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Weed Management and Soil Micro-organisms Studies in Irrigated Summer Groundnut (*Arachis hypogaea* L.)

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The yield of groundnut crop depends upon various agronomic management practices. One of the major factors responsible for low productivity of groundnut is the problem of weeds. Weeds not only compete with the crop for nutrients, moisture, light and space as in other crops, but also interfere in pegging and pod development resulting in poor pod yield. Uncontrolled weed growth reduced groundnut yield to the tune of 76% (Gnanamurthy and Balasubramaniyan, 1998).

Controlling the weeds with conventional method i. e. hand hoeing is not only laborious and inefficient but also expensive. Moreover, weeding becomes difficult after the initiation of reproductive stages of growth and it also hinders the pegging and pod formation. Sometimes, wet soil conditions due to frequent pre-monsoon/monsoon rains do not permit hoeing when the crop is due for this operation. In intensive farming system, the use of highly persistent herbicides poses serious residual problems to succeeding sensitive crops. On the other hand, less persistent herbicides break down soon and allow the weeds to emerge in later stages of crop growth. In view of above consideration, an integrated weed management approach is the only option for controlling weeds. The present investigation was therefore conducted to study the integrated effect of different weed control treatments on weeds, soil micro-organisms and growth and development of groundnut.

A field experiment was conducted during **kharif** 2007 at the Students' Research Farm, Department of Agronomy, Punjab Agricultural University, Ludhiana on loamy sand soil, testing low in available N and medium in P and K to study the integrated effect of different weed control treatments on weeds, soil micro-organisms as well as on growth and development of groundnut. The experiment was laid out in randomized block design with four replications comprising 14 treatments i. e. fluchloralin 0.675 kg/ha pre-plant with and without hand weeding, alachlor 1.25 kg/ha pre-emergence (pre-em.) fb one hand weeding, alachlor 2.5 kg/ha pre-em., trifluralin 0.75 kg/ha pre-plant fb one hand weeding, trifluralin alone 1.0 kg and 1.25 kg/ha pre-plant, pendimethalin 0.75 kg/ha pre-em. fb one hand weeding, pendimethalin 1.0 kg/ha pre-em., oxyfluorfen 0.25 kg/ha pre-em. fb one hand weeding, oxyfluorfen 0.375 kg and 0.50 kg/ha pre-em., two hand weedings at 20 and 40 DAS and unweeded (control). Followed by application of one hand weeding was done 40 DAS in herbicidal treatments. All the recommended production technology was followed to grow the crop successfully.

Weed flora of the experimental field consisted of *Digitaria sanguinalis* L., *Commelina benghalensis*, *Cyperus rotundus*, *Digera arvensis*, *Acrachne racemosa* and *Mollugo verticillata*. The data on major weed flora are given in Table 1 which show that the experimental field was dominated by *Cyperus rotundus*.

Unweeded control recorded significantly more population of all the weeds. Two hand weedings at 20 and 40 DAS, alachlor at 1.25 kg/ha, fluchloralin at 0.675 kg/ha, trifluralin at 0.75 kg/ha, pendimethalin at 0.75 kg/ha and oxyfluorfen at 0.25 kg/ha each followed by one hand weeding at 40 DAS proved to be effective in controlling the population of *D. sanguinalis* and *C. benghalensis*. Population of *C. rotundus* was also lower in all integrated weed control treatments than alone application of herbicides.

Trifluralin at 0.75 kg/ha followed by one hand weeding produced lowest (858 kg/ha) weed dry matter (Table 1) which was closely followed by alachlor at 1.25 kg/ha, pendimethalin at 0.75 kg/ha, oxyfluorfen at 0.25 kg/ha each followed by one hand weeding and two hand weedings at 20 and 40 DAS, however, all the weed control treatments were at par with each other except alone application of fluchloralin at 0.675 kg/ha. These results are in agreement with the findings of Gnanamurthy and Balasubramaniyan (1998) and Walia *et al.* (2007) who reported that two hand weedings and integration of herbicides with one hand weeding controlled growth of weeds and dry matter accumulation better than herbicides alone in **kharif** groundnut upto harvest.

Highest weed control efficiency (WCE) of

62.0% was recorded in trifluralin at 0.75 kg/ha fb one hand weeding and it was closely followed by alachlor at 1.25 kg/ha followed by one hand weeding (Table 1). Rathi *et al*. (1986) also obtained higher WCE with alachlor when integrated with one hand weeding.

Alachlor at 1.25 kg/ha fb one hand weeding was the best treatment producing maximum number of branches/plant which was statistically at par with the other weed control treatments except pendimethalin alone at 1.0 kg/ha (Table 2). The maximum number of pods/plant was produced by oxyfluorfen at 0.25 kg/ha followed by one hand weeding and alachlor at 1.25 kg/ha followed by one hand weeding which were at par with trifluralin at 0.75 kg/ha followed by one hand weeding at 40 DAS. The maximum number of filled kernels/pod was obtained in fluchloralin at 0.675 kg/ha followed by one hand weeding at 40 DAS, trifluralin at 1.25 kg/ha and pendimethalin at 0.75 kg/ha. Oxyfluorfen at 0.25 kg/ha followed by one hand weeding produced highest 100-kernel weight which was statistically at par with all the other herbicidal and integrated weed control methods except fluchloralin at 0.675 kg/ha and alachlor at 2.5 kg/ha. The high degree of weed control as observed in these treatments might have contributed appreciable increases in these yield attributing characters. Pannu *et al*. (1991) also reported that translocation and accumulation of photosynthates to pods and kernels were higher under weed free conditions.

Oxyfluorfen at 0.25 kg/ha followed by one hand weeding at 40 DAS produced maximum pod yield (2412 kg/ha) which was statistically at par with two hand weeding treatments, fluchloralin at 0.675 kg/ha followed by one hand weeding, trifluralin at 0.75 kg/ha followed by one hand weeding, trifluralin alone at both the doses, pendimethalin at 0.75 kg/ha followed by one hand weeding, oxyfluorfen at 0.50 kg/ha and alachlor at 1.25 kg/ha followed by one hand weeding (Table 2).

The best treatment which produced highest haulm yield was oxyfluorfen at 0.25 kg/ha followed by one hand weeding and it was at par with trifluralin at 0.75 kg/ha followed by one hand weeding, trifluralin alone at both the doses, pendimethalin 0.75 kg/ha followed by one hand weeding, oxyfluorfen alone at both the doses and alachlor at 1.25 kg/ha followed by one hand weeding treatments. The increase in pod and haulm yield in alone herbicidal and integrated weed control treatments was due to less weed dry matter, more number of branches/plant, more number of pods/plant and more 100-kernel weight in these treatments. Tiwari and Dhakar (1997) and Walia *et al*. (2007) also reported that application of herbicides alongwith cultural practice facilitated peg penetration and pod development thus increased the pod yield.

The highest numerical value (51.8%) was obtained in trifluralin at 0.75 kg/ha followed by one hand weeding at 40 DAS (Table 3). The oil content in unweeded (control) was the lowest (44.8%) among all the treatments. Singh *et al*. (1997) also reported that oil

Table 1. Effect of different weed control treatments on population of weeds, dry matter of weeds and weed control efficiency in groundnut

Treatments	Dose (kg/ha)	*Digitaria sanguinalis*/m^2	*Commelina benghalensis*/m^2	*Cyperus rotundus*/m^2	Dry matter of weeds (kg/ha)	WCE (%)
Fluchloralin, ppi	0.675	51	40	83	1452	35.7
Alachlor, pre-em	2.5	47	39	80	1041	53.9
Two hand weedings, 20 and 40 DAS	-	39	35	74	987	56.3
Fluchloralin, ppi fb HW 40 DAS	0.675	40	35	77	1019	54.9
Trifluralin, ppi fb HW 40 DAS	0.75	34	32	75	858	62.0
Trifluralin, ppi	1.0	48	39	82	1167	48.3
Trifluralin, ppi	1.25	46	38	83	1021	54.8
Pendimethalin, pre-em. fb HW 40 DAS	0.75	36	32	76	912	59.6
Pendimethalin, pre-em.	1.0	48	40	82	1126	50.1
Oxyfluorfen, pre-em. fb HW 40 DAS	0.25	38	32	75	962	57.4
Oxyfluorfen, pre-em.	0.375	51	40	83	1371	39.3
Oxyfluorfen, pre-em.	0.50	49	37	82	1134	49.8
Alachlor, pre-em. fb HW 40 DAS	1.25	36	28	76	862	61.8
Unweeded control	-	63	53	90	2257	-
LSD (P=0.05)		10	11	3	541	-

ppi–Pre-plant incorporation, pre-em–Pre-emergence. fb–Followed by, HW–Hand weeding, NS–Not Significant.

content remained unaffected with different weed control treatments.

The maximum oil yield (704.3 kg/ha) was obtained in trifluralin at 0.75 kg/ha followed by one hand weeding which was at par with oxyfluorfen at 0.25 kg/ha, pendimethalin 0.75 kg/ha, trifluralin at 1.0 and 1.25 kg/ha, fluchloralin at 0.675 kg/ha alone and integrated with one hand weeding, alachlor at 1.25 kg/ha followed by one hand weeding, alachlor at 2.5 kg/ha, oxyfluorfen at 0.50 kg/ha and two hand weedings.

On the day of spray viable count of bacteria recorded in the treatments of two hand weedings at 20 and 40 DAS and unweeded control was higher than it was recorded with application of herbicides (Table 4) indicating initial toxic effect. The treatments of trifluralin at lower dose integrated with one hand weeding, pendimethalin at 0.75 kg/ha fb one hand weeding, pendimethalin at 1.0 kg/ha, oxyfluorfen and alachlor at lower doses integrated with one hand weeding recorded at par population of bacteria with two hand weedings and unweeded control. However, the application of fluchloralin, alachlor at higher dose, trifluralin and oxyfluorfen both at the higher doses recorded significantly lower bacterial population than two hand weedings and unweeded control. Trifluralin at 0.75 kg/ha fb one hand weeding, trifluralin at 1.25 kg/ha, pendimethalin at 1.0 kg/ha, oxyfluorfen at 0.25 kg/ha fb one hand weeding and lower dose of alachlor at 1.25 kg/ha integrated with one hand weeding recorded significantly higher actinomycetes population as

Table 2. Effect of different weed control treatments on yield attributing characters, pod yield and haulm yield in groundnut

Treatments	Dose (kg/ha)	No. of branches/ plant	Pods/ plant	Kernels/ pod	100-kernel weight (g)	Pod yield (kg/ha)	Haulm yield (kg/ha)
Fluchloralin, ppi	0.675	14.6	15.0	1.40	56.6	1950	7250
Alachlor, pre-em.	2.5	14.7	15.3	1.46	56.8	2016	7210
Two hand weedings, 20 and 40 DAS	-	15.0	15.6	1.47	58.6	2187	7430
Fluchloralin, ppi, fb HW 40 DAS	0.675	14.7	17.4	1.48	57.8	2296	7340
Trifluralin, ppi, fb HW 40 DAS	0.75	15.2	20.5	1.43	58.5	2319	7530
Trifluralin, ppi	1.0	14.9	16.0	1.44	57.8	2267	7460
Trifluralin, ppi	1.25	15.1	18.0	1.48	58.0	2307	7420
Pendimethalin, pre-em. fb HW 40 DAS	0.75	15.3	17.3	1.48	57.2	2298	7450
Pendimethalin, pre-em.	1.0	13.9	16.2	1.42	56.9	1856	6930
Oxyfluorfen, pre-em fb HW 40 DAS	0.25	15.2	20.6	1.44	59.1	2412	7980
Oxyfluorfen, pre-em.	0.375	14.4	16.0	1.47	57.1	2029	7450
Oxyfluorfen, pre-em.	0.50	14.9	17.1	1.45	58.2	2303	7520
Alachlor, pre-em, fb HW 40 DAS	1.25	15.4	20.6	1.46	58.7	2349	7620
Unweeded control	-	12.6	13.0	1.41	53.9	1526	6380
LSD (P=0.05)		1.1	1.9	NS	2.2	293	542

ppi–Pre-plant incorporation, pre-em–Pre-emergence. fb–Followed by, HW–Hand weeding, NS–Not Significant.

compared to unweeded (control). However, highest actinomycetes population (51.3×10^4 cfu/g dry soil) was recorded in pendimethalin at 1.0 kg/ha. In case of fungi, trifluralin at 1.0 kg/ha was the only treatment to record significantly lowest count of 21.0×10^3 cfu/g dry soil as compared to unweeded (control). All the other treatments recorded either at par or higher count. Oxyfluorfen at 0.25 kg/ha recorded highest count of fungi (35.0×10^3 cfu/g dry soil).

At 20 days after spray the highest bacterial population 113.9×10^6 cfu/g dry soil was recorded with the treatments of alachlor at 1.25 kg/ha fb one hand weeding and it was at par with oxyfluorfen at 0.25 kg/ha fb one hand weeding at 40 DAS. The lowest population of bacteria, 30.9×10^6 cfu/g dry soil was recorded with trifluralin at 1.0 kg/ha. However, all other treatments showed at par population of bacteria and were significantly higher than trifluralin at 1.25 kg/ha, oxyfluorfen at 0.50 kg/ha and unweeded control. Actinomycetes population showed non-significant differences at 20 days after spray and its number was either reduced or remained almost same in some treatments than it was present on the day of spray and might be due to environmental factors. However,

Table 3. Effect of different weed control treatments on oil content and oil yield of groundnut

Treatments	Dose (kg/ha)	Oil content (%)	Oil yield (kg/ha)
Fluchloralin, ppi	0.675	47.8	532.2
Alachlor, pre-em.	2.5	48.2	601.9
Two hand weedings, 20 and 40 DAS	-	48.6	651.1
Fluchloralin, ppi, fb HW 40 DAS	0.675	48.2	667.0
Trifluralin, ppi, fb HW 40 DAS	0.75	51.8	704.3
Trifluralin, ppi	1.0	48.4	689.1
Trifluralin, ppi	1.25	48.2	675.4
Pendimethalin, pre-em. fb HW 40 DAS	0.75	49.8	695.8
Pendimethalin, pre-em.	1.0	47.4	518.3
Oxyfluorfen, pre-em, fb HW 40 DAS	0.25	48.4	703.9
Oxyfluorfen, pre-em.	0.375	46.6	568.7
Oxyfluorfen, pre-em.	0.50	46.8	661.2
Alachlor, pre-em. fb HW 40 DAS	1.25	46.8	649.4
Unweeded control	-	44.8	383.1
LSD (P=0.05)		NS	116.8

ppi–Pre-plant incorporation, pre-em–Pre-emergence. fb–Followed by, HW–Hand weeding, NS–Not Significant.

numerically maximum population of actinomycetes 32.3 × 10^4 cfu/g dry soil was obtained in two hand weedings and it was closely followed by trifluralin at 1.0 kg/ha. All the treatments recorded significantly higher fungi count as compared to unweeded control.

At 90 days after spray, maximum population of bacteria i. e. 67.3 × 10^6 cfu/g dry soil was recorded in fluchloralin at 0.675 kg/ha fb one hand weeding and it was at par with oxyfluorfen at 0.375 kg/ha and pendimethalin at 1.0 kg/ha. The highest population of actinomycetes 30.8 × 10^4 cfu/g dry soil was recorded in alachlor at 2.5 kg/ha and the minimum population 9.7 × 10^6 cfu/g dry soil was recorded in pendimethalin at 0.75 kg/ha fb one hand weeding at 40 DAS. The highest and lowest populations of fungi (49.0 × 10^3 and 19.4 × 10^3 cfu/g dry soil) were found in treatments of fluchloralin at 0.675 kg/ha fb one hand weeding and oxyfluorfen at 0.50 kg/ha, respectively. Sidhu (1982) also reported that bacterial, fungal and actinomycetes population in soil was affected by the application of herbicides in groundnut but their population in soil started increasing few days after spray due to the degradation of herbicides in soil.

Table 4. Effect of different weed control treatments on periodic viable count of microorganisms in groundnut

Treatments	Dose (kg/ha)	Viable count (cfu/g dry soil) on the day of spray			Viable count (cfu/g dry soil) 20 days after spray			Viable count (cfu/g dry soil) 90 days after spray		
		Bacteria x 10^6	Actino-mycetes x 10^4	Fungi x 10^3	Bacteria x 10^6	Actino-mycetes x 10^4	Fungi x 10^3	Bacteria x 10^6	Actino-mycetes x 10^4	Fungi x 10^3
Fluchloralin, ppi	0.675	43.9	24.5	26.6	69.6	19.6	67.8	47.4	20.0	25.2
Alachlor, pre-em.	2.5	41.7	27.3	29.8	71.6	25.4	44.7	56.0	30.8	35.6
Two hand weedings, 20 and 40 DAS	-	78.9	15.4	23.0	89.8	32.3	37.4	38.1	18.7	34.2
Fluchloralin, ppi fb HW 40 DAS	0.675	45.3	25.8	24.8	78.0	22.7	98.3	67.3	20.6	49.0
Trifluralin, ppi fb HW 40 DAS	0.75	62.9	29.2	34.0	75.8	27.2	77.2	48.8	20.3	24.2
Trifluralin, ppi	1.0	45.2	22.7	21.0	30.9	32.1	74.7	57.9	22.6	23.5
Trifluralin, ppi	1.25	35.2	28.6	25.0	58.7	19.0	103.8	46.3	22.0	21.8
Pendimethalin, pre-em. fb HW 40 DAS	0.75	75.6	31.3	25.8	74.8	19.1	47.3	48.4	9.7	30.0
Pendimethalin, pre-em.	1.0	63.5	51.3	32.8	72.8	20.7	37.6	60.0	12.5	23.7
Oxyfluorfen, pre-em, fb HW 40 DAS	0.25	56.5	29.5	35.0	108.0	17.9	73.4	35.5	21.5	30.6
Oxyfluorfen, pre-em.	0.375	37.4	25.7	24.6	77.6	25.8	58.7	63.4	20.0	24.6
Oxyfluorfen, pre-em.	0.50	37.3	17.6	30.5	55.8	22.4	36.5	42.6	14.5	19.4
Alachlor, pre-em, fb HW 40 DAS	1.25	64.5	41.2	33.8	113.9	27.4	42.8	40.8	15.8	35.5
Unweeded control	-	73.9	18.4	23.6	62.1	21.4	26.5	40.0	14.6	29.9
LSD (P=0.05)		28.4	7.4	1.4	23.1	NS	9.6	9.3	6.0	6.5

ppi–Pre-plant incorporation, pre-em–Pre-emergence. fb–followed by, HW–Hand weeding, NS–Not Significant.

Results indicated that initial reduction in counts was due to inhibitory effect of these herbicides. At later stage i. e. 20 and 90 days after spray these herbicides lost their potency, probably due to their degradation in soil. Hence, it may be concluded that the herbicides used in the present studies do not leave any adverse effect on the soil microflora in the soil after few days/months of their application.

Among the different weed control treatments oxyfluorfen at 0.25 kg/ha fb one hand weeding recorded maximum pod yield (2412 kg/ha) which was at par with all other integrated weed control treatments, two hand weedings at 20 and 40 DAS, trifluralin alone at both the doses 1.0 and 1.25 kg/ha and oxyfluorfen at 0.50 kg/ha. There was reduction in micro-organism due to the application of all herbicidal treatments in the early stage which recovered afterwards due to the degradation of herbicides in soil.

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