

Sustainable production with *in-situ* moisture conservation under maize based cropping system in North East Hill region

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ABSTRACT

Identification of region specific sustainable cropping system is mostly needed for food and environmental security. In this direction an experiment was conducted at ICAR research complex for NEH region with five maize based cropping system with four soil moisture conservation measures. The result indicated that highest (9.50 t ha⁻¹) maize equivalent yield was obtained from Maize-French bean system ; retention of maize stalk much was also found to be useful.

Keywords : Cropping system, mulch, soil moisture, sustainability

Maize is cultivated in sequence with different crops under various agro-ecologies of the country. It has a wide adaptability and compatibility under diverse soil and climatic conditions. In North-Eastern Himalayan region, maize is the second most important food grain after rice. Maize is mostly grown under *rainfed* condition in upland as main crop. After harvesting of *kharif* crops, the cultivation of *rabi* crops limits due to lack of sufficient soil moisture availability. This region generally receives enough amount of rainfall in monsoon, however, resulted in frequent occurrence of moisture stress in dry season due to erratic distribution of rainfall. Therefore, conservation of available soil moisture is essential to cultivate *rabi* season crop. Retention of crop residue like maize stalk on the soil surface in combination with zero tillage initiates process that lead to improve soil quality and overall enhancement of resource use efficiency. Crop residue on soil surface form a barrier to water loss by evaporation and increase the amount of moisture store in the plant root zone and available to the crop.

Zero tillage offers the benefit of retaining surface residue and reduces soil water losses (Ghosh *et al.*, 2010). Thus, zero tillage is a viable option for conserving moisture besides saving energy and promoting soil health. In addition to zero tillage, mulching could conserve residual soil moisture to be utilized by a winter crop (Sarkar *et al.*, 2007). Mulching is useful practice in *rainfed* areas for controlling erosion, weed growth and conserving moisture as well as nutrient in the soil profile (Sharma *et al.*, 2010). Therefore, the experiment has been formulated with different mulching materials as one of the suitable moisture conservation technique for cultivating a *rabi* or pre-*rabi* crops after maize under zero tillage.

MATERIALS AND METHODS

The experiment was conducted at ICAR research complex for NEH Region with five cropping system viz, Maize-fallow (CS₁), Maize-toria (CS₂), Maize-french bean (Bush type-BT) (CS₃), Maize-French bean (Pole type-PT) (CS₄), Maize-blackgram (CS₅) and four soil moisture conservation (SMC) measures as sub plot treatments viz, no mulch (M₀), *in-situ* maize stalk mulch (MSM) (M₁), M₁+*Ambrosia* sp. 10 t ha⁻¹ (M₂), M₁+*Tephrossia* sp. 10 t ha⁻¹ (M₃) in split plot design. In *kharif*, maize was sown on 30th April, and harvested on 9th August. After maize in *rabi*, French bean (bush and pole type) and blackgram were shown on 24th August, and toria on 21st September and harvested on 2nd November, 16th November, 1st December and 16th December, respectively. After the harvest of maize, furrows were opened in between two maize rows using a manual furrow and recommended doses of fertilizers and seeds were placed in the furrows and covered with soil and the mulch materials were adjusted back between the rows to cover the soil surface on the same day immediately after sowing. After the germination of seeds, the maize stovers were cut and spread all over the field just above the mulches to cover the soil surface. This way, there were two layers of mulch *i.e.* MSM and *Ambrosia/Tephrossia* mulch to cover the soil surface.

RESULTS AND DISCUSSION

The result from the experiment revealed that highest maize equivalent yield (MEY) was obtained from Maize-French bean (PT) system under M₁+ *Tephrossia* mulch (9.50 t ha⁻¹) followed by M₁+ *Ambrosia* mulch (8.83 t/ha). The MEY of maize-French bean (PT) system under MSM+ *Tephrossia* mulch was 120% higher than maize-toria cropping system under no mulch. The higher MEY of maize-French bean (PT) under MSM+ *Tephrossia*

Table 1: Interaction effect of maize equivalent yield as influence by cropping systems and soil moisture conservation measures (t ha⁻¹).

| Treatments | Maize - fallow | Maize - toria | Maize – F.bean (BT) | Maize – F.bean (PT) | Maize - blackgram | Mean |
|---|----------------|---------------|---------------------|---------------------|-------------------|------------|
| No mulch | 3.12 | 4.31 | 6.42 | 7.22 | 5.58 | 4.7 |
| <i>In-situ</i> MSM | 3.12 | 4.53 | 6.59 | 8.01 | 6.25 | 5.1 |
| MSM+ <i>Ambrosia</i> | 3.12 | 4.56 | 7.14 | 8.83 | 6.93 | 5.5 |
| MSM+ <i>Tephrossia</i> | 3.12 | 4.75 | 7.94 | 9.50 | 7.46 | 5.9 |
| Mean | 3.12 | 4.54 | 7.02 | 8.39 | 6.55 | |
| | | | | SEm(±) | LSD(0.05) | |
| Cropping systems | | | | 0.10 | 0.33 | |
| SMC measures | | | | 0.07 | 0.20 | |
| For SMC at same or different level of CS | | | | 0.15 | 0.48 | |
| For CS at different level of SMC | | | | 0.14 | 0.40 | |

Table 2: Interaction effect of cropping systems and soil moisture conservation measures on system productivity (kg ha⁻¹ day⁻¹) of *rabi* crops

| Treatment | Maize - fallow | Maize – toria | Maize – F.bean (BT) | Maize – F.bean (PT) | Maize – black gram | Mean |
|---|----------------|---------------|---------------------|---------------------|--------------------|-------------|
| No mulch | 31.8 | 23.2 | 37.5 | 37.8 | 27.9 | 31.6 |
| <i>In-situ</i> MSM | 31.8 | 24.4 | 38.6 | 41.9 | 31.3 | 33.6 |
| MSM+ <i>Ambrosia</i> | 31.8 | 24.5 | 41.8 | 46.2 | 34.6 | 35.8 |
| MSM+ <i>Tephrossia</i> | 31.8 | 25.5 | 46.4 | 49.8 | 37.3 | 38.2 |
| Mean | 31.8 | 24.4 | 41.1 | 43.9 | 32.8 | |
| | | | | SEm(±) | LSD(0.05) | |
| Cropping systems | | | | 0.47 | 1.54 | |
| SMC measures | | | | 0.29 | 0.94 | |
| For SMC at same or different level of CS | | | | 0.65 | 1.9 | |
| For CS at different of SMC | | | | 0.74 | 2.2 | |

Table 3: Effect of cropping system and soil moisture conservation on economics (Rs. ha⁻¹)

| Treatments | Cost of cultivation | Gross return | Net return | B:C ratio |
|--|---------------------|--------------|------------|-----------|
| Cropping systems | | | | |
| Maize – Fallow | 30567 | 63440 | 31506 | 1.99 |
| Maize –Toria | 50848 | 87312 | 36464 | 1.72 |
| Maize - French bean (BT) | 55957 | 115976 | 60019 | 2.07 |
| Maize - French bean (PT) | 60091 | 155376 | 95286 | 2.58 |
| Maize –Blackgram | 54265 | 116561 | 62296 | 2.15 |
| Soil moisture conservation measures | | | | |
| No mulch | 49887 | 98206 | 48318 | 1.97 |
| <i>In-situ</i> MSM | 50269 | 104322 | 54053 | 2.08 |
| MSM+ <i>Ambrosia</i> | 51159 | 110892 | 59733 | 2.17 |
| MSM+ <i>Tephrossia</i> | 51159 | 117512 | 66352 | 2.30 |

MSM - Maize stalk mulch, *BT* - Bush type, *PT* - Pole type.

mulch might be due to higher yield of French bean seed and subsequently higher price of bush type French bean seed. Mulching practices helps in the conservation of soil moisture in the root zone thus facilitates root proliferation and availability of nutrients to crop roots. As a result, grain yield under mulch plot are higher than that of no mulching (Das *et al.*, 2014).

Cropping systems and soil moisture conservation measures on system productivity was interacted significantly. The higher system productivity was in maize-french bean (PT) under MSM+ *Tephrossia* mulch (49.8 kg ha⁻¹ day⁻¹). The higher system productivity in maize-french bean (PT) system was due to short duration and higher productivity of french bean (PT) as compared to other *rabi* crops. The higher system productivity with the inclusion of shorter duration crop in maize-based cropping systems was reported by Walia *et al.* (2011).

Economic analysis was carried out for various maize-based cropping systems. The average cost involved in production of maize was Rs. 30567 ha⁻¹. The highest cost of cultivation was recorded in maize-french bean (PT) cropping system as compared to other cropping systems. The cost of cultivation in maize-french bean (PT) system was 97 Per cent higher than maize-fallow cropping system. This might be due to higher involvement of labour for staking purpose in pole type French bean. Choudhary and Kumar (2013) found that there was higher cost of cultivation in maize-french bean system (PT) than maize-fallow system. In case of soil moisture conservation measures, the cost of cultivation under MSM+ *Tephrossia* mulch and MSM+ *Ambrosia* mulch were similar as the treatment cost of mulching involved was similar under these two treatments.

Significant effect of cropping system and SMC measures was recorded on gross return, net return and benefit cost ratio (B:C ratio). Among the cropping system, maximum gross return (Rs.155376 ha⁻¹), net return (Rs.95286 ha⁻¹) and B:C ratio (2.58) were in maize-French bean (PT) cropping system. The gross return, net return and B:C ratio under maize-french bean (BT) and maize-blackgram system were *at par* with each other. The maize-french bean (PT) system recorded gross return of Rs.155376 ha⁻¹ and proved to be most remunerative system as compared to other cropping systems. The higher gross return in this system might be due to higher market price of pole type french bean seed and high value of produced. Similar finding was recorded by Walia *et al.* (2011). Higher gross return and net return in maize-french bean system was also reported by Choudhary and Kumar (2013). Prakash *et al.* (1993) attributed higher monetary return due to higher market price of seed. Lowest B:C ratio was recorded in maize-

toria system (1.72). This might be due to lower yield and lower market price of toria.

Significant influence of SMC measures were recorded on gross return, net return and B:C ratio. Highest gross return, net return and B:C ratio was found under MSM+ *Tephrossia* mulch followed by MSM+ *Ambrosia* mulch. This might be due to higher productivity under MSM+ *Tephrossia* mulch. Das *et al.* (2003) reported that addition of crop residues was found to increase net return and B:C ratio.

Maize-French bean (PT) cropping system recorded highest maize equivalent yield, system productivity and net return. Thus, it can be concluded that maize-French bean cropping system under retention of maize stalk mulch along with *Tephrossia* or *Ambrosia* mulch is a recommendable option for sustainable production and higher net return for North East hill region.

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