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Integrated weed management in maize

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Abstract

A field experiment was conducted to find out the integrated effect of cultural and chemical weed control methods to manage weeds in maize during *kharif* 2004 and 2005 at Palampur. Intercropping of soybean with maize resulted in significant reduction in the population of *Digitaria sanguinalis*, the most predominant weed (45.7%) and increased the grain yield of maize by 60.9% over unweeded solid maize. Intercropping of soybean with maize (1:1) in combination with pre-emergence metolochlor at 1.0 kg ha^{-1} resulted in significantly higher grain yield of maize with additional yield of soybean by reducing the population and dry weight of weeds. Application of atrazine 1.5 kg ha^{-1} followed by (*fb*) atrazine 0.75 kg ha^{-1} and atrazine 1.0 kg *fb* atrazine 0.75 kg ha^{-1} behaving statistically similar recorded significantly lower total weed dry weight, were the next superior treatments in increasing grain yield of maize. These two treatments provided season long control of weeds particularly that of *Ageratum conyzoides* which in other treatments increased the total weed count as well as total weed dry weight. Weeds in unweeded solid maize reduced the grain yield of maize by 59.7 and 61.5% over best treatment of maize + soybean in integration with metolachlor 1.0 kg/ha during 2004 and 2005, respectively. Intercropping of soybean with maize (1:1) in combination with metolochlor 1.0 kg ha^{-1} resulted in significantly higher maize equivalent yield and thereby net returns over unweeded solid maize. This was followed by intercropping of soybean with maize (1:1) in combination with hand weeding. Weed index was lowest and treatment efficiency index, weed management index, agronomic management index and integrated weed management index were highest under intercropping coupled with metolachlor followed by intercropping supplemented with hand weeding. Crop resistance index was highest under closer spacing coupled with mulch and hand weeding followed by closer spacing in combination with mulch and atrazine, intercropping with hand weeding and intercropping with metolachlor.

Key words: Integrated weed management, maize, maize equivalent yield.

Introduction

Being a rainy season crop, maize (*Zea mays*) is heavily infested with weeds from the time it is sown till harvesting. This is because of frequent rains encouraging several flushes of weeds, hot and humid climate congenial for the growth of weeds especially grasses, wider row spacing and increased use of fertilizers. Hoeing 20 days after sowing (DAS) followed by earthing up 40-50 DAS or mechanical weeding with bullock's (30-35 DAS) is the prevalent practice for managing weeds throughout the state. The weeds appearing thereafter are used to feed animals. The weed fodder is nutritionally poor, therefore, it is not a viable practice. Sowing maize in closer spacing and harvesting alternate rows in the silking stage gives additional yield of fodder without affecting grain yield. Atrazine is the commonly used herbicide in maize. Its pre- and early post-emergence application is the most effective. *Ageratum conyzoides* appearing at the tasseling stage of the maize was advocated to be suppressed by another application of atrazine at two to three leaf stage of the weed. Intercropping of soybean has been reported to reduce weed pressures in maize considerably (Tripathi and Singh, 1987). Pendimethalin and metolachlor are the important herbicides for controlling weeds in maize + soybean inter-cropping system. Herbicide combinations have an added advantage of broader activity spectrum (Walia *et al* 2007; Rana *et al*, 1998). Therefore, keeping the

above facts in view, the present investigation was undertaken.

Materials and Methods

A field experiment was conducted during the two consecutive *kharif* seasons of 2004 and 2005 at Palampur. The soil of the test site was silty clay loam in texture, acidic in reaction (pH 5.6) and medium in available N (284.8 kg/ha), P (14.6 kg/ha) and K (268 kg/ha). Twelve treatments consisted of intercropping of soybean between two rows of maize (1:1) in combination with unweeded check, pendimethalin (1.0 kg/ha), metolachlor 1.0 kg/ha and one hand weeding, solid maize in combination with unweeded check, handweeding 30 DAS *fb* atrazine 1.0 kg/ha, atrazine 1.5 kg/ha *fb* atrazine 0.75 kg/ha, atrazine 1.0 kg/ha *fb* atrazine 0.75 kg/ha, mechanical weeding at 20 DAS *fb* atrazine 1.0 kg/ha, tank mix application of pendimethalin 0.75 kg/ha + atrazine 0.75 kg/ha, maize-closer row spacing of 30 cm (harvesting of alternate rows for fodder purpose) + mulch for 30 DAS *fb* 1 hand weeding and maize closer row spacing of 30 cm (harvesting of alternate rows for fodder purpose) + mulch for 30 DAS *fb* atrazine 1.0 kg/ha were tested in randomized block design with three replications. Mulch as per the treatment was applied using farm waste cum weeds at 5 t/ha. Maize Hybrid 'KH-101' was sown on June 8, 2004 and June 17, 2005 and was harvested on September 25, 2004 and October 10, 2005. The crop was fertilized with 120 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha through urea (46% N), single super phosphate (16% P_2O_5) and muriate of potash (60% K_20), respectively. The required quantity of half N and whole P_2O_5 and 40 kg K_2O was drilled at the time of sowing. The remaining half N was band placed in two equal splits at knee height and tasseling stages of crop growth. Herbicides as per treatments were applied with backpack power sprayer using 600 litre water/ha. Pre-emergence application of herbicides (pendimethalin, metolachlor and atrazine) was made within 48 hours of sowing. Rest of the management practices were followed in accordance with the recommended package of practices.

Weed count and dry weight were recorded at two spots using a quadrate of 50 cm x 50 cm and expressed as number and g m^{-2}, respectively. Yields were harvested from net plot. Economics of the treatments was computed based upon prevalent prices. Weed index (WI), crop resistance index (CRI), treatment efficiency index (TEI), weed management index (WMI), agronomic management index (AMI) and integrated weed management index (IWMI) were determined as per Walia (2003).

Results and Discussion

Weeds: *Digitaria sanguinalis* was the most predominant weed constituting 45.7% of the total weed flora. The other major weeds were *Ageratum conyzoides* (14.2%), *Polygonum alatum* (13.8%), *Commelina benghalensis* (11.4%), *Echinochloa colona* (8.7%) and *Panicum dichotomiflorum* (6.2%). Farmers practice, intercropping of soybean coupled with pendimethalin/ metolachlor/ hand weeding, pendimethalin coupled with atrazine and closer spacing coupled with mulch and atrazine during both the years and mechanical weeding fb atrazine during 2005, significantly reduced the count of *Digitaria sanguinalis* (Table 1). The superiority of pendimethalin and metolachlor in controlling *Digitaria sanguinalis* has been reported (Rana *et. al.*, 1999). Atrazine was not effective against *D. sanguinalis* as count of this weed under closer spacing + mulch + atrizine and atrazine 1.0-1.5 + atrazine 0.75 kg ha^{-1} was not significantly different from its count under unweeded check. *Digitaria sanguinalis* resistance to atrazine has also been documented (Cheema *et. al.* 1991). The population

of *Panicum dichotomiflorum* was significantly lower under intercropping of soybean *fb.* pendimethalin or metolachlor and pendimethalin + atrazine in 2005. Count of *Commelina benghalensis* was significantly lower in farmers' practice, mechanical weeding fb atrazine, closer spacing coupled with mulch and hand weeding and intercropping + metolachlor over the unweeded check. There was a tremendous build up of *Commelina* in the pendimethalin treated plots and its population under intercropping + pendimethalin treated plots was significantly higher than unweeded check. The population of *Commelina* as well as *Ageratum* also appeared to be suppressed in the weedy check due to competition from grassy weeds especially *D. sanguinalis*. *Ageratum* appeared in the field at the tasseling stage of the maize. Its population was considerably higher under all the treatments except atrazine treated plots. The populations of *Echinochloa* and *Polygonum* appeared to be contagious or random in distribution rather than uniform. Therefore, in spite of wide variation in treatment effects, their count was not significantly affected.

All the treatments (Table 2) significantly reduced total weed dry weight in 2005. However, intercropping of soybean alone and in integration with pendimethalin and closer spacing coupled with mulch and hand weeding did not significantly affect total weed dry weight over the unweeded solid maize in 2004. Intercropping of soybean supplemented with hand weeding being at par with intercropping with metolachlor, closer spacing with mulch and hand weeding/atrazine, pendimethalin + atrazine and atrazine 1-1.5 *fb* atrazine 0.75 kg ha^{-1} resulted in significantly lower total weed dry weight in 2004. Atrazine 1.5 *fb* atrazine 0.75 kg ha^{-1} remaining at par with atrazine 1.0 *fb* atrazine 0.75 kg ha^{-1}, intercropping of soybean alone resulted in lower total weed dry weight in 2005. Reduction in dry matter accumation of weeds with integrated treatments has also been reported by Mundra *et al* (2003) and Patel *et al* (2006).

Grain yield

All the treatments were significantly superior to weedy check in increasing the grain yield of maize (Table 2). Intercropping of soybean coupled with metolachlor resulted in highest grain yield. However, this was at par with intercropping + hand weeding during both the years and mechanical weeding + atrazine, closer spacing coupled with mulch and hand weeding, atrazine 1-1.5 + atrazine 0.75 and intercropping with pendimethalin during 2005. The magnitude of increase in yield owing to intercropping of soybean coupled with metolachlor over the unweeded solid maize was 148.3 and 160.2% during 2004 and 2005, respectively. Intercropping alone could increase maize grain yield over unweeded solid maize by 57.2 and 67.3% during 2004 and 2005, respectively, besides additional yield of soybean by suppressing the weeds effectively. Tripathi and Singh (1987) also obtained significantly higher maize grain yield with superior weed control due to intercropping. Intercropping alone was comparable to farmers' practice of hoeing 20 DAS followed by earthing up 40-50 DAS. Closer spacing + mulch for 30 days + hand weeding/atrazine not only gave additional green fodder yield but comparable maize grain yield as farmers' practice (Table 2). Maize stover and soybean straw yield followed the same trend as their grain yields (Table 3).

Maize grain equivalent yield

All weed control treatments were significantly superior to weedy check in influencing maize grain equiyalent yield (Table 3). Maize grain equivalent yield was significantly higher under

Table 1. Effect of different treatments on species wise weed count (No m^{-2}) at 90 DAS in maize

Treatment	*Echinochloa*		*Digitaria*		*Panicum*		*Cyperus*	*Commelina*		*Ageratum*		*Polygonum*
	2004	2005	2004	2005	2004	2005	2004	2004	2005	2004	2005	2004
Maize + Soybean (1:1)												
Unweeded	5.9 (58.6)	4.7 (26.6)	5.7 (34.6)	6.7 (61.3)	1.6 (2.6)	3.1 (9.3)	1.4 (1.3)	7.3 (74.6)	7.3 (53.3)	1.6 (2.6)	3.2 (20.0)	3.0 (16.0)
Pendimethalin 1.0 kg/ha	1.6 (2.6)	3.1 (12.0)	1.4 (1.3)	2.1 (6.6)	1.0 (0.0)	1.6 (2.6)	1.4 (1.3)	8.5 (80.0)	8.9 (80.0)	10.4 (112.0)	20.0 (400.0)	1.0 (0.0)
Metolachlor 1.0 kg/ha	1.0 (0.0)	2.8 (13.3)	1.4 (1.3)	2.7 (8.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	2.6 (8.0)	10.3 (106.6)	25.3 (566.6)	1.0 (0.0)
Hand weeding (HW)	1.4 (1.3)	5.1 (26.6)	2.6 (8.0)	2.9 (12.0)	1.4 (1.3)	3.6 (13.3)	1.4 (1.3)	2.2 (5.3)	2.1 (6.6)	12.7 (162.6)	20.9 (437.3)	1.4 (1.3)
Maize												
Mechanical weeding *fb* atrazine 1.0 kg/ha	1.0 (0.0)	4.2 (17.3)	9.1 (120.0)	2.1 (6.6)	2.7(9.3)	4.2 (17.3)	1.0 (0.0)	1.4 (1.3)	2.0 (4.0)	4.3 (28.0)	29.5 (873.3)	1.0 (0.0)
Closer spacing + mulch *fb* HW	3.5 (18.6)	4.1 (17.3)	3.1 (12.0)	3.1 (9.3)	1.6 (2.6)	3.7 (13.3)	1.4 (1.3)	1.6 (2.6)	2.0 (4.0)	15.0 (229.3)	36.4 (133.3)	1.0 (0.0)
Closer spacing + mulch *fb* atrazine 1.0 kg/ha	6.0 (50.6)	3.7 (13.3)	11.5 (133.3)	8.5 (72.0)	3.6 (13.3)	5.1 (25.3)	1.0 (0.0)	4.5 (29.3)	7.6 (61.3)	1.8 (4.0)	2.8 (9.3)	1.0 (0.0)
Pendimethalin 0.75 + atrazine 0.75 kg/ha	1.4 (1.3)	2.2 (6.6)	4.7 (29.3)	3.1 (12.0)	2.0 (4.0)	1.4 (1.3)	1.4 (1.3)	4.9 (33.3)	7.3 (61.3)	6.0 (44.0)	20.9 (409.3)	1.4 (1.3)
Atrazine 1.50 *fb* atrazine 0.75 kg/ha	1.0 (0.0)	3.9 (14.6)	10.2 (120.0)	8.0 (64.0)	1.0 (0.0)	4.4 (20.0)	1.0 (0.0)	2.4 (5.3)	3.6 (17.3)	3.5 (18.6)	1.0 (0.0)	1.0 (0.0)
Atrazine 1.0 *fb* atrazine 0.75 kg/ha	2.5 (10.6)	4.5 (20.0)	9.6 (106.6)	9.4 (88.0)	2.6 (12.0)	5.1 (25.3)	1.0 (0.0)	2.7 (9.3)	5.2 (28.0)	5.3 (46.6)	1.0 (0.0)	1.0 (0.0)
Farmer's practice	2.8 (13.3)	3.7 (13.3)	1.0 (0.0)	1.4 (1.3)	2.2 (5.3)	3.7 (13.3)	1.0 (0.0)	2.5 (6.6)	1.4 (1.3)	22.5 (532.0)	35.6 (1273.3)	1.0 (0.0)
Unweeded	3.1 (13.3)	4.0 (20.0)	8.8 (110.6)	8.0 (65.3)	3.0 (10.6)	3.3 (13.3)	1.0 (0.0)	3.0 (9.3)	5.7 (34.6)	6.0 (44.0)	3.0 (10.6)	4.8 (53.3)
CD (P=0.05)	NS	NS	6.17	3.6	NS	1.4	NS	4.1	3.01	5.4	3.92	NS

Values given in the parentheses are the original means

Table 2. Effect of different treatments on total weed count (90 DAS), total dry matter accumulation (90 DAS) and grain yield of maize

Treatments	Total weed count (No m^{-2})		Total weed dry weight (g m^{-2})		Grain yield (kg ha^{-1})				Green fodder/grass yield (q ha^{-1})	
					Maize		Soybean			
	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005
Maize + Soybean (1:1)										
Unweeded	13.7 (197.3)	3.0 (170.6)	8.7 (86.3)	6.7 (45.2)	5133	3151	116	212	-	-
Pendimethalin 1.0 kg/ha	13.1 (190.6)	22.4 (501.3)	8.1 (67.2)	8.7 (75.8)	6466	4164	134	244	-	-
Metolachlor 1.0 kg/ha	11.0 (121.3)	24.2 (596.0)	5.4 (29.3)	8.1 (66.6)	8111	4900	139	254	-	-
Hand weeding (HW)	13.5 (182.7)	22.2 (496.0)	4.2 (17.3)	8.2 (70.4)	7889	4295	161	294	-	-
Maize										
Mechanical weeding *fb* atrazine 1.0 kg/ha	11.7 (160.0)	30.3 (918.6)	6.1 (47.2)	8.0 (63.3)	6533	4180	-	-	-	-
Closer spacing + mulch *fb* HW	16.3 (268.0)	37.0 (1376.0)	7.6 (57.3)	9.1 (83.3)	6600	4043	-	-	62.2	75.2
Closer spacing + mulch *fb* atrazine 1.0 kg/ha	14.6 (217.3)	13.4 (181.3)	10.5 (111.4)	7.7 (59.2)	5066	3808	-	-	86.6	78.6
Pendimethalin 0.75 + atrazine 0.75 kg/ha	10.5 (122.0)	20.0 (490.6)	5.8 (32.8)	9.3 (87.6)	5267	3563	-	-	-	-
Atrazine 1.50 *fb* atrazine 0.75 kg/ha	11.9 (146.6)	10.8 (116.0)	6.1 (39.7)	5.4 (29.8)	5533	4121	-	-	-	-
Atrazine 1.0 *fb* atrazine 0.75 kg/ha	13.6 (185.3)	12.7 (161.3)	7.0 (52.0)	7.0 (49.1)	6400	4277	-	-	-	-
Farmer's practice	14.1 (202.6)	36.0 (1302.6)	7.7 (59.6)	7.5 (56.4)	5711	3450	-	-	35.9	28.9
Unweeded	23.0 (257.3)	11.8 (114.0)	11.2 (126.7)	6.7 (45.3)	3266	1883	-	-	-	-
CD (P=0.05)	5.96	3.43	3.57	1.68	1179	1216	-	-	-	-

Values given in the parentheses are the original means

intercropping of soybean *fb* metolachlor or hand weeding. The extent of increase in maize grain equivalent yield due to intercropping + metolachlor and intercropping + hand weeding over the unweeded solid maize was 178.1 and 166.0%, respectively. The next superior treatment in increasing maize grain equivalent yield was intercropping coupled with pendimethalin. However, it was at par with mechanical weeding *fb* atrazine, closer spacing + mulch + hand weeding and atrazine 1-1.5 + atrazine 0.75 kg ha.

Net return

Owing to higher maize grain equivalent yield, intercropping + metolachlor resulted in highest net returns over unweeded solid maize. This was followed by intercropping + hand weeding. Intercropping + metolachlor and intercropping + hand weeding gave Rs 15976/ha and Rs 10211/ha more net returns over weedy as compared to the farmers' practice (Table 3). All the other treatments except pendimethalin + atrazine and intercropping alone were also superior to farmers' practice in influencing net returns over weedy check. However, due to the low cost of the herbicide, atrazine 1.5 + atrazine 0.75 kg/ha and atrazine 1.5 + atrazine 0.75 kg/ha gave higher marginal benefit cost ratio of 13.5 and 8.98, respectively. These were followed by pendimethalin + atrazine, intercropping + metolachlor and mechanical weeding + atrazine.

Impact assessment

In the present investigation, treatments were imposed over a long span of time, the weed biomass production may not exactly decides the extent of crop yield loss. Also the wide row spacing offers a lot of non-competitive area for the emergence and growth of several flushes of weeds. However, a treatment which keeps the weeds below the threshold levels especially at the critical period of crop weed competition is desirable. Therefore, to provide a logistic support to treatment results and draw appropriate conclusions, indices like WCE, TEI, WMI, AMI, IWMI, crop resistance index (CRI) were worked out and presented in Table 4. The WCE under different treatments ranged from 46.4 in intercropping + metolachlor to 64.3% only in pendimethalin + atrazine. The grain yield of maize was negatively associated with weed biomass (r=0.59).

TEI which indicates the weed killing potential of a treatment and their influence on the crop, was highest under intercropping + metolachlor, followed by intercropping + hand weeding. WMI, AMI and IWMI were also highest under intercropping + metolachlor *fb* intercropping + hand weeding, intercropping + pendimethalin, closer spacing + mulch + hand weeding and mechanical weeding + hand weeding in that order. Weed index is a measure of the efficacy of a treatment when compared with farmers practice was lower under intercropping + metolachlor followed by intercropping + HW, mechanical weeding + atrazine, atrazine 1.0 + atrazine 0.75 kg ha^{-1} and closer spacing + mulch + hand weeding. CRI was highest under closer spacing + mulch + hand weeding *fb* closer spacing + mulch + atrazine, intercropping + hand weeding, intercropping + metolachlor and atrazine 1.0 + atrazine 0.75 kg ha^{-1}. From the present investigation it may be concluded that intercropping of soybean with maize (1:1) in combination with pre-emergence metolochlor at 1.0 kg ha^{-1} was the most viable proposition in producing higher grain yield of maize with additional yield of soybean. In pure maize, atrazine 1.5 kg ha^{-1} followed by (*fb*) atrazine 0.75 kg ha^{-1} and atrazine 1.0 kg *fb* atrazine 0.75 kg ha^{-1} were the superior treatments in suppressing weeds and increasing grain yield of maize.

Table 3. Effect of treatments on maize stover, soybean haulm, maize grain equivalent yield and economics

Treatments	Maize stover (kg ha^{-1})		Soybean haulm yield (kg ha^{-1})		Maize grain equivalent yield (kg ha^{-1})			Gross return over weedy (Rs ha^{-1})	Net return over weedy (Rs ha^{-1})	MBCR
	2004	2005	2004	2005	2004	2005	Mean			
Maize + Soybean (1:1)										
Unweeded	6930	4569	128	254	5520	3858	4689	15454	11964	3.43
Pendimethalin 1.0 kg/ha	8730	6038	147	293	6913	4977	5945	24812	19542	3.71
Metolachlor 1.0 kg/ha	10949	7105	153	305	8574	5747	7161	33980	29560	6.69
Hand weeding (HW)	10650	6228	177	353	8425	5275	6850	31485	23795	3.09
Maize										
Mechanical weeding *fb* atrazine 1.0 kg/ha	8820	6061			6533	4180	5357	20969	17939	5.92
Closer spacing + mulch *fb* HW	8910	5862			6600	4043	5322	27733	19488	2.36
Closer spacing + mulch *fb* atrazine 1.0 kg/ha	6840	5522			5066	3808	4437	22257	17732	3.92
Pendimethalin 0.75 + atrazine 0.75 kg/ha	7110	5166			5267	3563	4415	13942	12162	6.83
Atrazine 1.50 *fb* atrazine 0.75 kg/ha	7470	5975			5533	4121	4827	16818	15133	8.98
Atrazine 1.0 *fb* atrazine 0.75 kg/ha	8640	6202			6400	4277	5339	20811	19376	13.50
Farmer's practice	7709	5003			5711	3450	4581	18064	13584	3.03
Unweeded	4409	2730			3266	1883	2575	-	-	-
CD (P=0.05)					1179	1216	1198	-	-	-

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Table 4. Effect of treatments on different indices

Treatments	WCE	TEI	WMI	AMI	IWMI	WI	CRI
Maize + Soybean (1:1)							
Unweeded	53.1	1.36	1.1	0.10	0.60	9.57	3.6
Pendimethalin 1.0 kg/ha	48.7	2.18	2.08	1.08	1.58	-16.04	4.24
Metolachlor 1.0 kg/ha	46.4	2.99	3.12	2.12	2.62	-42.00	4.95
Hand weeding (HW)	49.4	2.87	2.61	1.61	2.11	-33.0	4.97
Maize							
Mechanical weeding *fb* atrazine 1.0 kg/ha	54.6	2.38	1.98	0.98	1.48	-16.9	4.58
Closer spacing + mulch *fb* HW	52.3	2.24	2.04	1.04	1.54	-16.2	6.33
Closer spacing + mulch *fb* atrazine 1.0 kg/ha	51.0	1.48	1.42	0.42	0.92	3.1	5.86
Pendimethalin 0.75 + atrazine 0.75 kg/ha	64.3	2.00	1.11	0.11	0.61	3.6	4.81
Atrazine 1.50 *fb* atrazine 0.75 kg/ha	61.6	2.28	1.42	0.42	0.92	-5.4	4.89
Atrazine 1.0 *fb* atrazine 0.75 kg/ha	54.4	2.35	1.97	0.97	1.47	-16.5	4.56
Farmer's practice	56.9	1.81	1.37	0.37	0.87	-	4.13
Unweeded						43.8	1.0
CD (P=0.05)	-	-	-				

WCE. Weed control efficiency: TEI. treatment efficiency index: WMI. weed management index: AMI. agronomic management index: IWMI. integrated weed management index: WI. weed index and CRI. crop resistance index

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References

Cheema SS, Dhaliwal DK and Sahota TS 1991. Agronomy: Theory and Digest, Kalyani Publishers 1/1, Rajendra Nagar, Ludhiana, pp 274.

Mundra SL, Vyas AK and Maliwal PL 2003. Effect of weed and nutrient management on weed growth and productivity of maize (*Zea mays* L.). Indian J. Weed Sci. **35**: 57-61.

Patel VJ, Upadaya PN, Patel JB and Meisuriya MI 2006. Effect of herbicide mixtures on weeds in *kharif* maize in middle of Gujarat conditions. Indian J. Weed Sci. **38**: 57.

Rana SS, Sharma JJ and Manuja S 1998. Evaluation of promising herbicide mixtures for weed control in maize (*Zea mays* L.). New Agriculturist **9** (1& 2): 1-5.

Rana SS, Rana RS, Jangpo B and Angiras NN 1999. Studies on integrated weed management in rajmash (*Phaseolus vulgaris* L.) under Sangla valley conditions of Himachal Pradesh. Indian J. Weed Sci. **31**(3&4): 218-21.

Tripathi B and Singh CM 1987. Weed control in maize and maize + soybean intercropping systems. Indian J. Weed Sci. **19** (1&2): 1-8.

Walia US, Singh S and Singh B 2007. Integrateed control of hardy weeds in maize (*Zea mays* L.). Indian J. Weed Sci. **39** (1&2): 17-20.

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