Rainwater harvesting practices and resource conservation in agroforestry system in red soils of Bundelkhand

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ABSTRACT : A field study was conducted to evolve a suitable *in-situ* rainwater harvesting practice for resource conservation and augmenting growth of *aonla* in agroforestry system on sloping lands in red soils of Bundelkhand region. The treatments (farmer's practice of *aonla* planting with 0.027 m^3 pit (control), pit filled up to 0.75 m with 1 m^3 pit, crescent shaped micro-catchment with 1 m^3 pit and V-shaped micro-catchment with 1 m^3 pit) were laid out in RBD in four replications in runoff plots of 21 m × 14 m at 2% slope. In inter-spaces, black gram - Indian mustard crop sequence was practiced. Results showed that highest runoff (38.9%), soil loss (3.79 tha^{-1}) and nutrient loss (Organic carbon, N, P and K), lower grain yield in black gram (221 kg ha^{-1}) and Indian mustard (1082 kg ha^{-1}) and low growth of *aonla* (height 1.83 m and girth 1.3 cm) were recorded under farmer's practice. However, lowest runoff (23.3%), soil loss (1.97 tha^{-1}) and nutrient loss, higher grain yield of black gram (334 kg ha^{-1}) and Indian mustard (1580 kg ha^{-1}) and higher growth of *aonla* (height 2.21 m and girth 1.5 cm) were obtained under V-shaped micro-catchment. Based on the present findings, V-shaped micro-catchment could be a suitable *in-situ* rainwater conservation practice for resource conservation and enhancing yield of intercrops and growth of *aonla* under *aonla*-based agroforestry system on sloping lands in red soils of Bundelkhand region.

Key words: Black gram, *Emblica officinalis* rainwater conservation, Indian mustard and red soils.

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1. INTRODUCTION

Bundelkhand region (7.04 M ha) of central India has undulating terrain, scarce vegetation cover, hostile climate and unfavorable edaphic conditions. Nearly 70% of total area of the region has been affected by varying degree of erosion hazards (Tiwari and Narayan, 2010). The red soil which comprise 50% of geographical area of the region are mostly found on higher elevation (uplands) and are adversely affected with the problem of soil erosion, low productivity and even crop failure due to frequent drought and long dry spells during rainy season. Though the rainfall received is scanty and erratic but high intensity showers received during the monsoon season result sizable runoff (runoff ranged between 50 to 60% of rainfall and soil loss between 8 to 9 t ha^{-1} at 2% slope on cultivated fallow land in red soils) and soil loss (Lakaria *et al*., 2010). About 53% area comes under rainfed agriculture and crop intensity is about 111%, consequently there exists a large proportion of cultivable waste and fallow land (Singh and Singh, 2010; Tiwari and Narayan, 2010**).** *Aonla* (*Emblica officinalis* Gaertn.) on account of its drought resistance and wider adaptability appears to be a better choice for the region. It is an important minor fruit which is quite hardy, prolific bearer, highly nutritive with medicinal values and a remunerative fruit crop. During recent years, this crop is gaining ground on account of its drought hardiness, non-perishable nature of the fruit, readily available market and high remuneration. Due to its increasing demand in *Ayurvedic* medicines, an expansion of the area under its cultivation has become necessary to meet the demands of pharmaceutical companies. In view of the diverse medicinal use of *aonla* and its increasing commercial significance in the country, there is an urgent need to give immediate attention towards problems and prospects in its cultivation. However, the greatest bottleneck in its expansion is the poor survivability and growth of plants. The survival of horticultural plantation under traditional planting practices is very low on account of low *in-situ* moisture conservation in red soils. Harvesting of rainwater and *in-situ* moisture conservation is the only viable alternative to artificial irrigation. This minor fruit has bright prospects for extending its cultivation in red soils under suitable agroforestry system. Black gram [*Vigna mungo* (L.) Hepper] and Indian mustard [*Brassica juncea* (L.) czernj & Cossson] could be grown in inter-spaces of *aonla* for getting regular income up to eight years when the root system and growth of *aonla* are not much developed. In view of

above, a field study was undertaken to evolve a suitable *in-situ* rainwater harvesting practice for resource conservation, augmenting growth of *aonla* and obtaining sustainable production under *aonla*-based agroforestry system in red soils of Bundelkhand.

2. MATERIALS AND METHODS

A field experiment was conducted during 2011-12 to 2012-13 at *ICAR-Indian Institute of Soil & Water Conservation,* Research Centre, Datia (25^0 40' N, 78^0 28' E and 342.42 m above MSL), Madhya Pradesh. The climate of Datia is semi-arid with an average annual rainfall of 865 mm. Nearly 90% of the total precipitation is received in the monsoon extending from middle of June to September. The July and August months experience the heaviest rainfall, receiving on an average more than 250 to 300 mm during most of the years. Long dry spells during monsoon are also common features. The soil of experimental site comes under red soil (alfisol) which have developed over granite and gneiss type parent material. These are course gravelly textured, shallow, neutral to slightly alkaline in reaction, having low organic carbon and available nutrients. The experimental soil was sandy loam in texture with pH-7.3, organic carbon-0.31%, EC-0.12 dS m^{-1}, available N, P & K-396.7, 20.5 & 230.7 kg ha^{-1}, respectively. The experiment consisted of four treatments *viz*. T_1-farmer's practice of *aonla* planting with 0.027 m^3 pit (control); T_2-pit filled up to 0.75 m with 1 m^3 pit; T_3-crescent shaped micro-catchment with 1 m^3 pit and T_4-V-shaped micro-catchment with 1 m^3 pit. These treatments were evaluated under randomized block design with four replications in runoff plots of 21 m × 14 m at 2% slope. Six *aonla* plants (var. Kanchan) per plot were planted at a spacing of 7 m × 7 m. In inter-spaces, black gram (Var. Azad 2) was grown on contours as rainfed crop during rainy season and Indian mustard (Var. Pusa Vasundhra) in winter season under limited irrigation adopting recommended package of practices. Black gram was sown on 8th July and harvested on 20th September, 2011, however, during 2012, it was sown on 12th July and harvested on 29th September. Indian mustard was sown on 9th November, 2011 and harvested on 22nd March, 2012, however, during 2012, it was sown on 21st October, 2012 and harvested on 19th March, 2013. Black gram received a rainfall of 435.2 and 808.6 mm during 2011 and 2012, respectively, during crop growth period. Indian mustard received 11.0 and 89.0 mm rainfall during crop growth period during 2011-12 and 2012-13, respectively. Each runoff plot was equipped with multi-slot device. Daily runoff was measured and runoff samples were also collected for estimation of sediment. Runoff was measured by diverting 1/11th part of the runoff to the collection tanks with the help of eleven slot multi-slot device. Event wise runoff was measured and summed to calculate the total seasonal runoff (Singh *et al*., 1977). The number of runoff causing storms studied between sowing to harvest of crops was 14 and 12 during 2011-12 to 2012-13, respectively. Observations on growth, yield and yield attributes of crops were recorded at harvest. Soil analysis was done using standard chemical procedures. The tree height was measured with the help of a long pole marked in meters. Tree collar girth was recorded at the time of planting and after one and two years of plantation at a height of 15 cm above the ground level. The data was analyzed statistically as per the standard procedure given by Gomez and Gomez (1984) for interpretation of results and drawing conclusions.

3. RESULTS AND DISCUSSION

Runoff and soil loss

Results of two years showed that highest runoff (38.9% of rainfall) was recorded under farmer's practice which was reduced considerably under different *in-situ* rainwater harvesting practice to the extent of 30.9, 27.7 and 23.3% under pit filled upto 0.75 m, crescent and V-shaped micro-catchment, respectively (Figure 1). It indicated that different *in-situ* rainwater harvesting practices *viz*. pit filled up to 0.75 m, crescent and V- shape micro-catchment reduced runoff by 20.8, 28.8 and 40.1% over farmer's practice. Similarly, highest soil loss (3.79 t ha^{-1}) was obtained under farmer's practice and it was decreased to 2.86, 2.50 and 1.97 t ha^{-1} under pit filled up to 0.75 m, crescent and V-shaped micro-catchment over farmer's practice. In terms of per cent reduction, soil loss was decreased by 24.5, 34.0 and 48.0% under pit filled up to 0.75 m, crescent and V-shaped micro-catchment, respectively, over farmer's practice.

Nutrient loss

Nutrient loss in terms of organic carbon, N, P & K also decreased under different *in-situ* rainwater harvesting practice over farmer's practice (Figure 2). The highest organic carbon loss (16.9 kg ha^{-1}) in runoff was recorded under farmer's practice which decreased noticeably under different *in-situ* rainwater harvesting practice to the extent of 24.9, 34.3 and 46.2% under pit

filled up to 0.75 m, crescent and V-shaped micro-catchment, respectively over farmer's practice. Likewise, highest loss of N, P & K (6.2, 2.7 and 7.7 kg ha^{-1}, respectively) in runoff was recorded under farmer's practice and reduced considerably under different *in-situ* rainwater harvesting practices. Among different treatments, lowest N, P & K loss (4.1, 1.6 & 4.6 kg ha^{-1}, respectively) was observed under V-shaped micro-catchment.

Yield of intercrops

In-situ rainwater harvesting practices were not only helpful in reducing runoff, soil loss and nutrients loss but also in increasing yield of intercrops (Figure 3). The lowest yields of black gram (221 kg ha^{-1}) and Indian mustard (1082 kg ha^{-1}) were recorded under farmer's practice, whereas the highest yields of black gram (334 kg ha^{-1}) and Indian mustard (1580 kg ha^{-1}) were recorded under V-shaped micro-catchment. Intermediate yields of black gram and Indian mustard were obtained under rest of *in-situ* rainwater harvesting treatments.

Growth of *aonla*

Growth of *aonla* in terms of plant height and plant girth increased under different *in-situ* rainwater harvesting practices (Figure 4). The lowest plant height (1.26 cm) was recorded under farmer's practice and it increased by 6, 16 and 21% under pit filled up to 0.75 m, crescent and V-shaped micro-catchment, respectively over farmer's practice. Similarly, the lowest plant girth (1.83 cm) was recorded under control and it increased by 2, 4 and 19% under pit filled up to 0.75 m, crescent and V-shaped micro-catchment, respectively over farmer's practice.

Various *in-situ* rainwater harvesting practices helped in conserving higher rainwater, reduced soil and nutrients loss that in turn resulted in higher growth of *aonla* plants besides higher yield of intercrops over control. The findings of present study are in accordance with earlier findings of Kumar *et al.* (2014). Higher growth of *aonla* plants under different *in-situ* moisture conservation treatments can be attributed to the better moisture conservation for longer period of growth, which improved the nutrient uptake by the plant. These results conform the findings of several workers, who also reported enhanced growth of fruit plants due to better conservation of soil moisture (Oweis and Hachum, 2003; Badhe and Magar, 2004; Oweis and Hachum, 2006; Lal *et al.*, 2011).

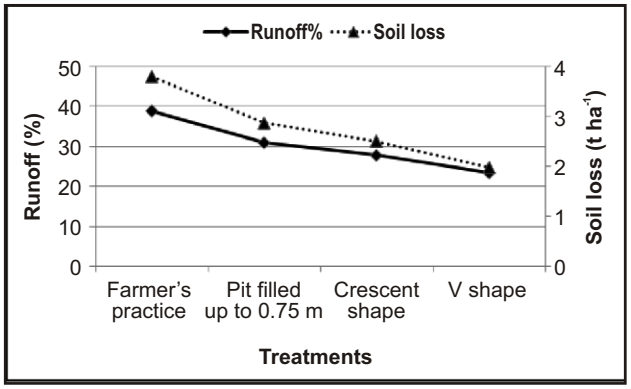

Fig. 1. Runoff and soil loss as influenced by different treatments

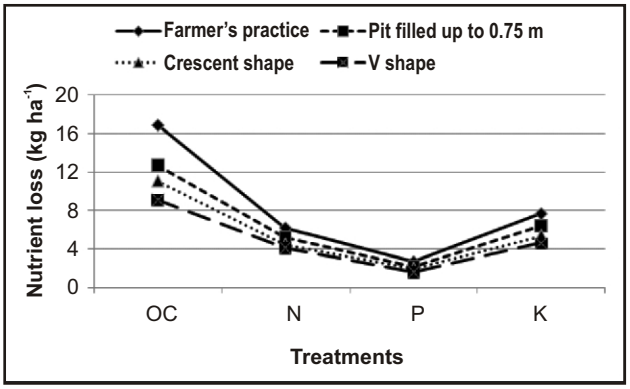

Fig. 2. Nutrients loss as influenced by different treatments

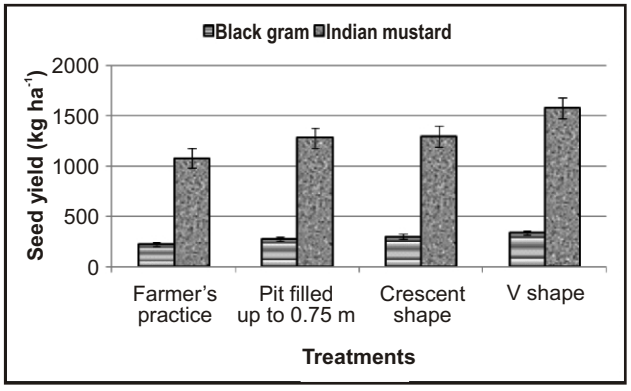

Fig. 3. Seed yield of crops as influenced by different treatments

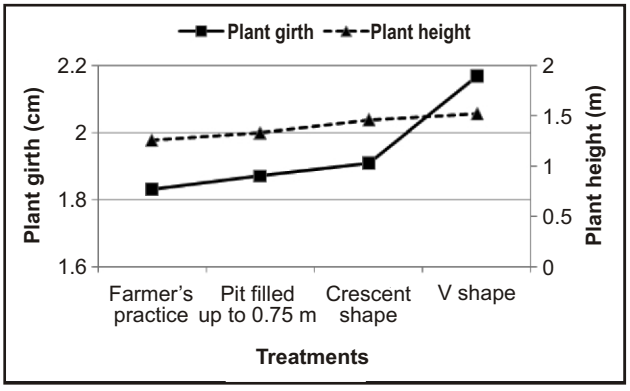

Fig. 4. Growth of aonla under various treatments

4. CONCLUSION

Based on the findings of present study, it can conclusively said that V-shaped micro-catchment could be a suitable *in-situ* rainwater conservation practice for resource conservation and enhancing yield of intercrops and growth of *aonla* under *aonla*-based agroforestry system on sloping lands in red soils of Bundelkhand region.

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