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On-farm evaluation of fertilizer application and conservation tillage on productivity of cotton + pigeonpea strip intercropping on rainfed Vertisols of central India

D. Blaise*, G. Majumdar, K.U. Tekale

Central Institute for Cotton Research, Division of crop production, P.O. Bag No. 2, Shankar Nagar, Nagpur 440 010, Maharashtra, India

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Abstract

Cotton + pigeonpea strip intercropping is a traditional cropping system in central India. On-farm trials were conducted on five farms each on medium deep soils (MDS) and deep soils (DS) during 2001–2002 and 2002–2003 on Vertisols under rainfed conditions to evaluate the effect of technological interventions on cotton + pigeonpea system. The interventions (applying recommended dose of fertilizer (RDF), conservation tillage (CT) with in situ green manure + RDF (CT_1) and CT_1 + zinc sulphate (CT_2)) were compared with the farmers' practice (FP). Cotton (*Gossypium hirsutum* L.) and pigeonpea (*Cajanus cajan* (L.) Millsp.) were sown in 6:2 row ratio at a spacing of 0.75 m × 0.75 m on MDS and 0.90 m × 0.90 m on DS. Mean seed cotton yield was significantly greater in 2001–2002 (809 kg ha^{-1}) compared to 2002–2003 (508 kg ha^{-1}), while the reverse was true for pigeonpea grain yield. Averaged over years, seed cotton yield did not differ between locations (MDS versus DS). However, in 2001–2002 seed cotton yield was significantly greater on DS (855 kg ha^{-1}) than on MDS (764 kg ha^{-1}). Seed cotton yield increased by 114 with application of RDF, while the contributions for CT and Zn application were 51 and 76, respectively. Seed cotton yield increase in plots with interventions was because of more and heavier bolls (2.66–2.75 g) retained per plant than the FP (2.39 g). Pigeonpea grain yield was 80 kg ha^{-1} higher on DS than on MDS. For the interventions, yield followed the trend: $CT_2 \geq CT_1 \geq RDF > FP$, suggesting the need to apply fertilizers to pigeonpea. Fibre quality was better in the cotton grown on DS than on MDS. Marginal benefit:cost ratio (MBC) was the greatest for the RDF (3.08) followed by CT_2 (1.71) and CT_1 (1.41). Considering the farmer's low-income and high-risk nature of rainfed farming, investment on herbicide (US$ 37 ha^{-1}) could be a deterrent to adopting CT.

Keywords: *Cajanus cajan*; Conservation tillage; Fibre quality; *Gossypium hirsutum*; Zinc sulphate

1. Introduction

Intercropping various crops, such as greengram (*Vigna radiata*), blackgram (*Vigna mungo*) and

* Corresponding author. Tel.: +91 7103 275536; fax: +91 7103 275529.
E-mail address: blaise_123@rediffmail.com (D. Blaise).

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soybean (*Glycine max*) in between cotton rows have been reported to be highly productive and profitable (Birajdar et al., 1987; Dhoble et al., 1990; Patil et al., 1996). However, farmers continue to practice the traditional cotton + pigeonpea strip intercropping (6–8:2 row ratio of cotton–pigeonpea) which occupies about 1.5 million hectares in central India. Vertisols and associated soils are the major soil group in this region (Murthy et al., 1982) and the area is predominantly rain dependent. Because of better moisture retention, deep Vertisols (>1.2 m) have been found ideal for cotton cultivation (Pundarikakshudu et al., 1992). However for economic reasons, cultivation extends to soils of lesser depths, too (<0.60 m) (Venugopalan and Blaise, 2001).

Poor soil fertility (low organic C, available N, P and Zn content) is a major reason for the low productivity of the rainfed ecosystems, apart from the erratic nature of the monsoon. Therefore, it is essential that farmers at least supply adequate amounts of nutrients through fertilizers (Prasad, 2003). Moreover, to maintain the soil organic carbon (SOC), soils must be supplied with animal manure and crop residues—the primary carbon sources. However, availability of farmyard manure is on a decline (Prasad, 2003) and supplies of crop residues available at harvest are limited (Blaise and Ravindran, 2003). Alternative options to improve SOC are green manuring (Thorup-Kristensen et al., 2003) and conservation tillage (CT) (Blevins and Frye, 1993). Improved cotton lint yields in the US have been reported with green manure legumes as an intercrop and conservation tillage practices (Keisling et al., 1994; Daniel et al., 1999; Varco et al., 1999). Both cotton and pigeonpea have a slow growth habit initially and therefore offer little cover to the soil surface. During heavy intensity thunderstorms (July–September), large amounts of run-off and soil loss occur on the Vertisols because of their low infiltration rates (Burnett, 1989). Providing a cover crop and minimizing tillage operations can improve the soil quality and productivity of these rainfed ecosystems. However, a major reason for the non-adoption of intercropping, in central India, is that it interferes with inter-row cultivation and weed control is difficult. With the availability of selective herbicides on the market, conservation tillage is possible and intercropping may become acceptable to the farmers.

Improvements in textile processing have led to increased emphasis on improved cotton fibre properties (Patil and Singh, 1994). Several studies were extended to include effects of fertilizers (Bauer et al., 1993; Fritschi et al., 2003), tillage (Bauer and Busscher, 1996; Pettigrew and Jones, 2001), irrigation (Constable and Hearn, 1981) and cover crops (Bauer and Busscher, 1996; Daniel et al., 1999) on fibre quality. Singh and Bhan (1993) observed that the fibre quality was improved with green manure applied as mulch. However, information on the combined effects of these management practices on fibre quality is limited for cotton grown under rainfed conditions of central India.

Most of the research has been conducted in research stations and little is known about the performance of conservation tillage practices or green manure on farmers' fields with traditional management. Modern technologies developed at research institutions most often do not suit to the conditions of small-scale farmers. Furthermore, these farmers practice traditional agriculture. On-farm adaptive research is a step in the direction of demonstrating to the farmers the benefits of the improved technology vis-a-vis gaining an insight into their problems and constraints.

The present investigation was conducted on farmers' fields in a participatory mode with the active and collaborative participation of the farmers on medium deep and deep Vertisols. On-farm trials were conducted to determine the impact of the technological interventions (conservation tillage and application of recommended dose of fertilizers (RDF)) compared with the farmers' practice (conventional tillage and application of sub-optimal level of fertilizer). The effects of the management practices on cotton fibre quality were also determined.

2. Materials and methods

On-farm trials were conducted for 2 years (2001 through 2003) in Nagpur district (21°9′N and 17°7′E) under rainfed conditions. The trials were conducted on five farmer fields each on the medium deep soils (MDS) and deep soils (DS). The depth of the MDS and DS ranged from 0.45 to 0.60 and 1.2 to 1.5 m, respectively. The soils at the study sites had an alkaline