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# Weed management in maize under rainfed organic farming system

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## ABSTRACT

Field experiment was conducted under organic farming for three consecutive years during 2008-09 to 2010-11 to study the effect of different non-chemical weed management practices on productivity and weed infestation in maize in mid altitude (950 m MSL) of Meghalaya, India. Total eight treatment in three replication were evaluated on maize. Grain weight/cob of maize was maximum under mulching with fresh *Eupatorium* sp. biomass after earthing up at 30 days after sowing (DAS). The highest maize yield was recorded under mulching with fresh *Eupatorium* 10 t/ha, but it was statistically at par with two hand weeding (HW) at 20 and 40 DAS, weed free check and soybean green manure incorporation in situ + one HW. Two HW, soybean green manure incorporation + one HW and mechanical weeding (20 DAS) + one HW (after earthing up) were found to be effective in weed reduction in maize. Weed control efficiency was recorded maximum under two HW which was at par with mechanical weeding (20 DAS) + one HW. Available N, P, K and soil organic carbon concentration after 3-croppoing cycles were maximum under mulching with fresh *Eupatorium* 10 t/ha treatment followed by soybean green manuring + one HW (45 DAS) than those under other weed management practices. Thus, mulching with fresh *Eupatorium* (after earthing up) and soybean green manuring + one HW were the recommendable options for sustainable organic maize production under high rainfall hill ecosystem of North-East India.

**Key words:** Hill ecosystem, Mulching, Maize, Organic farming, Rainfed, Weeds control efficiency

Maize (*Zea mays* L.) is the second most important crop after rice in North East region (NER) of India and maize is predominant crop in the upland ecosystem of the region (Das *et al.* 2010). Maize is among the high yielding crops and has great economic importance to the hill and mountain ecosystem as food, feed and fodder. Maize is cultivated as rainfed crop in subtropical mid hills ecosystem. Although yield potential of maize varieties is high but it has so far could not been realized upto its potential due to several constraints.

Weed infestation is a major factor in pulling down the yield of crop. Rainy season maize suffers from severe weed competition. Weed infestation causes yield losses varying from 28-100% depending upon the intensity, nature and duration. The losses caused by weeds exceed the losses from any other category of agricultural pests (Sharma *et al.* 2010). Weeds compete with the crop plants for sunlight, moisture and nutrients (Kumar *et al.* 2013 and Saeed *et al.* 2013) and deprive the crops from vital resources (Lehoczkyand Reisinger 2003). As a wide spaced crop, maize suffers from heavy weed infestation during *Kharif* season. The climate (high rainfall, congenial temperature and humidity) of the NER is favourable for luxuriant weed growth especially during rainy season. Maize is sensitive to weeds especially in early stages of development and thus, weed infestation during germination to 45 days after sowing (DAS) causes maximum reduction in yield. Weeds not only decrease crop yield but also harbour insect-pest and diseases and in some cases, they serve as an alternate host for these pest. In organic farming, the weed problems are further high mainly due to application of organic manure, mulches, biomass which exacerbates the weed multiplication and growth.

Thus, it was necessary to devise organic system of weed control comprising of cultural, mechanical, biological and physical practices to manage weeds without synthetic herbicides and chemicals which promote weed suppression, rather than weed elimination. Hand Weeding (HW) is the most popular method of removing weeds in NER of India. However, HW is tedious, time consuming and labour demanding. Mulching is an effective method of weed control without using chemicals. The use of biomass from facultative weed such as *Eupatorium* as mulch has been reported a good source of organic matter

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and weed suppressor for several upland crops in Himachal Pradesh (Acharya *et al.* 1998). Application of *Eupatorium* mulch along with HW gave significantly higher yield of upland rice compared to control in Nepal (Gaire *et al.* 2013). A promising way to use allelopathy in weed control is using extracts of alleloopathic plants as natural herbicides (Ankita and Mittal 2012). Keeping in view the importance of weed management in organic crop production, the present investigation was carried out to study the effect of various non-chemical weed management practices on weed population, dry weight, yield of maize and soil properties at mid-altitude of eastern Himalayas.

## MATERIALS AND METHODS

Field experiments were carried out for consecutive three years in the mid hills of Meghalaya under rain-fed terrace condition during rainy seasons (*Kharif)* of the year 2008-09 to 2010-11. The soil of the experimental site was sandy clay loam in texture, acidic in reaction (pH 4.9) with 1.80% soil organic carbon (SOC). The soil was low in available N (180.0 kg N/ha) and P (9.5 kg P/ha) and medium in available K (175.1 kg K/ha).

Field experiment was laid out in randomized block design with eight treatment in three replications. Treatments were, mechanical weeding at 20 DAS + one HW at 45 DAS, mulching with fresh biomass of *Eupatorium adhenophorum* 10 t/ha after earthing up at 30 DAS, aqueous leaf extract (10%) spray of *Lantana* and pine (*Pinus kesiya*), two HW - 1$^{st}$ before earthing up (20 DAS) and 2$^{nd}$ after earthing up (45 DAS), aqueous leaf extract spray of *Lantana* and pine + one HW after earthing-up (35 DAS), soybean green manure incorporation in situ during earthing up + one HW (45 DAS), weed free check (HW at 10, 25, 40, 55 and 70 DAS) and weedy check.

Mechanical weeding was performed with the help of wheel hoe and leaf extract was sprayed directly in the inter row spaces of maize. One row of soybean was grown simultaneously in between two rows of maize as green manure crop and incorporated into the soil at 30 days after germination during earthing up. FYM was applied on N equivalent basis and P requirement was compensated through rock phosphate. Neem cake was applied 150 kg/ha as general dose in all the treatments to control soil borne pathogens. A uniform dose of organic manure to supply recommended dose of N and P in maize (60:26.2 kg/ha) was used. Data on weeds (density, dry weight) were recorded at 30 and 60 DAS from two randomly selected quadrants (0.5 x 0.5 m) from each treatment during maize growing period. Weeds were uprooted gently, roots washed and their counts were recorded. Weeds were oven dried at 70$^{0}$C for 48 hours after sun drying for recording dry weight. Weed control efficiency (WCE) was calculated by using following formulae given by Mani *et al.* (1973). Yield attributes and yield of maize were recorded from each treatment at harvesting stage.

The initial and post-harvest soil samples (after 3 years) were collected (500 g composite sample, one sample from each plot) from 0-15 cm depth for analyzing the available N, P, K status, SOC and soil microbial biomass carbon (SMBC). The soil samples were air dried, processed and passed through 2 mm sieve, and used for analyzing soil fertility parameters such as available N by the alkaline permanganate method (Subbiah and Asija 1956), available P by $NaHCO_3$ extraction method (Olsen and Sommers 1982) and available K by neutral normal $NH_4OAC$ extraction method (Knudsen *et al.* 1982). SMBC was estimated by soil fumigation technique **(**Anderson and Ingram 1993**)**. Bulk density (ñb) was determined by the core method (Blake and Hartge 1986) using cores of 5.8 cm height and 5.4 cm diameter at 0-15 cm depth and oven dried at 105$^{0}$C (one sample per plot).

Experimental data pertaining to each parameter were subjected to statistical analysis by using technique of analysis of variance and their significance was tested by "F" test (Gomez and Gomez, 1984). Standard error of means (SEm+) and least significant difference (LSD) at 5% probability (P=0.05) were worked out for each parameter studied to evaluate differences between treatment means.

## RESULTS AND DISCUSSION

### Effect on weeds

The predominant weed species observed in the experimental field during rainy season were *Ageratum conizoides, Alternanthera phyloxiroides, Bidens pilosa, Borrevia hispida, Galinsoga parviflora* and *Spilanthus acemella* among broad-leaved weeds*; Cynodon dactylon, Digitaria marginata, Digitaria sanguinalis*, *Panicum repens* and *Eleusine indica* among grasses and *Cyperus rotundus* and *Fimbristylis miliacea* among sedges. Number of broad-leaved weeds were found maximum followed by grasses and sedges irrespective of weed management practices. All the weed management practices were effective in suppressing total weed density and dry matter as compared to weedy check. Minimum weed population and dry weight at 30 and 60 DAS were recorded under weed free check (Table 1). Two HW, soybean green manure incorporation + one HW and mechanical weeding (20 DAS) + one HW (after earthing up) was also found effective in reducing weed population to the extent of 72, 67 and 68% in 30 DAS and 77, 78 and 80% in 60 DAS as compared to weedy check, respectively. This result was in line with the findings of Syawal (1998) who reported that HW effectively controlled weeds.

In general, weed dry weight was found higher at 30 DAS compared to 60 DAS in all the treatments except weedy check and aqueous leaf extract spray of *Lantana* and pine which may be due to suppression of weed growth by maize canopy at later growth stages (Table 1). Lower weed biomass during 60 DAS than 30 DAS indicated that increasing plant canopy covered the open niches which otherwise might have been utilized by weeds (Gul *et al.* 2009). Pooled weed control efficiency (WCE) of different treatments ranged from 71.33-91.97 and 31.59-72.90% in 30 and 60 DAS, respectively. Among all the treatments, two HW at 20 and 45 DAS and mechanical weeding at 20 DAS and one HW at 45 DAS was recorded maximum WCE compared to other treatments. The finding confirms the results of Gul *et al.* (2009).

### Yield attributes and yield

Although the cob length in maize did not vary significantly across the treatments, highest cob length was recorded under mulching with fresh *Eupatorium* 10 t/ha and soybean green manuring + one HW as compare to rest of treatment except weed-free check (Table 2). It might be due to addition of nutrients and moisture conservation through application of *Eupatorium* as mulch. The number of seeds/cob were the highest under weed free check, however it was statistically at par with mulching with weed biomass. The grain weight/cob was also highest under mulching with weed biomass. Three years average grain yield of maize was maximum (3.87 t/ha) under fresh *Eupatorium* mulching followed by two HW at 20 and 40 DAS (3.64 t/ha) and soybean

**Table 1. Population density, dry weight and weed control efficiency as influenced by various organic weed management practices (pooled mean of 3 years)**

| Treatment | Population density (no./$m^2$) | | Dry weight ($g/m^2$) | | Weed control efficiency (%) | |
|---|---|---|---|---|---|---|
| | 30 DAS | 60 DAS | 30 DAS | 60 DAS | 30 DAS | 60 DAS |
| Mechanical weeding at 20 DAS + one HW at 45 DAS | 158 | 75 | 9.41 | 4.2 | 86.1 | 94.8 |
| Mulching with fresh *Eupatorium* 10 t/ha after earthling up at 30 DAS | 225 | 90 | 12.9 | 17.5 | 74.6 | 78.6 |
| Aqueous leaf extract (10%) spray of *Lantana* and pine | 359 | 235 | 26.0 | 44.6 | 48.6 | 34.2 |
| Two HW -1st before earthing up (20 DAS) and 2nd after earthing up (45 DAS) | 145 | 88 | 7.2 | 4.2 | 85.9 | 94.9 |
| Aqueous leaf extract spray of *Lantana* and pine + one HW after earthing up (35 DAS) | 185 | 91 | 11.7 | 6.7 | 76.9 | 91.7 |
| Soybean green manure incorporation in situ + one HW (45 DAS) | 156 | 84 | 10.5 | 4.9 | 79.2 | 94.0 |
| Weed free check (HW at 10, 25, 40, 55 and 70 DAS) | 4 | 2 | 0.8 | 0.2 | 98.4 | 99.8 |
| Weedy check | 493 | 392 | 50.7 | 81.6 | - | - |

HW: Hand weeding; DAS: Days after sowing

**Table 2. Yield attribute and yield of maize as affected by organic weed management practices (pooled mean of 3 years)**

| Treatment | Maize | | |
|---|---|---|---|
| | Cob length (cm) | Seeds /cob | Grain weight /cob (g) |
| Mechanical weeding at 20 DAS + one HW at 45 DAS | 14.5 | 262 | 127 |
| Mulching with fresh *Eupatorium* 10 t/ha after earthling up at 30 DAS | 15.1 | 281 | 137 |
| Aqueous leaf extract (10%) spray of *Lantana* and pine | 14.3 | 263 | 126 |
| Two HW -1st before earthing up (20 DAS) and 2nd after earthing up (45 DAS) | 14.5 | 281 | 119 |
| Aqueous leaf extract spray of *Lantana* and pine + one HW after earthing up (35 DAS) | 14.5 | 268 | 105 |
| Soybean green manure incorporation in situ + one HW (45 DAS) | 15.1 | 280 | 126 |
| Weed free check (HW at 10, 25, 40, 55 and 70 DAS) | 15.4 | 285 | 129 |
| Weedy check | 14.1 | 244 | 81 |
| LSD (P=0.05) | NS | 5.2 | 4.4 |

HW: Hand weeding; DAS: Days after sowing

**Table 3. Effect of soil properties as influenced by various weed management practices after 3-cropping cycles**

| Treatment | Bulk density ($g/cm^3$) | SOC (g/kg) | Available N (kg/ha) | Available P (kg/ha) | Available K (kg/ha) | SMBC (µg/g dry soil) |
|---|---|---|---|---|---|---|
| Mechanical weeding at 20 DAS + one HW at 45 DAS | 1.25 | 22.9 | 256 | 24.1 | 275 | 232 |
| Mulching with fresh *Eupatorium* 10 t/ha after earthling up at 30 DAS | 1.19 | 23.6 | 278 | 30.8 | 280 | 272 |
| Aqueous leaf extract (10%) spray of *Lantana* and pine | 1.27 | 22.5 | 245 | 21.7 | 264 | 199 |
| Two HW -1st before earthing up (20 DAS) and 2nd after earthing up (45 DAS) | 1.24 | 23.0 | 260 | 23.9 | 263 | 250 |
| Aqueous leaf extract spray of *Lantana* and pine + one HW after earthing up (35 DAS) | 1.23 | 22.8 | 253 | 22.5 | 266 | 251 |
| Soybean green manure incorporation in situ + one hand weeding (45 DAS) | 1.21 | 23.9 | 280 | 29.0 | 274 | 258 |
| Weed free Check (HW at 10, 25, 40, 55 and 70 DAS) | 1.28 | 23.0 | 226 | 18.8 | 259 | 241 |
| Weedy check | 1.18 | 24.4 | 270 | 20.3 | 277 | 271 |
| Initial value | - | 19.6 | 219 | 12.5 | 245 | - |
| LSD (P=0.05) | 0.03 | 1.7 | 17 | 4.6 | 13 | 15 |

HW: Hand weeding; DAS: Days after sowing; SOC - Soil organic carbon

green manure incorporation in situ+ one HW (3.64 t/ha). Mulched biomass added large quantity of nutrients and the additional nutrients over that applied through manure might have contributed to the increased yield of maize (Sharma and Acharya 2000 and Sharma *et al.* 2010).

**Soil fertility**

At the end of three cropping cycles, mulching with fresh *Eupatorium* (after earthing up) 10 t/ha resulted in higher SOC (23.6 g/kg), available N (278.0 kg/ha), P (30.80 kg/ha) and K (280.1 kg/ha) in soil followed by soybean green manure incorporation in situ + one HW than other treatments (Table 3). Percentage increase of SOC, available N, P and K were 20.4, 27.1, 76.0 and 14.3% respectively, under mulching with fresh *Eupatorium* (after earthing up) 10 t/ha relative to respective initial values (Table 3). Whereas, these enhancement in relation to two HW were 2.6, 6.8, 28.8 and 6.6%, respectively. Bulk density was recorded the lowest and soil SMBC was the highest under mulching with fresh *Eupatorium* (after earthing up) 10 t/ha treatments. Long term application of organic amendments were reported to improvement in SOC, available N, P and K in soil, thereby sustaining the soil health (Panwar *et al*. 2010). The use of weed biomass (shrubs) such as *Eupatorium adhenophorum* as mulching material for soil and moisture conservation and fertility build up in crop production has been also reported by other researchers (Acharya *et al.* 1998 and Gaire *et al.* 2013).

It can be concluded that mulching with weed biomass such as fresh *Eupatorium* (after earthing up) and soybean green manuring in maize + one HW are the recommendable options for organic maize production under high rainfall hill ecosystem of North-East India.

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**REFERENCES**

Acharya CL, Kapur OC and Dixit SP. 1998. Moisture conservation for rainfed wheat production with alternative mulches and conservation tillage in hills of north-west India. *Soil and Tillage Research* **46**: 153-163.

Anderson JM and Ingram JSI. 1993. *Tropical Soil Biology and Fertility*, CAB, UK.

Ankita G and Chabbi M. 2012. Effect of allelopathic leaf extract of some selected weed flora of Ajmer district on seed germination of *Triticum aestivum* L. *Science Research Reporter* **2**(3): 311-315.

Gul B, Marwat KB, Hassan G, Khan A, Hasim S and Khan IA. 2009. Impact of tillage, plant population and mulches on biological yield of maize. *Pakistan Journal of Bot*any **41**(5): 2243-2249.

Blake GR and Hartge KH. 1986. Bulk density. pp. 363-376. In: *Methods of Soil Analysis, Part I*, (Ed. A. Klute) ASA Monograph No. 9. Madison, WI.

Das A, Patel DP, Munda GC and Ghosh PK. 2010. Effect of organic and inorganic sources of nutrients on yield, nutrient uptake and soil fertility of maize (*Zea mays*)- mustard (*Brassica campestris*) cropping system. *Indian Journal of Agricultural Sciences* **80**(1): 85–88.

Dayan FE. 2002. Natural pesticides. pp. 521–525. In: *Ncylopedia of Pest Management.* (Ed. D. Pimentel), Inc., New York.

Gaire R, Dahal K R and Amgain L P.2013. Effect of different mulching materials on weed dynamics and yield of direct seeded rice in Chitwan, *Agronomy Journal of Nepal* **3**: 73-81.

Gomez KA and Gomez AA. 1984. *Statistical Procedure for Agricultural Research*. 2nd Ed. International Rice Research Institute, John Wiley and Sons, New York, Singapore.

Knudsen D, Peterson G A and Pratt P F. 1982. Lithium, sodium, and potassium. In: Methods of soil analysis, part 2: Chemical and microbiological properties, (Eds. Page AL, Miller RH and Keeney DR), American Society of Agronomy Wisconsin, USA.

Kumar B, Kumar R, Kalyani S and Haque M. 2013. Integrated weed management studies on weed flora and yield in *Kharif* maize. *Trends in Biosciences* **6**(2): 161-164.

Lehoczky E and Reisinger P. 2003. Study on the weed-crop competition for nutrients in maize. *Communications in Agricultural and Applied Biological Sciences* **68**: 373-80.

Mani VS, Gautam KC and Chakraborthy. 1973. Losses in crop yield due to weed growth. *Proceedings of the National Academy of Sciences* **14**: 142-158

Olsen SR and Sommers LE. 1982. Phosphorus. In: *Methods of Soil Analysis, Part 2: Chemical and Microbiological Properties,* (Eds. Page AL, Miller RH and Keeney DR), Agronomy Monograph 9,ASA and SSSA, Madison, Wisconsin, USA

Padhi AK and Panigrahi RK. 2006. Effect of intercrop and crop geometry on productivity, economics, energetic and soil fertility status of maize based intercropping systems. *Indian Journal of Agronomy* **51**(3): 65-67.

Panwar NR, Ramesh P, Singh AB and Ramana S. 2010. Influences of organic, chemical and integrated management practices on soil organic carbon and soil nutrient status under semi-arid tropical conditions in central India. *Communication in Soil Science and Plant Analysis* **41**: 1073-1083.

Sharma AR, Singh R, Dhyani SK and Dube RK. 2010. Moisture conservation and nitrogen recycling through legume mulching in rainfed maize (*Zea mays*) – wheat (*Triticum aestivum*) cropping system. *Nutrient Cycling in Agroecosystems* **87**(2): 187-197.

Sharma PK and Acharya CL. 2000. Carry- over effect of residual soil moisture with mulching and conservation tillage practices for sowing of rainfed wheat (*Triticum aestivum* L) in North-West India. *Soil and Tillage Research* **57**: 43-52.

Subbiah BV and Asija GL. 1956. A rapid procedure for the estimation of available N in soils. *Current Science* **25**:259-260.

Syawal Y. 1998. Composition shift and other characteristics of weeds and yield of sweet corn on Andisols with N fertilization and weeding at critical period of the crop. *Publikasi Berkala Penelitian Pascasarjana Universitas Padjadjaram* **9**(2): 18-33.