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Session 7: Nutrient Management: Innovative Use of 4R's in Conservation Agriculture

ORAL ABSTRACTS

Nitrogen Recovery and Agronomic Efficiency of Rice under Tropical Conditions as Affected by Nitrogen Fertilizer and Legume Crop Rotation

Motior M. Rahman, Sofian, M. Azirun and Amru, N. Boyce
Institute of Biological Sciences, Faculty of Science, University of Malaya Kuala Lumpur, Malaysia mmotiorrahman@gmail.com/mmotiorrahman@edu.my

Background

Nitrogen is quantitatively the most essential nutrient for plants and a major constraint and contributing factor for low productivity in most rice-based cropping systems in Asia. The intensive cultivation of cropping practices with high yielding rice varieties requires better soil and nutrient management [1]. Imbalanced rates and injudicious methods of N fertilizer application can lead to poor N efficiency, N losses due to leaching and other chemical and biological processes in soil [2]. In Malaysia, rice growers cultivates two rice per year and sometimes five crops in a two year period but crop rotation practices of rice with tropical legume crops are not often used [3]. This has brought about soil fertility deterioration, which threatens the ecosystem through intensive application of inorganic chemical fertilizers. The practice of using tropical legume crops alone or in combination with inorganic N fertilizers, offers promising scope as N supplement to rice crop rotation systems. No systematic research has been carried out on the consequence of N in the productivity of legume crops and their effects on soil N contributions to the yield and N use efficiency of the following rice crop in Malaysia. The present study was undertaken to assess the addition of legume residues to nitrogen agronomic efficiency (NAE), and nitrogen recovery efficiency (NRE) and also the amount of fertilizer N essential for optimizing rice yield when legumes are enclose in the system.

Results

Rice after winged bean grown with N at the rate of 4 g N m^{-2} achieved significantly higher NRE (30-33%) and NAE (24-27 g g^{-1}) in both years. Data from two growing seasons for each crop showed that rice after winged bean without fertilizer, rice after long bean with N fertilizer at the rate of 4 g N m^{-2} can produce rice yield equivalent to that of rice after fallow with N fertilizer at rates of 8 g N m^{-2}.

Applications and Implications for Conservation Agriculture

Legume plant residues are able to provide sufficient N to the soil for the rice crop and rice after winged bean or other tested legume crop rotation indicated a positive response for rice production without deteriorating soil fertility, which will sustain production levels and concurrently conserve the environment.

Experimental Approach

The experiments were carried out at the greenhouse, University of Malaya, Kuala Lumpur, Malaysia during 2010 and 2011. Bush bean, long bean, mung bean and winged bean were fertilized with N fertilizer at rates of 0, 2, 4 and 6 g N m^{-2}while corn and rice fertilized at rates 0, 4, 8 and 12 g N m^{-2}in the first cycle of the experiment in 2010. Corn was used as non-N_2-fixing reference plant for estimation of N_2 fixation by N difference method (NDF). Each crop was tested in an individual experiment and each experiment was conducted under completely randomized design with four replications. Rice was transplanted as the 2nd crop after harvesting of first crop cycles. After completion of the 1st cycle of rice crop, all legumes and corn were grown in the same pot as third crop in the 2nd cycle. No N fertilizer or other chemical fertilizers were applied in the 2nd year, to estimate the enduring effect of legume residues for the next crop. The NDF was used to estimate the contributions of BNF to total N accumulation in the legumes. The N-efficiency parameters were calculated for each treatment. Data were analyzed following analysis of variance and treatment means were compared based on the least significant difference (LSD) test at the 0.05 probability level.

Results and Discussion

The highest NRE (30-33%) was obtained by rice after winged bean with 4 g N m^{-2} in both years. The NRE values were 20-29% in 2010 and 20-28% in 2011 for rice after bush bean or long bean or mung bean (Table 1). In our study the NRE values were lower compared to NRE values (42%) obtained in other countries [4]. A possible reason could be due to the present study was carried out under greenhouse conditions which does not show the full potential of legume performance while in other countries studies were conducted in field condition.

Table 1. Nitrogen recovery efficiency (%) of rice as affected by N fertilizer and legume residue

N (g m^{-2})		Rice-B. bean		Rice-L. bean		Rice-M. bean		Rice-W. bean		Rice-Corn		Rice-fallow	
2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
0	0	0.0c	0.0d	0.0c	0.0d	0.0c	0.0d	0.0d	0.0d	0.0c	0.0c	0.0c	0.0d
4	0	28.8a	27.5a	28.8a	27.5a	27.5a	25.0b	32.5a	30.0a	10.0b	9.8b	25.5a	20.0a
8	0	29.5a	23.8b	29.4a	23.8b	28.8a	28.8a	20.0b	18.8b	16.3a	11.1a	25.0a	16.3b
12	0	19.6b	20.0c	19.6b	20.0c	20.0b	20.0c	15.0c	13.3c	15.0a	12.4a	18.3b	13.3c

(B-bush, L-long, M-mung, W-winged)

Rice after winged bean grown with 4 g N m^{-2} recorded the highest NAE (24 g g^{-1} to 27 g g^{-1}) for both years (Table 2). The results showed that increase in the application of N caused the decline of NAE. The superior NRE and NAE of all tested legume crops were directly linked to the lower rate of N fertilizer application. Among the tested legume plants winged bean was capable of producing greater amount of biomass and providing high quantities of total N, in addition to fixing higher quantities of N.

Table 2. Nitrogen agronomic efficiency (g g^{-1}) of rice as affected by N fertilizer and legume residues

N (g m^{-2})		Rice-B. bean		Rice-L. bean		Rice-M. bean		Rice-W. bean		Rice-Corn		Rice-fallow	
2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
0	0	0.0d	0.0d	0.0d	0.0c	0.0d	0.0d	0.0d	0.0d	0.0c	0.0c	0.0d	0.0d
4	0	13.0a	12.5a	21.2a	17.1a	14.8a	12.9a	26.9a	23.6a	14.7a	16.3a	21.2a	13.8b
8	0	10.7b	9.7b	15.1b	11.4b	12.6b	11.4b	16.3b	14.7b	15.5a	14.3b	18.7b	15.1a
12	0	7.4c	6.5c	12.8c	11.1b	8.3 c	7.8 c	12.2c	12.5c	13.3b	12.2b	15.2c	11.4c

Legume crop residues incorporation in rice after winged bean and rice after long bean crop rotation systems was effective in producing a satisfactory yield even in 2011 when rice after winged bean was grown without N fertilizer (data not shown). NUE declined with higher levels of fertilizer N used, reflecting poor N utilization by the rice crop. This indicated that though rice rotation with legume crops play a significant role in the improvement of grain yield, higher levels can be sustained by compatible and proper management of residues and N fertilizer. Without significant loss of yield level, winged bean plant residue incorporation can be an alternative source to N fertilizer for sustainable rice yield. However the incorporation of long bean plant residues require N fertilizer (4 g N m^{-2}) and can be an alternative to the sole use of N fertilizer.

References

1. Kirda, C., M.R. Derici, and J.S. Schepers. 2001. Yield response and N-fertilizer recovery of rainfed wheat growing in the Mediterranean region. Field Crops Res. 71:113-122.

2. Russell, A.E., D.A. Laird, and A.P. Mallarino. 2006. Nitrogen fertilization and cropping system impacts on soil quality in Midwestern Mollisols. Soil Sci. Soc. Am. J. 70:249-255.

3. Huggins, D.R. and W.L. Pan, 2003. Key indicators for assessing nitrogen use efficiency in cereal-based agroecosystems. J. Crop Prod. 8(1-2):157-186.

4. Raun, W.R., and G.V. Johnson. 1999. Improving nitrogen use efficiency for cereal production. Agron. J. 91:357–363.

Nutrient Dynamics under Conservation Agriculture -based Cropping Systems

Y.S. Saharawat*, and B.S. Dwivedi
*Division of Soil Science and Agricultural Chemistry
Indian Agricultural Research Institute (IARI), Pusa
New Delhi-110012 India
yssaharawat@gmail.com

In past, The Green Revolution has paid dividends through impressive agricultural growth, which helped to keep balance between demand and supply in the past five decades . But, the increase in future food production will largely come from today's most intensively cultivated land but these systems must also meet stricter environmental standards and sustain natural resources (Jat et al. 2011). The challenges are further exacerbated with the increasing input cost especially of the nutrients, depleting water resources, vulnerability of soil fertility and health to degradation. In the last five decades in India nutrient use has increased by 1573%, total food grain production by 145% with an increase in area of just 3.5% and average yield increase of 125%. Therefore, the input use efficiency especially nutrient use efficiency is decreasing at a fast pace. Conservation agriculture (minimal soil disturbance, surface retention of crop residues & efficient crop rotations) based management practices has proved to produce more at less costs, reduce environmental pollution, promote conjunctive use of organics (avoids residue burning), and improve soil health. However, shift from conventional plow based farming practices to crop management practices based on key elements of conservation agriculture have varied nutrient dynamics and hence, the nutrient management perspective. Therefore, the current study was initiated to evaluate the short-term (after 2- years) nutrient dynamic and availability under different tillage, residue and diversified cropping system namely rice-wheat, rice-maize, maize-wheat, cotton-wheat and pigeonpea-wheat system. The study revealed that after two year of field experimentation, on an average the organic Carbon (OC) enhanced by 19% in conservation agriculture systems over the conventional practice and by 24% over the initial soil content (Fig.1). The maximum enhancement in organic C was recorded in CA based rice-wheat system followed by cotton-wheat and pigeonpea-wheat system. Similarly, conservation agriculture based systems maintained higher available N (33%) (Fig. 2) and K (49) (Fig. 3) content in soil compared with conventional practice. The enhancement in available N was recorded highest in pigeonpea-wheat system (65%) followed by rice-wheat (23%) and cotton-wheat system (12%). But the K content enhanced by 74% in rice-wheat system followed by 51% in cotton-wheat system and 23% in pigeonpea-wheat system.

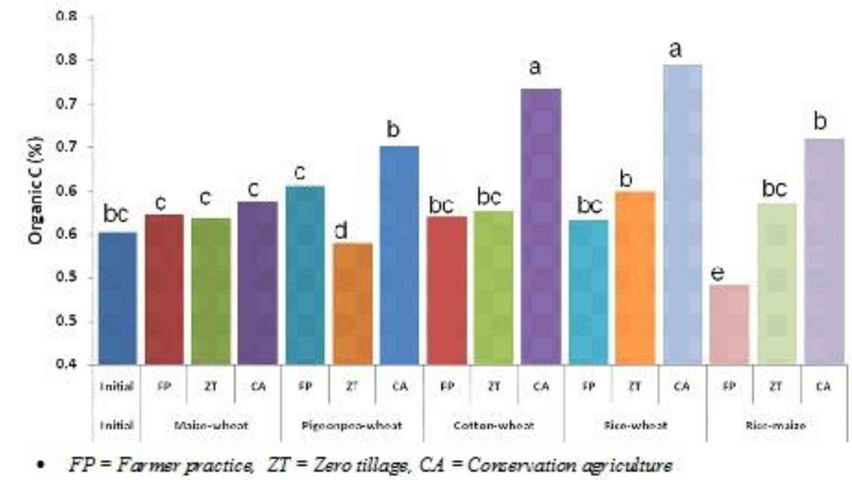

Figure 1. Organic carbon (%) under different tillage and residue management practices after two years of field experimentation

Whereas, in the surface soil the P availability decreased by 15% in conservation agriculture based system. The field study suggest that the key elements of conservation agriculture i.e. minimal soil disturbance, surface retention of crop residues & efficient crop rotations have significant effect on the soil nutrient dynamics and its availability to plants. Therefore, there is a need to conduct systematic studies to understand the nutrient dynamics and kinetics under conservation agriculture based systems.

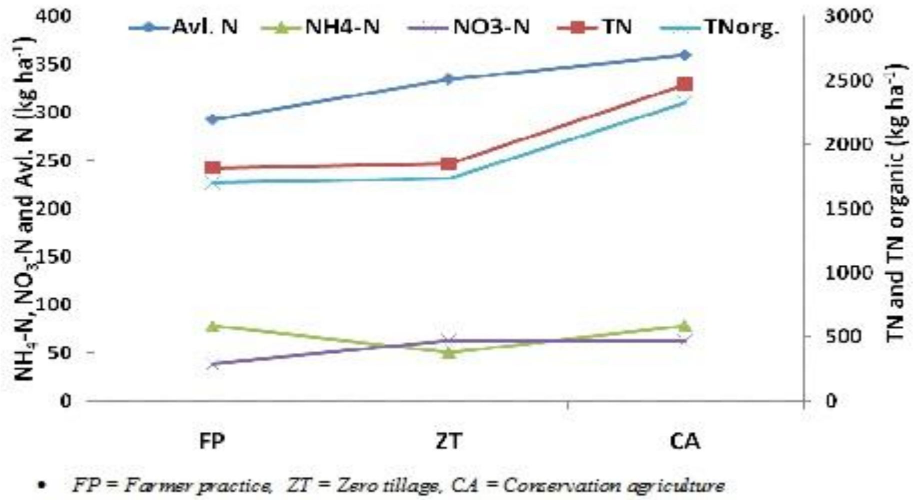

Figure 2. Changes in nitrogen fractions under different tillage and residue management practices after two years of field experimentation

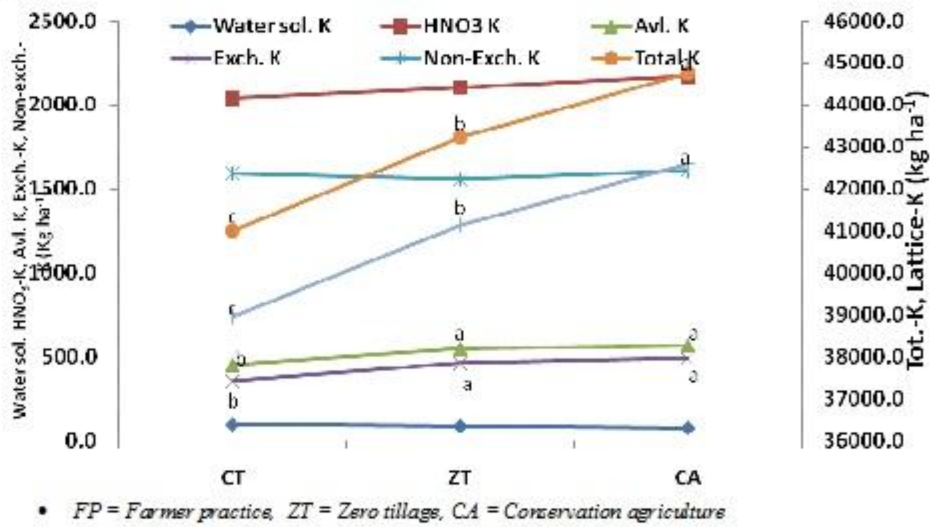

Figure 3. Changes in potash fractions under different tillage and residue management practices after two years of field experimentation

Jat, M.L., Saharawat, Y.S., and Gupta, Raj. 2011. Conservation agriculture in cereal systems of South Asia: Nutrinet management perspectives. Karnataka Ji. Agric. Sci. 24(1): 100-105

Successful 4R Nutrient Stewardship Extension Techniques: Fertilizer Rate, Source and Placement

John Heard
Manitoba Agriculture, Food and Rural Development Box 1149, Carman MB R0G 0J0 Canada
John.Heard@gov.mb.ca

For 20 years the University of Manitoba and provincial extension staff have annually delivered the Manitoba Crop Diagnostic School to provide advanced agronomic training and crop scouting skills to 400+ agronomists and farmers in mid July. Nutrient management is one of the featured lesson areas and we pride ourselves on delivering an engaging, hands-on learning experience. The following five lessons and techniques are a sampling of our more effective approaches.

1. Nutrient Deficiency Symptoms: Crop nutrient deficiencies are very difficult to show on the well managed soils of a university research station. Therefore we have used two strategies to provide training in identification of macro and micronutrients (Heard et al, 2011). For macronutrients, four large “sand boxes” were constructed and filled with coarse sand with very low nutrient content. After several years of subtle deficiencies, we have depleted these soils to the extent that phosphorus, potassium and sulphur deficiencies can be observed in corn, soybeans, wheat, canola and sometimes alfalfa. Use of domestic water supplies prevented expression of sulphur deficiency until we switched to using collected rainwater or deionized water.

To show micronutrient deficiencies, four large hydroponic beds were constructed outdoors so plants would grow under field light and temperature conditions. Nutrient solutions were prepared and circulated on a 10 minute schedule through the silica sand medium. Seeds of corn, soybeans, wheat and canola were pre-germinated and transplanted into the sand. The most striking nutrient deficiencies were zinc deficiency in corn, canola, soybeans and wheat, copper deficiency in wheat and corn and boron deficiency in canola and wheat. Some of these deficiencies were very severe and have never been observed “in the wild”.

2. Nitrogen and Phosphorus Ramp Calibration Strips: Nitrogen Ramp Calibration Strips (NRCS) are a well described and practiced extension technique in Oklahoma (Edmonds et al, 2008). These involve hand application of nitrogen fertilizer in small, increasing increments (up to 100 -200 lb N/ac) in a strip or ladder within a field of cereal, corn or canola.. It resembles the first replicate of a research plot, without the randomization. Farmers and agronomists would then visually assess the increasing vigour and “greenness’ of the crop and choose what they predict to be the appropriate rate to maximize yield at the lowest rate. Besides training the eye for such assessments we introduced tools such as the SPAD chlorophyll meter, the GreenSeeker sensor, colour charts and relative growth measures. We also used this to introduce new soil nitrogen based fertilizer recommendations for wheat, barley and canola. Several ag consultants took this technique to the field to assess whether manure was providing sufficient nitrogen for full yield potential.

Fellow forage extension staff modified this nitrogen ramp technique to address inadequate phosphorus nutrition in several alfalfa-based forage fields (Bittner et al, 2010). Results were striking on P depleted fields: yield increased up to 4 fold, alfalfa composition increased, forage protein and nutrient value increased. These simple but very visible strips were featured at forage and pasture tours over the past 4 years and have prompted farmers to utilize their manure resource and fertilizer in replenishing their soils.

3. Sniff assessment of enhanced efficiency fertilizer products: An array of specialty nitrogen fertilizers and enhanced efficiency products have been developed to increase N efficiency by managing losses. For those products targeted at reducing volatilization loss from surface application, we used a simple "sniff test" for product efficacy. Equal amounts of nitrogen fertilizer were added to the surface of moist soil in small, enclosed plastic containers. Within 2-3 days unprotected urea hydrolyses, producing ammonia gas (NH_3). Cracking the lid for a sniff leaves a lasting impression with participants, encouraging further discussion on volatilization management focused on products and soil risk factors such as moisture, texture and pH. We also demonstrate how agronomists can use NH_3 dositubes to estimate in-field losses from surface applied urea-based fertilizers (Heard, 2013).

4. 3-D Soil Blocks for Seed and Fertilizer Placement: Under conservation tillage, proper seed and fertilizer placement is critical to optimize nutrient efficiency while avoiding seed injury. An exercise to illustrate proper and high risk placement was developed by carving "3-D blocks of soil" from Styrofoam. Participants were provided with seed and fertilizer openers, a soil test report, and fertilizer and seed samples. They considered those factors which may compromise seed safety, seedbed integrity and nutrient efficiency to develop an appropriate fertilizer rate, source, placement and timing recommendation for the farmer.

5. Phosphorus Run Off Demonstration: Some 80% of runoff and agricultural phosphorus entering surface waters in Manitoba results from spring snowmelt rather than in-season runoff and soil erosion. A mobile rainfall simulator was assembled to illustrate both in-season erosion losses and snowmelt losses from soils with varying texture, slope and crop cover. In-soil band placement of phosphorus is a key BMP being promoted. Besides the Crop Diagnostic School this has been featured at 15 field days and winter extension events across Manitoba.

References:

Bittner, R., T. Clark, D. Stoyanowski and J. Heard. 2010. Phosphorus ramp calibration strips demonstrate economical yield improvement in alfalfa crops. In Proc. 2010 Manitoba Agronomists onference. Winnipeg, MB. http://www.umanitoba.ca/faculties/afs/agronomists_conf/media/Ray_Bittner_poster.pdf

Edmonds D.E., M.C. Daft, W.R. Raun, J.B. Solie, and R.K. Taylor. 2008. Determining Mid-Season Nitrogen Rates with Ramp Calibration Strip Technology. Better Crops with Plant Food. Vol. 92. 2008.

Heard, J., V. Bisht and A. Iverson. 2011. Nutrient Deficiency Training with Field and Hydroponically Grown Crops. In Proc. 2011 Manitoba Agronomists Conference. Winnipeg, MB. http://www.umanitoba.ca/faculties/afs/agronomists_conf/media/John_Heard_Nutrient_Deficiency_poster.pdf

Heard, J. 2013. Field agronomists can measure ammonia volatilization losses. In proc. 2013 Manitoba Agronomists Conference. Winnipeg, MB. http://www.umanitoba.ca/faculties/afs/agronomists_conf/media/2013_Heard_measuring_ammonia_losses Dec_4.pdf

Productivity and Farmers' Perceptions of Rice-Maize System Performance Under Conservation Agriculture, Mixed and Full Tillage, and Farmers' Practices in Rainfed and Water-Limited Environments of Southern Bangladesh

T.J. Krupnik[1*], S. Yasmin[1], Md. Shahjahan[1], A. McDonald[1], K. Hossain[1], E. Baksh[1], F. Hossain[1], A.S.M.A. Kurishi[1], A., A.A Miah[1], Md. A.-Al Mamun[1], B.M.S. Rahman[1], and M. Gathala[1].
[1.] International Maize and Wheat Improvement Center – Bangladesh.
* Corresponding Author: H. 10/B, R. 53, Gulshan-2, Dhaka, 1213. Bangladesh. t.krupnik@cgiar.org.

Background

Recent Government of Bangladesh initiatives call for $7 billion of development investment aimed at the sustainable intensification of dry *Rabi* season cropping in the south of Bangladesh (MOA and FAO, 2012). In this region, *Rabi* season water access is limited, necessitating either year-round rainfed cropping, or *Rabi* production using limited irrigation, in addition to rainfed, monsoon *Aman* season rice. The challenge, therefore, is to develop high yielding and profitable crop management practices and rotations that capitalize on soil moisture reserves and sparse irrigation, to provide high and stable yields.

Rotating maize with rice might comprise part of the solution to this problem. As Bangladesh's most rapidly expanding and cereal with cash markets linked to the expanding poultry industry, farmers are increasingly interested in *Rabi* maize in addition to *Aman* rice. However, little is known regarding what crop management practices are 'best-bets' in the south. This research responds by assessing the performance of various tillage systems including conservation agriculture (CA) in rice-maize rotations in rainfed and water-limited environments in Southern Bangladesh.

Experimental Approach

Farmer-managed but researcher supported split-plot experiments were established in *Rabi* 2011 with four main-plot factors, including CA (T1: unpuddled transplanted *Aman* rice (UPTR) – strip tilled and machine planted *Rabi* maize, both with 30% rice and maize residue retention (RR)), mixed tillage (T2: puddled transplanted *Aman* rice (PTR) with 30% rice RR – strip tilled and machine planted *Rabi* maize with no RR), full tillage (T3: PTR in *Aman* – 2–3 pass tilled and hand planted *Rabi* maize, both with no RR), and farmers' practices (T4: PTR in *Aman* – also fully tilled but hand planted *Rabi* maize, both also with full residue removal). T1–3 used the same fertilizer and pest management input rates and timings, while in T4 each farmer choose and applied their own input management regimes. Following *Rabi* 2011, the initial main plots (all of which used maize variety NK40) were split in half, and two rice varieties were imposed as sub-plots for *Aman* (BRRI 41 and 52, saline and submerge tolerant, respectively). NK40 was subsequently used again in each sub-plot for the second maize crop, followed again by BRRI 41 (saline tolerant) and 52 (submergence tolerant) in the split plots for *Aman*. Trials were conducted in two production environments for two years, including two rainfed (Khulna (n = 10 farmers) and Patuakhali, (n = 5)), and thee limited irrigation locations (Shatkira (n = 10), Patuakhali (n = 5), Barisal (n = 5)).

Results and Significance for Conservation Agriculture

System (maize + rice) grain yields were rarely significantly different at the tillage system × variety level, but they were always significant at the main-plot (tillage) and sub-plot (variety) levels. In contrast to studies citing a long time horizon until CA demonstrates yield gains (Brouder and Gomez- Macpherson, 2014), we generally observed superior yields under T1 and T2 in both Year 1 and 2 in each rainfed location (Figure 1). In Khulna, high rainfed maize yields for all treatments were also observed, likely the result of the presence of a shallow (< 2.5 m), and relatively non-saline shallow water table within the rooting zone. Rice varietal performance was inconsistent between years at the sub-plot level. Similar main- and sub-plot yield trends were observed for the irrigated locations. Lower cross-treatment yields in Barisal resulted from farmers' inability to apply >2 irrigations from shallow tube wells, whereas in Shatkira and Patuakhali, 3 irrigations were possible. In both rainfed and irrigated environments during

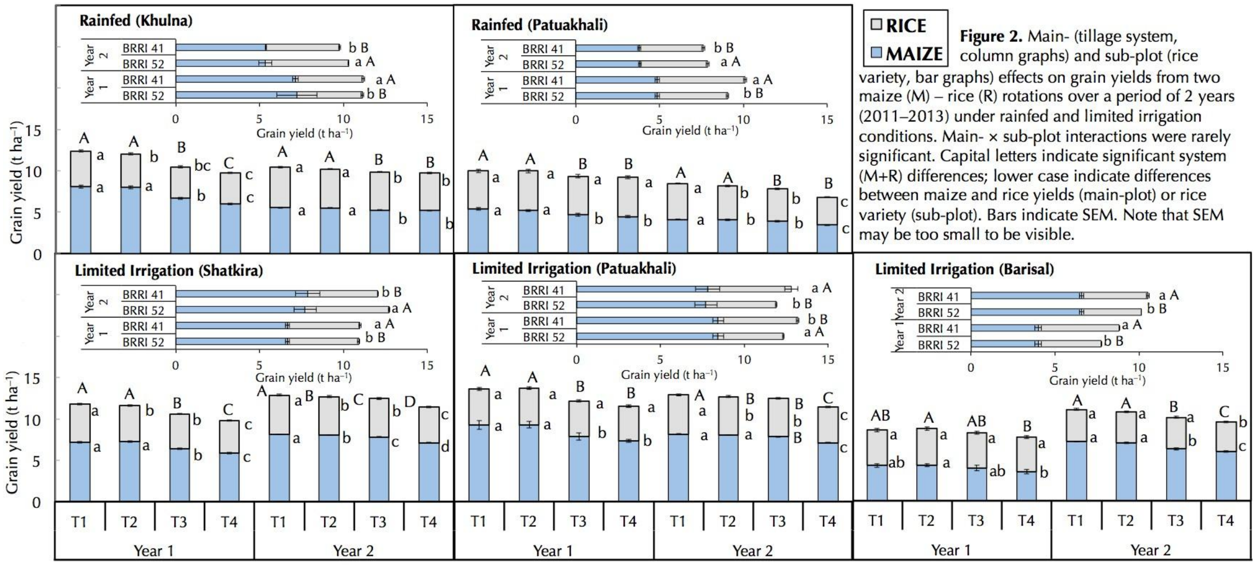

Figure 2. Main- (tillage system, column graphs) and sub-plot (rice variety, bar graphs) effects on grain yields from two maize (M) – rice (R) rotations over a period of 2 years (2011–2013) under rainfed and limited irrigation conditions. Main- × sub-plot interactions were rarely significant. Capital letters indicate significant system (M+R) differences; lower case indicate differences between maize and rice yields (main-plot) or rice variety (sub-plot). Bars indicate SEM. Note that SEM may be too small to be visible.

Rabi, T1 and T2 were planted at 2–7 days in advance of T3 or T4. The former required extra time for soilmoisture to reach appropriate conditions for full tillage and then hand planting, while the latter required several time-consuming rounds of pre-tillage before planting. Maize yields can decline with late planting. The combination of earlier planting + improved soil moisture availability following *Aman* rice under strip tillage with RR may have contributed to high yields, though further research is needed for confirmation.

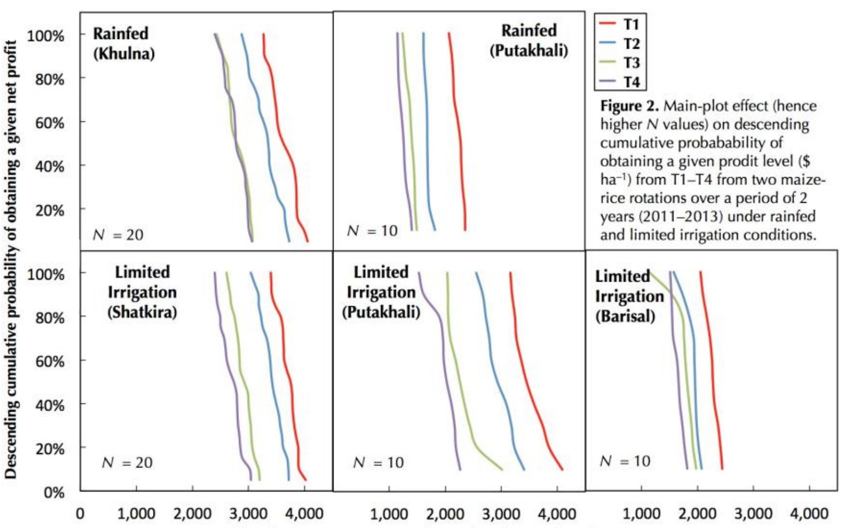

Figure 2. Main-plot effect (hence higher *N* values) on descending cumulative probability of obtaining a given prodit level ($ ha⁻¹) from T1–T4 from two maize-rice rotations over a period of 2 years (2011–2013) under rainfed and limited irrigation conditions.

The combination of higher yields, and reduced production costs for tillage, resulted in consistently higher profit potentials in T1 and T2 (Figure 2). In T1, forgoing PTR had a dramatic cost- reducing effect. Rice yields did not suffer under unpuddled transplanting in T1, and in two cases, T1 rice yields actually exceeded T2, T3 and T4. Farmers hypothesized that this resulted from reduced transplant shock, because seedlings could not be plunged into the soil at the same depth as when puddled, encouraging enhanced tillering. However, while time and cost saving, farmers complained that UPTR in T1 was difficult, and that hired laborers who perform transplanting would be unlikely to accept UPTR as a practice. Most farmers consequently preferred T2 to T1 for its combination of high yields and increased profits over T3 and T4. While not 'fully CA' due to soil puddling during *Aman*, farmer participants were more interested to adopt T2. This highlights the importance of maintaining a flexible interpretation of CA management practices, as farmers should be encouraged to adapt crop management systems to suit their own needs and socioeconomic circumstances.

References

Brouder, S.M. and H. Gomez-Macpherson. 2014. The impact of conservation agriculture on smallholder agricultural yields: A scoping review of the evidence. Ag. Eco. Env. 187:11–32.

MOA and FAO, 2012. Master Plan for Agricultural Development in the Southern Region of Bangladesh.

Ministry of Agriculture (MoA) and FAO, Dhaka, Bangladesh, p. 122.