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Research Paper

Efficiency of herbicides in groundnut (*Arachis hypogaea*) under hot arid conditions of Rajasthan

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ABSTRACT

A field experiment was conducted during the rainy seasons of 2014 and 2015 at A.R.S. Bikaner, Rajasthan to test the efficiency of different weed-control measures in groundnut (*Arachis hypogaea* L.). The experiment comprising 14 weed-control treatments of 1.0 kg pendimethalin (PPI), 1.0 kg pendimethalin (PE), 800 g imazethapyr + pendimethalin (PE) (2 + 30% Ready mix), 900 g imazethapyr + pendamethalin (PE) (2 + 30% Ready mix), 1,000 g imazethapyr + pendamethalin (PE) (2 + 30% Ready mix), 50 g imazethapyr (3–4 leaf stage), 70 g imazethapyr (3–4 leaf stage), 60 g imazethapyr + imazemox (Ready mix at 3–4 leaf stage), 70 g imazethapyr + imazemox (Ready mix at 3–4 leaf stage), 40 g oxyfluorfen (3–4 leaf stage), 50 g fenoxaprop p-ethyl (3–4 leaf stage), 62 g propaquizafop (3–4 leaf stage), 2 hand-weedings and weedy check in randomized block design (RBD) with 3 replications. 2 hand-weedings were found most effective in the controlling weeds in groundnut and recorded the lowest weed count and weed dry matter of both broad-leaf and grassy weeds. Among the different herbicides, application of imazethapyr + pendamethalin 1,000 g resulted in the lowest weed count and weed dry matter of both broad-leaf and grassy weeds as well as significantly highest yield attributes and yield, viz. dry-matter accumulation, pods/plant, pod, haulm and biological yield/ha in groundnut over all the other herbicidal treatments. The maximum net returns of 97.2 × 10^3₹/ha and benefit: cost ratio (2.41) were recorded under 2 hand-weeding treatment. Among the different herbicides, application of imazethapyr + pendamethalin 1,000 g resulted in higher net returns of 88.1 × 10^3₹/ha and benefit: cost ratio (2.29).

Key words *:* Groundnut, Herbicides, Imazethapyr, Pendimethalin

Groundnut is major oilseed crop and king of vegetable oilseeds in India. It is also known as peanut, earthnut, monkey nut and goobers and grown in both tropical and sub-tropical regions and in the continental part of temperate countries. India produced 7.54 million tonnes groundnut from 5.95 million ha area, with an average yield of 1,268 kg/ha of groundnut, while the contribution of Rajasthan in production was 0.68 million tonne from 0.35 million ha area, with an average yield of 1963 kg/ha (GoI, 2015). Since it is a rich source of protein (26%) and contains 45% oil, it is one of the most important crops for producing edible oil. The low yield of groundnut is attributed to many factors, weeds is of serious nature, causing huge loss. Competition of weeds with the crops is very high during 50 to 60 days period. This one was found to be critical one for crop-weed competition (Mahadkar *et al*., 1993). Weeds when allowed to compete till harvest depleted 162.8 kg N, 21.7 kg P_2O_5, 141.8 kg K_2O/ha. Herbicides and hand-weeding significantly brought down the nutrient removal by weeds and enhanced the uptake of nutrient by groundnut crop (Yadav *et al*., 1983). Weeds reduce yield by competing with the groundnut plants for resources such as sunlight, space, moisture and nutrients (Upadhyay, 1984) throughout the growing season. Besides, weeds also create problem during digging and inverting procedures and reduce harvesting efficiency. Harvesting losses increases as the biomass of weeds slow down the field-drying of groundnut vines and pods and increases the possibility of exposure to rainfall. Some weeds also found to have allellopathic effect on groundnut crop (Bansal, 1993). Weeds act as host for causal organisms of various diseases and insect-pests. During initial growth of crop there is relatively less crop canopy which allows higher weeds growth and thus groundnut crop becomes more susceptible to competition with weeds in the earlier growth period of the crop. The present experiment

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was carried out to study efficiency of different herbicides in controlling weeds in groundnut under hot arid conditions of Rajasthan.

MATERIALS AND METHODS

A field study was conducted the during rainy (*kharif*) seasons of 2014 and 2015 at Research farm of Agriculture Research Station, Swami Keshwanand Rajasthan Agricultural University, Bikaner (28.00° to 28.16° N, 72.55° to 73.42° E and 234.7 m above mean sea-level). Fourteen weed control treatments, viz. 1.0 kg pendimethalin (PPI), 1.0 kg pendimethalin (PE), 800 g imazethapyr + pendimethalin (PE) (2 + 30% Ready mix), 900 g imazethapyr + pendamethalin (PE) (2 + 30% Ready mix), 1000 g imazethapyr + pendamethalin (PE) (2 + 30% Ready mix), 50 g imazethapyr (3–4 leaf stage), 70 g imazethapyr (3–4 leaf stage), 60 g imazethapyr + imazemox (Ready mix at 3–4 leaf stage), 70 g imazethapyr + imazemox (Ready mix at 3–4 leaf stage), 40 g oxyfluorfen (3–4 leaf stage), 50 g fenoxaprop p-ethyl (3–4 leaf stage), 62 g propaquizafop (3–4 leaf stage), 2 hand-weeding and weedy check, were evaluated in randomized block design with 3 replications. All doses of herbicides were applied in one hectare area basis. The soil was loamy sand, having 0.08% organic carbon, 8.2 *p*H, 78, 22 and 210 kg/ha available N, P and K respectively. Groundnut 'HNG 10' was sown on 21 June 2014, and 26 June 2015 at 30 cm row spacing and was harvested on 24 October 2014 and 28 October 2015 respectively. Recommended dose of fertilizers (20 kg N + 40 kg P + 40 kg K/ha) was applied basal dose through urea, single superphosphate (SSP) and murate of potash (MoP) respectively. Pre plant incorporation of pendimethalin was done before sowing while pre-emergence application of pendimethalin was carried out next day of sowing. Post-emergence application of imazethapyr was done 25 DAS as per the treatment with knapsack sprayer. Weed density was recorded by using quadrate of 0.25 m^2 at 60 DAS in all the treatments and then converted into number of weeds/m^2. The weeds were dried in oven till a constant weight and then transformed into g/m^2 by using the appropriate formula. Growth, yield parameters and yield of groundnut were recorded for 2 consecutive years. The data on weed count were subjected to square root transformation ($\sqrt{x + 0.5}$) to normalize their distribution (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Weeds

The experimental field was infested with *Amaranthus spinosus*, *Digera arvensis,* Tri*anthema portulacastrum*, *Gisekia poredious*, *Mollugo verticillata*, *Euphorbia hirta*, *Aristida depressa*, *Portulaca oleracea*, *Cenchrus biflorus*, *Cleome viscosa*, *Tribulus terrestris*, *Corchorus tridense*, *Cyperus rotundus*, *Eleusine verticillata*, *Eragrostris tennela* and *Aerva tomentosa* etc weeds in both the years.

All the weed-control treatments were able to significantly reduce weed density and dry weight of weeds compared to weedy check (Table 1). Two hand-weedings resulted in the lowest weed density and dry weight of weeds. However, among the different treatments, pre-emergence application of imazethapyr + pendamethalin 1,000 g and its lower doses, imazethapyr 50 and 70 g, imazethapyr + imazemox 60 and 70 g were found to be at par with each other in respect of these weed parameters. Imazethapyr + pendamethalin 1,000 g was found effective in reducing the density and dry weight of both broad-leaf and grassy weeds, followed by its lower doses. Lower density of weeds by imazethapyr + pendamethalin primarily appeared due to broad-spectrum activity of herbicidal combination, particularly on establishment of plants of both broad-leaf and grassy weeds and its greater efficiency to retard cell-division of meristems, as a result of which weeds dry rapidly. It is well established fact that herbicides are inferior to hand-weeding in case of legumes. The results were confirmed by the findings of Kantar *et al.* (1999), where about 84.6% weed biomass was controlled with application of imazethapyr. Papierniks *et al.* (2003) also recommended use of imazethapyr in legumes, which inhibits acetohydroxy acid synthase and the synthesis of branched chain amino acids. Data further revealed that application of fenoxaprop p-ethyl 50 g/ha and propaquizafop 62 g/ha as post-emergence also reduced the weed dry-matter compared to weedy check. Pendimethalin 1.0 kg/ha as PPI and pre-emergence was found effective in controlling grassy weeds.

Yield attributes and yield of groundnut

Different weed-management practices had significant impact on yield attributes and yield of groundnut crop (Table 2). Significantly higher dry-matter, pods/plant, kernels-pod, 100-kernel weight and shelling percentage were recorded under 2 hand-weeding treatment. Among the herbicidal treatments, imazethapyr + pendimethalin 1,000 g resulted in significantly higher dry matter per plant, which was at par with its lower levels as well as 2 hand-weedings. This may be attributed to the decreased weed population and lesser dry weight of weeds resulting in decreased competition by weeds to moisture, light and nutrients. The effect of which can be traced back to increased dry-matter accumulation in stem, leaves and pods. The dry-matter production and its accumulation in reproductive parts depends on the photosynthetic ability of the plant and can be analysed through leaf area and dry-mat-

ter accumulation in leaves, which in turn influence the photosynthetic ability, performance and yield of the crop. The results corroborate with the findings of Yadav *et al.* (2014). Pendimethalin 1.0 kg/ha as PPI and pendimethalin 1.0 kg/ha as pre- emergence was next best herbicide for increasing dry matter, pods/plant kernels/pod, 100-kernel weight and shelling percentage, followed by imazethapyr + imazemox 60 and 70 g/ha. This might be owing to minimized competition of weeds with main crop for resources, viz. space, light, nutrients and moisture, with adoption of effective weed-control methods. Singh and Giri (2001) also concluded that proper weed control was responsible for increase in plant height and dry-matter production in groundnut. However, in case of other herbicidal treatments, imazethapyr 50 and 70 g, imazethapyr + imazemox 60 and 70 g/ha, oxyfluoren 40 g/ha, fenoxaprop p-ethyl 50 g/ha and propaquizafop 62 g/ha recorded higher yield and yield attributes of groundnut compared to weedy check but remained at par with each other.

All weed-management practices significantly enhanced pod, haulm and biological yields over weedy check, and significantly higher yield was obtained in 2 hand-weedings treatment (Table 2). However, there was no significant difference in imazethapyr 50 and 70 g/ha, imazethapyr + imazemox 60 and 70g/ha with each other between pod, haulm and biological yields. This might be owing to the fact that 2 hand-weedings environment in crop facilitated better peg initiation and development at the critical growth stages of groundnut which tends to increase number of pods/plant and pod yield/ha. Raj *et al*. (2008) also reported higher profitable pod yield of summer groundnut keeping the crop under 2 hand-weedings condition. Significantly lower number of pods and pod yield were recorded in the weedy check. There was no significant effect of weed-management practices on harvest index in groundnut.

Among the different herbicidal treatments, pod, haulm and biological yields of groundnut were found maximum with the treatment received imazethapyr + pendimethalin 1,000 g which was significantly superior to weedy check, fenoxaprop p-ethyl 50 g/ha, propaquizafop 62 g/ha, oxyfluorfen, pendimethalin 1.0 kg/ha as PPI and pre-emergence but statistically at par with imazethapyr + pendimethalin 800 g and 900 g/ha, imazethapyr 50 and 70 g/ha and imazethapyr + imazemox 60 and 70 g/ha. The increase in pod yield in above treatments might be owing to the fact that these treatments resulted in beneficial effect on final yield. Also the pod yield is an end product, which obviously depends upon the dry-matter production of crop growth and its partitioning into reproductive parts. Patra and Naik (2001) also reported increased pod number due to weed control treatments. The differential contribution of yield components towards pod yield was obtained with different treatments. Effective control of weeds by herbicides might have resulted in better availability of soil moisture and nutrients as evidenced by the beneficial effect on crop growth. The higher pod yield in imazethapyr + pendimethalin 1,000g/ha or its lower doses over weedy check might be due to suppression of weed seed germination and seedling development at early stages due to pre-

Table 1. Effect of different pre- and post- emergence herbicides on weed count and weed dry weight in groundnut (pooled over 2 years)

Treatment	Weed counts/m^2			Weed dry weight (g/m^2)
	Broad leaf	Grassy	Total	
Pendimethalin 1.0 kg (PPI)	7.29 (52.84)	1.25 (1.25)	7.38 (54.09)	23.34
Pendimethalin 1.0 kg (PE)	7.38 (54.02)	1.29 (1.26)	7.46 (55.27)	17.51
Imazethapyr + pendimethalin 800 g (PE)	2.66 (6.69)	1.09 (0.77)	2.79 (7.46)	1.26
Imazethapyr + pendimethalin 900 g (PE)	2.39 (4.18)	0.80 (0.19)	2.15 (4.36)	0.47
Imazethapyr + pendimethalin 1,000 g (PE)	1.77 (2.04)	0.83 (0.25)	1.59 (2.28)	0.33
Imazethapyr 50 g	2.80 (5.36)	1.77 (2.79)	2.89 (8.14)	11.14
Imazethapyr 70 g	2.57 (4.10)	1.61 (2.20)	2.54 (6.30)	5.95
Imazethapyr + imazemox 60 g	2.68 (5.05)	1.51 (1.82)	2.62 (6.87)	6.81
Imazethapyr + imazemox 70 g	1.88 (3.28)	1.18 (1.04)	2.12 (4.31)	1.13
Oxyfluorfen 40 g	5.49 (30.28)	1.25 (1.23)	5.6 (31.51)	19.49
Fenoxaprop p-ethyl 50 g	5.46 (29.80)	1.16 (0.99)	5.55 (30.79)	18.73
Propaquizafop 62 g	5.77 (33.01)	1.25 (1.14)	5.87 (34.15)	17.33
2 hand weeding	1.56 (2.01)	1.05 (0.74)	1.69 (2.75)	0.36
Weedy check	7.56 (33.25)	2.18 (2.99)	7.85 (61.37)	37.17
SEm±	0.30	0.20	1.76 0.73	
CD (P=0.05)	0.86	0.57	5.12 2.12	

Figures in parentheses indicate

Table 2. Effect of different pre- and post- emergence herbicides on growth, yield attributes and yields of groundnut (pooled over 2 years)

Treatment	Dry-matter accumulation (g/plant)	Pods/ plant	Kernels/ pod	100-kernel weight (g)	Shelling %	Pod yield (t/ha)	Haulm yield (t/ha)	Harvest index (%)	Net returns	Benefit: cost ratio
Pendimethalin 1.0 kg (PPI)	58.3	24.8	1.62	41.1	61.8	2.28	6.25	26.68	50.4	1.75
Pendimethalin 1.0 kg (PE)	62.2	27.2	1.65	41.2	61.5	2.43	6.83	26.21	58.3	1.87
Imazethapyr + Pendimethalin 800 g (PE)	71.3	31.0	1.67	42.2	62.1	2.87	7.25	28.51	75.5	2.10
Imazethapyr + Pendimethalin 900 g (PE)	72.6	31.0	1.70	42.6	62.8	2.96	7.43	28.59	79.7	2.17
imazethapyr + Pendimethalin 1,000 g (PE)	73.3	34.4	1.75	43.0	64.3	3.18	7.58	29.62	88.1	2.29
Imazethapyr 50 g	57.0	24.4	1.57	41.8	61.5	2.45	7.10	25.77	61.0	1.91
Imazethapyr 70 g	60.4	25.9	1.58	42.0	61.7	2.63	7.32	26.39	68.4	2.02
Imazethapyr + imazemox 60 g	59.7	26.6	1.63	41.8	61.6	2.68	7.38	26.52	69.8	2.03
Imazethapyr + Imazemox 70 g	60.9	27.1	1.67	42.4	61.8	2.72	7.49	26.67	71.7	2.05
Oxyfluorfen 40 g	55.1	17.6	1.6	42.1	60.9	2.01	5.83	25.5	38.5	1.58
Fenoxaprop p-ethyl 50 g	52.5	17.0	1.53	40.7	61.0	1.99	5.59	26.54	36.0	1.54
Propaquizafop 62 g	53.1	17.3	1.55	40.9	61.4	2.00	5.61	26.87	36.7	1.55
2 hand-weedings	79.2	36.1	1.77	44.0	65.9	3.40	7.95	29.91	97.2	2.41
Weedy check	49.5	13.9	1.53	39.5	60.7	1.66	4.93	26.49	23.2	1.37
SEm±	3.3	2.2	0.03	0.8	0.6	0.9	0.14	2.41	-	-
CD (P=0.05)	9.8	6.4	0.10	2.5	1.9	2.7	0.41	NS	-	-

emergent herbicides. Exceptional weeds emerged were removed through effects of these herbicides hence treatments get two hand weeding condition weeds were removed as and when they emerged from soil. Among different herbicidal treatments, imazethapyr + pendimethalin 1000g recorded 91.6, 53.9 and 63.4% higher pod, haulm and biological yield over weedy check. Kantar *et al.* (1999) also observed 63.6% higher seed yield over weedy check with application of imazethapyr.

Economics

The cost of cultivation was maximum in 2 hand-weedings, followed by imazethapyr + pendimethalin 800, 900 and 1,000 g/ha. All the weed-control treatments resulted in higher net returns and benefit: cost (B:C) ratio over weedy check, but the highest net returns and benefit: cost ratio were obtained with 2 hand-weedings treatment (Table 2). Among the herbicidal treatments, higher net returns (88.1 $\times 10^3$/ha) and benefit: cost ratio (2.29) ratio were recorded in imazethapyr + pendimethalin 1,000 g/ha, closely followed by its lower doses. This was owing to higher pod and haulm yields and subsequently lower cost of cultivation (Mene *et al.,* 2003) of groundnut crop which was increased in treatment receiving 2 hand-weedings due to the higher need of human labours and their higher wages. This cost was reduced in imazethypr 50 and 70 g/ha, imazethapyr + imazemox 60 and 70 g/ha and pendimethalin 1.0 kg/ha by using herbicides to effective control of weeds with minimizing human labours. Sasikala *et al.* (2004) and Rao *et al.* (2011) also reported higher net returns and benefit: cost ratio with pre- and post emergence application of herbicides. Weedy check recorded lower net returns and benefit: cost ratio and it is quite important to note that keeping the land free of weeds throughout the crop-growth period is practically impossible by the farmers, since it involves huge cost on labour. Among the other treatments, Imazethapyr +Imazemox 70 g/ha resulted in higher net returns (71.7×10^3/ha) with B:C ratio of 2.05 despite the higher cost involved.

Application of imazethapyr + pendimethalin 1,000 g/ha proved practically more convenient and economically best feasible weed-management herbicide in groundnut. Use of imazethapyr + pendimethalin 1,000 g/ha gave higher pod, haulm yield and net returns followed by its lower levels. Among post- emergence herbicides, application of imazethapyr + imazemox 70g/ha proved best in controlling weeds and improvement in yield.

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