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Effect of Chemical and Non-chemical Weed Management Practices on Weed Dynamics and Yield of Maize (*Zea mays* L.)

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ABSTRACT: Weed management through physical means (hand weeding) is laborious and expensive, while use of chemical herbicide resulting in pollution of environment and herbicide-resistant biotypes. Under the situation, integrated weed management approach involving non-chemical (hand weeding, intercropping, mulching etc.) and chemical (use of herbicides) methods in maize is very important to provide effective weed control for realizing high production. Therefore, to study the effect of chemical and non-chemical weed management practices on weed dynamics and yield of maize. The present study was conducted at the Research Farm of the School of Agriculture. Abhilashi University, Mandi (H.P.) during Kharif 2022. The experiment was laid out in randomized block design with three replications, consisting of nine weed management treatments. Results of the study revealed that non-chemical weed management treatments comprised of weed free (hand weeding at 25, 45 and 65 DAS), two hand weeding (25 and 45 DAS) and soybean intercropping + one hand weeding (25 DAS) being at par with each other resulted in significantly lower total weed dry weight, higher weed control efficiency, better crop growth (plant height, number of plants and dry matter accumulation), yield attributes (number of cobs per plant, number of grains per cob and 1000-grain weight) and higher yield (grain and straw) than rest of the chemical and non-chemical weed management treatments.

Keywords: Weed management, maize, intercropping, chemical methods, hand weeding, soybean, yield.

INTRODUCTION

Maize is the world's third most important cereal crop after wheat and rice, and a source of staple food to large number of human populations in the world (Mishra *et al.,* 2020). It is known as 'Queen of Cereals' because of its high production potential and wider adaptability (Kumawat *et al.,* 2019). In India, maize is cultivated on an area of 9.9 million hectares having production of 31.51 million tonnes with productivity of 3195 kg/ha (Anonymous, 2021). Maize is the major crop of Himachal Pradesh. In Himachal Pradesh, maize occupies an area of 267.41 thousand hectares with total production of 725.01 thousand tonnes and productivity of 2711 kg/ha (Anonymous 2022). 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 (Saini *et al.,* 2013). Unchecked weed growth in crop may results in grain yield losses to the extent of 100 per cent (Barla *et al.,* 2016). Weeds compete with the crop for nutrients, water, sunlight, space, and consequently interfere with the normal growth of crops (Kakade *et al.,* 2020). The various methods that are most widely used in the country for controlling weeds are non chemical i.e. physical, mechanical, cultural and chemical methods. Among the physical and mechanical methods are hand weeding and hoeing, cultural methods include mulching and intercropping and chemical methods involve the use of herbicides. Weed management through physical and mechanical means involves labour, animal and implement costs, making them more laborious, tiresome and expensive. On the other hand, reliance solely on chemical weed control involves excessive use of herbicides, resulting in pollution of the environment and herbicide-resistant biotypes. Intercropping 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 (Kumar *et al.,* 2018). The increased number of plants per unit area, as in case of intercrops, results in the reduction of weed biomass (Saini *et al*., 2013). Covering or mulching the soil surface can reduce weed problems by preventing weed seed germination or by suppressing the growth of emerging seedlings (Ramzan *et al*., 2016). No doubt cultural methods are useful but it will not be possible and economical to stick only to the single weed control strategy. Integrated weed management approach involving non-chemical (hand weeding, intercropping, mulching etc.) and chemical (use of herbicides) methods in maize and maize-based intercropping

system is very important to provide effective and acceptable weed control for realizing high production (Kumar *et al.,* 2018). Keeping in view the above facts and to observe the effect of chemical and non-chemical methods of weed management in maize, the present study was undertaken.

MATERIAL AND METHODS

A field experiment was conducted during Kharif 2022 at the Research Farm of the School of Agriculture, Abhilashi University, Mandi (H.P.) situated at 32^0 33´ N latitude and 77^0 00´ E longitude at an elevation of about 1408 meters above mean sea level in north-western Himalayas. The soil of experimental field was acidic in reaction (pH 5.6), medium in organic carbon (0.70%), low in available nitrogen (205 kg/ha), medium in available phosphorus (21.23 kg/ha) and potassium (192 kg/ha). The experiment was laid out in randomized block design with three replications, consisting of nine weed management treatments i.e. weed free (hand weeding at 25, 45 and 65 DAS) (T_1), soybean intercropping + one hand weeding at 25 DAS (T_2), two hand weeding at 25 and 45 DAS (T_3), atrazine @1.25 kg a.i./ha (PE) + one hand weeding at 25 DAS (T_4), atrazine @1.25 kg a.i./ha (PE) + 2,4-D @1 kg a.i./ha (PoE) at 25 DAS (T_5), one hand weeding at 25 DAS (T_6), soybean intercropping (T_7), mulching (T_8) and weedy check (T_9). 'MH-4642" variety of maize was sown using seed rate of 25 kg/ha at spacing of 60 cm row to row and 20 cm plant to plant. The crop was fertilized with recommended dose of nitrogen, phosphorus and potassium i.e. 120, 60, 40 kg/ha through urea, single super phosphate and murate of potash, respectively. Half dose of N and whole of P and K was applied at the time of sowing in all the treatments. Rest of nitrogen was applied in two equal splits: $1/4^{th}$ at knee height stage and $1/4^{th}$ at tasseling stage. To control the weeds in recommended herbicide treatments, pre-emergence application of atrazine @1.25 kg/ha and post emergence application of 2,4-D @1 kg/ha was made in 700 liters of water. In hand weeding treatment, hand weeding was done using hand hoe at 25 and 45 days after sowing. In mulching treatment, weeds were cut with sickle and left on surface and used as mulch. Weed population was recorded at 60 days after sowing using 50 cm × 50 cm quadrate. Data on weed density and weed dry matter accumulation have shown high degree of variation and hence were subjected to square root $\sqrt{(x + 0.5)}$ transformation. The growth parameters were recorded at monthly interval of crop growth period and yield attributes were recorded at the time of crop harvest. The crop was harvested treatment wise at maturity and grain yield per hectare was computed. The data recorded on various aspects in the present study were subjected to the statistical analysis using analysis of variance as per procedure suggested by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

The major weed flora of the experimental plots consisted of *Echinochloa colona* (22.81%), and *Digitaria sanguinalis* (10.36%) among grasses, *Commelina benghalensis* (20.52%), *Ageratum conzyoides* (13.95%) and *Bidens pilosa* (9.07%) among broad leaf weed and *Cyperus rotundus* (13.54%) among sedges. Other weed (9.74%) species included *Aeschynomene indica*, *Oxalis latifolia* and *Polygonum alatum.*

Effect on weeds: All the weed management treatments significantly influenced the total weed count and weed dry matter accumulation at 60 days after sowing. Among weed management treatments, weed free (hand weeding at 25, 45 and 65 DAS) being statistically at par with two hand weeding (25 and 45 DAS) resulted in significantly lower total weed count and weed dry matter accumulation over all other treatments. It might be due to the fact that weed free condition and two hand weeding at 25 and 45 days after sowing resulted in uprooting and mortality of weeds during early as well as later growth stages of crop, which led to lower weed density and weed dry matter accumulation. Similar results were also reported by Rani *et al.* (2011); Dutta *et al.* (2016).

An observation of data in Table 1 further indicated that soybean intercropping + one hand weeding (25 DAS) was found comparable with two hand weeding (25 and 45 DAS) and significantly superior over rest of the treatments. Herbicide treatments i.e. atrazine @1.25 kg a.i./ha (PE) + one hand weeding (25 DAS) and atrazine @1.25 kg a.i./ha (PE) + 2,4-D @1 kg a.i./ha (PoE) (25 DAS) being statistically at par with one hand weeding (25 DAS) also proved effective in controlling the weeds and maintained superiority over remaining treatments. Both mulching and soybean intercropping treatments were least effective but superior over weedy check.

Total weed control efficiency due to weed management treatments ranged from 55.52 to 80.16 per cent. Weed free (hand weeding at 25, 45 and 65 DAS) resulted in significantly higher total weed control efficiency of 80.16 per cent, which was statistically at par with two hand weeding (25 and 45 DAS) and soybean intercropping + one hand weeding (25 DAS). The best treatments were followed by herbicide treatments i.e. atrazine @1.25 kg a.i./ha (PE) + one hand weeding (25 DAS), atrazine @1.25 kg a.i./ha (PE) + 2,4-D @1 kg a.i./ha (PoE) (25 DAS) and one hand weeding (25 DAS) remaining at par with each other. Soybean intercropping and mulching treatments being at par with each other gave the lowest weed control efficiency of 50.84 and 55.52 per cent, respectively. Higher weed control efficiency under weed free and two hand weeding treatments might be attributed to effective control of weeds for a longer period resulting in low weed biomass. These results are in conformity with the findings of Arvadiya *et al.* (2012); Wasnik *et al.* (2022).

Effect on growth attributes: The data on effect of different weed management treatments on plant height (cm), numbers of plants (per m^2) and dry matter accumulation (g/m^2) of maize have been presented in Table 2. Plant height and dry matter accumulation of maize was significantly influenced by different weed management treatments at 90 days after sowing. Weed free (hand weeding at 25, 45 and 65 DAS) resulted in significantly taller plants and higher dry matter

accumulation by maize crop which remained statistically at par with soybean intercropping + one hand weeding (25 DAS) and two hand weeding (25 and 45 DAS) treatments. Following to, atrazine @1.25 kg a.i./ha (PE) + one hand weeding (25 DAS), atrazine @1.25 kg a.i./ha (PE) + 2,4-D @1 kg a.i./ha (PoE) (25 DAS) and one hand weeding (25 DAS) remaining at par with each other resulted in significantly taller plants and produced higher dry matter accumulation than rest of the treatments. Treatments comprised of one hand weeding (25 DAS) and soybean intercropping being at par with each other obtained higher plant height and dry matter accumulation than mulching treatment. Significantly lowest plant height and dry matter accumulation per square meter was recorded under weedy check. Number of plants per square meter was not significantly influenced by different weed management treatments at 90 days after sowing. However, numerically higher population of maize plant was observed with weed free treatment which was closely followed by soybean intercropping + one hand weeding (25 DAS) and two hand weeding (25 and 45 DAS) treatments.

The higher plant height and dry matter accumulation recorded in weed free, two hand weeding and soybean intercropping + one hand weeding treatments was due to effective control of weeds. Similar results showing increased plant height and dry matter accumulation due to weed free and hand weeding has also been reported by Lavanya *et al.* (2020); Subbulakshmi *et al.* (2009). Patel *et al.* (2017) also reported maximum plant height in plots where maize was intercropped with soybean.

Table 1: Effect of weed management treatments on total weed density, weed dry matter accumulation and weed control efficiency.

Treatments	At 60 days after sowing		
	Total weed density (No./m^2)	Total weed dry matter (g/m^2)	Weed control efficiency (%)
Weed free (Hand weeding at 25, 45 and 65 DAS)	11.35(129.32)	9.35(88.26)	80.16
Soybean intercropping + One hand weeding at 25 DAS	12.82(165.08)	10.74(115.50)	74.03
Two hand weeding at 25 and 45 DAS	11.08(146.20)	9.05(101.59)	77.16
Atrazine @1.25 kg a.i./ha (PE) + One hand weeding at 25 DAS	14.30(204.92)	12.15(147.98)	66.73
Atrazine @1.25 kg a.i./ha (PE) + 2,4-D @1 kg a.i./ha (PoE) at 25 DAS	14.62(214.16)	12.41(154.41)	65.28
One hand weeding at 25 DAS	15.01(225.52)	12.67(160.93)	63.82
Soybean intercropping	17.32(300.36)	14.78(218.64)	50.84
Mulching	16.50(272.34)	14.06(197.83)	55.52
Weedy check	23.64(559.00)	21.09(444.78)	00.00
SEm ±	0.37	0.34	3.08
CD(P)=0.05	1.10	0.96	6.24

(Values in parentheses are means of original values)

Table 2: Effect of weed management treatments on growth attributes of maize.

Treatments	At 90 days after sowing		
	Plant height (cm)	No. of plant (per m^2)	Dry matter accumulation (g/m^2)
Weed free (hand weeding at 25, 45 and 65 DAS)	262.1	7.20	1005.60
Soybean intercropping + One hand weeding at 25 DAS	260.4	7.19	970.50
Two hand weeding at 25 and 45 DAS	257.4	7.19	930.60
Atrazine @1.25 kg a.i./ha (PE) + One hand weeding at 25 DAS	236.5	7.17	852.63
Atrazine @1.25 kg a.i./ha (PE) + 2,4-D @1 kg a.i./ha (PoE) at 25 DAS	235.3	7.15	835.47
One hand weeding at 25 DAS	222.2	7.02	798.53
Soybean intercropping	202.6	6.90	695.63
Mulching	176.5	6.74	555.83
Weedy check	150.7	6.50	403.70
SEm ±	7.80	0.45	38.50
CD(P)=0.05	23.73	NS	113.53

Effect on yield attributes: The weed management treatments had significant effect on yield attributes viz. number of cobs per plant and number of grains per cob. Weed free resulted in significantly higher number of cobs per plant and grains per cob which remained statistically at par with soybean intercropping + one hand weeding (25 DAS) and two hand weeding (25 and 45 DAS) treatments and further these treatments behaved statistically similar to the treatments comprised of application of pre emergence herbicide atrazine @1.25 kg a.i./ha + one hand weeding (25 DAS) or post emergence herbicide 2,4-D @1 kg a.i./ha. Significantly

lowest number of cobs per plants and grains per cob were recorded with weedy check. The higher number of cobs per plant and number of grains per cob in treatments where weeds were effectively managed either by two hand weeding or soybean intercropping + one hand weeding or by herbicide combinations was due to the better environment provided by the effective control of weeds. Similar results regarding higher number of cobs per plant and number of grains per cob with the two hand weeding or application of herbicides have also been reported by Mathukia *et al.* (2014); Sanodiya *et al*. (2013).

Effect on yield: The different weed management treatments had significant effect on grain and straw yields of maize. Weed free condition resulted in significantly higher grain and straw yields of 4260 and 6351 kg/ha, respectively which remained statistically at par with soybean intercropping + one hand weeding (25 DAS) and two hand weeding (25 and 45 DAS) treatments. Treatments comprised of application of pre emergence herbicide atrazine @1.25 kg a.i./ha + one hand weeding (25 DAS) or post emergence herbicide 2,4-D @1 kg a.i./ha were the next best treatments. Weed free treatment produced 57.66, 41.43, 29.85, 21.37, 18.00, 16.84, 9.14 and 4.92 per cent more grain yield and 53.23, 35.54, 20.22, 19.17, 15.58, 14.97, 7.49 and 3.07 per cent more straw yield over weedy check, mulching, soybean intercropping, one hand weeding, atrazine @1.25 kg a.i./ha (PE) + one hand weeding, atrazine @1.25 kg a.i./ha (PE) + 2,4-D @1 kg a.i./ha (PoE), two hand weeding and soybean intercropping + one hand weeding treatments, respectively.

The results manifestly revealed that effective weed control under weed free, soybean intercropping + one hand weeding and two hand weeding treatments resulted in better yield attributes viz. number of cobs per plant and number of grains per cob which ultimately resulted in better grain and straw yields of maize compared to other treatments. Dereje *et al.* (2018) obtained higher maize grain and straw yields under weed free condition or two hand weeding due to lower weed competition with the crop for nutrients, water and light, which might have allowed the plants to accumulate more biomass and hence more photosynthate which upon translocation to the sink resulted in more yield components and hence more grain and straw yields. The suppression of weeds by the intercrops and removal of weeds by hand weeding in soybean intercropping + one hand weeding treatment might have provided the congenial environment to the crop for better growth and development which ultimately led to higher grain and straw yields of maize. Similar results regarding superior yield of maize due to effective weed control under maize + soybean intercropping system was obtained by Rani *et al*. (2011) and Rahimi *et al*. (2019). The increase in maize grain and straw yields due to removal of competition by weeds due to herbicides treatments i.e. 2,4-D + atrazine or atrazine + one hand weeding in maize has also been documented by Parameswari *et al.* (2017); Yakadri *et al.* (2015).

Table 3: Effect of weed management treatments on yield attributes and yield of maize.

Treatments	No. of cobs per plant	No. of grain per cob	1000-grain weight (g)	Grain yield (kg/ha)	Straw yield (kg/ha)
Weed free (hand weeding at 25, 45 and 65 DAS)	1.32	299	255	4260	6351
Soybean intercropping + One hand weeding at 25 DAS	1.29	295	254	4050	6156
Two hand weeding at 25 and 45 DAS	1.26	291	252	3870	5843
Atrazine @1.25 kg a.i./ha (PE) + One hand weeding at 25 DAS	1.23	274	251	3543	5400
Atrazine @1.25 kg a.i./ha (PE) + 2,4-D @1 kg a.i./ha (PoE) at 25 DAS	1.23	271	250	3493	5361
One hand weeding at 25 DAS	1.21	266	249	3350	5133
Soybean intercropping	1.17	255	248	2988	4661
Mulching	1.08	245	246	2495	3968
Weedy check	0.94	228	244	1808	2970
SEm ±	0.03	8.00	20.35	140.33	218.33
CD(P)=0.05	0.10	24.00	NS	420.99	654.91

CONCLUSIONS

The study conclusively indicated that non chemical weed management treatments comprised of weed free, two hand weeding and soybean intercropping + one hand weeding being at par with each other resulted in significantly lower weed dry weight, higher weed control efficiency, higher yield attributes and yield (grain and straw) of maize than chemical and other non chemical weed management treatments.

FUTURE SCOPE

Soybean intercropping + one hand weeding can be the best non-chemical weed management option in maize crop under mid hill conditions of Himachal Pradesh.

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Conflict of Interest. None.

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