost all the major river basins cross over boundaries of the nation. Among rice and wheat cropping systems, irrigated rice, is a heavy water consumer as it took around 5000 litres of water to produce 0.01 quintal of rice. Rice–wheat cropping system consumes about $11{,}650\ m^3\ ha^{-1}$ water out of which $7650\ m^3\ ha^{-1}$ is by rice. Thus, the water table in some pockets is declining down at alarming rates. In view of