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Non-chemical methods of weed management in maize under organic production system

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ABSTRACT

A field experiment was conducted to study the non-chemical methods of weed management in organically grown maize during the year 2010 and 2011. Among the 9 weed management treatments, soybean intercropping + one mechanical weeding (20 DAS) and 2 mechanical weeding (20 and 40 DAS) + mash intercropping being at par with each other resulted in significantly lower weed dry weight, higher yield attributes and maize equivalent yield over other treatments. One mechanical weeding at 20 DAS gave highest benefit-cost ratio of 4.3 followed by 2 mechanical weeding at 20 and 40 DAS and soybean intercropping + 1 MW (20 DAS), which gave the benefit : cost ratio of 2.3.

Key words: Equivalent yield, Maize, Organic, Weed control, Weed control efficiency

Maize (*Zea mays* L.*)* is a versatile crop, growing across a range of agro–ecological zones. Being a rainy season and widely spaced crop, maize gets infested with variety of weeds and subjected to heavy weed competition during the first 4-6 weeks after emergence. Practice of using heavy inputs and intensive cultivation has led to heavy weed infestation which remains to be the most devastating reason for lowering grain yield by 83% (Usman *et al.* 2001). Herbicide used to be a key component in almost all weed management strategies, but indiscriminate use of these herbicides has resulted in serious ecological and environmental problems. A strong need was felt to discover the alternative weed management options in organic agriculture (Economou *et al.* 2002). Integrated weed management includes the combination of cropping practices for efficient and economical weed control (Swanton and Weise 1996). Intercropping within the organic agricultural production has an important role in weed control. The wider row spacing in maize can be used to grow short duration legumes which not only act as smoother crop, but also give additional yield (Shah *et al.* 2011). The increased number of plants per unit area, as in case of intercrops, results in the reduction of weed biomass (Bulson *et al.*1997).

Despite best management practices being adopted, the per hectare yield of *Kharif* crops including maize tends to be low due to the reverse nutrient competition offered by weeds as rains and humidity support luxuriant growth of weeds which can reduce the maize yield up to 60.8% (Gaur *et al.* 1991). Keeping in view the negative effects of herbicides, the present study was undertaken to observe the effect of non-chemical methods of weed management in maize under organic production system.

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MATERIALS AND METHODS

A field experiment was conducted during *Kharif* 2010 and 2011 at the Research Farm of Department of Organic Agriculture, Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur. The area represents the mid-hill wet temperate zone of Himachal Pradesh. The soil of the experimental site was silty clay loam in texture, acidic in reaction (pH 5.6), medium in organic carbon (0.57%), low in available nitrogen (205.0 kg/ha), available phosphorus (9.5 kg/ha) and medium in available potassium (180.0 kg/ha). The experiment was laid out in randomized block design with nine treatment combinations and three replications. The treatments comprised of mechanical weeding (MW) at 20 DAS, 2 mechanical weeding (MW) at 20 and 40 DAS, hand weeding (HW) at 20 DAS, 2 hand weeding at 20 and 40 DAS, soybean intercropping with no weeding, soybean inter-cropping + 1 MW (20 DAS), soybean intercropping + 1 HW (20 DAS), 2 MW at 20 and 40 DAS + mash intercropping (40 DAS) and unweeded check. Weed population was recorded from the unweeded check plots at 120 days after sowing for the purpose of calculating the percent infestation of different weed species. The total dry weight of weeds was recorded at 120 days after sowing.

RESULTS AND DISCUSSION

Effect on weeds

The major weeds were: *Echinochloa* sp. *(E. colona* (L.) Link and *E. crusgalli* (L.) P. Beauv.), *Digitaria sanguinalis* (L.) Scop. and *Panicum dichotomiflorum* Michx. among grasses, *Cyperus* sp. *(C. esculentus* L. and *C. iria* L.*)* among sedges and *Commelina benghalensis* L. among broad-leaved. The grasses, broad-leaved weeds and sedges constituted about 65.4, 21.5 and 13.1% of total weed flora. Under mid-hill conditions of Himachal Pradesh, similar weed flora has been reported earlier in maize fields by Saini and Angiras (1998).

Effect on crop

Different weed control treatments significantly affected number of cobs, cob length, grains/cob and, 1000 grains weight compared to that of unweeded control plot (Table 1). It has been found that two MW (20 and 40 DAS), 1 HW/1 MW (20 DAS), two HW/MW (20 and 40 DAS) and 1 MW (20 DAS) being statistically at par with each other recorded significantly higher number of cobs/ha and higher cob length over the remaining treatments. Soybean inter-cropping (no weeding) was as good as 1 HW in suppressing weeds and producing significantly longer cobs and higher number of cobs/ha over unweeded control. During both the years of study, grains/cob and 1000-grain weight were significantly higher over unweeded check but were statistically at par among the different treatments except grains/cob during 2010. In 2011, 2 MW + mash inter-cropping and soybean inter-cropping +1 HW/1MW (20 DAS) produced significantly higher number of grains/ cob over all other treatments. Soybean inter-cropping though resulted in higher grains/ cob over unweeded check but recorded comparatively lower grains/cob over other treatments. Ali (1988) and Ghosh *et al*. (2007) also reported similar results.

Soybean intercropping + 1 MW (20 DAS), 2 MW (20 and 40 DAS) and 2 MW (20 and 40 DAS) + mash inter-cropping being at par with each other resulted in significantly lower weed dry weight and higher maize equivalent yield over all other treatments during both the years of experimentation. This might be due to the weed smothering ability of the legumes due to the profuse canopy which also resulted in higher weed control efficiency. Ali (1988), Ghosh *et al.* (2007) and Nongmaithem *et al.* (2012) also expressed similar opinions, where legumes with good canopy were most efficient for weed control. Hand weeding twice (20 and 40 DAS) being at par with 1 HW/1MW (20 DAS) were the next best treatments in controlling weeds and producing higher yields over the remaining treatments. Soybean inter-cropping though was least effective in suppressing weeds among all the treatments but it produced significantly higher maize equivalent yield and lower weed dry weight over unweeded control. Two mechanical weedings (20 and 40 DAS) being at par with soybean inter-cropping + 1 HW/1 MW (20 DAS) resulted in significantly higher maize/maize equivalent yield and lower weed dry weight over other treatments except 2 MW (20 and 40 DAS) + mash intercropping.

Mechanical weeding (20 DAS) resulted in significantly highest benefit–cost ratio of 4.6 and 4.0 during 2010 and 2011, respectively. This treatment was followed by 2 MW (20 and 40 DAS) and soybean inter-cropping + 1 MW each of which resulted into 2.3 B:C ratio. It was closely followed by 2 MW + mash inter-cropping which gave on an average 2.2 B:C ratio. All the weed

Table 1. Effect of various weed control treatments on yield attributes of maize

Treatment	Number of cobs/ha ($x10^3$/ha)		Cob length (cm)		Grains/cob		1000-grain weight (g)	
	2010	2011	2010	2011	2010	2011	2010	2011
Mechanical weeding (MW) 20 DAS	72.4	65.7	17.5	16.8	311.6	303.2	211.7	212.2
Mechanical weeding (MW) (20 and 40 DAS)	73.9	66.4	17.0	17.1	308.2	315.1	218.6	212.5
Hand weeding (HW) 20 DAS	65.2	62.6	16.5	15.9	302.3	286.4	205.0	198.4
Hand weeding (HW) 20 and 40 DAS	71.5	65.3	17.1	16.6	315.2	315.7	214.7	209.0
Soybean intercropping (no weeding)	64.7	59.5	15.6	16.0	292.5	280.7	206.8	196.4
Soybean intercropping + 1MW (20 DAS)	73.6	67.4	17.5	17.2	333.4	312.5	215.2	211.0
Soybean intercropping + 1 HW (20 DAS)	71.8	65.5	17.6	17.0	329.6	302.5	212.5	208.1
2 MW 20 and 40 DAS + mash intercropping	74.7	68.8	17.9	16.8	340.1	298.5	215.8	210.4
Unweeded check	48.6	45.5	14.8	13.9	182.4	165.4	195.8	188.4
LSD (P=0.05)	3.5	3.8	0.8	0.7	15.1	17.5	15.6	16.2

DAS - Days after sowing, MW - Mechanical weeding, HW- Hand weeding

Table 2. Effect of treatments on weed dry weight, weed control efficiency, maize equivalent yield and benefit: cost ratio

Treatment	Weed dry weight (g/m^2)		Weed control efficiency (%)		Maize grain equivalent Yield (t/ha)		Benefit: cost ratio	
	2010	2011	2010	2011	2010	2011	2010	2011
Mechanical weeding(MW) at 20 DAS	42.8	54.6	58.2	56.6	3.42	2.95	4.6	4.0
Mechanical weeding (MW) at 20 and 40 DAS	24.3	28.7	76.3	77.2	3.65	3.28	2.7	2.6
Hand weeding(HW) at 20 DAS	49.5	62.3	51.7	50.5	3.25	2.64	2.9	1.7
Hand weeding (HW) at 20 and 40 DAS	33.8	35.4	67.0	71.9	3.44	3.02	1.3	1.2
Soybean intercropping (no weeding)	46.4	65.7	54.7	47.8	2.80	2.48	1.5	1.6
Soybean intercropping + 1 MW at 20 DAS	28.4	31.2	72.4	75.2	3.84	3.35	2.4	2.1
Soybean intercropping + 1 HW at 20 DAS	31.5	36.2	69.2	71.2	3.71	3.24	1.7	1.5
2 MW at 20 and40 DAS+ mash intercropping	27.6	21.4	73.0	83.0	3.82	3.56	2.1	2.3
Unweeded check	102.4	125.8	-	-	2.15	1.84	-	-
LSD (P=0.05)	12.5	5.7	-	-	0.24	0.21	-	-

management treatments resulted in significantly lower weed dry weight and higher weed control efficiency over unweeded check during both the years of study (Table 2). Irrespective of number of weedings, the mechanical weedings produced lower weed dry weight as compared to the hand weeding, however, the differences were non-significant. Two mechanical/hand weedings at 20 and 40 DAS being at par with soybean intercropping + 1 mechanical/hand weeding at 20 DAS produced significantly lower weed dry weight and higher weed control efficiency over the remaining treatments during both the years of experimentation.

Soybean intercropping suppressed second flush of weeds to a great extent. Two mechanical weedings (20 and 40 DAS) + mash intercropping gave the highest weed control efficiency due to profuse canopy as has also been observed by Ali (1988) and Ghosh *et al.* (2007). Soybean inter-cropping was as effective as one hand weeding (20 DAS) in suppressing the weeds during both the years. However, it was also at par with one mechanical weeding during first year as was evident from weed dry weight and weed control efficiency (Table 2). Kandasamy and Chandrasekhar (1998) reported that the traditional (non-chemical) methods of weed control effectively minimized weed competition and maximized maize yield.

It was concluded that under organic farming conditions, soybean intercropping + 1 mechanical weeding (20 DAS) or 2 mechanical weedings (20 and 40 DAS) could be the best options for non-chemical management in maize.

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