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Effect of tillage systems on weed control, yield and fibre quality of upland (*Gossypium hirsutum* L.) and Asiatic tree cotton (*G. arboreum* L.)

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Abstract

Asiatic diploid ($n = 13$) cotton (*Gossypium arboreum* L.) is grown on Vertisols of central India with limited amounts of fertilizers and pesticides under rainfed conditions. In an earlier study it was established that reduced tillage (RT) systems improved productivity of tetraploid ($n = 26$) upland cotton (*G. hirsutum* L.). Such information is currently not available for the Asiatic cotton. Field studies were continued from 2002–2003 through 2004–2005, to determine the effect of tillage systems on weed control, yield and fibre quality. Tillage treatments continued for 6 years before this phase of the study. The experiment was conducted in a split plot design, with three tillage systems as main plots and combination of species (*G. arboreum* and *G. hirsutum*) and N rates (60 and 75 kg N ha^{-1}) as subplots. Conventional tillage (CT) involved mouldboard ploughing + four to five inter-row cultivations and was compared with two levels of RT. RT_1 being pre-emergence herbicide application with two inter-row cultivations by a bullock drawn hoe and RT_2 was only herbicide application with no inter-row cultivation. Weed density (monocot and dicot weeds) was significantly lower on the RT than on the CT plots. Consequently, the RT plots had accumulated less weed dry matter. Seed cotton yield was affected by tillage systems in 1 out of 3 years. In 2002–2003, the yield trend was: $RT_1 > CT > RT_2$. The tillage × species interaction was significant in 2002–2003 and 2004–2005 and combined-across-years. Averaged over years, Asiatic *G. arboreum* produced 8% less seed cotton with treatment RT_2 than with CT. Upland, *G. hirsutum* produced 118–134 kg ha^{-1} additional seed cotton on the RT than with CT. Differences in maturity and rooting habit probably contributed to the two species differing in their tillage requirement. The Asiatic cottons were early maturing and are known to possess a deeper root system than the upland cotton. The tillage × N and species × N interactions were not significant. Average seed cotton yield with the 75 kg N was 15.7% more than the 60 kg N ha^{-1} plots. Among fibre properties, fibre length was significantly better with treatment RT_1 than with the CT in 2 out of 3 years. In summary, seed cotton yield of upland *G. hirsutum* cotton was higher with RT system, whereas converse occurred with *G. arboreum*. There were no adverse effects of RT on fibre quality.

Keywords: Conservation tillage; Fibre length; Fibre strength; Nitrogen; Vertisols; Weed biomass

1. Introduction

Cotton (*Gossypium* spp.) is the major cash crop in central India. It is grown on about 5.4 million hectare as a rainfed crop. Vertisols and associated soils are the predominant soil group in the region. Availability of the high yielding tetraploid ($n = 26$) upland cotton (*Gossypium hirsutum*) varieties, hybrids, and more recently the Bt transgenic cottons on the local market, have resulted in a decline in the area under the traditionally grown Asiatic diploid ($n = 13$) cotton (*G. arboreum*). Notwithstanding these changes, Asiatic diploid cottons are still grown on about 15–20% of the area. Low cost of the

Abbreviations: CT, conventional tillage; RT, reduced tillage; DAP, days after planting

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seed is the main reason why farmers still prefer the Asiatic diploid cottons (Choudhary and Laroia, 2001).

The *G. arboreum* cottons are tall growing and erect and are also referred to as ‘tree cottons’. The leaves are deep lobed okra-type having an upper and lower palisade layer with a reduced spongy parenchyma in between. Whereas, upland cottons have broad leaves with an upper palisade layer and a lower spongy parenchyma (Bhatt and Andal, 1979). Vegetative (monopodial) branches are thin and ascending compared to the horizontal spreading nature in upland *G. hirsutum* (Fryxell, 1984). Fruiting branches are two-jointed with tapering capsules (boll) usually having three locules. The bolls of Asiatic *G. arboreum* are of a vertical habit, facing the ground. The seed cotton is loosely held and is shed after the bolls open fully. Bolls of the upland *G. hirsutum* are erect with four to five locules. With the advent of the high yielding upland cottons, the Asiatic cottons were displaced and their cultivation shifted to the marginal lands. In addition, limited amounts of fertilizers and pesticides are applied to them. Asiatic and upland cotton in the rainfed areas of central India are grown either as a monoculture or intercropped with legumes, mainly pigeonpea (*Cajanus cajan*).

Productivity of cotton in this region is generally low because of the poor soil fertility and rain dependence. Furthermore, conventional tillage (CT) is the common practice followed. Primary tillage involves mouldboard ploughing once every 2–3 years. In the years where no mouldboard ploughing is done, two criss-cross harrowings are done. During the cropping season, frequent inter-row cultivations (four to six times) are made to control weeds. These many tillage operations performed offer not only an effective control of weeds but also accelerate oxidation of organic matter. In these regions heavy rainfall is received in the months of July–August, and Vertisols tend to become sticky and wet. Consequently, timely weed control is not possible. Because of the slow initial growth of cotton, up to 40–60 days after planting is considered the critical period for weeding (Patil et al., 1993). Early season weed control is essential; otherwise significant yield decline occurs. For effective weed management of dryland cotton a combination of herbicides, inter-row cultivation and manual weeding was suggested (Giri and Bhosle, 1997; Walker et al., 2005). With the integration of herbicides, the number of tillage operations can be reduced and conservation tillage systems such as reduced tillage (RT) system can be adopted (Torbert et al., 2002). However, weed control may be a problem in the RT systems. Adoption of conservation tillage systems lead to a greater percentage of freshly shed weed seeds remaining on the soil surface and may result in a different emergence pattern for seedlings (Froud-Williams et al., 1984; Taylor et al., 2005). In an earlier study over 5 years (1996–1997 through 2000–2001), Blaise and Ravindran (2003) observed greater density of dicot weeds in the RT compared to the CT systems. Taylor et al. (2005) reported cultivation stimulated seedling emergence of the monocot weed awned canary grass (*Phalaris paradoxa*) compared with plots that received no cultivation. Furthermore, seeds persisted least when the soil was tilled. Information on the effects of tillage on weed density and biomass accumulated under tropical rainfed conditions is limited.

On Vertisols, the RT systems have been reported to yield equal to or better than the CT systems (Blaise et al., 2005; Constable et al., 1992; Hulugalle et al., 2004). In a study over 5 years, yield of the *G. hirsutum* was significantly greater with the RT compared to the CT systems in the first 3 years; while in the next 2 years, yield of the RT plots were equal to the CT (Blaise and Ravindran, 2003). At present, we do not have information on the effect of tillage systems on *G. arboreum* vis-à-vis *G. hirsutum*.

Nitrogen (N) is generally considered to be a major limiting factor (low soil N status) and is usually applied in sufficient amounts to meet the crop needs. Mineralization–immobilization processes in soil affect the availability of N to the crop. High C/N ratios and lignin contents cause slow mineralization of cotton crop residues (Hulugalle and Weaver, 2005). Rochester et al. (1997) on irrigated Vertisols of Australia observed lower soil mineral N content at planting with stubble retained compared to the stubble removed plots. Recycling of poor-quality cotton crop residues and reduced mineralization because of RT may lower N available to the cotton crop. Therefore, in the already N-deficient soils, immobilization processes may further aggravate N deficiency and potentially reduce yields in the RT systems. On the silty loams of Louisiana, USA, additional N was needed with the RT systems compared to the CT systems (Boquet et al., 2004). Whereas on the irrigated Vertisols of Australia, Constable et al. (1992) observed that the optimum N dose was lower for the RT than the CT. Information on whether N requirement is modified by the tillage systems for rainfed cotton in central India is unavailable.

Development of high-speed spinning technology, has led to an increasing demand for cotton with high fibre strength. The industry is concerned that the production technologies do not adversely affect fibre quality. Reported effects of tillage have been inconsistent. Some