Weed Control in Maize through Triazine Herbicides

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Maize, an important *kharif* crop of India, is invaded by a wide spectrum of grassy and broad-leaved weeds which grow luxuriently due to favourable conditions of moisture and temperature throughout the growing season of the crop. A heavy loss in grain yield due to weed-competition has been estimated in this crop (Nizamuddin and Rehman 1960; Sharma *at al*; 1965; Mani *et al* 1967). The weed competition in the early crop growth results in more yield reduction than in the latter period (Moolani, 1965).

Popular methods of weed control in maize in the farmer's fields still include hand weeding or hoeing in between the crop rows. Promising chemicals can supplement cultivation in such crop and is also very necessary to advace and intensify maize growing, since older methods are time taking and expensive. For the last two decades 2, 4-D has been extensively tried all over the country on various crops including maize (Anon, 1958; Nizamuddin and Rehman, 1960) which still has limitted scope in view of the fact that 2, 4-D is not an effective herbicide for grass-weed control. In recent years triazine herbicides have been found effective on grassy and nongrassy weeds in maize (Gupta and Gangwar 1966; Saghir and Chaudhary 1967; Mani *et al*. 1966) but their recommended doses appear to be high and more expensive than manual method of weeding. (Singh and Singh 1966; Roy and Sharma, 1968) which may further limit the cultivation due to longer persistance in the soil.

To find out an effective, econcmics & optimum dose of a soil-applied herbicide for weed control in accordance with soil, weather and cropping programme, a field investigation was undertaken during the *kharif* season of 1966-67 and 1967-68 at the Agroncmy Research area of Punjab Agricultural University, Hissar (Haryana).

MATERIALS AND METHODS

The soil of the experimental field was sandy loam with medium fertility. Rainfall and the temprature during the experimental period is given in table 1.

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Table I :— Meterological Data for the Experimental Period.

Months	Max. Temperature °C			Min. Temperature °C			Rainfall in m.m.		
	1966	1967	Average	1966	1967	Average	1966	1967	Average
July	37.5	36.3	36 9	25.0	24.3	24.6	38 5	165 0	101.7
August	33.0	33 8	33.4	23 0	23.8	23.4	225.0	212.8	218,9
September	32.5	34.1	33,3	21.5	23.1	22.3	130.0	45.8	87.9
October	31.0	35.0	33,0	19.5	23 0	21.2	—	3.1	1.5
Average	33,5	34.8	341.5	22.2	23.5	22 8	98.3	106.6	1025

Various mechanical and chemical methods of weed control in maize were included in the trial. Treatments given below were replicated thrice in a Randomised block design.

Treatments	*Symbol*
Unweeded control	T_0
Weeded control	T_W
Interculture	T_1
Simazine @ 1 kg a. i./ha (pre-em.)	S_1
Simaziue @ 1 kg a. i./ha (pre-em) + Interculture	S_1H
Simazine @ 2 kg a. i./ha (pre-em.)	S_2
Atrazine @ 1 kg a. i./ha (pre-em.)	A_1pre.
Atrazine @ 2 kg a. i./ha (pre-em.)	A_2pre.
Atrazine @ 1 kg a. h./ha (post-em.)	A_1post
Atrazine @ 2 kg a. i./ha (post-em.)	A_2post
Interculture plus 2, 4-D amine @ 0.75 kg a e./ha (post-em.)	HD
2, 4-D amine salt @ 0.75 kg a. e /ha (post-em.)	D

Hybrid maize variety Ganga 101 was sown in 60 cm spaced rows having plant to plant distance of 30 cm in gross plots of 3 6 × 8 0 m Nitrogen in the form of calcium ammonium nitrate and P_2O_5 in form of super phosphate were applied @ 100 and 40 kg/ha, respectively.

The data on crop yield (grain and karbi) and dry weight of weeds were recorded in both years whereas observations on shoot height (33, 63 and 93 days after sowing), days to 50% taselling and plant stand at harvest were taken in 1967-68 only. The flag leaf of the plant at the initiation of taselling was also analysed for nitrogen percentage in the second year.

The residual effect of herbicides on the following crop of wheat (variety, Kalyan 227) was studied in 1967-68. Nitrogen was applied to the wheat crop @ 100 kg/ha. Weeds in the wheat crop were controlled by application of 2, 4-D (amine) @ 0.7 kg a e./ha.

The schedule of agricultural operations were as under :—

Operations / *Maize crop*	*1966-67*	*1967-68*
Sowing	20 th July	14th July
Pre-emergence treatments	1 st July	15th July
Post-emergence treatments	11th August	5th August
Weeding	3rd & 4th August	28th July & 12th August
Interculture	8th & 18th August	1st & 12th August
Irrigation	5th & 20th October	25th September and 7th October
Harvesting	1st November	24th October

RESULTS

(i) *Effect on maize growth* :— Pre-emergence treatmen: of either rates of simazine and atrazine caused yellowing of newly emerged maize foliage. However within a period of 10 days the plants under low dose of simazine and both rates of atrazine regained normalacy. But the plants subjected to 2 kg a.i./ha simazine treatment took an extra period of one week to change their leaf colour into green. The plant mortality was also observed in this treatment. The treatment of atrazine has given comparatively less set back of crop growth than simazine. Post-emergence application of atrazine and 2, 4-D could not show any adverse effect on growth of crop.

Pre-emergence applications of simazine @ 2 kg a.i./ha stunted the plant height, delayed reproductive growth and lowered the final stand of the crop. The inhibitions in growth in this treatment was more pronounced in the early growth stage (Table 2). Growth and final stand of the crop was poor in the treatments of control, 2, 4-D amine and hand hoeing.

(ii) *Effect on crop yield* :— Pre-emergence application of either of simazine or atrazine at 1 kg a. i. / ha gave maximum increase in maize yield (Table 3). Amongst the different weed control treatments, pre-emergence application of simazine @ 2 kg a. i./ha produced the lowest yield.

Table 2 :— Effect of treatments on Maize Growth (1667-68)

Treatments	Plant Height* (cm)			Days needed for 50% tasselling	Plant stand/ ha at harvest
	33	63	93		
T_o	27.3	168.0	170.5	58	34,800
T_W	29.0	182.1	184 6	58	40,800
T_H	27.9	175.1	178.0	59	31,200
S_1	24.2	180.1	184.8	62	42.600
S_1H	32.2	180.5	184.5	62	40,800
S_2	17.0	155.5	162.1	70	36,000
A_1Pre.	24.7	187.0	190.6	61	43,200
A_2Pre.	23.3	171.9	178.7	63	43,200
A_1Post	29.5	180.7	183.4	59	44,400
A_2Post	25.7	172.9	175.8	59	46,200
HD	27.8	175.3	178.8	59	42,000
D	27.7	165.1	170.6	58	36,000

*Days after sowing.

Table 3 :— Effect of treatments on the yield of Maize and nitrogen percentage of crop and weed.

Treatments	Grain yield (q/ha)			Karbi yield (q/ha)			Nitrogen % of crop & weeds
	1966	1967	Mean	1966	1967	Mean	1967
T_o	15.00	19.52	17.26	42.56	54.58	48.57	2.10
T_W	27.50	28.93	28.21	79 26	96.24	87.75	2.63
T_H	24.40	23 15	23.77	68.50	83.33	75.91	2.36
S_1	28.33	29.76	28.54	80 25	102.19	91.22	3.61
S_1H	29.38	28.39	28.88	78.82	92.26	85.54	3.73
S_2	21.43	17.50	19 46	60.19	73.39	66.79	2.45
A_1Pre.	28.00	28 81	28 45	80.10	99 22	89.66	3.50
A_2Pre.	25.30	23.33	24.31	72.36	93.27	82.81	2.75
A_1Post	25.06	27 38	26.22	70.08	85.29	77.68	2.45
A_2Post	23.09	22 02	22.55	65.14	83.33	74 23	2.81
HD	23.75	24.76	24.26	66.37	59.52	62.94	2.46
D	16.61	19.76	18,18	45.06	56.84	50.95	1.93
							B. leaf weeds 3.85
							Grassy weeds 2.28
C.D. (at 1% level)	5.07	8.52					

Table 4 :— Effect of treatments on Dry weight of weeds.

Treatments	Dry Weight (q/ha)		
	1966	1967	Mean
T_0	58.19	56.54	57.36
T_W	0.00	0.00	0.00
T_H	20.75	16.84	18.79
S_1	0.00	0.00	0.00
S_1H	0.00	0.00	0.00
S_2	0.00	0.00	0.00
A_1 Pre.	0.00	0.00	0.00
A_2 Pre.	0.00	0.00	0.00
A_1 Post	12.84	14.88	13.61
A_2 Post	5.42	6.90	6.16
HD	8.40	9.94	9.20
D	55.06	54.58	54.82

Table 5:—Residual effect of treatments on the yield of wheat (1667-68)

Treatments	Yield (q/ha)	
	Grain	Straw
T_0	45.35	125.94
T_W	39.47	116.86
T_H	42.81	117.83
S_1	36.32	124.32
S_1H	41.87	125.62
S_2	43.72	116.86
A_1 Pre.	40.80	127.24
A_2 Pre.	39.99	114.58
A_1 Post	35.84	124.32
A_2 Post	37.07	99.00
HD	42.04	115.88
D	44.86	128.21

Table 6 :– Economics of treatments

Treatment	Cost of Weed control operation	Crop Value	Crop value minus treatment cost	Additional profit over control
	Rs.	Rs.	Rs.	Rs.
T_0	0.00	1451.05	1451.05	—
T_W	140.00	2413.45	2273.45	822.40
T_H	56 00	2043.45	1987.45	536.00
S_1	92 74	2453.90	2361.16	910.11
S_1H	120.74	2449.30	2328.56	877.51
S_2	178.48	1696.15	1517 67	66.62
A_1pre.	97.00	2439.80	2342.80	891 75
A_2pre.	147.00	2115.75	1928.75	477.70
A_1post	77 00	2223.80	2126.80	675.75
A_2post	147.00	1949,65	1762.65	311.60
HD	57.16	2012.20	1955.04	503.99
D	29.16	1527.35	1498.19	47.14

Basis of calculation :

Labour required/ha per weeding	20
Labour required/ha per hoeing	8
Labour wages	Rs. 3.50/day
Cost of 2, 4-D amine (720 gm/1)	Rs. 21.20/1
Cost of simazine (50% W.P.)	Rs. 42.87/kg
Cost of atrazine (50% W.P.)	Rs. 45/kg
Price of maize grain	Rs. 70/q
Price of karbi	Rs. 5/q

(iii) *Effect on weeds* :— Pre-emergence treatment of simazine and atrazine proved most effective in controlling broadleaved and grassy weeds as compared to the post-emergence application of atrazine (Table 4). Although the application of 2, 4-D controlled broadleaved weeds but proved ineffective in reducing the weight of weeds obtained at harvest.

(iv) *Residual effect on wheat yield* :— The weed control treatments given in maize did not show any significant adverse effect on the yield of the following crop of wheat variety Kalyan 227, a high yielding dwarf wheat (Table 5).

(v) *Effect on nitrogen percentage of crop and associated weeds*:—The nitrogen percentage of maize leaves was improved in all the treatments other than 2, 4-D (Table 4). The increased nitrogen was noted in the pre-emergence treatments of simazine and atrazine applied @ 1 kg a. i /ha. Broad leaf weeds contained more nitrogen than grassy weeds.

(vi) *Economics of Treatments* :— Pre-emergence application of simazine and atrazine at 1 kg a. i. / ha gave the maximum financial return of Rs 910 and Rs 891 respectively (Table 6). The next treatment was hand weeding.

DISCUSSION

The trend of treatments response to maize crop and associated weeds was almost same in both years which is to be expected because of similarity in the rainfall. The optium dose of soil applied herbicides such as simazine and atrazine is dependent on the soil type, rainfall and nature of weed infestation. Therefore, technology of weed control through such herbicides needs to be worked out for different agro-climatic regions of the country.

The findings of this experiment have already indicated the superiority of pre-emergence application of simazine or atrazine @ 1 kg a. i./ha over other weed control treatments included in the experiment. It has also been shown that in the present soil and weather conditions it is unsafe to use high doses of simazine as it retards the growth and the yield of the maize crop. However, under different conditions, Gupta and Gangwar (1966) and Roy and Sharma (1968) have recommended more than 2 kg a.i./ha. The recommendations emerged from this experiment are strictly applicable to locations where the soil is sandy loam and low in organic matter, and rainfall during the *kharif* season is below 50 cm. The lower doses ought to be preferred because of high cost of simazine in India and the minimization of risk in the successful cultivation of the subsequent crops.

Triazine herbicides inhibit the photochemical activity of isolated chloroplasts according to many investigators (Moreland, 1959; Exer, 1961). It has been also shown that these herbicides also inhibit photosynthesis in resistant species but CO_2 utilization by maize returns normal within a few weeks after treatment (Van Oorschot and Belksma, 1961). In this experiment the early growth of maize plants was invariably stunted in all the treatments of simazine and atrazine but afterwards normalacy was regained in the treatments other than simazine @ 2 kg a. i./ha. Reduction in the forage yield was obtained by Fink and Fletchall (1967) in maize subjected to simazine or atrazine treatments when harvested 5 weeks after the sowing. This is due to early growth inhibition in maize crop treated with triazine herbicides. The plants subjected to high dose of simazine took more period to recover from the growth inhibition and thus the reproductive growth was delayed. Phototoxic effects of higher doses of simazine on maize has been also reported by Saghir and Choudhari (1967) and Roy and Sharma (1968). In confrontly with the findings of others (Saghir & Choudhari, 1967; Fink & Fletchall, 1967), atrazine appears to be more selective for maize as compared to simazine.

Dry weight of weeds in 2, 4-D treatment was high inspite of its effectiveness against broad leaf weeds. This may be due to the profuse growth of grassy weeds as the result of the elimination of competition from broadleaf weeds.

Nitrogen content of maize plant was improved in accordance with reduction in the extent of weed competition and the vigour of the crop. Since high dose of simazine and atrazine has produced adverse effect on the crop growth, the nitrogen content in these treatments was less as compared with the lower rate.

Application of simazine or atrazine made to the maize crop four months before the sowing of the *rabi* crop did not show any toxic effects on wheat. Mani *et al* (1966) also did not notice any residual effect of triazine herbicides on the following crop of wheat. Therefore, pre-emergence treatment of simazine or atrazine @ 1 kg a. i./ha can easily be adopted by the cultivators in maize-wheat rotation.

SUMMARY

A field experiment on the control of weeds in hybrid maize was conducted at the Research Farm of Punjab Agricultural University, Hissar during 1966-67 and 1967-68. The soil was sandy loam and the total rainfall during the *kharif* season was less than 50 cm. The residual effect of treatments was studied on the *rabi* crop of wheat in 1967-68.

Pre-emergence application of simazine or atrazine @ 1 kg a. i./ha was found most effective in controlling broadleaf and grassy weeds in the maize

crop. These treatments gave maximum yield of maize and consequently proved to be most remunerative. The treatment of hand weeding came next to these treatments The following crop of wheat did not suffer in its yield from simazine or atrazine application made to maize.

Pre-emergence treatments of simazine and atrazine @ 1 kg a. i. / ha also increased the nitrogen uptake of the crop plant.

Simazine application @ 2 kg a. i./ha proved toxic to the maize crop and reduced the yield.

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