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ScienceDirect

International Soil and Water Conservation Research 3 (2015) 112–118

www.elsevier.com/locate/iswcr

Conservation agriculture impact for soil conservation in maize–wheat cropping system in the Indian sub-Himalayas

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Received 19 February 2015; received in revised form 27 April 2015; accepted 2 May 2015

Available online 14 May 2015

Abstract

Conservation agriculture (CA) is considered as a suitable technique for soil erosion control, productivity enhancement, and improved economic benefits. To investigate these issues, an experiment was conducted under rainfed conditions using grass vegetation strip (VS) with minimum tillage, organic amendments and weed mulch during June 2007–October 2011 at Dehradun, Uttarakhand in the Indian Himalayan region. Results showed that the mean wheat equivalent yield was ~47% higher in the plots under with CA compared with conventional agriculture in a maize–wheat crop rotation. Mean runoff coefficients and soil loss with CA plots were ~45% less and ~54% less than conventional agriculture plots. On average, after the harvest of maize, soil moisture conservation up to 90 cm soil depth for wheat crop was 108% higher under CA than conventional agriculture plots. The net return from the plots with CA was 85% higher, and when expressed net return per tonne of soil loss, it was four and half times higher than conventional practice. Results demonstrate that the suitable CA practice (a grass strip of Palmarosa with applied organic amendments (farmyard manure, vermicompost and poultry manure) along with weed mulching under conservation tillage) enhances system productivity, reduces runoff, soil loss and conserve soil moisture.

Keywords: Vegetation strips; Organic amendments; Weed mulch; Minimum tillage; Soil conservation

1. Introduction

Conservation agriculture (CA) is a concept for resource-saving agricultural crop production that strives to achieve acceptable profits together with sustained production, while concurrently conserving the environment. Conservation agriculture is characterized by three interlinked principles, namely continuous minimum mechanical soil disturbance, permanent organic soil cover and diversification of crop species grown in sequence or associations (FAO, 2010). Productivity losses of 13.4 m tonnes of food grain, worth nearly 2 billion US dollars due to soil erosion have been reported in rainfed areas of India (Sharda, Dogra, & Prakash, 2011). Maize crop productivity losses of 8.0–10.30 kg ha^{-1} have been reported in the Indian Sub-Himalayas (Ghosh, Dogra, Sharma, & Dadhwal, 2012). Vegetation strips are effective for control of soil erosion. For example, in the Shivalik hills, in the east-west mountain chain of the Himalayas, silt is transported by

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Peer review under responsibility of IRTCES and CWPP.

http://dx.doi.org/10.1016/j.iswcr.2015.05.001

runoff and deposited near natural vegetation strips (VS). This sediment deposition and later tillage leads to the formation of benches, ranging from 15–40 m in length and 3–5 m in width. Other advantages of VS are reduced sheet, rill and ephemeral gully erosion, improved water management, stabilized slopes and sediment entrapment. This also improves the potential for additional fodder and green manure.

Panicum maximum (Guinea grass), *Vetiveriazizanioides* (Khuskhus) and *Eulaliopsisbinata* (Bhabar) have been found suitable for vegetation strips in the Shivalik hills (Sur & Sandhu, 1994; Lal, Sharma, &, Mishra, 1996). These three species are used as barriers for effective erosion and sediment control because they form an erect, stiff and uniformly dense hedge so as to offer high resistance to overland water flow. Also, the dense rooting habits bind soil to prevent rilling and scouring near the barrier, and they are tolerant to moisture and nutrient stress, and quickly re-establish top growth after rain (Dewald et al., 1996; Grimshaw & Helfer, 1995). These vegetation strips result in minimal loss of crop yield, the species do not proliferate as weeds, they do not compete for moisture, nutrients and light, they are not hosts for pest and diseases, and they often provide some additional economic benefits to farmers (Bhardwasj, 1994; Bharad & Bhatkal, 1991). For example, Palmarosa (*Cymbopogon martini*) is a grass species that that yields oil of high economic value (0.04–0.05% oil), with potential for reducing slope erosion and capturing sediment. However, the efficiency of grass species such as *Cymbopogon martini* (Palmarosa), for reducing runoff and soil loss has not been tested.

Minimum and zero tillage are recommended for soils of the Indian Himalayan region due to reduced cost of cultivation, more retention of soil water, and physical protection of soil organic carbon (SOC) (Bhattacharyya, Ved-Prakash, Kundu, Srivastva, & Gupta, 2009, and Bhattacharyya, Tuti, Kundu, Bisht, and Bhatt, 2012a, 2012b). This combination of minimum till (MT), coupled with various organic amendments, farmyard manure, vermicompost, poultry manure, weed mulching and VS of grasses, prompted the testing of a novel soil management system with the potential for multiple economic and environmental benefits (Bhattacharyya, Fullen, Davies, & Booth, 2010). Our objective was to evaluate the effectiveness of CA (MT, VS, organic amendment and weed mulching) compared with conventional agriculture on runoff, soil loss, moisture conservation and yield for a maize–wheat cropping sequence under rainfed conditions for Entisols in the northwestern hills. The hypothesis was that VS with weed mulch and manure application under MT will reduce runoff and soil loss, conserve soil moisture, and enhance crop yields on gently sloping lands.

2. Materials and methods

2.1. Study area

A fixed plot field study was conducted from June 2007 to October 2011 at the Research Farm of the ICAR—Central Soil and Water Conservation Research and Training Institute, Selakui, Dehradun, India (30°20'40'N latitude, 77°52'12'E longitude) at 516.5 m above mean sea level on a 2% slope. The climate of the region is sub-temperate; with mean annual rainfall (1956–2011) of 1625 mm, 80% occurring during the rainy season (June–September). Climatic characteristics of the experimental site are given in Fig. 1.

2.2. Lay out and establishments of vegetation trips and treatments

The experiment was laid out on a 2% slope, with vegetation grass strips of Palmarosa (Fig. 2) in maize–wheat crop rotations.

The experiment was laid out in a randomized block design with three replications, each measuring 100 × 20 m (2000 m^2) with the following three treatments:

(1) Conventional agriculture
100:60:40 N: P_2O_5:K_2O + conventional tillage (CT) + chemical weeding
(2) Conservation agriculture
Farmyard manure (FYM5 t/ha) + vermicompost(1.0 t/ha) + poultry manure (2.5 t/ha) + minimum tillage (MT) + 3 weed mulch (20, 40 and 60 days after sowing) + Palmarosa (*Cymbopogon martini*) as vegetation strips.