Indian Journal of Agronomy **59** (1): 18–22 (March 2014)

Review/Overview

Effect of weed management on crop productivity of winter maize (*Zea mays*) + potato (*Solanum tuberosum*) intercropping system in Shiwalik foothills of Jammu and Kashmir

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Received : July 2013; Revised accepted : December 2013

ABSTRACT

A field experiment was conducted during the winter season (*rabi*) 2009–10 and 2010–11 at Jammu. Four intercropping treatments, viz. sole maize, sole potato (*Solanum tubrosum* L.), maize (*Zea mays* L.) + potato (additive series) and maize + potato (replacement series), in main plots and 6 methods of weed-control practices, viz. weedy check, weed free, alachlor @1.5 kg/ha pre-emergence, atrazine @ 0.5 kg/ha pre-emergence, alachlor @ 2.0 kg/ha early post-emergence and atrazine @ 0.75 kg/ha post emergence in sub-plots were used to assess the productivity and profitability of winter maize + potato intercropping system. Sole winter maize and sole potato gave significantly higher yields than winter maize + potato grown in additive and replacement series in the respective order. Amongst the intercropping treatments, winter maize + potato (additive series) gave significantly higher yield of 16 t/ha compared to replacement series. Pre-emergence application of atrazine 0.5 kg/ha resulted in significantly lower dry-matter accumulation of all the weed species and highest weed-control efficiency leading to significantly higher crop productivity. Maximum net profit of 92.1 × ₹10^3/ha was recorded in winter maize + potato (additive series) but higher benefit: cost ratio of 2.3 was recorded with winter maize + potato grown in replacement series with application of either 0.5 kg/ha atrazine or alachlor @ 1.5 kg/ha pre-emergence

Key words: Crop production, Maize, Potato, Intercropping, Weed-control, Weed-control efficiency

Of late winter maize is assuming the status of being one of the most important and well-adopted cereal crops to be grown after rice in irrigated areas, with high productivity. The acreage of winter maize in India is increasing briskly owing to its higher productivity and net profit compared to traditional rainy season (*kharif*) crop. The average productivity of winter maize in India is 4.0 t/ha, which is double as compared to 2.0 t/ha productivity of conventional *kharif* maize (DMR, 2007). Intercropping in intensively cultivated areas is one of the most promising options for crop diversification of sustainable agricultural production system in India and weed management in intercropping system demands concerted efforts to provide weed-free environments to both main and component crop for attaining higher productivity levels. (Shah *et al.*2007). The development of wide spectrum of herbicides in the past has opened up excellent opportunities for chemical weed control in component crops of differential nature growing in association with each other. Physical manipulations of intercrop environments for weed control very closely resemble to those used for sole crops. Several researchers have suggested that more competitive crops provide cover and high plant density available in intercropping gives huge competition to weeds and reduces weed biomass. Intercropping has a great potential as a mean of weed control because it offers the possibility of a consortia of crops capturing a great share of available resources as compared to that in sole cropping. The wider row spacing in maize provides ample amount of options to grow short-duration crops in the inter-row space which will not only act as smother crop, but will give additional yield in spatial and temporal terms. Weed-control approach involving intercropping with herbicides and non-chemical methods in winter maize based cropping system provides effective and acceptable weed management for realizing high production. Besides, intercropping also reduces weeding cost and realizes higher total productivity of the system in

Based on part of Ph.D. Thesis of first author submitted to SKUAST Jammu, Chatha, Jammu and Kashmir (Unpublished)

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terms of monetary returns. Hence, present investigation was initiated to study the effect of weed management on crop productivity of winter maize + potato intercropping system in Shiwalik foothills of Jammu and Kashmir.

MATERIALS AND METHODS

The field experiment was conducted during the winter (*rabi*) season of 2009–10 and 2010–11 at the research farm of Division of Agronomy, Sher-e-Kashmir University of Agriculture Science and Technology, Jammu (32° 40ˆ N and 74⁰58ˆ E 332 mean sea-level). The soil was sandy loam, neutral in reaction, low in organic carbon and available nitrogen, medium in available phosphorus and potassium. The experiment was conducted in spilt-plot design with 3 replications in a fixed lay out. The main plot treatments consisted of 4 intercropping systems: (i) sole maize, (ii) sole potato, (iii) maize + potato (additive series), (iv) maize + potato (replacement series), while the sub-plot treatments were 6 methods of weed-control practices (i) weedy check, (ii) weed-free, (iii) alachlor @1.5 kg/ha pre-emergence, (iv) atrazine @ 0.5 kg/ha pre-emergence, (v) alachlor @ 2.0 kg/ha early post emergence and (vi) atrazine @ 0.75 kg/ha post-emergence. Winter maize 'Bulland' of 175 days duration and potato 'Kufri Sinduri' of 120 days duration were sown at row-to-row spacing of 60 cm. Application of fertilizer in sole maize was 175–60–30 kg N-P-K/ha. Full dose of P and K along with one-third of N were applied basal at the time of sowing and rest of N was applied in 2 equal splits–one-third in mid of January at knee high stage and the one-third at pre-tasseling stage, whereas in case of sole potato was 120–60–120 kg N-P K/ha. Herbicides were sprayed by knapsack sprayer fitted with flat fan T-jet nozzle using a spray volume of 500 l/ha. Weedy check plots remained infested with native population of weeds till harvest. Observations on weeds were recorded with the help of quadrate 0.5 m × 0.5 m placed randomly at 2 spots in each plot at harvest. The data on weeds were subjected to square root transformation ($\sqrt{X} + 0.5$) to normalize their distribution. Maize-equivalent yield was calculated by using standard formula on the basis of minimum support prices of component crops for the main produce and prevailing market prices for the inputs. Weed indices like weed-control efficiency was calculated by using the formulae suggested by Mishra and Mishra (1997) and weed index was calculated by using the formulae suggested by Raju (1998). Weed-smothering efficiency (WSE) was worked out by adopting the formula suggested by Subramanian *et al.* (1993).

The uptake of major nutrients in grain/ tuber of winter maize and potato and also weed samples were worked out by multiplying per cent nutrient content with their respective dry matter accumulation at harvest.

RESULTS AND DISCUSSION

Weeds

The experiment field was infested with *Medicago sativa*, *Anagallis arvensis*, *Melilotus alba*, *Convolvulus arvensis*, *Chenopodium album*, *Trachysperum species*, *Dacus carota*, *Phalaris minor*, *Poa annua*, *Cynodon dactylon* and *Cyperus rotundus* at harvest. Sole winter

Table 1. Effect of intercropping and weed-management on weed-density and dry weight at harvest in maize + potato intercropping treatments (pooled data of 2 years)

Treatment	Weed density/m²			Weed dry weight (g/m²)		
	Grasses	Sedges	Broad leaved weeds	Grasses	Sedges	Broad leaved weeds
Intercropping						
Sole maize (Sole potato)	4.02 (19.4)	4.70 (27.8)	6.52 (55.6)	3.15 (6.8)	3.93(20.7)	7.31 (67.8)
Winter maize + potato(additive series)	3.21 (12.1)	4.21 (22.6)	5.03 (34.0)	2.82 (8.2)	3.54(14.6)	6.22 (46.1)
Winter maize + potato(replacement series)	3.97 (18.8)	4.48 (26.8)	6.65 (57.5)	3.45 (13.1)	3.94 (19.1)	7.00 (54.9)
SEm±	0.09	0.09	0.04	0.06	0.04	0.03
CD (P=0.05)	0.26	0.24	0.12	0.17	0.12	0.10
Weed management						
Weedy check	6.79 (45.5)	9.50 (89.5)	12.43 (154.8)	5.18 (26.2)	8.72 (73.2)	11.76 (139.5)
Weed free	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 0.00	1.00 (0)
Alachlor pre @ 1.5 kg/ha	3.93 (14.8)	4.03 (15.5)	5.93 (35.3)	3.30 (10.0)	3.59 (10.1)	7.20 (50.1)
Alachlor early post @ 2.0 kg/ha	5.03 (24.8)	5.00 (24.2)	7.74 (60.0)	4.12 (16.0)	4.02 (13.7)	9.13 (83.0)
Atrazine pre @ 0.5 kg/ha	2.52 (5.8)	3.44 (11.2)	4.01 (16.2)	2.41 (4.9)	2.83 (5.1)	5.05 (25.0)
Atrazine post @ 0.75 kg/ha	3.15 (9.5)	3.81 (13.8)	5.29 (27.8)	2.85 (7.5)	3.10 (6.8)	6.39 (40.1)
SEm±	0.06	0.05	0.05	0.03	0.05	0.20
CD (P=0.05)	0.16	0.13	0.13	0.09	0.13	0.52

The data were subject of $\sqrt{x+1}$ transformation; Figures in the parentheses are original values

maize resulted in higher weed density, which was significantly higher than sole potato and winter maize + potato (additive series), whereas the lowest total weed density was recorded in winter maize + potato (additive series). This might be due to the fact that slow initial growth and wider row spacing of maize provided relatively conducive conditions for growth of weeds (Pandey *et al*., 2003). Amongst weed-management practices, lowest total weed density and weed biomass were recorded with application of atrazine pre-emergence @ 0.5 kg/ha, which was followed by post-emergence application of atrazine @ 0.75 kg/ha. Better efficacy and prolonged effectiveness of applied herbicides, which did not allow weeds to germinate and even resulted in rapid depletion of carbohydrate reserves of weeds already germinated through rapid respiration, senescence of leaves, reduction in leaf area and diminution of photosynthesis process (Roy *et al.,* 2008).

Highest weed-control efficiency at harvest for winter maize was recorded with pre- emergence application of atrazine @ 0.5 kg/ha (85.47%), followed by post-emergence application of atrazine @ 0.75 kg/ha (Fig. 1). However, lowest weed index was recorded with pre-emergence application of atrazine @ 0.5 kg/ha. Application of lower optimum dose of herbicides reduced the cost of weed-management assisted weed shifts, prevented herbicides resistance in weeds (Singh *et al*., 2005). Among the intercrops, winter maize + potato (additive treatments) registered higher weed-smothering efficiency (WSE) than maize with potato in replacement treatments, which might be due to the fact that additive series ensured better coverage of soil surface from the beginning and diminished light penetration to the soil reducing the weed growth and ensuring better WSE (Fig.3). Tripathi *et al*. (2008), reported similar findings.

Grain yield and equivalent yield of winter maize

Intercropping of winter maize + potato (additive series) significantly enhanced grain yield (3.6 t/ha) (Table 2) of winter maize. Inclusion of potato as an intercrop with winter maize reduced early stage of crop-weed competition due to smothering effects on weeds compared to sole winter maize and sole potato, thereby increased the yield indices and finally the maize-equivalent yield of winter maize. Amongst the weed control practices, pre emergence application of atrazine @ 0.5 kg/ha recorded significantly higher grain yield which was statistically at par with post-

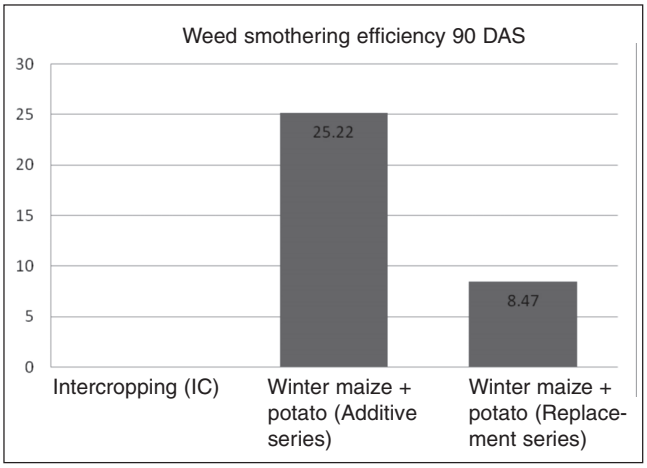

Fig. 2. Effect of intercropping treatments on weed-smothering efficiency in winter maize + potato intercropping system at 90 days after sowing

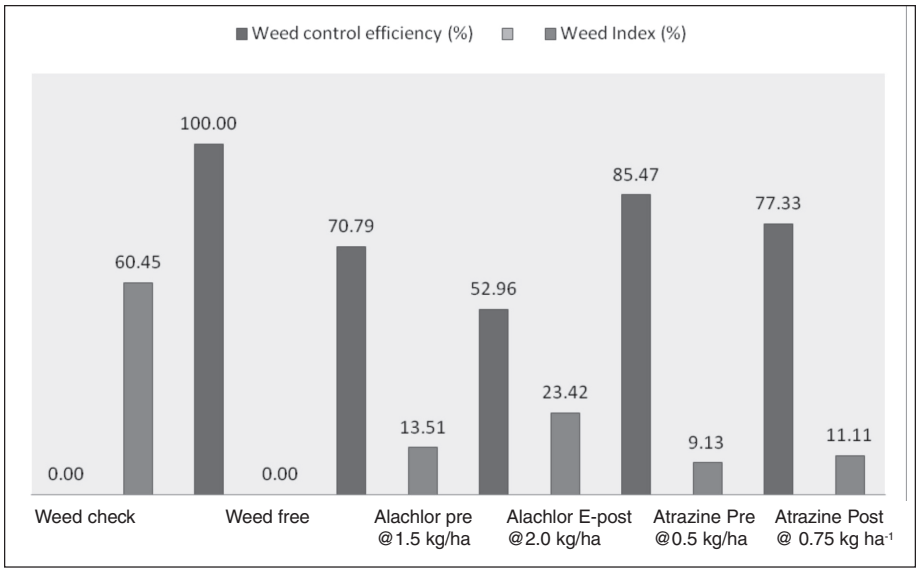

Fig. 1. Effect of different herbicidal treatments on weed-control efficiency and weed index in winter maize + potato intercropping system

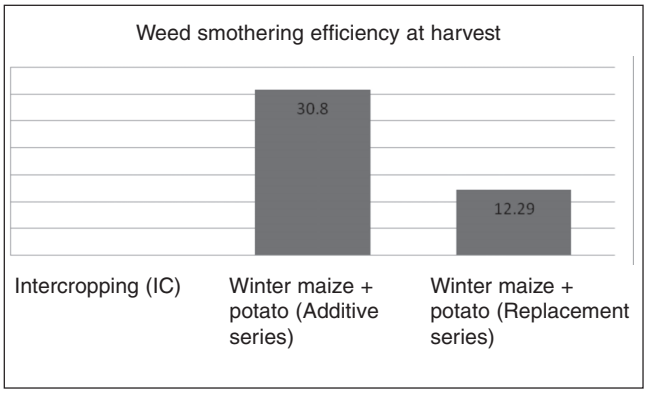

Fig. 2. Effect of intercropping treatments on weed-smothering efficiency in winter maize + potato intercropping system at harvest.

emergence application of atrazine @ 0.75 kg/ha and pre-emergence application of alachlor @ 1.5 kg/ha.

Highest maize-equivalent yield was achieved higher in winter maize + potato (additive series) and was statistically at par with sole potato. Amongst the herbicidal treatments, significantly higher maize-equivalent yield was recorded with pre-emergence application of Alachlor @ 1.5 kg/ha which was statistically at par with pre-emergence application of atrazine @ 0.5 kg/ha due to superiority in yield attributes of crop components.

Nutrient dynamics by weed and crop

Significantly lowest depletion of NPK (8.93 kg N, 3.20 kg P_2O_5 and 9.49 K_2O kg/ha) was recorded with winter maize + potato (additive series) due to efficient control of weeds which resulted in lowest weed dry matter (Table 3). Maximum removal of N, P and K by weeds was recorded in weedy check due to higher dry matter of weeds which enabled them to absorb more nutrients. Pre-emergence application of atrazine @ 0.5 kg/ha resulted in significantly lowest N, P and K uptake by weeds which was followed by post-emergence application of atrazine @ 0.75 kg/ha, whereas significantly highest values of N, P and K uptake by weeds were recorded with alachlor E-POST @ 2.0 kg/ha which showed relatively lower efficacy against weed infestation.

Higher uptake of NPK of grains was recorded in winter maize + potato (additive series) due to higher biomass of crops. The total uptake of N, P and K by grains of winter maize was found to be significantly higher in weed-free conditions. All the herbicidal treatments recorded significantly higher total nutrient uptake than the weedy check. The highest N, P and K (124.92 kg N, 30.66 kg P_2O_5 and 126.84 kg K_2O/ha) uptake was recorded with atrazine pre-emergence @ 0.5 kg/ha which was statistically at par with alachlor pre-emergence @ 1.5 kg/ha (Table 3). The results confirm the findings of Mundra *et al*. (2002).

Economics

All the maize-based intercropping system recorded significantly higher net returns and benefit: cost ratio compared to sole winter maize. Maximum net profit was recorded in winter maize + potato (additive series) but higher benefit: cost ratio was recorded with winter maize

Table 2. Effect of intercropping and weed-management on yield and economics of maize + potato of the intercropping system (pooled data of 2 years)

Treatment	Maize (t/ha)	Potato (t/ha)	MEY* (t/ha)	Cost of cultivation (×10³ ₹/ha)	Net returns (×10³ ₹/ha)	Benefit: cost ratio
Intercropping						
Sole maize	4.8	-	4.8	14.4	26.1	1.9
Sole potato	-	23.7	15.3	47.0	83.2	1.8
Winter maize + potato (additive series)	3.6	19.2	15.9	44.2	92.1	2.1
Winter maize + potato (replacement series)	2.3	14.5	11.7	30.6	69.1	2.3
SEm±	0.06	0.3	0.2	-	-	-
CD (P=0.05)	0.14	0.9	0.5	-	-	-
Weed management						
Weedy check	1.75	12.3	7.3	31.5	30.3	0.9
Weed free	4.4	21.5	13.8	43.2	74.1	1.6
Alachlor pre @ 1.5 kg/ha	3.8	20.9	13.0	32.7	78.1	2.4
Alachlor early post @ 2.0 kg/ha	3.4	20.1	12.3	33.0	71.8	2.2
Atrazine pre @ 0.5 kg/ha	4.0	20.5	12.9	32.0	78.5	2.5
Atrazine post @ 0.75 kg/ha	3.9	19.4	12.3	32.1	72.9	2.4
SEm±	0.06	0.03	0.1	-	-	-
CD (P=0.05)	0.13	0.7	0.3	-	-	-

MEY, Maize-equivalent yield

Table 3. Effect of intercropping and weed management on N, P and K uptake by crops and weeds under maize + potato system (pooled data of 2 years)

Treatment	Nutrient removal by crops (kg/ha)			Nutrient uptake by weeds (kg/ha)		
	Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium
Intercropping						
Sole maize	62.7	28.1	65.6	12.5	4.3	14.5
Sole potato	124.9	19.5	122.7	17.7	4.0	19.6
Winter maize + potato (additive series)	150.2	33.6	149.5	8.9	3.2	9.4
Winter maize + potato (replacement series)	116.5	29.4	123.6	11.0	4.0	13.7
SEm±	1.15	0.39	1.44	0.17	0.09	0.40
CD (P=0.05)	3.32	1.14	4.01	0.48	0.28	1.08
Weed management						
Weedy check	64.1	15.1	66.6	33.6	10.6	40.3
Weed free	139.6	35.3	139.7	0.0	0.0	0.0
Alachlor pre @ 1.5 kg/ha	123.5	30.7	127.2	10.0	3.0	10.4
Alachlor early post @ 2.0 kg/ha	111.2	26.4	115.8	15.7	5.0	17.6
Atrazine pre @ 0.5 kg/ha	124.9	30.6	126.8	6.2	1.7	7.1
Atrazine post @ 0.75 kg/ha	118.3	27.6	116.0	9.5	2.8	10.4
SEm±	0.74	0.33	0.73	0.18	0.08	0.25
CD (P=0.05)	2.57	0.96	2.14	0.59	0.22	0.74

+ potato grown in replacement series. All the weed-control treatments gave considerably higher net profit over weedy check (Table 2). Higher net returns and benefit: cost ratio were recorded in atrazine pre-emergence @ 0.5 kg/ha, followed by alachlor pre-emergence @ 1.5 kg/ha and atrazine post-emergence @ 0.75 kg/ha.

Based on 2 years study, it was concluded that winter maize + potato intercropping system along with the application of atrazine pre-emergence @ 0.50 kg/ ha and alachlor pre-emergence @ 1.5 kg/ ha was found effective in reducing weed population and resulted in higher economic returns.

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