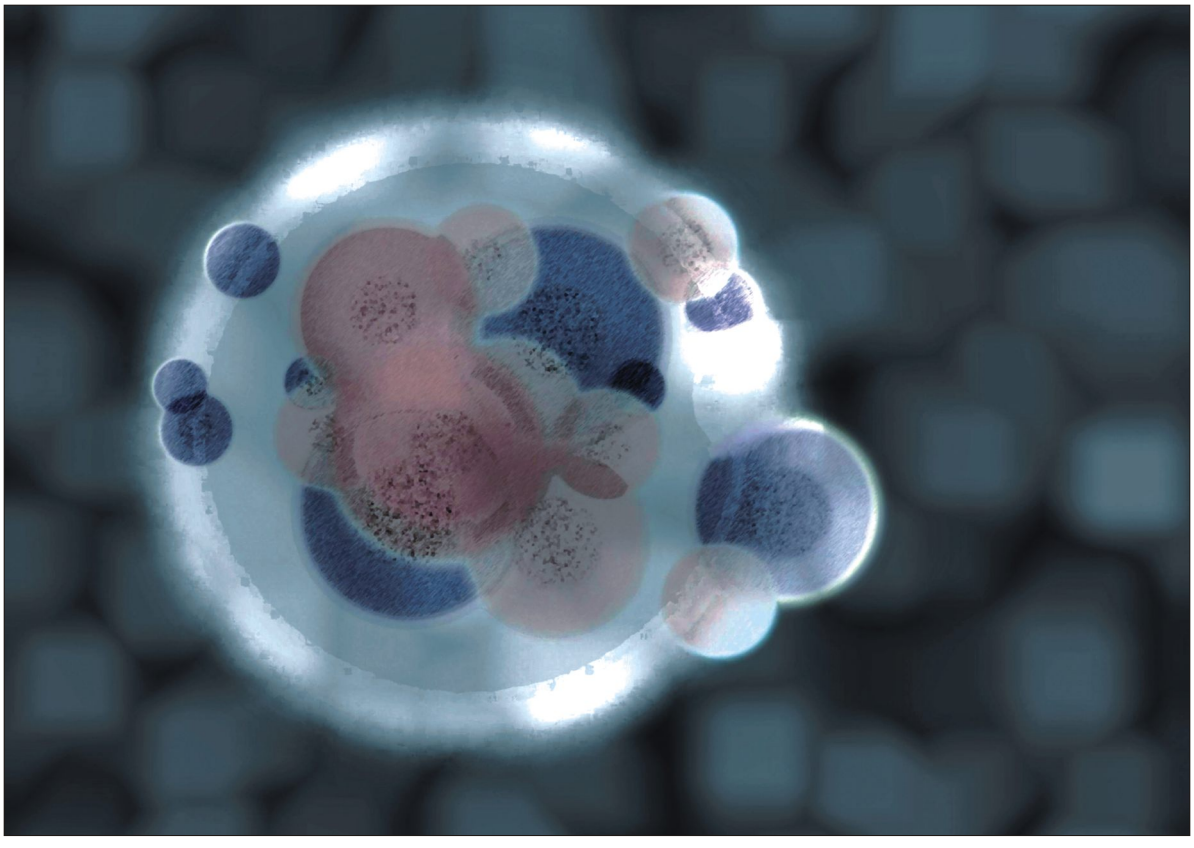

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Economic Efficacy of Different Pre- and Post-emergence Herbicides to Control Weeds in Chickpea (*Cicer arietinum* L.)

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Abstract: The study on weed control in chickpea was conducted at the National Agricultural Research Centre, Islamabad to evaluate the performance of selected Pre-emergence herbicides; ronstar, stomp, tolkin and tribunil and post-emergence herbicides; flex, fusilade and tribunil. Treatment-wise per hectare cost incurred on pre-emergence herbicides was Rs.540, Rs.247, Rs. 270 and Rs.369, whereas on post-emergence herbicides,it was Rs.36, Rs. 225, Rs.261, Rs.374, Rs. 369 and Rs.1050. These herbicides were applied alone and in combinations to study broad spectrum performance, if any. Two checks, hand weeded and weedy plots were kept for comparison of yield and economic gains. Chickpea variety was CM-72. Almost all the herbicides treated and hand weeded plots controlled the weeds density per unit area by 21 to 141% and significantly increased the grain yield by 14 to 141% or 332 kg ha^{-1} to 735 kg ha^{-1}. Amongst pre-emergence herbicides, ronstar and Stomp gave the highest net return/per rupee investment of Rs.1:3.76 and Rs.1:2.74 respectively, followed by tribunil and tolkan to the tune of Rs.1: 2.70, while the post-emergence herbicide Fusilade applied at 0.75 and 0.50 kg a.i. ha^{-1} gave net return of Rs.2.36 and 2.10. post-emergence herbicide flex followed these treatments and earned net return of Rs.1.99. Low return from flex alone or when mixed with fusilade are likely due to phytotoxicity caused by flex being non-selective against broadleaf plants. Hand weeding though gave quite reasonable yield of 776 kg ha^{-1}, yet its return were lowest because of low labor efficiency at high cost of prevailing daily wages.

Key words: Chickpea, pre. and post-emergence herbicides, weed control, Economic efficacy, Islamabad, Pakistan

Introduction

Chickpea (*Cicer arietinum* L.) is the most demanded food legumes crop of the region, therefore, preferably grown in India, Pakistan, Turkey, Sudan, Sri Lanka and Bangladesh. Its cultivated acreage in the world vary from 8.6 million ha to 9.6 million ha and production 5.9 million tonnes to 8.9 million tonnes and yield 685 to 718 kg ha^{-1}. During this period, this trend in Pakistan ranged between 0.82 to 1.04 million ha, 0.37 to 0.56 million tonnes and yield 453 to 543 kg ha^{-1}. Besides many constraints responsible for limiting per hectare production of this crop, ignorant weed has been recognized one of the most crucial factors as their losses in chickpea ranged between 11 to 57% (Ali *et al*., 1988). Ahmed (1951, 1954) reported that loss of production in the crops in Pakistan due to weeds alone were to the extent of 10%, while Hack (1968) observed annual losses in yields of crops of Pakistan due to weeds only to be worth Rs.300/-million. In Pakistan, 11.3% of the total crop losses are due to weeds as compared to world losses of 9.5% (Crammer, 1967). Gill *et al*. (1978) reported yield losses 15-50%. Ozair (1987) and Riaz (1987) observed that the magnitude of yield losses due to weed pest in summer and winter pulses ranged between 75-84%. Nabi and Ansari (1977) reported that weeds not only compete with crops for water, light and nutrient but also impart physiological disorder to man and livestock and economic resources. Malik (1983) reported that hand weeding did not increase the seed yield of chickpea, while application of 1.5 kg ha^{-1} maloran (chlorbromuron), 2.5 kg tribunil (Methbenzthiazuron) or 4 kg igran (Terbutran) ha^{-1} increased yields from 0.82 to 0.95, 0.91 and 1.41 t ha^{-1} respectively. Alhawat *et al*. (1981) investigated that clean weeding increased the yield of Bengal gram (*Cicer arietinum*), lentil (*Lens culinarus Medik*), pea (*Pisum sativum*), cowpea (*Vigna unguiculata*) and mung (*Vigna radiata*) by 107, 150, 90, 85 and 90%, respectively. Weeding only once increased yields by 72, 113, 57, 40 and 26%. Mahoney (1981) found that net returns were relatively higher with chemical weed control and resulted in seed yields of 1.87 t ha^{-1} compared with 1.34 t ha^{-1} without weed control. Ali *et al*. (1988), Bernal (1981), Pandey (1981), Mittal and Singh (1983) and Singhte *et al*. (1984) reported that the application of weedicides help in controlling weeds population, increase in grain yields and net return. Binswanger and Shethy (1977) found once hand-weeded plots of sorghum, pearl millet, groundnut, paddy, chillies, pigeonpea and chickpea increased yield by 48,40, 81, 73, 91, 40, 18 and 60% respectively. Cultural and mechanical methods of weeding are prevalent in our country, although experimental results revealed that chemical operations have been very effective and economical (Nabi and Ansari, 1977). Singhte *et al.* (1984) investigated that incessant rains during the early crop season normally limit the weeding operations, therefore, chemical weeding under such circumstances, become indispensable and can be the excellent alternate. The present study was, therefore, conducted to evaluate the effect of different weedicides for chickpea, which can be cost effective and acceptable to the growers of this crop.

Materials and Methods

The experiment was planted on 10th Nov., 1988 and 13th Nov., 1988, during rabi season at National Agricultural Research Centre, Islamabad. Chickpea variety was CM-72. The seed was drilled manually within rows at seed rate of 60 kg ha^{-1} at 30 cm inter-row spacing. Plants were thinned

four weeks after sowing to maintain optimum plant population. Per hectare NPK fertilizer was applied at 20:50:0 at the time of land preparation. Crop management practices included two pre-plant ploughing and levelling within the block with land planker. There were no rains till 3-4 weeks after planting, therefore, flood irrigation was done. Pre-emergence herbicides namely tribunil (Methabenzthiazuron 70% W.P.), stomp (Pendimethalin 4EC 75% WP), ronstar (Oxadiazon 2EC, 75% W.P. 2% granules and 4 lb flowable) and tolkan (Isoprotoron 50% W.P. flowable and formulated in different combinations) were applied at of 1.25, 1.25, 3.00 and 1.25 kg a.i. ha^{-1}, whereas post-emergence herbicides were fusilade (Fluazifopbutyl 2EC 4EC) (at both rates 0.50 and 0.75 kg a.i. ha^{-1}), flex (Fomesafen 2 L.C.), fusilade + flex, fusilade + flex, tribunil, hand weeding (twice) and weedy check. These herbicides were applied at 0.50, 0.75, 0.13, 0.50 + 0.13, 0.75 + 0.13 and 1.25 kg a.i. ha^{-1}. Data were recorded on weed control by pre. and post-emergence herbicides, visual observations and phytotoxicity effects are given in Table 1. Weedicides were applied in diluted form with water and were sprayed into the plots with a manually operated knapsack sprayer mounted with a hollow-cone type brass nozzles. Pre-emergence herbicides were applied three days after sowing, while post-emergence were applied when weeds attained 4-5 leaf growth stages. Less weed population was due to the low natural precipitation and drought Harvesting was done from three randomly selected 1 m^2 spot in each treated plot. The three samples of chickpea were pooled and threshed. The yield data was averaged and analyzed statistically. Economic analysis of the data was done using the Partial Budget Method as devised by the agriculture price comission (Agriculture Price Commission, 1989). The cost benefit ratios were calculated by dividing the extra benefits attained from the enhanced yield by the extra costs incurred for each treatment. The cost included labor charges at Rs. 30/man for 20 man days for first weeding and 15 man days for the second weeding, Herbicide prices , labor for herbicide application at Rs. 50 ha^{-1}, equipment charges at Rs. 30/day and threshing of additional yield at Rs. 10/40 kg of chickpea has been calculated and is given.

Results and Discussion

Pre-emergence herbicides: Amongst pre-emergence herbicides, pendimethalin (Stomp) at of 1.26 kg a.i. ha^{-1} though gave good weed control as observed through visual observations, caused severe crop toxicity in terms of delayed germination, stunt growth, short inter-nodes and dark green color. Except tolkan, other pre-emergence herbicides suppressed the crop growth (Table 2). In general, on an average weed control was obtained by these herbicides (Table 3). Herbicides longitivity assessed interms of weed re-growth at the end of the crop season indicated that oxadiazon (Ronstar) nicely suppressed grasses and the broad-leaf weeds to the tune of 70 and 50% respectively. Non-significant re-growth of weeds until the time of crop harvest is due to the longer persistence of the pendimethaline, which was next to the weed free check (Hand weeded plots) (Table 2). The results are inconfirmity with Singh *et al*. (1985) that fluchoralin and methabenzthiazuron at 1.5 kg ha^{-1} pre-em. increased yield by 79 and 66% respectively. Inter-cropping with wheat and sowing in narrow rows (30 cm apart) gave promising results. Buhler and Werling (1989) reported that imazaquin applied at 0.07 kg ha^{-1} controlled pre-sowing weeds 90% before no-till sowing of soybean, 95% or more of grass weeds and 83% or more of the broad-leaved weeds. Singh *et al*. (1987) found that pre.em. application of methabenzthiazuron , fluchlorolin and alachlor at 1 kg ha^{-1} controlled all weeds effectively to increase crop yield. The results are also inconfirmity with Tewari and Trivedi (1985) that emergence of weeds was highly inhibited by 0.08 kg terbutyrn, 1.0 kg oxadiazon and 1.0 kg isoproturon, all pre-em. herbicides.

Post-emergence herbicides: Fusilade at both rates of 0.50 and 0.75 kg a.i. ha^{-1} and in combination with Flex at 0.13 kg a.i. ha^{-1} controlled 100% grasses. Flex alone or with Fusilade caused slight phytotoxicity to chickpea which was however recovered at the advanced growth stages. Tribunil is recommended both as pre. and post-emergence and observed that weed control was almost similar. However, post-emergent application caused severe crop phytotoxicity (Table 2), which consequently decreased the yield. Fusilade and flex were not very persistent throughout the crop season. Relatively better control of grasses can be attributed to systemic action of fusilade due to which it inhibited or reduced re-sprouability of the perennial grasses (Table 2). At an average, stomp, ronstar, tribunil, tolkan, fusilade and flex increased grain yield by 21.2 to 141% over control upto eight weeks in chickpea. Kukula *et al*. (1985) found that weed infestation was higher in winter than in spring sown chickpea with a yield reduction of 7.5% recorded in winter-sown cv. ILC 482. Post-emergence herbicides are not recommended due to possible phytotoxic effects, however 1 kg. a.i. fusilade (Fluazifop-butyl) ha^{-1} proved selective control of grass weeds, if applied when grasses were 10-15 cm high. Winter-sown chickpea was less resistant than spring-sown crops to *O.crenata*. Similar results were also reported by Gill and Brar (1977), Gill *et al*. (1978), Misra and Tosh (1978) and Majeed *et al*. (1983). However, Gill *et al*. (1978) observed that tribunil applied after first irrigation at 4-5 leaf stage and inactive tillering was not effective against wild oats. Yadav and Singh (1988) reported that tribunil at 0.75 and 1.50 kg ha^{-1} provided the highest yields from chemical control (2.2 t and 2.08 t. resp.) followed by basalin at 0.5 and 1.0 kg (2.07 t for both rates). Fusilade was the least effective herbicide and some phytotoxicity was noted from ronstar (Oxadiazon), which was tested at 0.75-1.50 kg ha^{-1}.

All the herbicides, except nitrofen gave more than 100% higher grain yield of green gram than the unweeded control, but trifuluralin and chloramben proved more promising. In clusterbean, alachlor, trifluralin and nitrofen proved effective in controlling weeds, giving a yield equal to that of the hand-weeded treatment (Daulay and Singh, 1982). Hand-weeding also remained ineffective in controlling weeds only by 17% in both the years because of labor intensive strategy, which is even beyond the reach of resource-poor farmer (Haqqani *et al*.,1989). Similar results were reported by Gill *et al*. (1978), while Bhardwaj (1978), Misra and Tosh (1978) and Majeed *et al*. (1983) reported hand-weeding (generally 2 hoeings and one hand weeding) as better or at least comparable with chemical herbicides. Hence, it is easy to control weeds where their population is in abundance and

Table 1: Chemical, commercial and common names of herbicides, formulation doses and mode of application in chickpea crop

Chemical name	Commercial name	Common name Formulation	Herbicide"Kg A.I. ha^{-1}"	Application mode
1-3,Dimetgy1-3 (2-benzothiazoly) Urea	Tribunil	Methabenz-thiazuron	7% W.P.	1.25	Pre-emergence
N-(1-Ethylopropyl) 3,4, dimethylen 2,6, dinitro	Stomp	Pendimethalin	4EC, 75% W.P.	1.25	---do---
2-tert-butyl-4-(2,4-dichloro-5, isopropyl-oxyphesyl-1,3,4,-oxadiazo-line-5-1	Ronstar	Oxadiazon	2 EC, 75% W.P. 2% granules, and 4 lb Flowable	3.00	---do---
3-(4-isoprophyl phenyl-1-1-dimethyl Urea	Tolkan	Isoprotoron	50% w. P. flowable and formulated In different combinations	1.25	---do---
Butyl 2-(4-5 trifluoro-methyl-2-pyrindy-loxy (pgebixt) oriouibate	Fusilade	Fluazifop-butyl	2 EC, 4 EC	0.50	Post-emergence
---do---	---do---	---do---	---do---	0.75	---do---
5-(2-chloro-4--(trifluoromethyl phenoxy)-N (methyl-sulfonyl)-nitroben-zamide	Flex	Fomesafen	2 L. C.	0.13	---do---
S No. 5 + S No.7			S. No. 5 + S No.7	0.50 + 0.13	---do---
S No. 5 + S No.7				0.75 + 0.13	---do---
S No. 1	Tribunil			1.25	---do---

Note: The information has been extracted from a book entitled "Agricultural Chemicals" written by W. T. Thomson, 1983-84. Pp: 49, 165, 167, 199, 218

mostly grassy nature or broad-leaved weeds like Chenopodium,Convolouslus or Rumex spp, where weeds with less height and trailing or spread nature (*Anagalis*; *Melilotus*; *Coronopus*, *Vicia*, *Medicago* and *Fumaria spp*) are less competitive to suppress the yield.

Economic analysis: The economic analysis revealed that application of weedicides seems to be economical in all treatments over hand-weeding and more specially over control in enhancing yield level by 21 to 141% and accumulating net return over control (Table 4). Treatment-wise net return against per rupee spent was calculated to the tune of Rs.2.70, 2.74, 3.76 and 2.70 in case of pre-em. herbicides; tribunil, stomp, ronstar and tolkan, respectively. Similarly, the net gain out of the post-emergent was in the order of Rs. 2.10, 2.36, 1.99, 1.31, 0.88, 1.47 and 0.45, respectively. Stomp proved its worth in controlling weeds as a pre-emergence herbicide and earned highest net return followed by tolkan, tribunil and ronstar, whereas flex at 0.13 a.i. ha^{-1} also showed excellent performance in controlling weeds, while in combination with other chemicals, it showed inability to perform well because of its non-recipient behavior towards combining chemical ratio, which ultimately reduced the yield. Hand free (Check) though gave desireable yield of 776 kg ha^{-1} but earned low returns because of an intensive labor technology (Table 3). Similar results were reported by Bhardwaj (1978). Majeed and Hussain (1983) and Majeed *et al*. (1983) reported that amongst the herbicides and cultural practices, Dicuron M.A.60

Table 2: Visual observations for the weed control and chickpea phytotoxicity by pre and post emergence herbicides

Treatment	Rate"Kg. a.i. ha^{-1}"	Grasses	Weed category Broadleaf	Sedges	Remarks
		(Rating)[2]			
A. Pre-emergence:					
Methabenzthiazuron (Tribunil)	1.25	8	6	6	Suppressed crop
Pendimethalin (Stomp)	1.25	8	9	8	severe phtotoxicity
Oxadiazon (Ronstar)	3.00	7	8	3	---do---
Isoprotoron (Tolkan)	1.50	6	7	4	Excellent stand
B. Post-emergence:					
Fluzaifop-butyl (Fusilade)	0.50	10	0	2	Good stand, no phytotoxicity
Fluazifop-butyl (Fusilade)	0.75	10	0	2	---do---
Fomesafen (Flex)	0.13	0	8	3	Herbicide sensitive
Fluazifop-butyl + Fomesafen	0.50 +0.13	10	8	4	Phytotoxicity Supprressed growth
Fluazifop-butyl + Fomesafen	0.75 +0.13	10	10	-	---do---
Methabenzthiazuron	1.25	6	8	3	More damage than Pre-emergence
Weed free (Check)	Twice	10	10	10	Excellant stand
Weedy (Check)	None	0	0	0	Poor and suppressed canopy

Table 3: Weeds control in chickpea by Pre. And Post-emergence herbicides

Treatment	Rate "Kg. a.i. ha^{-1}"	Total weeds/m2	Weed density/m2			
			Broadleaf 2		Grasses 3	
			Total No	Control %	Total No	Control %
A. Pre-emergence:						
Methabenzthiazuron (Tribunil)	1.25	53	40	33	13	9
Pendimethalin (Stomp)	1.25	45	36	38	9	47
Oxadiazon (Ronstar)	3.00	21	14	76	7	50
Isoprotoron (Tolkan)	1.50	65	52	1	13	13
B. Post-emergence:						
Fluazifop-butyl (Fusilade)	0.50	56	49	18	7	48
Fluazifop-butyl (Fusilade)	0.75	65	54	9	11	23
Fomesafen (Flex)	0.13	90	79	33	11	23
Fluazifop-butyl + Fomesafen	0.50 +0.13	54	49	19	5	62
Fluazifop-butyl + Fomesafen	0.75 +0.13	55	49	18	6	53
Methabenzthiaz-uron	1.25	45	32	46	13	5
Weed free (Check)	Twice	53	46	24	7	47
Weedy (Check)	None	74	60	-	14	-

W.P. not only controlled the maximum weeds (96.87), but also yielded the highest return of 3.30/per rupee invested, registering an increase of 37% over control. Riaz (1987) found that application of pendimethalin at 1 kg. a.i. ha^{-1} and hand weeding at 14 and 28 days after emergence (DAE) increased yield of mungbean by 61% and earned highest cost:benefit ratio of 1:4.95. Sarwar *et al.* (1988) concluded that dicuron M.A. 60 W.P. at of 2.5 kg/h, buctril M at 1.75 l ha^{-1}, hand-weeding and bar harrowing gave higher grain yield of 55.7, 39.8, 34.9 and 11.0 percent respectively over un-weeded check, whereas maximum marginal rate of return obtained by the use of dicuron M.A. 60 W.P., buctril, hand-weeding and bar harrowing was 44.97, 38.69, 25.63 and 8.95 percent respectively. Zafar (1985) concluded that by spending one rupee on weeding with dosanex,dicuron , tribunil and hand-weeding, one can get Rs.3.60, 3.24, 2.96 and 2.65 respectively, as a return. Akobundu (1981) and Hawkins *et al.* (1971) investigated that the profitability of herbicide use was

Table 4: Economic analysis of weed control methods in chickpea of pre. and post-emergence satages

Treatment	Price Rs./Kg	Yield Kg ha^{-1}	Cost of weed-icides "Rs"	Incre-ase in yield	Value of incre-ase in yield	Expen-ses of weed control	Net return over control	Returns/per Rs. Spent
A. Pre-em:								
Tribunil	295	945	369	422	2532	685	1847	2.70
Stomp	196	1003	247	480	2880	578	2109	2.74
Ronstar	180	1261	540	738	4428	935	3493	3.76
Tolkan	180	874	270	351	2106	569	1537	2.70
B. Post-em:								
Fusilade	450	831	225	308	1848	596	1052	2.10
Fusilade	450	917	388	394	2364	703	1661	2.36
Flex	275	902	36	249	1674	560	1114	1.99
S Nos. 5 + 7		679	261	156	936	406	530	1.31
S Nos. 5 + 7		632	374	109	654	347	307	0.88
Tribunil		701	369	178	1068	433	635	1.47
Weed free (Check)		776	1050	2531	1518	1050	468	0.45
Weedy (Check)		523	-	-	-	-	-	-

very high, ranging from US $ 3.30 to 4.89/$ 1 herbicide cost. The results are also in agreement with Wilcut *et al*. (1987, 1991) that net returns ha^{-1} given by hand weeding and weed-free are $ 213 and $ 146-426 respectively. On the basis of present findings, ronstar, stomp, tolkan, tribunil are recommended as pre-emergence weedicides, while fusilade and flex as post-emergence. It is further suggested to look into the combination ratios of fusilade with Flex to make their use more effective.

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