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**Title: Conservation agriculture effects on yield and profitability of rice-based systems in the Eastern Indo-Gangetic Plain**

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### **Supplementary Material**

### **Method S1. Nutrient management**

### Both lentil and mung bean were fertilized during final land preparation at the rate of 20 kg N ha-1 and20 kg P ha-1 as diammonium phosphate (DAP), 20 kg K ha-1 as muriate of potash (MP), 10.8 kg S ha-1 as gypsum and 1 kg B ha-1 as boric acid, as recommended by the Pulses Research Centre, Bangladesh. The BINA (Bangladesh Institute of Nuclear Agriculture)-LT-18 *Rhizobium* inoculum for lentil and BINA-MB-1 *Bradyrhizobium* inoculum for mung bean were applied at the rate of 50 g kg-1 seed.

For wheat, fertilizers were applied at the rate of 68-30-45-20-2.6-1 kg ha-1 of N, P, K, S, Zn and B in the form of urea, DAP, MP, gypsum, zinc sulphate and boric acid respectively, as recommended by the Bangladesh Agricultural Research Council (2012). Two-thirds of the urea and all of DAP, MP and gypsum were applied before land preparation for CT. The remaining one-third of urea was applied as a top dressing before the first irrigation. Only DAP fertilizer was drilled with seed by VMP while the other fertilizers were broadcast before seeding in SP and BP plots and all fertilizers were broadcast before tillage operations in CT plots for lentil, wheat and mung bean. Both puddled and non-puddled rice were fertilized by broadcast application of 90, 10, 35, 12 and 1 kg ha-1 of N, P, K, S and Zn, respectively. All of the P, K, S and Zn were broadcast before transplanting and N was applied in two equal installments at 21 and 42 days after transplanting (DAT).

### **Method S2. Management of biotic stresses (weed, disease and pest)**

In lentil, wheat and mung bean, weeds were killed prior to seeding using a pre-sowing application of glyphosate in all treatments. In every year, one manual hand weeding was done at 25-30 days after sowing (DAS). The seeds of wheat were treated with the fungicide Provex® as 3 g kg-1 seed just before sowing. The plants were monitored regularly to detect any diseases and insects on plants and any plant protection measures were done as required. The wheat crops were supervised to prevent bird damage to sown seed and to seedlings up to 25 DAS. The herbicide Affinity® (carfentrazone) was 2.5 g L-1 of water was applied after the first irrigation. In Year 1 and Year 2, soap solution (25 g of detergent powder L-1 of water) was sprayed to control aphids which appeared sporadically in the experimental field of wheat. Aphid infestation was severe for wheat in Year 3 and Malathion 57 EC® at 3 ml L-1 of water was applied then. In Year 3, root diseases of lentil (causal organisms: *Sclerotium rolfsii, Fusarium avenaceum*, *Fusarium solani*, *Rhizoctonia solani*, *Pythium* sp. etc) were scored visually for each plot as a percentage of total plant population. Selective fungicides, Secure® 600 wg (fenamidone + mancozeb), Bavistin® 70 wp (carbendazim) and Rovral® 50 wp (iprodion), were applied before or at first appearance of fungal diseases; e.g. collar rot (*Sclerotium rolfsii*) and stemphylium blight of lentil (*Stemphylium sp*). The pod borer infestation in mung bean was sporadic throughout the experimental field in each year in both locations and an insecticide, Wonder 5 G® (emamectin benzoate) at 1 g L-1 of water was applied when the pod borer infestation was high. No debilitating diseases were noted for mung bean.

Glyphosate was applied 7-10 days before transplanting monsoon rice to kill weeds and remnant mung bean stover. Rifit 50 EC® (Pretilachlor) was also applied onto the ponded water in transplanted rice fields at 5 DAT to control grasses, sedges and broad-leaved weeds. Amistar Top® (azoxystrobin 20 % and difenoconazole 12.5 %) at 1 ml L-1 of water was applied to control sheath blight diseases. Virtako®WDG (Thiamethoxam 1% + Chlorantraniliprole 0.5% GR) insecticide was applied at a rate of 5 g L-1 of water at 20-25 DAT and 60 DAT to control stem borer and leaf curling worm of rice.

**Method S3. System rice equivalent yield**

The grain yield and price of each crop relative to rice were used to calculate the rice equivalent yield (REY) of lentil, wheat and mung bean using the following formula (Alam et al., 2017):

REY (cropn) = Yn (Pn/Pr)

where, Yn is the yield of crop ‘n’, Pn is the price of crop ‘n’ (US$ t-1) and Pr is the price of rice. The prices of rice, lentil, wheat and mung bean used were 209, 804, 257 and 644 US$ t-1, respectively, as calculated from the local market prices at Rajshahi in May 2013, using 1 US$ = 77.7 Bangladeshi Taka. System REY was calculated as the sum of the REY of each crop in the cropping system year (November to October).

**Table S1. Details of the three crop establishment treatments at Alipur and Digram.**

|  |  |
| --- | --- |
| Crop establishment method | Details |
| Strip planting (SP) | * VMP used to till strips of 4-5 cm wide and 5-7 cm depth * row to row distance – 20 cm for both wheat and lentil * tillage and seed placement – 5-7 cm depth |
|  | Figure S1. Strip planting system |
| Bed planting (BP) | * VMP used to make and reshape the beds * width of bed tops – 30 cm * width of bed base – 45 cm * width of furrow base – 10 cm * height of the bed (from base of the furrow to the level of the bed top) – 11 cm * the beds were reshaped during sowing of each non-rice crop * two rows of each crop per bed with a row spacing on the beds of 20 cm (cereal crop) or 20-25 cm (legume crop) * reshaping of beds is a mode of reduced tillage while newly formed beds (first crop only) involve a high level of soil disturbance |
|  | Figure S2. Bed planting system |
| Conventional tillage (CT) | * Non-rice crops: Three passes of full rotary tillage using a rotary tiller powered by a 2-WT, tillage to 6 to 9 cm depth, incorporating residue, seed broadcast before final rotary tillage operation followed by a single land levelling using planking. * Rice crop: Three to four wet tillage operations by a 2-WT operated power tiller followed by one planking. Then 25-30 day-old seedlings from the nursery bed were manually transplanted into main field (puddled soil) with one to two seedlings per hill in lines at 20 X 20 cm spacing. All residues of previous legume crops were incorporated only at 50 % residue plot during puddling. |
|  | Figure S3. Conventional tillage |

**Table S2. Details of residue management protocols and the amounts retained for each crop of the lentil** – **mung bean** – **monsoon rice cropping sequence at Alipur in 2010-13.**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Crop number | Crop residue | Year  (and residue type) | High residue plot | | Low residue plot | |
| Residue weight  (t ha-1) | Anchored residue height (cm) | Residue weight  (t ha-1) | Anchored residue height (cm) |
|  | Previous rice residue[[1]](#footnote-1) | 2010  (Loose) | SP - 5, BP - 5, CT - 5 |  | SP - 2, BP - 2, CT - 2 |  |
| 1 | Lentil residue | 2010-11  (Loose) | 100 % residue returned to the same plot after mung bean sowing  SP - 2.1, BP - 1.6, CT - 1.9 |  | No above ground residue retained |  |
| 2 | Mung bean residue | 2011  (Anchored) | 100 % residue retained except pods (estimated residue weight from the following year)  SP - 2.38, BP - 2.91, CT - 2.44 | SP - 75, BP - 72, CT - 77 | No above ground residue retained |  |
| 3 | Rice residue | 2011  (Anchored) | SP - 4.11, BP - 3.50, CT - 3.96 | SP - 60, BP - 60, CT - 60 | SP - 1.90, BP - 1.59, CT - 1.77 | SP - 24, BP - 24, CT - 24 |
| 4 | Lentil residue | 2011-12  (Loose) | 100 % residue returned to the same plot after sowing  SP - 1.93, BP - 1.83, CT - 2.05 |  | No above ground residue retained |  |
| 5 | Mung bean residue | 2012  (Anchored) | 100 % residue retained except husk  SP - 2.38 , BP - 2.91, CT - 2.44 | SP - 61, BP -60, CT - 60 | No above ground residue retained |  |
| 6 | Rice residue | 2012  (Anchored) | SP - 4.30 , BP - 3.98, CT - 4.81 | SP - 61, BP -61, CT - 61 | SP - 2.31 , BP - 1.95 , CT - 2.05 | SP - 24, BP - 24, CT - 24 |
| 7 | Lentil residue | 2012-13  (Loose) | 100 % residue returned to the same plot after sowing of mung bean  SP - 1.85, BP - 1.80, CT - 1.34 |  | No above ground residue retained |  |
| Total amount of residue (t ha-1) retained during 7 successive crops | | | SP - 24.05, BP - 23.53, CT - 23.94 |  | SP - 6.21, BP - 5.54, CT - 5.82 |  |

The residue from the previous rice was retained for planting Crop 1. The residue from Crop 1, was retained for Crop 2, and so on; Anchored residue – Standing residue

**Table S3. Details of residue management protocols and the amounts retained for each crop of the wheat** – **mung bean** – **monsoon rice cropping sequence at Digram in 2010-13.**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Crop number | Crop residue | Year  (and residue type) | High residue plot | | Low residue plot | Anchored residue height (cm) |
| Residue weight (t ha-1) | Anchored residue height (cm) | Residue weight  (t ha-1) |
|  | Previous rice residue | 2010  (Anchored) | SP - 3.28, BP - 3.28, CT - 3.28 | SP - 45, BP - 45, CT - 45 | SP - 1.73, BP - 1.73, CT - 1.73 | SP - 18, BP - 18, CT - 18 |
| 1 | Wheat residue | 2010 - 11  (Anchored) | SP - 2.73, BP - 2.64, CT - 2.46 | SP - 47, BP - 47, CT - 47 | SP - 1.45, BP - 1.61, CT - 1.32 | SP - 19, BP - 19, CT - 19 |
| 2 | Mung bean residue | 2011  (Anchored) | 100 % residue retained except pods (estimated from the following years)  SP - 3.86 , BP - 3.53, CT - 3.83 | SP - 52, BP - 50, CT - 54 | No above ground residue retained |  |
| 3 | Rice residue | 2011  (Anchored) | SP - 5.46, BP - 5.42, CT - 5.43 | SP - 63, BP - 63, CT - 63 | SP - 2.47, BP - 2.26, CT - 2.48 | SP - 25, BP - 25, CT - 25 |
| 4 | Wheat residue | 2011 - 12  (Anchored) | SP - 3.58, BP - 3.20, CT - 3.33 | SP - 50, BP - 50, CT - 50 | SP - 1.80, BP - 1.53, CT - 1.83 | SP - 20, BP - 20, CT - 20 |
| 5 | Mung bean residue | 2012  (Anchored) | 100 % residue retained except husk  SP - 3.86, BP - 3.53, CT - 3.83 | SP - 54, BP - 50, CT - 52 | No above ground residue retained |  |
| 6 | Rice residue | 2012  (Anchored) | SP - 5.39, BP - 4.73, CT - 5.38 | SP - 55, BP - 55, CT - 55 | SP - 2.33 , BP - 2.67, CT - 3.22 | SP - 22, BP - 22, CT - 22 |
| 7 | Wheat residue | 2012 - 13  (Anchored) | SP - 3.99, BP - 3.67, CT - 3.51 | SP - 52, BP - 52, CT - 52 | SP - 1.98, BP - 1.73, CT - 1.68 | SP - 21, BP - 21, CT - 21 |
| Total amount of residue  (t ha-1) retained during 7 successive crops | | | SP - 32.2, BP - 30.0, CT - 31.1 |  | SP - 11.8, BP - 11.5, CT - 12.3 |  |

The residue from the previous rice was retained for planting Crop 1. The residue from Crop 1, was retained for Crop 2, and so on; Anchored residue – Standing residue

**Table S4. Agronomic details for the lentil** – **mung bean** – **monsoon rice cropping sequence at Alipur during 2010-2013.**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Year | Crop | Variety | Seed rate  (kg ha-1) or  seedlings of rice hill-1 | Date of sowing | Date of harvesting | Row spacing  (cm) |
|
| 2010-11 | Lentil | BARI Masur 6 | 34 | 10-11 November, 2010 | 8 March, 2011 | 20 cm |
| 2011 | Mung bean | BARI Mung 6 | 37.5 | 21 March, 2011 | 28 May-10 June, 2011 | SP and  BP - 30 cm |
| 2011 | Monsoon rice | Hybrid rice Tej  (Bayer Crop Science) | Two seedlings hill-1 | 8 July, 2011 | 24 October, 2011 | SP and BP - 20 cm |
| 2011-12 | Lentil | BARI Masur 6 | 34 | 11-12 November, 2011 | 5 March, 2012 | SP and  BP - 25 cm |
| 2012 | Mung bean | BARI Mung 6 | 37.5 | 23 March, 2012 | 28 May, 2012 | SP - 25 cm,  BP - 20 cm |
| 2012 | Monsoon rice | Hybrid rice  (ACI-1) | Two seedlings hill-1 | Seeding-6 June, 2012  Planting-5 July, 2012 | 9 October, 2012 | SP and BP - 20 cm |
| 2012-13 | Lentil | BARI Masur 6 | 34 | 17-18 November, 2012 | 11 March, 2013 | SP and BP - 20 cm |

Note: Transplanting of monsoon rice in non-puddled soil for SP and BP; puddled soil for CT

**Table S5. Agronomic details for the wheat** – **mung bean** – **monsoon rice cropping sequence at Digram during 2010-2013.**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Year | Crop | Variety | Seed rate  (kg ha-1)  rice seedlings-1  hill-1 | Row spacing  (cm) | Date of sowing (and or transplanting of monsoon rice) | Date of harvesting |
|
| 2010-11 | Wheat | BARI Gom 24 (Prodip) | 120 | 20 | 13 December, 2010 | 3 April, 2011 |
| 2011 | Mung bean | BARI Mung 6 | 37.5 | 20 | 12 April, 2011 | 20 June, 2011 |
| 2011 | Monsoon rice | Local variety Swarna | Two seedlings  hill-1 | 20-25/15 | 12 July, 2011 | 21 November, 2011 |
| 2011-12 | Wheat | BARI Gom 24 (Prodip) | 120 | 20 | 23-24 December, 2011 | 29 March, 2012 |
| 2012 | Mung bean | BARI Mung 6 | 37.5 | 20 | 17 April, 2012 | 17-30 June, 2012 |
| 2012 | Monsoon rice | BRRI Dhan 51 | Two seedlings hill-1 | 20-25 | 13 July, 2012 | 15 November, 2012 |
| 2012-13 | Wheat | BARI Gom 24 (Prodip) | 120 | 20 | 3-4 December, 2012 | 29 March, 2013 |

Note: Transplanting of monsoon rice in non-puddled soil for SP and BP; puddled soil for CT

**Table S6. Prices of inputs and outputs and rates used for calculating cost of production and profits in different years for conducting economic analysis**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Particulars! | lentil | | | wheat | | | Mung bean | Rice | |
| 2010-11 | 2011-12 | 2012-13 | 2010-11 | 2011-12 | 2012-13 | 2012 | 2011 | 2012 |
| Grain sale price (US$ kg-1) | 0.90 | 1.03 | 1.16 | 0.32 | 0.32 | 0.32 | 0.77 | 0.26 | 0.26 |
| Straw price (US$ kg-1) | 0.03 | 0.03 | 0.04 | 0.01 | 0.01 | 0.01 | - | 0.05 | 0.05 |
| Labour wages (US$ person-day-1) | 2.57 | 3.22 | 3.86 | 2.57 | 3.22 | 3.86 | 3.22 | 3.22 | 3.86 |
| Seed (US$ kg-1) | 1.29 | 1.42 | 1.54 | 0.45 | 0.45 | 0.45 | 1.03 | 0.64 | 0.64 |
| Fertilizer | | | | | | | | | |
| Urea | - | - | - | 0.21 | 0.21 | 0.21 | - | 0.21 | 0.21 |
| DAP (US$ kg-1) | 0.39 | 0.40 | 0.41 | 0.39 | 0.40 | 0.41 | 0.40 | 0.39 | 0.39 |
| MoP (US$ kg-1) | 0.17 | 0.18 | 0.18 | 0.17 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 |
| Gypsum (US$ kg-1) | 0.23 | 0.24 | 0.26 | 0.23 | 0.24 | 0.26 | 0.24 | 0.24 | 0.24 |
| Zinc sulphate | - | - | - | 1.54 | 1.54 | 1.54 | - | 1.54 | 1.54 |
| Boric acid (US$ kg-1) | 2.57 | 2.57 | 2.57 | 2.57 | 2.57 | 2.57 | - | - | - |
| Cost of CTLR (US$ ha-1) | 57.92 | 57.92 | 57.92 | 57.92 | 57.92 | 57.92 | 57.92 | 57.92 | 57.92 |
| Cost of CTHR (US$ ha-1 pass-1) | 78.87 | 78.87 | 78.87 | 78.87 | 78.87 | 78.87 | 57.92 | 57.92 | 57.92 |
| Laddering cost for CT (US$ ha-1) | 14.48 | 14.48 | 14.48 | 14.48 | 14.48 | 14.48 | 14.48 | 19.31 | 19.31 |
| Application of fertilizers, seed sowing and land leveling for CT (US$ ha-1) | 24.13 | 24.13 | 24.13 | 24.13 | 24.13 | 24.13 | 24.13 | 19.31 | 19.31 |
| Cost of BPLR (US$ ha-1) | 33.78 | 33.78 | 33.78 | 33.78 | 33.78 | 33.78 | 33.78 | 33.78 | 33.78 |
| Cost of BPHR (US$ ha-1) | 43.44 | 43.44 | 43.44 | 43.44 | 43.44 | 43.44 | 33.78 | 33.78 | 33.78 |
| Cost of SPLR (US$ ha-1) | 28.96 | 28.96 | 28.96 | 28.96 | 28.96 | 28.96 | 28.96 | 28.96 | 28.96 |
| Cost of SPHR (US$ ha-1) | 31.38 | 31.38 | 31.38 | 31.38 | 31.38 | 31.38 | 28.96 | 28.96 | 28.96 |
| Seedbed management for rice seedling raising | - | - | - | - | - | - | - | 48.26 | 48.26 |
| Seedling transplanting for CT (labour requirement ha-1) | - | - | - | - | - | - | - | 22.5 | 22.5 |
| Seedling transplanting for SP (labour requirement ha-1) | - | - | - | - | - | - | - | 52.5 | 52.5 |
| Seedling transplanting for BP (labour requirement ha-1) | - | - | - | - | - | - | - | 37.5 | 37.5 |
| Irrigation for rice (US$ ha-1) | - | - | - | 86.87 | 86.87 | 86.87 | 19.71 | 115.83 | 115.83 |
| Glyphosate (round-up) (US$ Lt-1) | 9.01 | 9.65 | 9.65 | 9.01 | 9.65 | 9.65 | 9.65 | 9.65 | 9.65 |
| Herbicide Affinity® (carfentrazone) | - | - | - | 19.31 | 19.31 | 19.31 | - | - | - |
| Bavistin® (Carbendazim) (US$ kg-1) (for lentil) | 25.74 | 25.74 | 25.74 | - | - | - | - | - | - |
| Rovral® (iprodione) (US$ kg-1) (for lentil) | 32.18 | 32.18 | 32.18 | - | - | - | - | - | - |
| Fyfanon 57 EC® (O,O-dimethyl phosphorodithioate of diethyl mercapto-succinate) (US$ L-1) (for lentil) | 6.44 | 6.44 | 6.44 | - | - | - | - | - | - |
| Other pesticide and fungicide cost (US$ ha-1) | - | - | - | - | - | - | 28.96 | 54.05 | 54.05 |
| Manual weeding cost (US$ ha-1) | 96.53 | 120.66 | 144.79 | - | - | - | 120.66 | 144.79 | 173.75 |
| Herbicide, pesticide and fungicide spraying cost (US$ ha-1) | 38.61 | 48.26 | 57.92 | 19.31 | 24.13 | 28.96 | 24.13 | 144.79 | 173.75 |
| Harvesting cost (US$ ha-1) | 77.22 | 96.53 | 115.83 | 77.22 | 96.53 | 115.83 | 193.05 | 173.75 | 173.75 |
| Carrying cost (US$ ha-1) | 28.96 | 36.20 | 43.44 | 48.26 | 48.26 | 48.26 | 9.65 | 38.61 | 38.61 |
| Thresher rent (US$ ha-1) | 77.22 | 77.22 | 77.22 | 96.53 | 96.53 | 96.53 | - | 38.61 | 38.61 |
| Threshing, cleaning and sun drying cost (US$ ha-1) | 77.22 | 96.53 | 115.83 | 38.61 | 48.26 | 57.92 | 144.79 | 115.83 | 115.83 |
| Fixed cost | | | | | | | | | |
| Land rental value (US$ ha-1 yr-1) at legume dominated system | 1158.30 | 1158.30 | 1158.30 | - | - | - | 1158.30 | 1158.30 | 1158.30 |
| Land rental value (US$ ha-1 yr-1) at cereal dominated system | - | - | - | 965.25 | 965.25 | 965.25 | 965.25 | 965.25 | 965.25 |

!1 US$ = 77.7 BDT for all particulars

**Table S7. Analysis of variance (ANOVA) for the volumetric soil water content (%) at Alipur and Digram site**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Source of variation | Soil depth  (cm) | | Crop establishment (CE) | | | | Residue levels methods | | | CE X Residue levels | | | | |
| 2010-11 | 2011-12 | | 2012-13 | 2010-11 | 2011-12 | 2012-13 | 2010-11 | | 2011-12 | 2012-13 | |
| The volumetric soil water content (%) at Alipur | | | | | | | | | | | | | | |
|  | 0-5 | | \*\* | \* | \*\* | | \*\* | \*\* | \*\* | ns | \* | | | ns |
|  | 5-10 | | \*\* | \* | ns | | ns | ns | \*\* | ns | ns | | | ns |
|  | 10-15 | | \*\* | ns | ns | | ns | ns | \*\* | ns | ns | | | ns |
| The volumetric soil water content (%) at Digram | | | | | | | | | | | | | | |
|  | 0-5 | \*\* | | \*\* | \* | | \*\* | \*\* | \*\* | ns | ns | | | ns |
|  | 5-10 | \*\* | | \* | ns | | ns | ns | \* | ns | ns | | | ns |
|  | 10-15 | \*\* | | ns | ns | | ns | ns | ns | ns | ns | | | ns |

\* Significant at P<0.05. \*\* Significant at P<0.01. ns, not significant; SP – strip planting; BP – bed planting; CT – conventional tillage; LR – low residue, HR – high residue

**Table S8. Analysis of variance (ANOVA) for some yield components of lentil and wheat**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Source of variation | Crop establishment (CE) | | | Residue levels (R) | | | CE X R | | |
| 2010-11 | 2011-12 | 2012-13 | 2010-11 | 2011-12 | 2012-13 | 2010-11 | 2011-12 | 2012-13 |
| Grain yield of lentil (t/ha) | \* | ns | \* | ns | \*\* | ns | \* | ns | ns |
| Straw yield of lentil (t/ha) | ns | ns | \* | ns | \*\* | ns | ns | ns | ns |
| Grain yield of wheat (t/ha) | ns | \*\* | \*\* | ns | ns | \* | ns | ns | ns |
| Straw yield of wheat (t/ha) | ns | \*\* | \*\* | \* | \*\* | \*\* | ns | ns | ns |

\* Significant at P<0.05. \*\* Significant at P<0.01. ns, not significant; SP – strip planting; BP – bed planting; CT – conventional tillage; LR – low residue, HR – high residue

**Table S9. Effects of crop establishment methods and crop residue retention levels on rice equivalent yield (REY) of the legume-dominated system at Alipur and the cereal-dominated system at Digram**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Crop establishment method (CE) **†** | Residue level (R) | | | *Mean* | Residue level | | *Mean* | Residue level | | *Mean* |
| HR1 | | LR | HR | LR | HR | LR |
| Crop season 2010-11 | | | | Crop season 2011-12 | | | Cumulative REY | | |
| Legume-dominated system in Alipur | | | | | | | | | | |
| SP | 11.8 | 13.1 | | 12.5 | 18.9 | 16.6 | 17.7 | 40.2 | 38.1 | 39.2 |
| BP | 10.5 | 10.3 | | 10.4 | 19.6 | 17.0 | 18.3 | 38.7 | 35.4 | 37.1 |
| CT | 13.1 | 11.9 | | 12.5 | 21.7 | 19.4 | 20.6 | 41.9 | 38.0 | 40.0 |
| *Mean* | 11.8 | 11.8 | |  | 20.0 | 17.7 |  | 40.3 | 37.2 |  |
| LSD10.05 |  |  | |  |  |  |  |  |  |  |
| CE | 1.2\*\* | | | | 1.6\*\* | | | ns | | |
| R | ns | | | | 0.8\*\* | | | 1.5\*\* | | |
| CE x R | 1.3\* | | | | ns | | | ns | | |
| Cereal-dominated system in Digram | | | | | | | | | | |
| SP | 10.1 | 9.7 | | 9.9 | 13.6 | 14.3 | 13.9 | 29.6 | 29.7 | 29.7 |
| BP | 10.2 | 9.4 | | 9.8 | 11.5 | 12.1 | 11.8 | 27.4 | 27.2 | 27.3 |
| CT | 9.4 | 10.3 | | 9.9 | 14.9 | 15.0 | 14.9 | 29.7 | 30.6 | 30.1 |
| *Mean* | 9.9 | 9.8 | |  | 13.3 | 13.8 |  | 28.9 | 29.2 |  |
| LSD10.05 |  |  | |  |  |  |  |  |  |  |
| CE | ns | | | | 1.6\*\* | | | 1.9\* | | |
| R | ns | | | | ns | | | ns | | |
| CE x R | ns | | | | ns | | | ns | | |

**†**CE – Crop establishment method; SP – strip planting; BP – bed planting; CT – conventional tillage; R – crop residue level; HR – high crop residue; LR – low crop residue; 1the least significant difference (LSD) at P≤0.05, ns – not significant, \* – significant at P≤0.05 and \*\* – significant at P≤0.01. . Lentil (2010-11) –monsoon rice (2011) were used to calculate system REY in 2010-11; heavy rainfall damaged mung bean (2011), hence, yield results were not available to add to the system REY in 2010-11. Lentil (2011-12) – mung bean (2012) – monsoon rice (2012) were used to calculate system REY in 2011-12.

**Table S10. Effects of crop establishment methods and residue retention levels on plant population at 30 days after sowing of mung bean at Alipur and Digram sites**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Crop establishment method (CE) **†** | Residue (R) | | Mean | Residue | | Mean |
| 2011 | | 2012 | |
| HR1 | LR | HR | LR |
| Plant population m-2 at 30 DAS in Alipur | | | | | | |
| SP | 33 | 36 | *34* | 36 | 37 | *36* |
| BP | 29 | 31 | *30* | 30 | 31 | *31* |
| CT | 31 | 35 | *33* | 31 | 33 | *32* |
| Mean | *31* | *34* |  | *32* | *33* |  |
| LSD20.05 | | | | | | |
| CE |  | ns |  |  | 3.4\*\* |  |
| R |  | 3.0\* |  |  | ns |  |
| CE x R |  | ns |  |  | ns |  |
| Plant population m-2 at 30 DAS in Digram | | | | | | |
| SP |  |  |  | 44 | 46 | *45* |
| BP |  |  |  | 39 | 40 | *40* |
| CT |  |  |  | 43 | 44 | *43* |
| Mean |  |  |  | *42* | *43* |  |
| LSD20.05 | | | | | | |
| CE |  |  |  |  | 2.3\*\* |  |
| R |  |  |  |  | 0.9\*\* |  |
| CE x R |  |  |  |  | ns |  |

**†**CE – Crop establishment method; SP – strip planting; BP – bed planting; CT – conventional tillage; R – residue level; HR – high residue; LR – low residue; 2the least significant difference (LSD) at P≤0.05, ns – not significant, \* – significant at P≤0.05 and \*\* – significant at P≤0.01.

**Table S11. Effects of crop establishment methods and residue retention levels on plant population (%) affected by root diseases of lentil in Year 3**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Crop establishment technique (CE) **†** | 14 Dec, 2012 | | | 23 Dec, 2012 | | | 26 Dec, 2012 | | |
| HR1 | LR | *Mean* | HR | LR | *Mean* | HR | LR | *Mean* |
| SP | 0.0 | 0.1 | 0.1 | 0.3 | 0.4 | 0.3 | 0.6 | 0.7 | 0.7 |
| BP | 4.0 | 2.7 | 3.4 | 7.5 | 4.8 | 6.1 | 10.0 | 6.0 | 8.0 |
| CT | 0.1 | 0.0 | 0.1 | 0.6 | 0.4 | 0.5 | 1.1 | 0.6 | 0.9 |
| *Mean* | 1.4 | 1.0 |  | 2.8 | 1.9 |  | 3.9 | 2.4 |  |
| LSD20.05 |  |  |  |  |  |  |  |  |  |
| CE | 2.8\* | | | 4.9\* | | | 6.5\* | | |
| Residue (R) | ns | | | ns | | | ns | | |
| CE x R | ns | | | ns | | | ns | | |

**†**CE – Crop establishment method; SP – strip planting; BP – bed planting; CT – conventional tillage; R – residue level; HR – high residue; LR – low residue; 2the least significant difference (LSD) at P≤0.05, ns – not significant, \* – significant at P≤0.05 and \*\* – significant at P≤0.01.

**Table S12. Generalised nutrient concentrations in crop residues of different crop species in rice-based systems**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Residue of different crops | Nutrients (g/kg) | | | |
| N | P | K | S |
| Rice residues | 4 | 1 | 15 |  |
| Wheat residues | 5 | 3 | 9 |  |
| Mung bean residues | 8 | 2 | 5 | 3 |
| Lentil residues | 8 | 2 | 5 | 3 |

Bangladesh Agricultural Research Council (2018)

**Table S13. Effects of crop establishment methods and residue retention levels on total root dry weight of lentil and wheat in 2013**

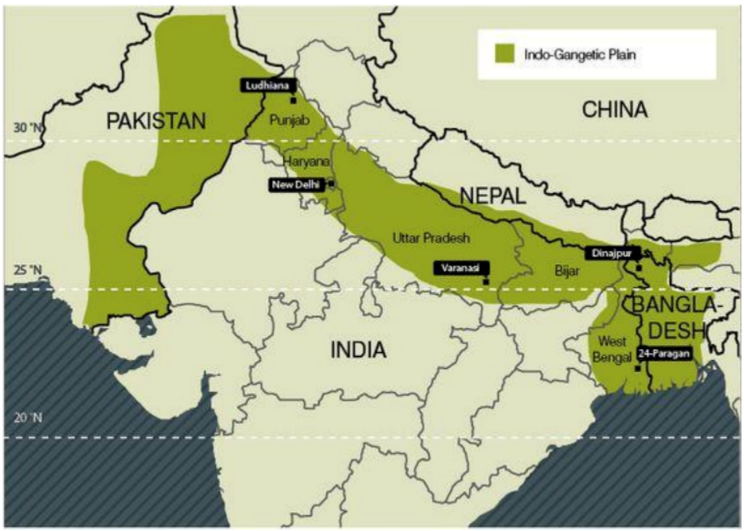
|  |  |  |  |
| --- | --- | --- | --- |
| Crop establishment technique (CE) **†** | Residue levels (R) | | |
| HR1 | LR | Mean |
| Lentil (g 0.03 m-2) at 0-20 cm soil depth at Alipur site | | | |
| SP | 0.50 | 0.44 | 0.47 |
| BP | 0.74 | 0.64 | 0.69 |
| CT | 0.51 | 0.44 | 0.48 |
| *Mean* | 0.58 | 0.51 |  |
| LSD20.05 |  |  |  |
| CE | 0.095\*\* |  |  |
| R | 0.041\*\* |  |  |
| T x R | ns |  |  |
| Wheat (g 0.04 m-2) at 0-70 cm soil depth at Digram site | | | |
| SP | 1.68 | 1.49 | 1.58 |
| BP | 1.99 | 1.84 | 1.92 |
| CT | 1.57 | 1.26 | 1.41 |
| *Mean* | 1.75 | 1.53 |  |
| LSD20.05 |  |  |  |
| CE | 0.29\*\* |  |  |
| R | 0.17\*\* |  |  |
| T x R | ns |  |  |

**†**CE – Crop establishment method; SP – strip planting; BP – bed planting; CT – conventional tillage; R – residue level; HR – high residue; LR – low residue; 2the least significant difference (LSD) at P≤0.05, ns – not significant, \* – significant at P≤0.05 and \*\* – significant at P≤0.01.



**2**

**1**



### Figure S4. Map showing the two experimental sites (dotted with 1 and 2) in Indo-Gangetic Plain – Alipur and Digram sites. Adapted from: [file:///Volumes/Working%20File/Office%20Document/Office%20Documents/Documents/2016/NUMAN/2020/2021/cse-2017-101\_final\_report.pdf](file:///C:\Volumes\Working%20File\Office%20Document\Office%20Documents\Documents\2016\NUMAN\2020\2021\cse-2017-101_final_report.pdf)



Figure S5. Regression of plant population m-2 and grain yield (t ha-1) for three years of results (2010-13) of lentil at Alipur (a) and wheat (b); and one year of results (2012) of mung bean at Digram (c).

**References**

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1. [↑](#footnote-ref-1)