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A comparison of farming practices and performance for wheat production in Haryana, India

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ABSTRACT

An extensive stratified survey was conducted in two different wheat growing seasons in all districts of Haryana (India) to evaluate current agronomic practices and assess performance in wheat production with the purpose of identifying where farmers can make further changes in practices. The survey involved 116 villages (927 farmers) in 2008 and 103 villages (823 farmers) in 2010. Different sized farming operations from each village were surveyed to represent all socio-economic categories of farmers. Agronomic inputs (tillage method, fertilizer practice, variety choice, time of sowing, irrigation, and rotation practice) and yield data are presented as mean data, and individual farmer's information is represented by regression tree (RT) analysis to highlight primary associations between cropping management and wheat yield and the technical efficiency (TE) measure. TE was calculated using the key agronomic variables obtained from the survey, and the farms with the highest TE values were assessed as having the superior 'best practice' technology. In the districts where the rice–wheat rotation was adopted, there was an overall higher level of TE. Where rice–wheat rotation is the main cropping practice (for example in Kaithal and Kurukshetra), many of the farmers have adopted zero tillage farming methods, with one third of farmers in Kaithal using zero tillage for planting wheat. In contrast, in Sirsa district where cotton was favoured by the farmers as their monsoon season crop, there were no farms where zero tillage was practised. Also, there was also no zero tillage farming where the pearl millet/cluster bean rotation was used as the monsoon season crop. In most cases farmers use a two applications of nitrogen fertilizer applied post-emergence, particularly in the rice–wheat and cotton–wheat districts. The survey also showed that application of potassium fertilizer and use of zinc is regionally specific and this is consistent with the soil maps that show the potential for deficiency of these nutrients in Haryana districts. Sowing in the rice–wheat districts was mostly at the recommended time in early November. The highest number of irrigations occurred in the districts using the pearl millet–wheat and cluster bean–wheat rotations where sprinkler irrigation is the main application practice. The analysis of TE provides a useful comparison when the 5 different farm size categories are separated. There was no difference in TE with farm size, suggesting the message concerning best practice for wheat production is available to and adopted by farmers irrespective of scale of operation. This analysis highlights where extension messages could be focused, whether for zero tillage in the non-rice districts, management of macro-nutrients, or the targeted use of micronutrients.

1. Introduction

Wheat (*Triticum aestivum*) is the most common crop used in rotation with other field crops grown in continuous cropping sequences in the state of Haryana, in north-west India. Haryana has 3.55 Mha of cultivated arable land with a cropping intensity of 185%. Wheat is grown as the winter crop and rice (*Oryza sativa*), cotton

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(*Gossypium hirsutum*), pearl millet (*Pennisetum glaucum*), cluster bean (*Cyamopsis tetragonoloba*) and sugarcane (*Saccharum spp.*) are the main monsoon season crops. Soil type and water availability are the main factors determining the rotation crop used with wheat. The annual rainfall for Haryana is about 530 mm, falling mostly in the hot period of June to September. Thus the wheat relies almost exclusively on irrigation sourced from either canals (42%) or groundwater (58%). Soils in the rice–wheat cropping areas are generally medium to heavy textured loams and clay loams, and the supply of good quality irrigation water is assured through the canal system or from tube-wells. The soils in other areas are light textured sandy, sandy loam or loamy sands, with limited water supply through canals coupled with deep bores to access ground water, and sometimes water quality in these areas can be poor.

There are more than 1.5 million farming families in Haryana, of which 34% are described as marginal farms (<1 ha size), 14% are small farms (1–2 ha), 13% semi-medium size farms (2–4 ha), 18% medium size farms (4–10 ha) and 21% are large farms (>10 ha) (Agricultural Census, 2010–11; http://agriharyana.nic.in/main.htm). Irrespective of farm size, the cultivation of wheat is highly mechanized, dependent on regular nutrient supplementation, weed and pest management, and there are a broad range of varieties available. The zero tillage method of establishing the wheat crop is practised by many farmers where the residues from the preceding crop are retained and the seed is sown with a one-pass operation using a tined implement (Hobbs and Gupta, 2004). Of the wheat grown, 80–85% is consumed as traditional Indian flat bread (chapatti) made mainly at home from unfermented whole grain flour dough (called *atta*) (Ortiz-Monasterio et al., 2007).

Wheat yields are high (5.2 t ha^{-1}) in Haryana and, with total wheat production at about 12 Mt, this area is often referred to as the 'grain bowl' of India. The farmers are receptive to new technology and target specific crop growth requirements as part of their routine procedure in best practice management (Coventry et al., 2013). Best practice recommendations for farmers are based on extensive field trials, which concentrate on producing as high yield as possible from a given set of inputs. The ability of farmers to improve yields and optimize economic returns depends on efficient farm practices, and technical efficiency (TE) is a commonly used measure of farm efficiency (Abdulai et al., 2013; Goyal and Suhag, 2003; Singh, 2007; Thiam et al., 2001). TE is defined as the ability of a decision-making unit (e.g. a farm) to produce maximum output given a set of inputs and technology (Thiam et al., 2001). Whilst the rate and extent of adoption of technology in Haryana is impressive (Lobell et al., 2009), there have been no studies specifically looking at wheat production amongst individual farmers, or what opportunities exist for them to improve their efficiency. In this paper we compare the key practices underpinning wheat production in the 21 regional districts of Haryana for seasons 2008 and 2010 with farm size as one of the defining socio-economic variables. We give quantitative details about the agronomic practices used in wheat production in Haryana for different socio-economic groups of farmers, regions, and cropping systems and use regression tree (RT) analysis to highlight primary associations between cropping management and wheat yield in two years. From these data we also develop TE estimates as a surrogate measure of the farmers' responsiveness to change. The TE analysis can indicate a group of farmers with a lower TE and thereby having more potential to increase yield using the same farm input, whilst RT can determine which input factors are more associated with output yield. With this approach we can identify the opportunities where farmers in Haryana can be responsive to technological change, and with additional socio-economic outputs from this study (manuscript in preparation) this will allow specific targeted extension activities to be implemented.

2. Methods

2.1. Farm survey

A block-based survey was conducted during two different wheat growing seasons, in 2007–08 (here called 2008) and in 2009–10 (here called 2010). Haryana has 21 districts and each district is divided into different blocks (these are not uniform size for each district) for administrative purpose, and each block has a similar number of villages within a district. Thus the size of each district, block and village used in this survey will vary. The survey in 2008 involved 116 villages (7–8 farmers per block) and included 927 farmers in the then 20 districts of Haryana and, in 2010, 823 farmers from 103 villages in 19 of the now 21 districts of Haryana (Fig. 1). The number of farmers surveyed in each district varied a little with availability of farmers and specific local survey protocols, and there were slight changes in the districts surveyed as the district boundaries changed in 2009. From each village, 2 marginal size (<1 ha), 2 small size (1–2 ha), 2 medium size (2–4 ha), and 2 larger size (>4 ha) farming operations were surveyed to broadly represent socio-economic categories of farmers, with the smaller scale farms recognized as being asset-poor farmers (Singh et al., 2010b). Specific blocks were identified through previous block survey analyses and related trial data sourced through the Indian Institute of Wheat and Barley Research (IIWBR) and CSS Haryana Agricultural University (CCS-HAU) (Singh et al., 2010b), to ensure a homogeneous grouping of farms based on crop rotation practice. A different cohort of farmers was used in 2008 compared with 2010. The survey targeted whole farm information on current wheat production practices, including information on variety choice, tillage, fertilizer practice, harvest method, weed and pest management, operational costs, and also information on farmer demographics and attitudes. Data relating to operational costs of wheat cultivation have been given in Coventry et al. (2013). As the literacy of all the participating farmers could not be assumed, each farmer was visited by IIWBR and CCS-HAU staff (Agricultural Development Officers) from the State Department of Agriculture (Haryana) with coordination by staff. These staff were trained in survey data compilation, to ensure standardized survey information input and coding. The data were collated using an Excel spreadsheet, and are presented here as mean data for the various farmer categories. Both regression tree (RT)and technical efficiency (TE) analysis were conducted on this same data set; RT can determine which input factors are more associated with output yield, whilst the TE analysis can indicate a group of farmers with higher efficiency to transfer farm input factors to the output (yield).

2.2. Regression tree analysis

Regression tree (RT) analysis was conducted to highlight the primary associations between cropping management and wheat yield, within each individual rotation, for these two seasons. The aim of RT is to explain the responses of a dependent variable (Y-variable) from a set of independent continuous variables or categorical variables (X-variables). The RT model progressively splits the data into subsets to find increasing homogeneity. The dependent data are split into a series of descending left and right child nodes derived from parent nodes. The process stops when no X-variables provide any additional information. The nodes where the construction ends are known as terminal nodes (Harding and Payne, 2012). Generally, the construction of a RT will result in overfitting. The tree will keep selecting X-variables to subdivide the individuals beyond the point that can be justified statistically, which lead to a large number of terminal nodes. An accuracy index was used here to prune the tree to remove the uninformative subbranches in this study. For each node of RT, the accuracy index is