Organic nutrient management and intercropping for improved rainwater conservation and productivity under rain fed maize-barley rotation

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Key words: Organic versus conventional, Intercropping, soil erosion, soil moisture, maize-barley, rain-fed

Abstract

Organic, inorganic and integrated nutrient management, and intercropping practices were compared in terms of productivity, soil erosion and rain water conservation under rain fed maize-barley rotation. Four main treatments included: N0: no fertilizers added, N1: inorganic fertilizers alone, N2: organic and inorganic fertilizers in equal ratio, and N3: organic composts alone. Sub treatments with green gram intercropping under maize were: I0:no intercropping I1: green gram intercropped and mulched in soil; I2: green gram intercropped for grain production. Results showed that the grain yields of maize and barley were at par under different nutrient management, while the straw yields were lower under organic treatments. Both the intercropping treatments reduced maize yields; while improved barley straw yields. Organic nutrient management and intercropping reduced the run off % and soil loss, and improved soil profile moisture, indicating improved rainwater conservation in soil.

Introduction

The rain fed agriculture is being practiced in about 60% of cultivated area in India; however the erratic rainfall during the past few decades has resulted in decline in farm productivity (Venkatswarlu and Prasad 2012). The increased biodiversity and improved soil moisture and nutrient conservation in organic agriculture make it more adaptable and resilient to erratic rain fall patterns under changing climate (Goh 2011). However, the vast yield gaps between organic and conventional agriculture farms and the perceived risk of decline in productivity has deterred many modern farmers from shifting to organic agriculture (Ponti et al 2012). In order to improve productivity and soil moisture regime, the present study was conducted to optimize different legume intercropping practices in combination with nutrient management under rain fed maize-barley rotation.

Material and methods

Field experiment: A field experiment was conducted under maize-barley rotation during period 2012-15, at Chandigarh, India (altitude of 370m above msl, latitude of 30°- 44' North and longitude of 76°-51' East). The agriculture land was undulating with 1% slope, moderately degraded, and sandy loam with low available soil nutrients. The climate was sub-tropical with mean monthly temperature highest at 41^{0}C and the lowest at 4.4 ^{0}C, and an annual average rainfall of 1100 mm, with 80% of total rainfall during monsoon season between mid-June to mid September. The composite maize variety, Girja and the green gram intercrop were sown at onset of monsoon rains and harvested by end of October.

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The malt variety of barley, DWRUB-52, was sown in November or December after winter rain and harvested in April.The nutrients as per N and P requirement of the crop were given through following main treatments: N0: Absolute Control (no nutrient added); N1: 100% nutrients through inorganic fertilizers (Urea, DAP and MOP); N2: Integrated Nutrient Management with 50% through inorganic fertilizers and 50 % through organic sources (FYM and vermicomposts in equal ratio); N3:100% through organic sources (FYM and vermicomposts in equal ratio). Green gram was intercropped with sub-treatments:I0: no inter cropping; I1: green gram intercropped and mulched in soil under maize; I2: green gram intercropped for grain production. The experimental design was split plot with plot size: 8m X 4m and three replications. No irrigation was given to both the crops. The pest or disease attacks were managed organically in all the treatments by commercially available Neem (*Azadirachta indica*) based pesticides.

Run off and soil loss: Soil erosion was monitored by installing specially designed multi-slot devisors installed at the lower end of treatment plots, so as to pass 2.5 % of the run off volume generated in the plots within 24 hours. The runoff waters from all the rain fall events were collected in the containers of capacity 200 liters placed in front of each plot. The run off volume was measured for each rain fall event during maize crop. The % run off was calculated from total volume of runoff water from each treatment and the total rainfall. The total soil loss was computed from dry weight of the sediment fraction present in run off water.

Soil profile moisture: Soil profile moisture percentage was determined every month gravimetrically from soil samples collected from different soil depths and was converted into volumetric water content (cm), using soil bulk density.

Statistical Analysis: The two-way ANOVA was applied for the analysis of variance to test the effect of nutrients, intercropping and their interactions on crop yields, run-off, soil loss and soil profile moisture. Standard deviation and Fisher's least significant difference (LSD) were determined to compare the significant differences between the means of the various treatments at $p< 0.05$.

Results

It was observed that both the maize and barley grain yields were higher than the control, but there was no significant difference between different nutrient management, but the straw yields were lower in organic treatments (Fig.1a and 1b). The grain yields from intercrop green gram ranged between 80 to 120 Kg ha^{-1}, with no significant difference between different treatments. Intercropping resulted in a significant decline in maize grain and straw yields (Fig 1a), while the barley yields were significantly improved (Fig.1b). Maize straw yields and barley yields were lower under organic treatments with no preceding intercrop; however intercropping improved the yields bringing it almost at par with the other nutrient treatments (Fig.1b).

Nutrients and intercropping significantly reduced the average run off % and soil loss, with minimum run off % under organic and inorganic treatments, and minimum soil loss under organic treatments when the intercrop was taken till maturity (2a and 2b). The soil profile moisture was significantly higher under organic treatments under both barley and maize, with highest moisture levels in deeper 30-90 cm profile (Fig.3a & 3b). The intercrop till maturity showed no significant effect on soil profile moisture under maize, but caused a significant decline under barley.

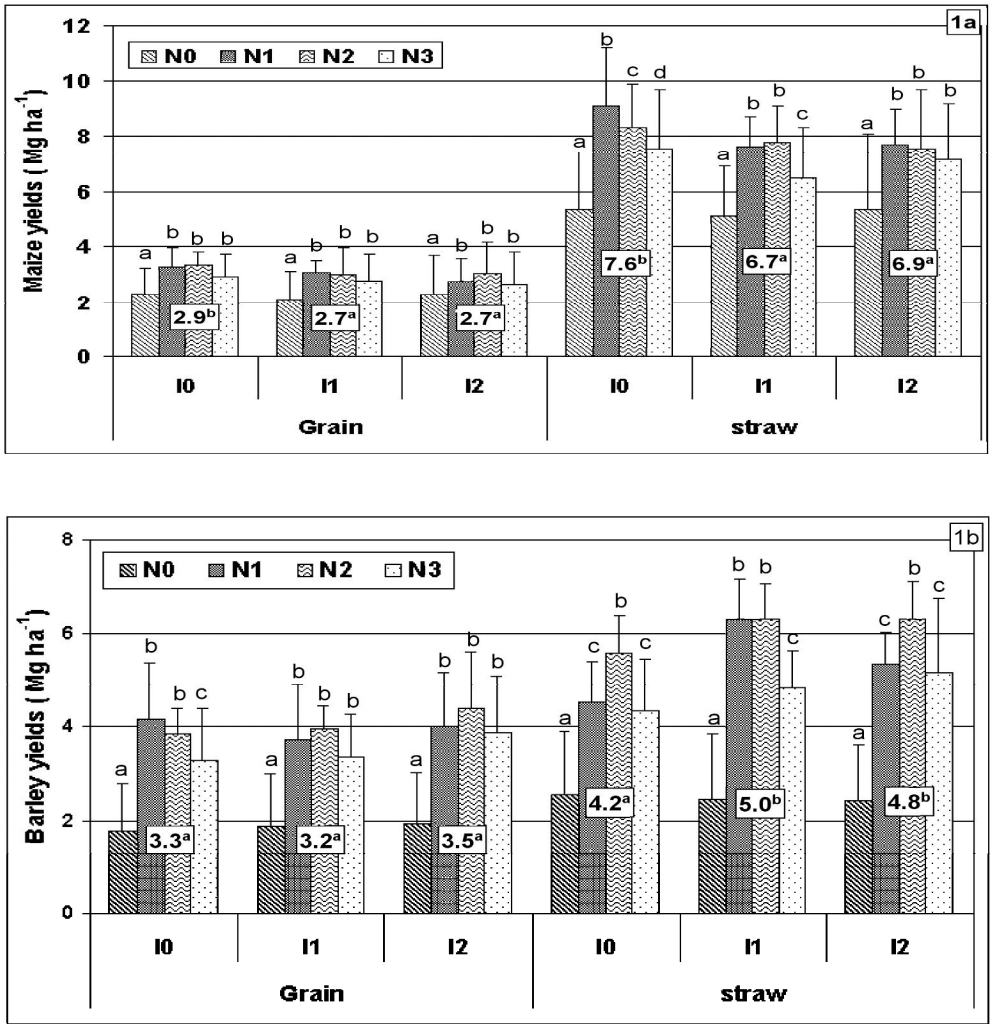

Figure 1 a & 1b: Grain and straw yields (3 years average 2012-15) of maize (1a) and barley (1b) as affected by nutrient source and intercropping. The means with same letter are not significantly different (p=0.05) within the group. The mean yield values of intercropping treatments are given in box and the values with similar superscript letters are not significant different. Error bars indicate standard deviation.

Discussion

The study shows that the legume intercropping not only plays a major role in reducing the yield gaps between organic and inorganic nutrient management, but also help to reduce runoff and soil erosion. Green gram intercropping till maturity reduced the maize yields, but this decline was compensated by additional green gram grain yields and improved barley yields due to a higher residual effects. Scalise *et al* (2015) reported that any decisive improvement in the soil fertility status of rain fed areas cannot be rapidly or easily achieved, unless crop rotations with intercropped legumes are adopted for several years. The present study also concludes that organic agriculture and green gram intercropping will sustain higher yields under rain fed conditions due to improved capacity to conserve rain water and soil moisture for combating drought.

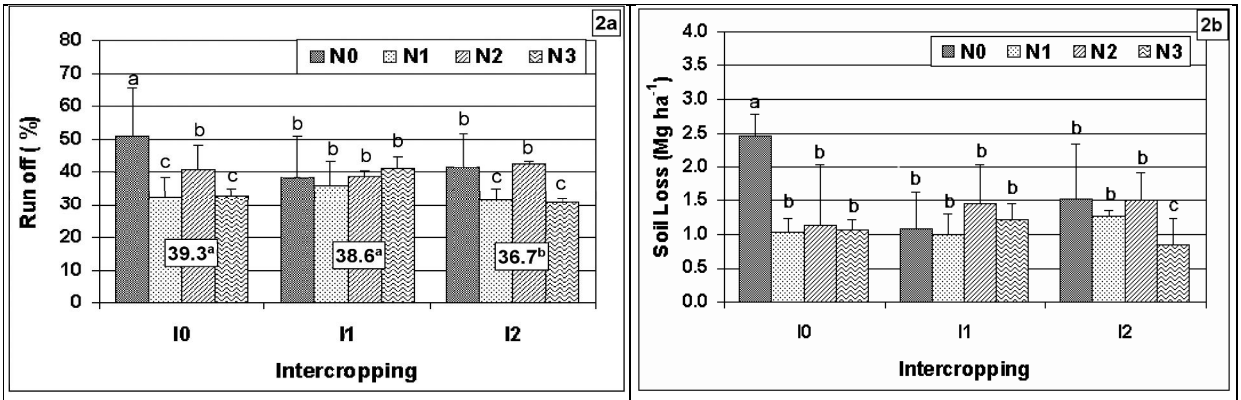

Figure 2 a-b: Average run off % (2a) and soil loss (2b) for years 2012-2015. The bars with the same letter are not significantly different (p=0.05). The mean intercropping effects in the box (1a) with similar superscript letter are not significantly different. Error bars indicate standard deviation

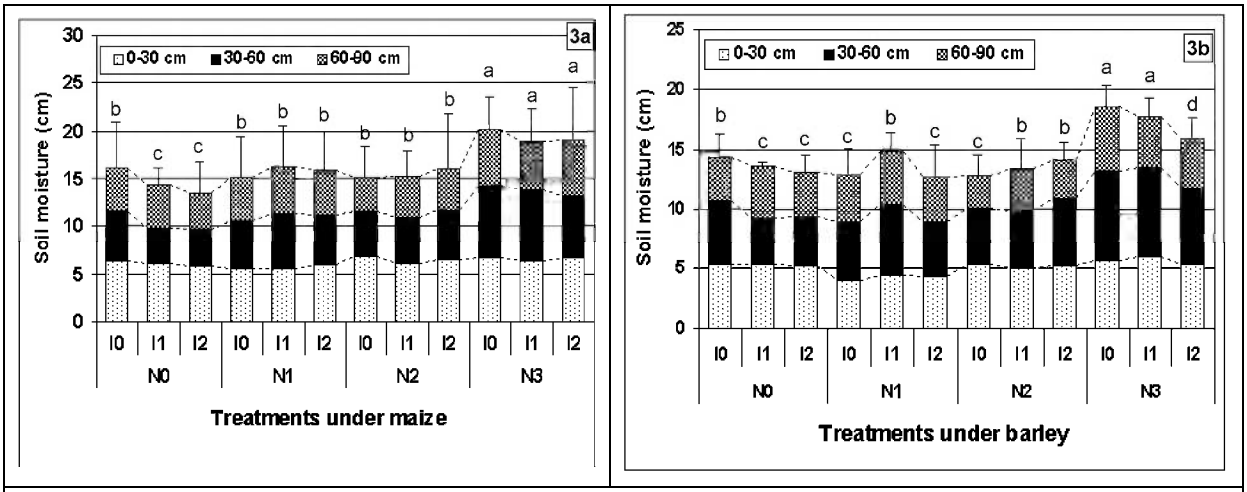

Figure 3 a-b: Soil profile moisture (0-90 cm soil depth) under maize (3a) and barley (3b) with relative contribution from different soil depths. The bars with the same letter are not significantly different (p=0.05). Error bars indicate standard deviation.

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