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Weeds and phosphorus management effect on groundnut productivity, oil content and nutrient uptake

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ABSTRACT

The present study was conducted at MPUAT, Udaipur, India, during two consecutive *Kharif* (rainy season) of 2016 and 2017 to assess the effect of weed management treatments and phosphorus levels on weeds; groundnut growth, yield, quality and probability of groundnut cultivation. A split-plot design was used with six weed management treatments *i.e.*, weedy check, weed free up to 60 days after seeding (DAS), pendimethalin 750 g/ha pre-emergence application (PE), oxyfluorfen 125 g/ha PE, imazethapyr 100 g/ha post-mergence application at 15 DAS (PoE) and quizalofop-ethyl 50 g/ha PoE at 15 DAS as main plots, and five phosphorus levels, *viz*. 0, 20, 40,60 and 80 kg P/ha as sub-plots with three replications. The lowest density of *Cyperus rotundus* and *Echinochloa colona* was recorded with imazethapyr and quizalofop-ethyl, respectively. The lowest density of other narrow-leaved weeds at 30, 60 DAS and harvest was registered with pendimethalin, quizalofop-ethyl and imazethapyr, respectively. Weed free up to 60 DAS was the most effective in managing weeds and increasing groundnut yield. Amongst herbicide treatments, imazethapyr 100 g/ha PoE recorded significantly minimum weed index, weed persistence index, crop resistance index, and the highest values of growth and yield parameters, and N, P and K uptake. Application of 60 kg P/ha has registered significantly the highest plant height, dry matter accumulation, 100 kernels weight and pod yield (1.76 t/ha), biological yield (4.86 t/ha) and also the harvest index (35.83%). Significantly higher protein and oil content were noticed when the crop was fertilized with 40 kg P/ha. The total N, P and K uptake by crop were significantly higher by 87.83, 92.10 and 60.97% over control, respectively with 80 kg P/ha.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is largely grown as a small holding crop in rainfed area under arid and semi-arid conditions in the world (Khan *et al.* 2018). In India, six states namely Gujarat, Rajasthan, Andhra Pradesh, Karnataka, Maharashtra and Tamil Nadu account for about 90% of the total groundnut area and production of the country. In India, groundnut is cultivated in on an area of 4.9 mha and production of 10.1 mt with productivity 2.06 t/ha (Government of India 2021). Rajasthan accounts nearly 15.08% of production on 10.48% cultivation area in 2016-17 (RAS 2018).

Among different constraints that limit the productivity of peanut in India, weed menace is a serious bottleneck as peanut is confronted with repeated flushes of diverse grassy, broad-leaved and sedge weeds cause substantial yield losses 24-70% (Jat *et al.* 2011). Thus, weed control is the foremost critical production practice in groundnut cultivation (Samant and Mishra 2014). Generally, weeds are controlled through hand weeding in groundnut, which is very expensive, laborious and sometimes damaging to the crop plants (Singh *et al.* 2014). Hence, there is a need to explore effective pre- and post-emergence herbicides for effective control of weeds in groundnut.

Phosphorus (P) is essential at all groundnut crop developmental stages till crop maturity. In addition, availability of P increases the N-fixing capacity and resistance to plant diseases (Malhotra *et al.* 2018 and Madhuri *et al.* 2019). P is most important for exploiting genetic potentials of the crop for its growth and development (Shen *et al.* 2011). Thus, the present study was carried out to identify suitable weed management treatments and optimum phosphorus dose for managing weeds and enhancing groundnut nutrient uptake, oil content and productivity.

MATERIALS AND METHODS

The present study was carried out during *Kharif* (rainy season) of 2016 and 2017 at Instructional Farm (24º35’ N latitude and 73°44’ E longitude at an altitude of 582.17 MAMSL), CTAE, MPUAT, Udaipur, Rajasthan, India. The experimental site is falls under agro-climatic zone IVa in South-Eastern region of Rajasthan, associated with typically semi-arid and sub-tropical climate. The analysis values of composite soil sample of experimental site have been furnished in (**Table 1**).

The experiment was laid out in a split-plot design comprised six weed management treatments as main plots, *viz*. weedy check, weed free up to 60 days after seeding (DAS), pendimethalin 750 g/ha pre-emergence application (PE), oxyfluorfen 125 g/ha PE, imazethapyr 100 g/ha post-emergence application (PoE) at 15 DAS and quizalofop-ethyl 50 g/ha as PoE at 15 DAS and five phosphorus levels as sub-plots *viz.* 0 (control), 20, 40, 60, and 80 kg P/ha as sub-plots. Three replications were maintained. Before sowing, till good tilth the field was thoroughly ploughed and leveled. Healthy treated groundnut (variety: *TG 37 A*) kernels were sown on 27.06.2016 and 06.07.2017 at spacing of 30 x 10 cm with a depth of nearly 4-5 cm by using seed rate of 100 kg/ha and harvested on 15.10.2016 and 25.10.2017, during 1st and 2nd trails, respectively. Pre- and post-emergence herbicides were applied at 2 and 15 DAS, respectively during rain free condition with a battery-operated knap-sack sprayer fitted with flat-fan nozzle. In weed free up to 60 DAS treatment, the weeds were removed manually to keep weed free up to 60 DAS while, weedy check plots were allowed to remain infested with weeds till crop harvest. The recommended dose of nitrogen 30 kg/ha and phosphorus (as per treatment) were applied as basal application using urea and DAP in the furrows below the kernel in all the plots. The rest of the packages of practices were adopted as per recommended in Rajasthan. Weed density was recorded from two randomly selected area of 0.25/m^2 using 0.5 x 0.5 m quadrat at 30, 45 DAS and harvest in each plot thereafter mean data were subjected to square root transformation $\sqrt{X+0.05}$ to normalize their distribution (Gomez and Gomez 1984). Weed index, herbicidal efficiency index, weed persistence index and crop resistance index were calculated using formulae as given ISA (2009). The plant height, dry matter accumulation, crop or relative growth rate, yield attributing parameters like 100 kernels weight and yield such as pod, biological and harvest index as well as protein content of kernel was analysed by Lowry protein assay method (Lowry *et al*. 1951) and oil content was determined by Soxhlit’s oil extraction method (Knowles and Watkins 1960). The percent of oil ingredient was calculated as follows:

Table 1. Physico-chemical characteristics of soil (0-15 cm depth) before start of the experiment

Soil physical properties						
Bulk density (Mg/m^3)	Particle density (Mg/m^3)	Porosity (%)	Particle size distribution (%)			Soil Texture
			Sand	Silt	Clay	
1.52	2.65	42.34	58.02	29.42	12.06	Sandy loam

Soil chemical properties					
Organic carbon (%)	Available soil nutrient (kg/ha)			Soil pH	EC (dS/m)
	N	P	K		
0.32	259.98	17.17	177.71	7.76	0.83

$$\text{Oil content (\%)} = \frac{\text{Weight of flask with extract - weight of empty flask}}{\text{Weight of sample taken}} \times 100$$

Further, total uptake of nutrients was worked out by using the following formula.

$$\text{Total nutrient uptake(kg/ha)} = \frac{\text{Nutrient concentration in pod/haulm (\%)} \times \text{Pod yield / haulm (kg/ha)}}{100}$$

Statistical analysis of the recorded data was carried out using analysis of variance technique for split plot design (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

There was a significant decrease in the density of weeds *i.e. Cyperus rotundus*, *Echinochloa colona* and other narrow-leaved weeds (other than *C. rotundus*, *E. colona* and *Cynodon dactylon)* due to tested weed management treatments as compared to weedy check (**Table 2**). The weed free recorded significantly lowest weed density and it was statistically superior to rest of the treatments. Among the herbicidal treatments, post-emergence application of quizalofop-ethyl was statistically superior than all other treatments in effectively reducing density of *E. colona* at 30, 45 DAS and harvest. Phosphorus application failed to significantly influence the weeds density.

Among the herbicide treatments, lowest weed index was registered with imazethapyr (2.86%) which was closely followed by pendimethalin (3.55%). Application of imazethapyr, pendimethalin, oxyfluorfen and quizalofop-ethyl recorded 1.09, 0.84, 0.65 and 0.48% herbicidal efficiency index, respectively. The minimum weed persistence index was recorded with imazethapyr (0.97), pendimethalin (0.99) followed by oxyfluorfen (0.99) and quizalofop-ethyl (1.02). The lower crop resistance index of total weeds was recorded under weed free (0.09) followed by imazethapyr (0.64), oxyfluorfen (0.78) and pendimethalin (0.80) than quizalofop-ethyl (0.99) (**Figure 1**). These results were in conformity with those of Adhikary *et al.* (2016).

The maximum plant height and dry matter accumulation were registered under weed free up to 60 DAS which was statistically at par with pendimethalin at 40 DAS and imazethapyr at harvest (**Table 3**). The crop fertilized with 60 kg P/ha increased the plant height by 36.33 and 29.78% and dry matter accumulation by 30.62 and 21.85% at 40 DAS and harvest, respectively when compared to control. Application of phosphorus up to 80 kg/ha registered significantly higher crop growth rate over control. The phosphorus beyond 20 kg/ha had no significant effect on CGR and phosphorus dosage rates effect on relative growth rate was non-significant. Weed free up to 60 DAS recorded maximum 100 kernels weight and was closely followed by imazethapyr and pendimethalin. The 100 kernels weight increased by 27.31, 4.97 and 2.53% with increased phosphorus levels from control-20, 20-40 and 40-60 kg P/ha, respectively (**Table 4**).

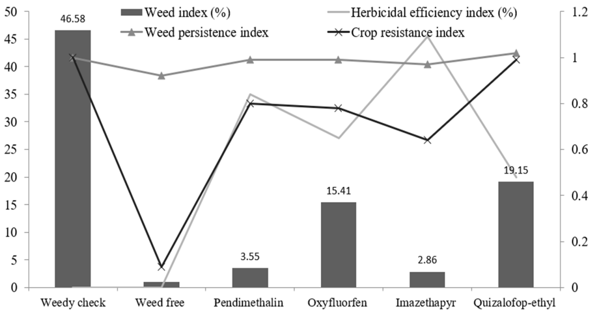

Figure 1. Effect of weed management practices on agronomic indices

The pod and biological yield increase over weedy check control was highest with weed free up to 60 DAS (87.16 and 51.91%) followed by imazethapyr (81.78 and 48.22%) and pendimethalin (80.54 and 47.34%) (**Table 4**). The enhanced yield attributing characters may be attributed to reduced

Table 2. Effect of weed management treatments and phosphorus levels on weeds density at different crop growth periods during *Kharif* season (pooled mean for two years)

Treatment	Weed density (no./m^2)								
	Cyperus rotundus			*Echinochloa colona*			Other narrow weeds		
	30 DAS	45 DAS	Harvest	30 DAS	45 DAS	Harvest	30 DAS	45 DAS	Harvest
Weed management									
Pendimethalin 750 g/ha PE	2.56 (6.08)	3.16 (9.58)	3.72 (13.50)	2.53 (5.94)	3.81 (14.01)	4.74 (22.02)	1.64 (2.20)	3.47 (11.62)	2.97 (8.33)
Oxyfluorfen 125 g/ha PE	2.75 (7.08)	3.17 (9.55)	3.78 (13.85)	2.65 (6.58)	3.81 (14.04)	5.13 (25.79)	2.65 (6.56)	4.10 (16.33)	4.01 (15.58)
Imazethapyr 100 g/ha PoE	2.28 (4.72)	2.79 (7.29)	3.44 (11.44)	2.47 (5.64)	3.20 (9.75)	4.62 (20.84)	2.33 (4.94)	3.37 (10.84)	2.73 (6.99)
Quizalofop-ethyl 50 g/ha PoE	3.03 (8.71)	3.85 (14.35)	4.26 (17.63)	2.17 (4.24)	2.84 (7.55)	3.87 (14.54)	1.99 (3.45)	2.88 (7.80)	3.00 (8.52)
Weed free up to 60 DAS	0.71 (0.00)	0.71 (0.00)	1.20 (1.07)	0.71 (0.00)	0.71 (0.00)	1.63 (2.21)	0.71 (0.00)	0.71 (0.00)	1.94 (3.35)
Weedy check	3.42 (11.32)	4.22 (17.33)	4.76 (22.21)	4.93 (23.84)	6.17 (37.66)	6.95 (47.91)	3.36 (10.82)	4.99 (24.41)	4.98 (24.33)
LSD (p=0.05)	0.13	0.07	0.07	0.10	0.07	0.09	0.08	0.04	0.06
Phosphorus levels (P kg/ha)									
20	2.45 (6.29)	2.98 (9.65)	3.52 (13.25)	2.56 (7.65)	3.41 (13.74)	4.49 (22.23)	2.11 (4.63)	3.25 (11.80)	3.26 (11.12)
40	2.46 (6.32)	2.98 (9.67)	3.53 (13.35)	2.58 (7.71)	3.42 (13.86)	4.50 (22.27)	2.11 (4.65)	3.25 (11.82)	3.27 (11.16)
60	2.46 (6.35)	2.99 (9.72)	3.53 (13.32)	2.59 (7.76)	3.43 (13.91)	4.50 (22.29)	2.12 (4.69)	3.26 (11.87)	3.27 (11.20)
80	2.47 (6.38)	3.00 (9.75)	3.53 (13.22)	2.60 (7.80)	3.44 (13.99)	4.50 (22.19)	2.13 (4.71)	3.26 (11.90)	3.30 (11.34)
0 (Control)	2.45 (6.26)	2.97 (9.62)	3.52 (13.27)	2.55 (7.61)	3.41 (13.68)	4.47 (22.10)	2.11 (4.62)	3.24 (11.77)	3.26 (11.10)
LSD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

competitiveness of weed due to greater efficacy of weed control treatments as reported by Choudhary *et al.* (2017) and Singh *et al.* (2018). Application of 60 kg P/ha resulted in an increase of 70.91 and 59.88% pod and biological yield over control, respectively. The improvement in plant growth by phosphorus application leading to an increase in photosynthetic activity and translocation of photosynthates with adequate nutrients to sink and subsequently resulting in better development of yield attributes resulting in higher groundnut yield (Meena *et al*. 2014 and Sibhatu *et al.* 2016).

The protein content of kernel was highest with weed free up to 60 DAS. Among herbicides, imazethapyr recorded significantly highest protein content (23.05%) in kernel followed by pendimethalin (22.40%) over oxyfluorfen (21.52%), quizalofop-ethyl (21.89%) and weedy check (**Table 4**). This might be due to increase protein content in kernel (Adhikary *et al.* 2016). Oil content in groundnut kernel was not significantly affected by tested weed management treatments. An increasing trend of protein and oil content in kernel was observed with the increase in application rate of phusphorus. The application of 40-60 and 60-80 kg P/ha were equally efficient in terms of increasing the protein and oil content and were statistically at par with each other. Because nitrogen is a basic constituent of protein and with increase in the rate of phosphorus application, nitrogen availability increased which resulted in increased protein and oil content in kernel (Malhotra *et al.* 2018).

Table 3. Effect of weed management treatments and phosphorus levels on growth parameters of groundnut during *Kharif* season (pooled mean for two years)

Treatment	Plant height (cm)		Dry matter accumulation (g/m^2)		CGR (g/m^2/day)	RGR (mg/g/day)
	40 DAS	Harvest	40 DAS	Harvest	Between 60 DAS and harvest	
Weed management						
Pendimethalin 750 g/ha PE	16.74	28.96	181.46	447.72	2.60	7.31
Oxyfluorfen 125 g/ha PE	14.67	26.99	168.05	407.72	2.33	7.16
Imazethapyr 100 g/ha PoE	15.98	30.46	179.47	456.94	2.66	7.32
Quizalofop-ethyl 50 g/ha PoE	14.98	27.95	170.07	411.22	2.33	7.18
Weed free up to 60 DAS	16.99	30.59	183.73	461.14	2.70	7.33
Weedy check	12.51	24.92	155.76	295.47	1.02	3.90
LSD (p=0.05)	0.84	1.30	4.31	14.16	0.14	0.31
Phosphorus levels (P kg/ha)						
20	14.89	27.60	172.84	404.45	2.23	6.71
40	15.66	29.26	179.60	423.59	2.33	6.74
60	16.70	30.46	185.22	437.08	2.39	6.65
80	17.05	30.77	186.00	443.01	2.43	6.70
0 (Control)	12.25	23.47	141.80	358.70	1.98	6.72
LSD (p=0.05)	0.40	0.51	2.45	5.96	0.10	NS

*DAS: Days after seeding; PE: Pre-emergence; PoE: Post-emergence

Table 4. Effect of weed management treatments and phosphorus levels on yield attributes, yield and quality of groundnut during *Kharif* season (pooled mean for two years)

Treatment	100 kernels weight (g)	Pod yield (t/ha)			Biological yield (t/ha)			Harvest index (%)	Protein (%)	Oil (%)
		2016	2017	Pooled	2016	2017	Pooled			
Weed management										
Pendimethalin 750 g/ha PE	38.93	1.70	1.78	1.74	4.64	4.79	4.71	36.85	22.40	46.22
Oxyfluorfen 125 g/ha PE	36.20	1.50	1.56	1.53	4.29	4.44	4.36	34.94	21.52	45.12
Imazethapyr 100 g/ha PoE	39.12	1.72	1.79	1.76	4.67	4.81	4.74	36.88	23.05	46.12
Quizalofop-ethyl 50 g/ha PoE	36.58	1.43	1.49	1.46	4.23	4.40	4.32	33.75	21.89	45.09
Weed free up to 60 DAS	39.95	1.79	1.83	1.81	4.78	4.94	4.86	37.06	23.67	46.63
Weedy check	30.40	0.94	0.99	0.97	3.16	3.24	3.20	30.24	21.42	44.29
LSD (p=0.05)	1.00	0.13	0.07	0.07	0.25	0.15	0.12	1.22	0.49	NS
Phosphorus levels (P kg/ha)										
20	36.83	1.45	1.48	1.47	4.25	4.36	4.31	33.74	21.87	45.20
40	38.66	1.66	1.73	1.70	4.65	4.80	4.73	35.26	22.41	45.88
60	39.64	1.72	1.79	1.76	4.77	4.95	4.86	35.83	22.53	46.09
80	39.87	1.73	1.81	1.77	4.80	4.98	4.89	35.90	22.74	46.27
0 (control)	28.93	1.02	1.04	1.03	3.00	3.08	3.04	33.34	21.25	44.45
LSD (p=0.05)	0.24	0.05	0.05	0.03	0.08	0.10	0.03	0.56	0.23	0.56

*DAS: Days after seeding; PE: Pre-emergence; PoE: Post-emergence

Table 5. Effect of weed management treatments and phosphorus levels on total nutrient uptake by groundnut during *Kharif* season (pooled mean for two years)

Treatment	Nutrient uptake(kg/ha)		
	Nitrogen	Phosphorus	Potassium
Weed management			
Pendimethalin 750 g/ha PE	116.75	28.78	50.00
Oxyfluorfen 125 g/ha PE	105.28	26.07	46.40
Imazethapyr 100 g/ha PoE	117.18	29.19	50.25
Quizalofop-ethyl 50 g/ha PoE	103.78	25.39	46.27
Weed free up to 60 DAS	121.60	30.08	51.83
Weedy check	72.03	17.21	34.48
LSD (p=0.05)	3.56	0.81	1.54
Phosphorus levels (P kg/ha)			
20	102.31	24.72	45.99
40	117.19	28.49	50.20
60	121.50	30.41	51.84
80	123.67	30.89	52.22
0 (control)	65.84	16.08	32.44
LSD (p=0.05)	1.31	0.31	0.50

DAS: Days after seeding; PE: Pre-emergence; PoE: Post-emergence

The N, P and K uptake by the crop was significantly highest with weed free up to 60 DAS followed by imazethapyr and pendimethalin whereas, pendimethalin and imazethapyr were found non-significant to each other in this regard but significantly superior over oxyfluorfen, quizalofop-ethyl and weedy check (**Table 5**). The higher nutrient uptake by crop might be due to decreased crop weed competition concurrently increased nutrient availability, better crop growth and higher crop biomass production coupled with more nutrient content (Samant and Mishra 2014, Singh *et al.* 2017).

Based on the results of this study, it is concluded that the post-emergence application of imazethapyr at 100 g/ha at 15 DAS and soil application of 60 kg P/ha results in adequate management of weeds and optimum groundnut pod yield.

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