Integrating wheat into the rice-based farming systems of southern Bangladesh

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Abstract

For subsistence farmers in southern Bangladesh, wet (transplanted aman and aus) and dry season (boro) rice production forms the basis of the family livelihoods and food security. Rice accounts for 94% of national food grain with over 54% of cultivatable land, during the dry (rabi) season, used in its production. Whilst boro rice will continue to be the dry season crop of choice for farmers in southern Bangladesh there is potential for other crops, such as wheat, to be grown on currently fallow lands. From the government perspective this is an attractive option in terms of national food security and balance of trade when it is considered that around half of the 2.95 million tonnes of wheat consumed annually is imported. Historically, wheat has been considered to be poorly adapted to the higher growing season temperatures and saline soils of the south. However, with the development of varieties exhibiting improved heat, salt and disease tolerance, and improved agronomic management and farmer training, dry land yields of 2.5 t/ha, and irrigated yields (a single irrigation 20 days after sowing) of 3 to 4.5 t/ha have been shown to be achievable as part of on-farm research on approximately 200 farms, in 7 districts, over 4 seasons (2006-2010). These yields are due, in part, to capillary rise from ground water tables that underlie the south, which at the commencement of the rabi season can be as shallow as <1 m and moving to a depth of 2 to 2.5 m by crop maturity. With an estimated ~800,000 ha of underutilised rabi-season land in the south there is scope to increase wheat production without detriment to boro rice production. If 25 % of this land was utilised and achieved grain yields of 2.75 t/ha, an additional ~0.5 million tonnes of wheat would be added to national production, contributing significantly to both food security and the national wheat deficit.

Key Words

Rabi season, Capillary rise, Wheat, Boro rice, Southern Bangladesh

Introduction

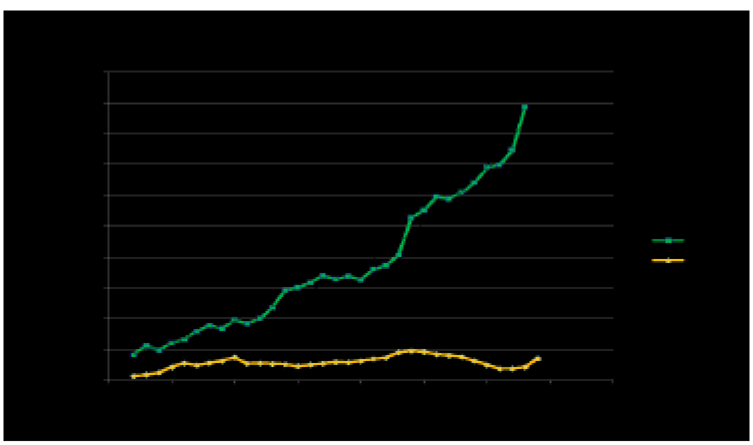


Figure 1. Production of wheat and boro rice from 1976 to 2009. Increases in area planted to boro and use of high yielding varieties (HYV) have resulted in a significant increase in production when compared to wheat for the same period (Bangladesh Bureau of Statistics (BBS)).

Bangladesh’s population of 150 million is supported by an agricultural economy with the majority of small holder farmers reliant on their own farm production for food security. Farming has traditionally relied on the production of wet-season rice (Transplanted Aman and Aus), with an additional irrigated rice crop (boro) grown during the rabi season (November to April) in conjunction with other cereals, vegetables and fodder crops. Overall rice production, which contributes 94% of the country’s food grain supply (Hossain *et al.* 2004), continues to grow, largely as a result of increases in area and yield of the rabi crop (Figure 1). Meanwhile, wheat (*Triticum aestivum*) production (Figure 1) has stagnated to the extent that internal production is now one half of Bangladesh’s annual consumption of 2.95 million tonnes (USDA grain report: BG9003 Dec 2009). High import prices and scarce foreign currency reserves have increased pressure within Bangladesh to raise domestic production.

Initial on-farm studies from 2003-05 pointed towards the potential to increase wheat production in southern Bangladesh (Rawson *et al*. 2006). This paper reports on more detailed on-farm studies from 2005-10 which evaluated the potential for increased cropping intensity in southern Bangladesh using new heat tolerant , disease resistant wheat cultivars, modified crop management and improved farmer training.

Wheat has traditionally been grown in the country’s cooler northern regions where 3 irrigations using ground water from tube wells has been essential in maintaining production. In the past 20 years however, boro rice has become the pre-eminent dry season crop, utilising the old irrigation areas and driving further expansion of irrigation infrastructure. Boro’s requirement for between 20 and 40 irrigations per season, in conjunction with reduced annual seasonal recharge of the water table, has put pressure on the water resource resulting in increases in depth to groundwater during the rabi in northern Bangladesh (Figure 2 and Harvey *et al.* 2006). Whilst there is some history of small areas of wheat being grown in the more northern areas of the south, it has been generally viewed as an unsuitable environment due to lack of adequate irrigation resources, high growing season temperatures, high soil EC levels in coastal regions (2ds/m to >15ds/m) and a sowing window considered too late for optimal production.

Methods

The on-farm seed multiplication (SMT) program was undertaken across 7 districts in southern Bangladesh between November 2006 and March 2010 and focussed on the demonstration of the potential for wheat as a component of a broader rice-based farming system. Whilst this program was aimed at seed multiplication and distribution, its other equally important aspects included the determination of wheat yield potential under a range of southern agro-ecological environments and the adaption of northern agronomic management systems to local conditions. SMTs, approximately 1000 m^2 in size, were established in collaboration with the land owners, on 6 farms during 2006-07 in the districts of Barisal (22.7?N, 90.4?E), Noakhali (22.8?N, 91.1?E) and Bhola (22.7?N, 90.6?E). In 2007-08 sites were increased to 87 with the addition of the south western districts of Jhalakathi (22.64?N, 90.2?E), Pirojpur (22.58?N, 90.05?E), Patuakhali (22.33?N, 90.4?E) and Barguna (22.15?N, 90.12?E). Activities continued in 2009-10 at 67 sites with numbers being reduced in line with the availability of field technical support for the on-farm program.

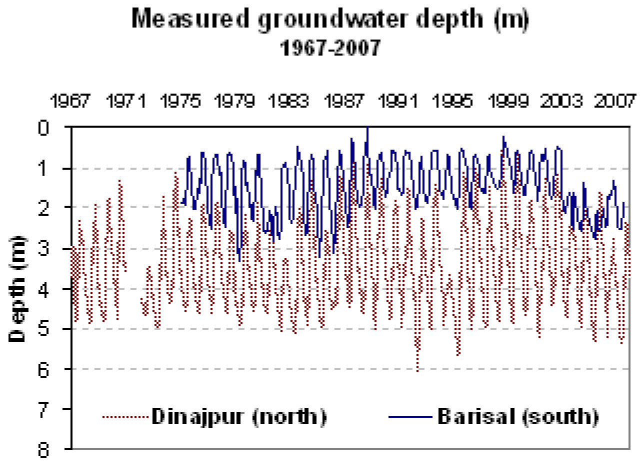
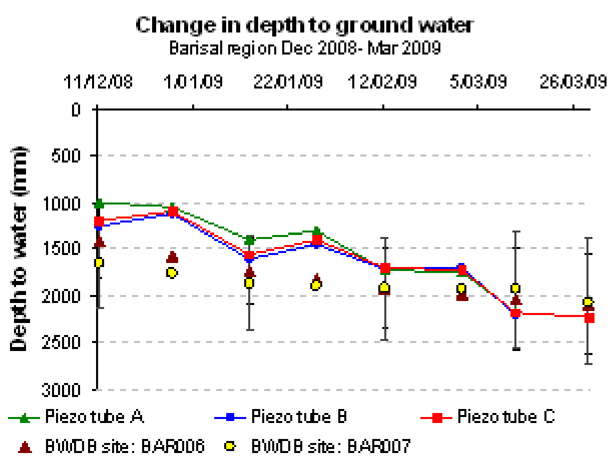


Figure 2. Monthly mean depth to ground water (m) for locations in the north (Dinajpur 25.62N, 88.63E) and south (Barisal 22.7?N, 90.4?E) of Bangladesh. Monitoring sites (DIN003 and BAR006) sourced from BWDB.

Traditional experimental protocol was followed in site selection, characterisation of local soil and climate, and crop agronomy, monitoring and data sampling, using an iterative evaluation and planning process to aid the direction of experimentation over the 4 seasons. SMTs were established to demonstrate and expose farmers to wheat as credible rabi season option, facilitate distribution of seed among district farmers and advance knowledge of the crops adaptive response to climate, geography and soil type. Each of the new wheat cultivars (*cv.* Shatabdi, Prodip, Bijoy, Sourav, and Sufi) were sown on individual farms under irrigated conditions using Bangladesh Wheat Research Centre (WRC) fertiliser recommendations. The cultivar Shatabdi was also grown as a non-irrigated dryland control on at least one farm per region per season. Nitrogen and irrigation management were evaluated in Barisal and Noakhali between 2007 and 2009 with WRC recommendations forming the basis of the research which explored opportunities for the manipulation of fertiliser and irrigation in terms of rate and timing of application.



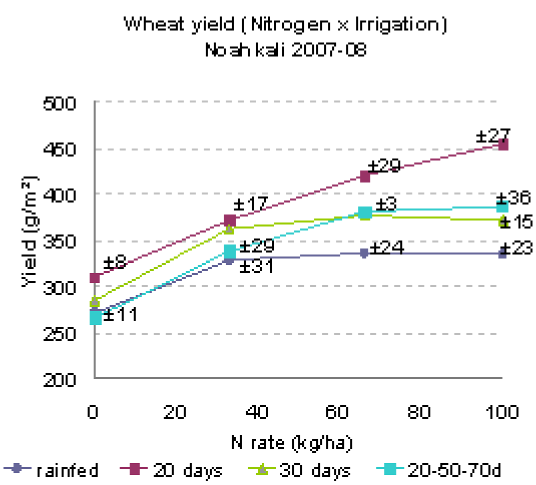


Figure 3. Measured depth of groundwater during 2008-09 rabi season for 3 piezometers installed in

Figure 4. Yield response for wheat to 4 nitrogen fertiliser rates (0, 33, 66, 100 kg ha^{-1})

the Barisal district (Piezo tubes A-C). Long-term mean groundwater depths for 2 BWDB recording sites in Barisal (BAR006 and BAR007) are included.

in the presence and absence of supplementary irrigation applied at 20, 30, and 20-50-70 DAS (2007-08 Noakhali irrigation x nitrogen trial).

Piezometers were installed to a depth of 3 m at selected SMT sites at the end of the monsoon in 2008. Depth to ground water was measured at 15 day intervals during the 2008-09 and 2009-10 seasons. Ground water data acquired from the Bangladesh Water Development Board (BWDB) for 6 southern districts were analysed for long term spatial and seasonal variability (1967 to 2007) and compared with ground water depths from project piezometers installed adjacent to experimental plantings (Figure 3).

Results and Discussion

Contrary to the northern Bangladesh wheat experience, trial results from 1 southern location (Barisal) in 2005-06 and 3 in 2006-07 (Barisal, Bhola and Noakhali) showed a yield penalty of only ~0.5 t/ha for dryland crops compared to those irrigated, when grown under a high level of agronomic management (weed control, fertiliser application and time of sowing). Whilst at first this was mystifying, observation of water levels in ponds adjacent to wheat crops at the time of harvest (March), coupled with analysis of regional BWDB ground water data, and observations from piezometers installed in 2008, showed water tables were higher in the south than the north with depths ranging from as shallow as 0.5 m at time of sowing to >2 m at crop maturity. This contrasted with the much deeper water tables (1.5 to 5 m depth) recorded in the north (Figure 2). Good wheat yields achieved without irrigation implied crops had access to the shallow groundwater through capillary rise.

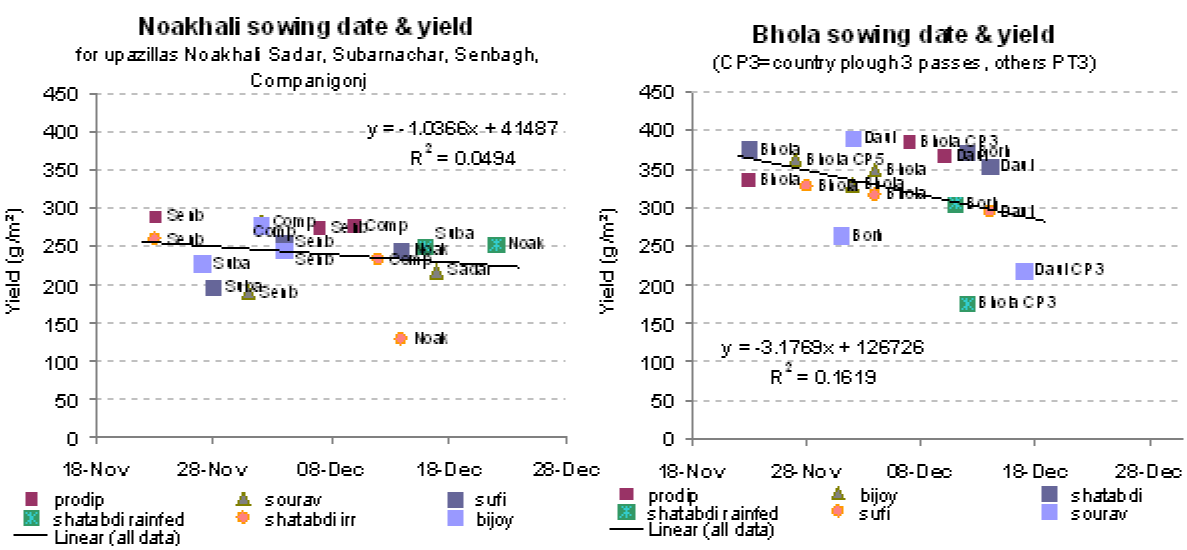


Figure 5. Yield response to sowing date from TOP trials at Noahkali and Bhola during the 2008-09 rabi season for 5 elite wheat cultivars (irrigated and dryland Shatabdi and irrigated Sourav, Sufi, Bijoy and Prodip).

This dynamic resource (in both time and space) and its potential contribution to crop yield is often overlooked when water management alternatives are being considered (Ayars *et al.* 2005). Results from water balance modelling indicate a potential contribution from capillary rise of 2-3 mm/day at maximum Leaf Area Index (LAI), adding in the range of 0.5 to 1.5 t/ha of additional grain yield (Poulton and Saifuzzaman 2010). Irrigation x nitrogen trials at Barisal and Noakhali (Figure 4) demonstrated the need for an irrigation at 20 days after sowing to optimise nutrient uptake. This finding now forms part of agronomic recommendations to minimise seasonal risk in southern wheat production.

Time of planting studies (TOP) from 2006 to 2009 demonstrated that wheat is able to be sown up until mid December in the south without a significant yield penalty. This is critical in terms of the overall farming system as it allows farmers to harvest the wet season rice crop and still have sufficient time to plant wheat, confident that yields will not be unduly jeopardised by what would be considered to be a late plant in the north. Yield results from sites at Bhola, and in the saline Noakhali region, for the 5 elite wheat varieties sown during November to December are presented in Figure 5. For the period of the study average yields attained at Bhola were 3.65 t/ha and at Barisal were 3.93 t/ha. In salt affected Noakhali they were 2.26 t/ha.

Conclusion

Based on the recommendation that 3 irrigations are required to grow high yielding wheat crops in northern Bangladesh, and the presumption that the southern environment was not suitable, nor the water resources available, little attention has been paid to southern wheat expansion. The introduction however, of new heat and disease tolerant wheat varieties, in combination with improved agronomy and water supply through capillary rise, has shown the potential for non-irrigated yields of 2.5 t/ha and up to 4.5 t/ha for crops irrigated once at 20 days after sowing. These findings have been validated in 200 on-farm trials in 7 southern districts over 4 seasons. Compared with the national average yield of 2.1 t/ha, which is predominately based on northern irrigation recommendations, this outcome has been achieved through sowing into a full soil water profile at the end of the monsoon and benefiting from access to shallow ground water. Utilizing the natural ground water cycle to provide water for crops such as wheat provides southern farmers with another rabi season option for fallow land without jeopardising existing boro rice production. Potentially available land has been estimated at ~800000 ha. Conservative adoption on only 25 % of this land and achieving grain yields of 2.75 t ha^{-1} would add an additional ~0.5 million tonnes to total production, contributing significantly to Bangladesh food security and balance of trade.

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