Indian Journal of Weed Science (2023) **55**(3): 282–286
http://dx.doi.org/10.5958/0974-8164.2023.00052.7

RESEARCH ARTICLE

Weed management with different herbicid combinations in winter groundnut under red sandy loam soils of Odisha, India

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Received: 8 February 2023 | Revised: 17 July 2023 | Accepted: 20 July 2023

ABSTRACT

A trial was conducted in red soils at the Research farm of AICRP on Groundnut, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, to study the effect of different weed control treatments on groundnut yield during two consecutive *Rabi* (winter) seasons of 2018-19 to 2019-20. Amongst the different herbicides, ready mix application of pendimethalin + imazethapyr along with manual weeding efficiently controlled weed density and weed dry matter of all types of weeds. It also incurred significantly higher yield attribute and yield of groundnut over all the other herbicidal treatments, *viz.* branch/plant (5 and 4.8), number of pods/plant (19.3 and 17.2), pod yield (2.63 and 2.35 t/ha) and haulm yield (4.10 and 3.93 t/ha), net returns of ₹ 82370 and 66740/ha and B: C (2.7 and 2.3) in 2018-19 and 2019-20, respectively. The lowest weed dry matter, weed density and weed index and WCE were recorded with this treatment at different stages of the crop growth period. The results obtained from the trial suggested that ready mix application of pendimethalin + imazethapyr along with manual weeding was the best measure to control all types of weeds effectively along with the highest pod yield.

Keywords: Groundnut, Manual weeding, Ready-mix herbicide, Weed control efficiency, Weed dry matter

INTRODUCTION

Groundnut (*Arachis hypogaea* L.), an important food and cash crop, has reserved its position because of its both domestic and export markets and nutritional value. India produced 10.1 million tons of groundnut from a 5.42 million ha area, with an average yield of 1.86 t/ha of groundnut (ANGRAU Groundnut Outlook Report, 2021-22) and contributes to 55% of the total oil seed production in the Country. One of the major constraints in groundnut production is weed menace. Weeds vigorously compete with the groundnut plant for resources (sunlight, space, moisture, and nutrients) during the growing season. The critical period of crop-weed control is 4-9 weeks after sowing for grasses and 3-6 weeks for broad-leaved weeds(Wesley *et al.* 2008). For a good yield, requires early management of weeds within 3–6 weeks after sowing for better groundnut production because the crop is not able to compete effectively with weeds, particularly before flowering and during pegging for essential resources. Compared to cultural methods, chemical control measures are quick, more effective, and time and labor-saving (Ahmad *et al.* 2004). Thus, the present study attempted to identify effective and economically viable methods of weed control for harnessing higher yield and productivity in groundnut crops.

MATERIALS AND METHODS

A field experiment was conducted in the research block of AICRP on Groundnut (All India Co-Ordinated Research Project) Odisha University of Agriculture and Technology, Bhubaneswar, Odisha during the *Rabi* (winter) 2018-19 to 2020-21. The year-wise total rainfall received during the crop growth seasons 2018-19 to 2019-20 were 45.6 and 163.4 mm, with 5 and 15 rainy days, respectively. The soil of the experimental plot was sandy loam textured with a pH of 5.4 consisting 0.54% organic matter.The soil contains total nitrogen, available phosphorus and potassium 251,27 and 85 kg/ha, respectively. The result indicates a medium level of nitrogen and potassium and high phosphorus. The trial was carried out in randomized completely block design with ten treatments, *viz.* pendimethalin 1.0 kg/ ha PE, pendimethalin + imazethapyr 1.0 kg/ha PE (ready mix), pendimethalin 1.0 kg/ha PE + quizalofop-p-ethyl 50 g/ha at 15 DAS, pendimethalin + imazethapyr 1.0 kg/ha PE (ready mix) + quizalofop-p-ethyl 50 g/ha at 15 DAS, pendimethalin 1.0 kg/ha PE + imazethapyr 75 g/ha at 15 DAS, pendimethalin 1.0 kg/ha PE + one manual weeding at 25 DAS,

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pendimethalin + imazethapyr 1.0 kg/ha PE (ready mix) + one manual weeding at 25 DAS, two manual weddings at 20 and 40 DAS, weed free and weedy check. The crop was fertilized with 20-40-40 N-P-K kg/ha. Groundnut variety 'Dharani' was sown at a spacing of 30 cm. PE of herbicides was applied as per the treatment immediately after the sowing. All other recommended package of practices was followed throughout the crop seasons. Weed count and dry weight of weeds per net plot, yield and yield attributes, were recorded at the time of crop harvest. In the case of the control plot, weeds were allowed to grow along with groundnut throughout the crop cycle, but in weed-free treatment, four times weeding was done manually to keep the plots free from weeds. The crop was raised under irrigated conditions asper as recommended package of practices. Densities and dry weight of weeds were recorded before and after post-emergence application and were subjected to log transformation before analysis. At the time of taking observation(40 and 70 days after sowing) for weed dry matter and density), a quadrant of 50 × 50 cm was placed at two places in each plot for collection of data. Weed dry weight was recorded after drying the weed samples at 70 °C for 48 hours in an oven. Weed control efficiency was calculated based on the data recorded at 40 and 70 DAS in groundnut as per the standard formula. Plant height (cm), branch no./ plant, was recorded just before harvesting. Pod and haulm yield (kg/ha), shelling%, and pod/plant were recorded after harvest of the crop. Data collected for various studies were subjected to the analysis of variance (ANOVA) appropriate to the design as given by Gomez and Gomez (1984). While the ANOVA indicated significant treatment effects, means were separated at $p<0.05$ and adjusted with Fisher's protected least significant difference (LSD) test. The significant differences between treatments were compared with the critical difference at a 5% level of probability. The economics of all the treatments were worked out. Weed control efficiency (WCE) denotes the magnitude of weed reduction due to weed control treatment. It was calculated by using the following formula suggested by Mani *et al.* (1973) WCE (%) =[(Weed dry weight (kg) in the un-weeded plot – Weed dry weight (kg) in the treated plot)x100]/ Weed dry weight (kg) in the un-weeded plot]

Weed index (WI) is defined as the magnitude of yield reduction due to the presence of weeds in comparison with weed-free checks. The weed index (WI) was calculated by using the following formula suggested by Gill and Vijayakumar,1969. WI (%) =[(Yield from weed-free plot – Yield from the treated plot) x 100]/Yield from the weed-free plot.

RESULT AND DISCUSSION

Effect of weed management in weed abundance in groundnut

The weed flora present in the experimental field consisted of seven species of broad-leaved weeds, five species of grasses and one species of sedge. The dominant broad-leaved weed flora were *Borreria hispida*, *Cleome rutidosperma*, *Cleome viscosa, Eclipta alba, Croton sparsiflorus, Celosia argentea, Phylanthus niruri*. Major grasses were *Digitaria sanguinalis, Digitaria ciliaris, Echinochloa colonum, Elusine indica, Dactyloctenium aegyptium* and the only dominant sedge was *Cyperus rotundus*.

The intensity of the broad-leaf, sedges and grasses differed with integrated weed management practices in Rabi groundnut. Higher biomass of total weeds occurred in the weedy check at 40 and 70 DAS in both years. Among various herbicidal treatments, pre-emergence application of pendimethalin + imazethapyr (ready-mix) *fb* manual weeding registered the lowest weed biomass in both years (**Table 1**) whereas, higher weed density and weed biomass was observed in pre-emergence application of Pendimethalin. The ready-mix combination of pendimethalin+ imazethapyr controlled up to 64% and 40% of weed population compared to weedy check and existing practice, respectively. This finding was in tune with (Solanki *et al*. 2005 and Kalhapure *et al*. 2013).

Effect of weed management on weed density, weed control efficiency and weed index in groundnut

The effect of different weed management strategies was significantly noticed in reducing weed density and dry matter under different treatments. The lowest weed density, weed dry matter and the highest weed control efficiency (WCE) were noticed under weed-free treatment. Among different herbicides used, ready mix application of pendimethalin and imazethapyr in combination with manual weeding significantly reduced weed dry matter (5.5 and 8.1, 52.2 and 38.7 g/m^2) and weed density (3.8 and 3.3, 3.9 and 5.5) at 40 and 70 DAS in 2018-19 and 2019-20, respectively but was at par with twice hand weedings at 20 and 40 DAS and pendimethalin *fb* manual weeding. It also recorded the highest WCE and WI at different intervals of crop growth periods. This might be due to a combination of both cultural and chemical methods found to be more effective in reducing the weed dry matter and weed density. These findings were with in tune Vora *et al.* 2019 and Bhatt *et al.* 2010.

Effect of weed management on plant growth attributes of winter groundnut

Different herbicides used in this weed management trial had significant positive impacts on plant growth parameters, yield attributes and yield of groundnut crops (**Table 3**). Significant lowest plant height and branch no. were recorded under weedy check and the highest values were observed in weed-free treatment. Two manual weedings registered significantly highest plant height of (45.6 cm and 41.5 cm in 2018-19 and 2019-20, respectively) over control. Ready-mix combination of pendimethalin and imazethapyr *fb* manual weeding registered highest no. branches/plant (5.0 and 4.8) in 2018-19 and 2019-20, respectively which was at par with twice manual weedings. Higher values of these parameters could be attributed to low crop-weed competition because of lesser weed density observed at the early crop stage and their consistent control over weeds at later stages under treatments. Similar findings were also reported by Yadav et *al.* (2014) and Singh and Giri (2001).

Effect of weed management on yield and yield attributes of groundnut

All herbicidal management practices along with twicehand weeding at 20 and 40DAS significantly resulted in higher pod and haulm yield over weedy check and weed-free treatment incurred the highest pod and haulm yield. The cumulative effect of the yield-attributing characters was reflected in terms of pod yield. The trend was similar in both the years. Amongst different herbicidal treatments, pendimethalin + imazethapyr (ready-mix) *fb* manual weeding incurred the highest pod (2.63 and 2.36 t/ha) and haulm yield(4.10 and 3.93 t/ha) in 2018-19 and 2019-20, respectively. The pod yield was (155% and 123% higher over weedy check in 2018-19 and 2019-20, respectively. It stands at par with the ready mix application of pendimethalin and imazethapyr

Table 1. Effect of different weed control methods on weed biomass and weed density in *Rabi* groundnut

Treatment	Weed density at 40 DAS (no./m^2)		Weed density at 70 DAS (no./m^2)		Weed biomass at 40 DAS (g/m^2)		Weed biomass at 70 DAS (g/m^2)	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Pendimethalin 1.0 kg/ha PE	5.3(27.7)	4.2(17.7)	5.8(32.7)	6.5(41.3)	9.1	11.5	79.1	88.4
Pendimethalin imazethapyr 1.0 kg/ha PE ready mix (RM)	4.9(24.0)	4.0(15.7)	5.7(31.7)	7.2(51.3)	8.7	18.6	70.3	78.8
Pendimethalin 0.75/1.0 kg/ha PE + quizafop-p-ethyl 50 g/ha at 15DAS	4.9(23.7)	3.4(11.3)	5.6(30.7)	5.8(33.3)	8.8	3.6	67.5	56.3
Pendimethalin + imazethapyr 1.0 kg/ha PE RM + quizafop-p-ethyl 50 g/ha at 15DAS	4.1(16.0)	5.3(27.7)	5.0(24.3)	5.5(29.7)	7.3	14.9	63.7	54.7
Pendimethalin 1.0 kg/ha PE + imazethapyr 75 g/ha at 15 DAS	4.7(22.0)	4.1(16.7)	5.2(26.7)	5.4(29.0)	8.4	15.2	64.5	59.2
Pendimethalin 1.0 kg/ha PE + MW at 25 DAS	4.4(19.0)	6.4(40.3)	4.7(21.7)	7.2(51.0)	6.9	5.7	58.1	52.1
Pendimethalin + imazethapyr 1.0 kg/ha PE RM + MW at 25 DAS	3.8(13.7)	3.3(10.3)	3.9(14.7)	5.5(30.0)	5.5	8.1	52.2	38.7
Two manual weddings (MW) at 20 and 40 DAS	4.3(18.3)	4.7(21.7)	4.3(18.3)	4.9(23.7)	5.7	6.2	55.6	40.3
Weedy check	8.7(75.0)	15.4(236.3)	9.8(96.0)	24.6(603.7)	15.1	36.3	157.8	240.1
Weed free	0.7(0.0)	0.1(0.0)	0.7(0.0)	2.5(5.7)	0.0	1.2	6.6	2.6
LSD (p=0.05)	0.54	0.92	0.56	0.68	1.82	4.82	3.07	6.2

Table 2. Effect of different weed control methods on weed control efficiency and weed index in *Rabi* groundnut

Treatment	WCE (%) at 40 DAS		WCE (%) at 40DAS		Weed index (%)	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Pendimethalin 1.0 kg/ha PE	39.7	68.3	49.9	63.2	53.0	48.2
Pendimethalin imazethapyr 1.0 kg/ha PE ready mix (RM)	42.4	48.8	55.4	67.2	46.7	42.9
Pendimethalin 0.75/1.0 kg/ha PE + quizafop-p-ethyl 50 g/ha at 15 DAS	41.7	90.1	57.2	76.6	42.7	34.6
Pendimethalin + imazethapyr 1.0 kg/ha PE RM + quizafop-p-ethyl 50 g/ha at 15 DAS	51.7	59.0	59.6	77.2	24.0	10.2
Pendimethalin 1.0 kg/ha PE + imazethapyr 75 g/ha at 15 DAS	44.4	58.1	59.1	75.3	38.3	33.0
Pendimethalin 1.0 kg/ha PE + MW at 25 DAS	54.3	84.3	63.2	78.3	33.7	28.1
Pendimethalin + imazethapyr 1.0 kg/ha PE RM + MW at 25 DAS	63.6	77.7	66.9	83.9	12.3	7.6
Two manual weddings (MW) at 20 and 40 DAS	62.3	82.9	64.8	83.2	28.5	18.0
Weedy check	-	-	-	-	65.7	58.7
Weed free	-	-	-	-	0.0	0.0

*Data in parentheses-original values

fb quizafop-p-ethyl as post-emergence applications with 2.28 and 2.29 t/ha pod yield in 2018-19 and 2019-20, respectively. The highest shelling % was incurred with twice manual weddings with 73.2 and 73.6% in 2018-19 and 2019-20, respectively, which was at par with a ready mix combination of pendimethalin and imazethapyr *fb* manual weeding over the other treatments. The higher yield might be due to higher shelling %, lesser weed density and dry matter observed at critical periods of crop-weed competition and reduced weed competition for limited resources which resulted increased number of sound mature pods per plant compared to other treatments (Olorunmaiye and Olorunmaiye 2009). Additional hand weeding at 20DAS after the pre-emergence application of pendimethalin + imazethapyr (ready-mix) could control the further flushes of weed flora which emerged early in case only pre-emergence herbicide application. The unweeded control treatment recorded significantly the lowest pod (1.03 and 1.05 t/ha in 2018-19 and 2019-20, respectively) and haulm (2.00 and 3.39 t/ha in 2018-19 and 2019-20, respectively) yield. Similar results were reported by Bhatt *et al.* (2010), Swetha *et al.* (2016), Vora *et al. (*2019).

Effect of weed management on economics and nutrient uptake in groundnut

Weed-free treatment registered the highest net return and the lowest was with a weedy check. Amongst different herbicidal treatments, the highest benefit and benefit–cost ratio was obtained from ready mix application of pendimethalin + imazethapyr in combination with manual weedings *fb* ready-mix application of same herbicididal combination with quizafop-p-ethyl at 15 DAS in both years (**Table 5**). This might be due to the increased cost of cultivation of groundnut crops under weed-free treatment due to the higher need of human labours and their higher wages. This cost was reduced in both the herbicidal treatments by using herbicides for effective control of weeds while minimizing human labours. Similar results were also reported by Sardana *et al.* (2006) and Rao *et al.* (2011).

The N, P and K uptake by the crop was significantly higher with weed-free treatment

Table 3. Effect of different weed control methods on Growth and yield attributes in *Rabi* groundnut

Treatment	Plant height (cm)		Branch/plant		Pod /plant	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Pendimethalin 1.0 kg/ha PE	29.7	32.9	3.4	3.2	7.2	10.3
Pendimethalin imazethapyr 1.0 kg/ha PE ready mix (RM)	26.1	31.8	3.6	3.5	7.3	10.8
Pendimethalin 0.75/1.0 kg/ha PE + quizafop-p-ethyl 50 g/ha at 15 DAS	22.9	35.8	4.1	4.2	8.0	11.3
Pendimethalin + imazethapyr 1.0 kg/ha PE RM + quizafop-p-ethyl 50 g/ha at 15 DAS	28.7	33.9	4.6	4.4	13.2	15.2
Pendimethalin 1.0 kg/ha PE + imazethapyr 75 g/ha at 15 DAS	26.1	39.2	4.3	4.2	8.3	12.0
Pendimethalin 1.0 kg/ha PE + MW at 25 DAS	23.8	37.2	4.4	4.2	10.6	13.0
Pendimethalin + imazethapyr 1.0 kg/ha PE RM + MW at 25 DAS	37.1	40.3	5.0	4.8	19.3	17.2
Two manual weddings (MW) at 20 and 40 DAS	45.6	41.5	4.9	4.8	17.1	17.5
Weedy check	18.1	21.4	2.7	2.8	6.9	8.2
Weed free	34.3	34.8	8.0	6.0	20.3	18.4
LSD (p=0.05)	2.2	5.11	0.47	0.64	1.37	1.96

Table 4 Effect of different weed control methods on yield and yield attributes in winter groundnut

Treatment	Shelling (%)		Pod yield (kg/ha)		Haulm yield (kg/ha)	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Pendimethalin 1.0 kg/ha PE	65.1	70.2	1410	1322	2607	2772
Pendimethalin imazethapyr 1.0 kg/ha PE ready mix (RM)	66.4	72.0	1600	1456	2810	3244
Pendimethalin 0.75/1.0 kg/ha PE + quizafop-p-ethyl 50 g/ha at 15 DAS	69.9	72.2	1720	1667	3001	3689
Pendimethalin + imazethapyr 1.0 kg/ha PE RM + quizafop-p-ethyl 50 g/ha at 15 DAS	70.1	75.2	2280	2289	3722	4611
Pendimethalin 1.0 kg/ha PE + imazethapyr 75 g/ha at 15 DAS	68.1	73.2	1850	1709	3049	3500
Pendimethalin 1.0 kg/ha PE + MW at 25 DAS	71.9	73.7	1990	1833	3250	3754
Pendimethalin + imazethapyr 1.0 kg/ha PE RM + MW at 25 DAS	71.7	76.1	2630	2355	4100	3933
Two manual weddings (MW) at 20 and 40 DAS	75.2	77.4	2145	2090	3520	4261
Weedy check	60.3	69.7	1030	1054	2000	3389
Weed free	75.6	77.6	3000	2550	4500	4033
LSD (p=0.05)	4.37	3.64	372.8	288.9	441.5	388.7

Table 5. Effect of different weed control methods on nutrient uptake and economics in winter groundnut

Treatment	Net Return		BCR		N (kg/ha)		P (kg/ha)		K (kg/ha)	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Pendimethalin 1.0 kg/ha PE	25844	24825	1.6	1.4	40.1	40.8	11.2	12.0	33.5	33.2
Pendimethalin imazethapyr 1.0 kg/ha PE ready mix (RM)	34595	33673	1.8	1.5	42.9	41.3	10.8	10.6	30.2	31.5
Pendimethalin 0.75/1.0 kg/ha PE + quizafop-p-ethyl 50 g/ha at 15 DAS	37622	34457	1.8	1.7	75.3	75.1	9.4	8.9	33.7	35.3
Pendimethalin + imazethapyr 1.0 kg/ha PE RM + quizafop-p-ethyl 50 g/ha at 15 DAS	64792	65340	2.3	2.1	65.4	64.3	13.8	14.4	32.8	33.1
Pendimethalin 1.0 kg/ha PE + imazethapyr 75 g/ha at 15 DAS	44905	36704	1.9	1.8	72.9	73.5	10.2	10.7	42.1	43.0
Pendimethalin 1.0 kg/ha PE + MW at 25 DAS	52875	41564	2.1	1.8	54.4	54.2	13.3	12.8	50.8	50.6
Pendimethalin + imazethapyr 1.0 kg/ha PE RM + MW at 25 DAS	82370	66740	2.7	2.3	77.5	76.1	13.1	13.6	45.7	46.3
Two manual weddings (MW) at 20 and 40 DAS	56415	68531	2.1	1.9	78.6	81.3	14.5	14.2	38.4	40.8
Weedy check	9420	10619	1.2	1.3	55.7	52.4	8.7	8.4	24.1	26.5
Weed free	96700	74008	2.4	2.2	107.9	105.3	17.2	18.1	51.7	56.8
LSD (p=0.05)					-	-	-	-	-	-

followed by two manual weedings and ready mix application of pendimethalin and imazethapyr *fb* manual weeding (**Table 5**). In 2018-19, the nutrient uptake was higher in twice manual weeding with 78.6, 14.5 and 38.4 kg/ha N, P and K closely followed by ready-mix combination of pendimethalin and imazethapyr *fb* manual weeding. The higher nutrient uptake by crop might be due to decreased crop weed competition at critical stages, which simultaneously increased nutrient availability, better crop growth, and dry matter production coupled with more nutrient content (Samant and Mishra 2014, Singh *et al.* 2017).

Conclusion

Ready-mix application of pendimethalin + imazethapyr *fb* manual weedings at 25 DAS proved effective in controlling all types of weeds, increased yield and nutrient uptake. Alternatively, farmers can go for the post-emergence application of quizalofop-p-ethyl in combination with ready mix application of pendimethalin and imazethapyr under grassy weed situations for better yield, weed control efficiency and economics.

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