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Research Paper

Herbicidal weed management in groundnut (*Arachis hypogaea*) and its residual effect on succeeding wheat (*Triticum aestivum*) crop

M.L. MEHRIYA[1], VIJAY LAXMI YADAV[2] AND NEELAM GEAT[3]

Agricultural Research Station, Agriculture University, Mandore, Jodhpur, Rajasthan 342304

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ABSTRACT

A field experiment was carried out at Mandore, Jodhpur, Rajasthan, during the rainy (*kharif*) and winter (*rabi*) seasons of 2017–18 and 2018–19, to study the herbicidal weed management in groundnut (*Arachis hypogea* L.) and its residual effect on succeeding wheat (*Triticum aestivum* L.) crop in the western Rajasthan. The experiment was laid out in a randomized block design with 14 treatments and replicated thrice. Weed-free (2 hand-weedings) treatment recorded significantly higher pod yield over rest of the treatments. Among the herbicidal treatments, pendimethalin 30 EC + imazethapyr 2 EC @ 1,000 g/ha pre-emergence (PE) treatment (T_5) led to the lowest weed density, weed biomass, and achieved the maximum weed-control efficiency. This T_5 treatment was statistically significant over the T_4 (pendimethalin 30 EC + imazethapyr 2 EC @ 750 g/ha PE), T_{12} [sodium aciflourfen 16.5% + clodinafop propargyl 8% @ 200 g/ha post-emergence (PoE)] and T_{11} (sodium aciflourfen 16.5% + clodinafop propargyl 8% @ 180g/ha PoE) in relation to pod yield. Our results also revealed that application of pendimethalin 30 EC + imazethapyr 2 EC @ 1000 g/ha PE enhanced the cropping system gross returns, net returns and benefit:cost (B:C) ratio over the control. But showed equal economic feasibility with pendimethalin 30 EC + imazethapyr 2 EC @ 750 g/ha PE, sodium aciflourfen 16.5% + clodinafop propargyl 8% @ 200 g/ha PoE and sodium aciflourfen 16.5% + clodinafop propargyl 8% @ 180 g/ha PoE. Imazethapyr + imazamox (pre-mix) @ 70 g/ha PoE also effectively controlled the weed in groundnut and found statically at par with above treatments. Residual effect of different concentrations of herbicide was not observed in succeeding wheat in groundnut–wheat cropping system.

Key words: Economics, Groundnut, Herbicide, Residual effect, Weed management, Wheat

Groundnut is the sixth most important oilseed and cash crops of India. Groundnut contributes more than 50% edible oil production of the country. It contains 48–50% of oil and 26–28% of protein, and is a rich source of dietary fibre, minerals and vitamins. India cultivates about 4.91 million ha and produces 9.18 million tonnes of groundnuts (DAC FW, 2018). In Rajasthan, it is grown on an area of 0.64 million ha, with production of 1.26 million tonnes and average productivity of state is 1966 kg/ha. It is mainly grown in arid and semi-arid districts of Rajasthan (DAC FW, 2018). There is tremendous scope for growing groundnut in sequence with other crop which will improve the soil health (N addition through biological nitrogen fixation, minimizing soil compaction, increasing soil organic matter) but also break the weed and pest cycles and minimizing any allelopathic effects (Sanford and Hairston, 1984; Yadav *et al*., 2003). Groundnut–wheat is an important cropping system of irrigated area of western Rajasthan (Rathore *et al.*, 2018).

A major constraint in groundnut production is the weed menace and losses caused by weeds are more than any other causes like insects, diseases and nematodes (Chaitanya *et al*., 2012). Competitional stress of weeds causes reduction in pod yield to the extent of 17–84% (Wesley *et al*., 2008; Nambi and Sundari, 2008). Thus, proper weed management is essential to get optimum yield. In modern agriculture, herbicides are commonly used as an alternative method to traditional methods of hand-weeding at initial period for better control of weeds. Use of pre- and post-emergence herbicides offers an alternative viable option for effective and timely control of weeds in groundnut. But, each herbicide has its own spectrum of weed-control. The timing of herbicide application also has much concern on weed-control efficiency. Sharma *et al.* (2015) reported

[1]**Corresponding author's Email:** mmehriya@yahoo.com

[1]Assistant Professor (Agronomy), [3]Assistant Professor (Plant Pathology); Agricultural Research Station, Mandore, Agriculture University, Jodhpur, Rajasthan 342 304; [2]Ph.D. Student (Agronomy), Sri Karan Narendra Agriculture University, Jobner, Jaipur, Rajasthan 303 329

that, application of selective pre-emergence herbicides like pendimethalin is effective in controlling weeds in groundnut. But it is less effective on some of the broad-leaf weeds and perennial sedge *Cyperus rotundus* (Sondhia *et al.,* 2015). Further, pre-emergence herbicides have been proved remarkably effective up to 20–25 days after sowing (DAS), but late coming weeds interfere with pegging, pod development and harvesting. Post-emergence application of imazethapyr 75 g/ha was recommended for control of weeds in groundnut, but the choice of succeeding crops is limited because imazethapyr persists in soil and plant for longer time with a half-life period of 33 months and is not effective against grasses (Sondhia *et al.,* 2015). Imazethapyr applied in clusterbean has been observed to show adverse effect on the succeeding crop of Indian mustard in the light soils (Sangwan *et al.,* 2016).

Herbicide application reduced weed control labour time by 96 – 99.9% in cultivation of groundnut (Arthur, 2016). However, application of higher dose of herbicides or persistent nature of herbicides may pose residual effect on succeeding crops and harm the soil microflora and fauna. Higher herbicide concentration decrease root nodular rhizobial microbiota, resulting in abnormal growth of *Arachis hypogaea* (Doughari and Madani, 2017). Therefore, this present experiment was planned to find out most effective herbicide in controlling the complex weed flora in groundnut under western Rajasthan conditions and residual effect of herbicides on succeeding wheat in groundnut–wheat cropping system.

MATERIALS AND METHODS

A field experiment was conducted during the rainy (*kharif*) and winter (*rabi*) seasons of 2017–18 and 2018–19 at Agricultural Research Station, Mandore, (26° 15' N to 26° 45' N and 73° 00' E) Jodhpur, Rajasthan. This research station falls under agro-climatic zone Ia (Arid Western Plains Zone) of Rajasthan. Soil of the experimental field was sandy loam in texture, low in organic carbon (0.13%), slightly alkaline in reaction (*p*H 8.2), and available nitrogen, phosphorus, potassium was 174 kg/ha, 22.2 kg/ha and 325 kg/ha, respectively. The climate of Jodhpur is typically arid with hot dry summers. The average annual rainfall is about 367 mm (CV 52%) and bulk of it (85 to 90%) is received from June to September (*kharif* season) by the south-west monsoon. Under the present investigation, different herbicides were taken to study their effect on weeds and crops. The experiment comprising 14 treatments, viz. T_1, pendimethalin 30 EC @ 1,000 g/ha PPI; T_2, pendimethalin 30 EC @ 1,000 g/ha PE; T_3, pendimethalin 30 EC + imazethapyr 2 EC @ 500 g/ha pre-emergence (PE); T_4, pendimethalin 30 EC + imazethapyr 2 EC @ 750 g/ha PE; T_5, pendimethalin 30 EC + imazethapyr 2 EC @ 1,000 g/ha PE; T_6, imazethapyr 10 SL @ 50 g/ha post-emergence (PoE); T_7, imazethapyr + imazamox (pre-mix) @ 50 g/ha PoE; T_8, imazethapyr + imazamox (pre-mix) @ 70 g/ha 15–20 days after sowing (DAS); T_9, imazethapyr + imazamox (pre-mix) @ 90 g/ha PoE; T_{10}, sodium aciflourfen 16.5% + clodinafop propargyl 8% @ 160g/ha PoE; T_{11}, sodium aciflourfen 16.5% + clodinafop propargyl 8% @ 180 g/ha PoE; T_{12}, sodium aciflourfen 16.5% + clodinafop propargyl 8% @ 200 g/ha PoE; T_{13}, weedy-check; and T_{14}, weed-free (2 hand-weedings at 20 and 40 DAS) was laid out in randomized block design with 3 replications. The required quantity of commercial formulation of each herbicidal treatment was sprayed with the help of knapsack sprayer fitted with flat-fan nozzle and water as a carrier @ 500 litres/ha. Incorporated pre-plant herbicides 1 day before sowing, pre-emergence herbicides were applied 1 day after sowing and post-emergence herbicides applied at 15-20 days after sowing. In the weedy check, no weeding practice was done. All the recommended improved practices were followed in this experiment including fertilizers and plant-protection measures. Weed counting was done by using quadrate of 0.5 m × 0.5 m^2 sizes at 2 places and dry weight of weeds from each plot was also recorded. Weed data were subjected to square-root transformation ($\sqrt{x+0.5}$) before statistical analysis. To access the residual effect of applied herbicides, after harvesting of the groundnut crop without any disturbance to the layout of experiment, each plot was manually prepared for sowing of succeeding wheat crop. The plant stand/m row, plant height (cm), tillers/plant, test weight (g), grain yield (kg/ha), biological yield (kg/ha) and harvest index (%) of wheat crop were recorded and data were used for analysis. Weed-control efficiency (WCE) was calculated with the following formula suggested by Mani *et al*. (1973):

$$\text{WCE (\%)} = \frac{\text{DMC - DMT}}{\text{DMC}} \times 100$$

where DMC, dry matter production of weeds/m^2 in weedy check; DMT, dry-matter production of weeds/m^2 in the treatment to be compared

Weed index is per cent reduction in pod yield due to weeds as compared to total yield of weed-free treatment. The weed index was calculated as:

$$\text{Weed index (\%)} = \frac{X-Y}{X} \times 100$$

Where X, pod yield from weed free plot; Y, pod yield from treatment for which weed index is to be worked out

RESULTS AND DISCUSSION

Weed flora

Weed species observed throughout the crop season in the experimental field belong to 3 caterogries, viz. grasses, Broad-leaf weeds (BLWs) and sedges. The grasses present in the experimental field were *Dactyloctenium aegyptium*, *Digitaria sanguinalis, Cynodon dactylon*, *Setaria glauca*, *Cenchurs ciliaris* and *Eragrostis amabilis*. The BLWs were *Amaranthus* spp., *Digera arvensis*, *Corchorus olitorius, Phyllanthus niruri*, *Tribulus terrestris, Celosia argentea, Phyllanthus maderaspatensis, Boerhavia erecta, Commelina benghalensis, Cleome viscosa, Cucumis callosus,* and the sedge was *Cyperus rotundus*. However, predominant weeds were *Cyperus rotundus*, *Setaria glauca*, *Dactyloctenium aegyptium*, *Eragrostis amabilis, Amaranthus* spp., *Phylanthus niruri* and *Digera arvensis*.

Effect on weeds

All the weed-management treatments showed significant effect in controlling weeds (Table 1). Minimum number of weeds and weed biomass were recorded under weed-free treatment (2 HW). Among herbicidal weed management, application of pendimethalin 30 EC + imazethapyr 2 EC @ 1,000 g/ha PE showed significantly greater efficacy in reducing total weeds count (no./m^2) and weed dry weight (g/m^2), which resulted in higher weed-control efficiency over rest of the treatments, but found equally effective with its lower dose treatment, i.e. pendimethalin 30 EC + imazethapyr 2 EC @ 750 g/ha PE. Similar results were reported by Singh *et al.* (2019). The lowest weed biomass was recorded under treated plot with sodium aciflourfen 16.5% + clodinafop propargyl 8% @ 200 g/ha PoE followed by sodium aciflourfen 16.5% + clodinafop propargyl 8% @ 180 g/ha PoE and imazethapyr + imazamox (Premix) @ 90 g/ha PoE among all the post-emergence herbicides. The results are in close conformity with findings of Biswal (2017) and Choudhary et al. (2017). The maximum weed counts and weed biomass were recorded under weedy check. Variations in the impact of different herbicides on weeds were due to their diverse mode of action and weed species.

Our present results are agreement with the study of Vaghasia and Nadiyadhara (2013), who reported that the lowest weed-control efficiency was recorded in unweeded treatment. This might be due to the continuous competition of groundnut crop with the obnoxious weed species for nutrient and moisture. Ramakrishna *et al.* (1990) and Dubey *et al.* (2010) observed the similar trend in efficacy of herbicide in groundnut crop.

Table 1. Effect of herbicidal weed management on weed growth, weed-control efficiency (WCE), and weed index (WI) in groundnut (pooled data of 2 years)

Treatment	Weed density (no./ m^2) at 60 DAS	Weed dry weight (g/m^2) 60 DAS	WCE (%)	WI (%)
T_1	6.6 (43.7)	179.33	53.88	26.67
T_2	6.4 (41.0)	164.17	57.78	19.45
T_3	7.2 (51.3)	173.70	55.32	19.37
T_4	4.2 (17.5)	66.46	82.91	6.22
T_5	3.6 (13.3)	49.47	87.28	3.13
T_6	7.4 (54.7)	180.73	53.52	26.49
T_7	7.2 (51.4)	131.07	66.29	25.20
T_8	5.5 (29.7)	76.31	80.37	16.67
T_9	5.2 (27.0)	69.17	82.21	18.42
T_{10}	7.3 (52.8)	154.42	60.28	25.69
T_{11}	4.4 (18.8)	69.33	82.17	15.46
T_{12}	3.8 (15.0)	57.59	85.19	14.81
T_{13}	10.8 (116.7)	388.83	0.00	55.64
T_{14}	0.7 (0.0)	0.00	100.00	0.00
SEm±	0.18	7.7	–	–
CD (P=0.05)	0.50	21.9	–	–

Details of treatments are given under Materials and Methods
*Figures in parentheses indicate original value; DAS, days after sowing;

Effect on crop

Significantly higher pod yield (3.25 t/ha) was recorded under weed-free treatment followed by pendimethalin 30 EC + imazethapyr 2 EC @ 1,000 g/ha PE and thereafter, pendimethalin 30 EC + imazethapyr 2 EC @ 750 g/ha PE which resulted in 2.98 and 2.91 t/ha pod yield respectively (Table 2). Among other herbicidal treatments, sodium aciflourfen 16.5% + clodinafop propargyl 8% @ 200 g/ha PoE and sodium aciflourfen 16.5% + clodinafop propargyl 8% @ 180 g/ha PoE were the next best treatments after pendimethalin 30 EC + imazethapyr 2 EC @ 1,000 g/ha PE and pendimethalin 30 EC + imazethapyr 2 EC @ 750 g/ha PE; and resulted in significantly better pod yield (2.72 and 2.70 t/ha) respectively. These results are in consonance with findings of Choudhary *et al.* (2017) and Singh *et al.* (2019). Non-significant difference of increments between weed-free, pendimethalin 30 EC + imazethapyr 2 EC @ 1,000 g/ha PE, and pendimethalin 30 EC + imazethapyr 2 EC @ 750 g/ha PE treatments were noticed because of similar weed-control across the crop-growth period. Weed-free and most of weed-control treatments recorded better development of yield-attributing characters and improved atmosphere which ultimately increased the yield of groundnut. In weedy check, crop plants faced more competition with weeds throughout life period which might have restricted the pod development, resulting in minimum number of seeds/pod and lesser seed weight due to ineffective weed control. The regression equation predicted linear reduction in the seed yield with a unit increase in the dry weight of weeds (Fig. 1). The extent of reduction could be 4.25 kg/ha for weed dry weight. The evaluation of weed-control efficiency of the different treatments and the regression of

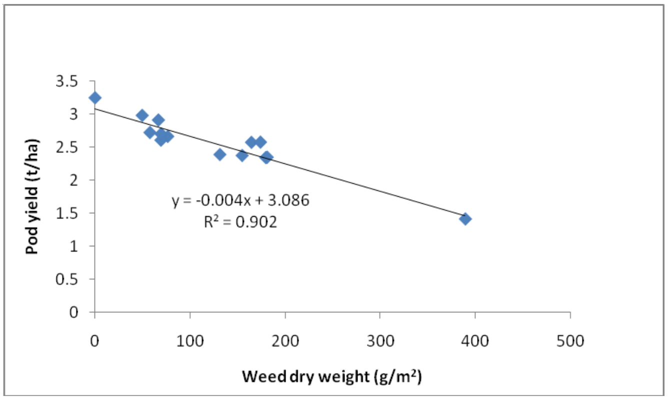

Fig. 1. Relationship between weed dry weight and pod yield of groundnut

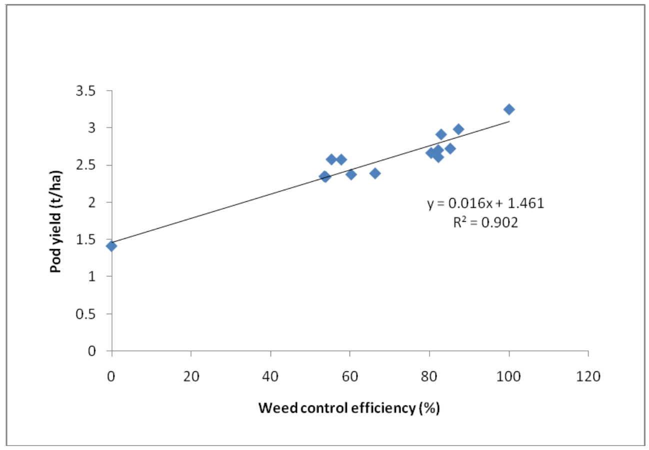

Fig. 2. Relationship between weed-control efficiency and pod yield of groundnut

yield on it revealed that 1% increase in the weed-control efficiency increased the grain yield by 16.5 kg/ha (Fig. 2).

Phytotoxicity symptoms on groundnut crop were studied and observed that none of the herbicidal treatments showed any type of phytotoxicity symptoms on groundnut crops at 1 to 10 days after application of herbicide.

Residual effect of herbicide on succeeding wheat crop

There was no residual effect of these applied herbicides in groundnut on succeeding wheat crop, as evident from final plant count/m row, plant height (cm), tillers/plant, biological yield (t/ha), 1,000-grain weight, harvest index (%) and grain yield (t/ha) of wheat, that were similar among herbicidal and unsprayed plots on the basis pooled data of 2 years (Table 3), indicating that, all the herbicides used as pre- and post-emergence are safe for raising succeeding wheat crop in rotation with groundnut. The residual effects of herbicides depend on soil texture, soil reaction, presence of organic matter in soil and climatic conditions. A long time gap between application of herbicides and crop harvesting, microbial degradation, and precipitation cause the degradation and leaching down of the herbicide (Idapuganti *et al.,* 2005). Our results are in line with the results of Yadav and Bhullar (2014), who reported that early post-emergence application did not leave any residue in the soil and there was no toxic effect to the succeeding

Table 2. Effect of herbicidal weed management on plant population, pods/plant, shelling, pod yield and 100-kernel weight of groundnut and economics of groundnut–wheat cropping system (pooled data of 2 years)

Treatment	Final plant population (“000”/ha)	Pods/plant	Shelling (%)	Pod yield (t/ha)			100-kernel weight (g)	Gross returns (×10³₹/ha)	Net returns (×10³₹/ha)	Benefit: cost ratio
				2017	2018	Pooled				
T_1	296	17.83	69.62	2.43	2.26	2.34	41.17	199.5	100.5	2.02
T_2	310	18.17	71.38	2.77	2.37	2.57	41.30	213.5	114.5	2.16
T_3	299	18.50	71.34	3.06	2.09	2.58	41.16	213.8	115.3	2.17
T_4	301	22.17	71.82	3.23	2.59	2.91	43.17	231.8	132.8	2.34
T_5	290	23.00	73.39	3.35	2.61	2.98	43.08	237.0	137.4	2.38
T_6	298	17.83	70.04	2.43	2.27	2.35	40.53	204.1	106.0	2.08
T_7	300	18.50	72.46	2.79	1.99	2.39	40.94	205.1	106.5	2.08
T_8	295	18.50	70.92	3.05	2.28	2.66	41.90	217.2	118.2	2.19
T_9	297	18.83	72.42	2.92	2.30	2.61	43.02	210.3	110.9	2.12
T_{10}	300	17.33	70.40	2.65	2.10	2.38	41.83	203.1	104.5	2.06
T_{11}	294	21.83	72.18	3.02	2.38	2.70	42.20	220.5	121.7	2.23
T_{12}	294	22.50	72.47	2.96	2.48	2.72	41.14	219.4	120.5	2.22
T_{13}	311	11.00	69.21	1.67	1.17	1.42	39.49	146.8	49.3	1.51
T_{14}	307	26.33	74.00	3.76	2.73	3.25	42.90	248.8	138.7	2.26
SEm±	6.1	0.66	1.95	0.20	0.10	0.11	0.92	6.4	6.4	-
CD (P=0.05)	NS	1.87	5.54	0.59	0.30	0.32	NS	18.1	18.1	-

Details of treatments are given under Materials and Methods
*Figures in parentheses indicate original value; DAS, days after sowing;

wheat crop. In western Rajasthan, groundnut is grown as irrigated crop (8–10 irrigations) and the moisture availability during the crop period leads to the detoxification of herbicides due to microbial activity. Similar results were also reported by Vaghasia and Nadiyadhara (2013). Sangeetha (2010) and Patil *et al.* (2013) also reported that, the early post-emergence application did not leave any residue in the soil and there was no toxic effect to the succeeding wheat crop. It might be shown that new formulation of herbicide with different doses could be very effective against most of the broad leaf and grassy weeds in groundnut.

Economics

All the treatments of weed management caused marked variation on gross returns, net returns and benefit: cost (B: C) ratio over the weedy check (Table 2). Gross returns were higher in weed-free treatment, but higher cost was involved in hand-weeding that consequently reduced net returns. This was due to more labour requirement under weed-free treatment to perform 1 operation which increased the cost of cultivation, while chemical weeding employed lesser number of labour which not only saved extra wages to labour, but also reduced the risk of drudgery involved in weeding and recorded higher monetary advantage. It is evident from data that highest net returns (₹137,400/ha) and B: C ratio (2.38) were recorded under pendimethalin 30 EC + imazethapyr 2 EC @ 1,000 g/ha, followed by similar lower dose treatment, i.e. pendimethalin 30 EC + imazethapyr 2 EC @ 750 g/ha as compared to rest of the treatments, including weedy check, but both the treatments stand next to weed-free in this regards and showed fewer monetary differences. After pendimethalin 30 EC + imazethapyr 2 EC @ 1,000 g/ha and pendimethalin 30 EC + imazethapyr 2 EC @ 750 g/ha, weed-free recorded higher B: C ratio than the other herbicidal treatments. Under different post-emergent herbicidal treatments sodium aciflourfen 16.5% + clodinafop propargyl 8% @ 200 g/ha PoE recorded higher net returns and B: C ratio and found ststistically at par with its lower dose treatment, sodium aciflourfen 16.5% + clodinafop propargyl 8% @ 180 g/ha PoE followed by imazethapyr + imazamox (pre-mix) @ 90 g/ha PoE and imazethapyr + imazamox (Pre-mix) @ 70 g/ha PoE. These results were also supported by Yadav and Bhullar (2014) and Biswal (2017).

Thus, pendimethalin 30 EC + imazethapyr 2 EC @ 1,000 g/ha as pre-emergence was found most effective herbicide in controlling the complex weed flora in groundnut under western Rajasthan conditions and all the herbicides which were used as pre-and post-emergence are safe for raising succeeding wheat crop in rotation with groundnut as no residual effect of herbicides was observed.

REFERENCES

Arthur, S. 2016. Evaluation of herbicides and fungicides on groundnut (*Arachis hypogaea* L.) quality and productivity. Master of Philosophy (M.Phil) Thesis. Department of Crop and Soil Sciences, Faculty of Agriculture, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

Table 3. Herbicidal weed management in groundnut and carry-over effect on succeeding wheat crop (pooled data of 2 years)

Treatment	Grain yield (t/ha)			Final plant population/m	Plant height (cm)	Tillers/ plant	Biological yield (t/ha)	Harvest index (%)	Test weight (g)
	2017–18	2018–19	Pooled						
T_1	3.91	3.20	3.56	25.1	80.1	8.2	9.22	38.8	42.2
T_2	4.29	3.06	3.68	24.9	84.4	7.9	9.21	40.2	41.8
T_3	4.26	3.09	3.67	22.9	83.9	8.1	9.30	39.7	42.4
T_4	4.39	2.97	3.68	25.2	81.6	8.8	9.36	39.5	41.7
T_5	4.42	3.11	3.76	24.4	84.0	8.1	9.41	40.2	40.9
T_6	4.35	3.22	3.79	25.4	82.3	7.9	9.59	39.6	40.1
T_7	4.19	3.26	3.72	26.3	81.2	8.0	9.45	39.6	40.1
T_8	4.29	3.01	3.65	22.9	81.7	8.6	8.91	41.1	40.5
T_9	3.87	2.98	3.42	23.8	80.8	8.5	8.70	39.7	42.2
T_{10}	4.21	3.12	3.67	24.9	82.7	8.7	9.37	39.2	41.4
T_{11}	4.39	2.97	3.68	24.4	82.1	8.8	9.29	40.4	41.6
T_{12}	3.91	3.19	3.55	25.6	81.8	7.9	9.14	39.0	41.3
T_{13}	3.88	2.94	3.41	24.2	80.2	8.6	8.76	39.3	41.2
T_{14}	3.96	3.28	3.62	23.7	83.5	8.1	9.28	39.2	42.3
SEm±	0.23	0.15	0.14	1.2	1.8	0.4	0.35	1.5	1.2
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS, Non-significant
Details of treatments are given under Materials and Methods
*Figures in parentheses indicate original value; DAS, days after sowing;

Biswal, S.S. 2017. Bio-efficacy of post-emergence application of sodium acifluorfen16.5% + clodinafop-propargyl 8% EC for weed management in groundnut. M.Sc. Thesis, Department of Agronomy, University of Agricultural Sciences, Gandhi Krishi Vigyan Kendra, Bengaluru, Karnataka.

Chaitanya, S., Shankaranarayana, V. and Nanjappa, H.V. 2012. Chemical weed management in *kharif* groundnut. *Mysore Journal of Agricultural Science* **46**(2): 315–319.

Choudhary, M., Chovatia, P.K., Jat, R. and Choudhary, S. 2017. Effect of weed management on growth attributes and yield of summer groundnut (*Arachis hypogaea* L.). *International Journal of Chemical Studies* **5**(2): 212–214.

DAC FW. 2018, *Agricultural Statistics at a Glance-2018.* Directorate of Economics and Statistics, Department of Agriculture, Co-operation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Government of India, New Delhi, 2017.

Doughari J.H. and Madani T. 2017. Effect of Herbicide (Pendant) Concentration on Arachis Nodular Rhizobial Microbiota Viability. *Journal of Agriculture and Life Sciences* 28–35.

Dubey, M., Singh, S., Kewat, M.L. and Sharma, J.K. 2010. Efficacy of imazethapyr against monocot weeds in groundnut. *Indian Journal of Weed Science* **42**(1–2): 27–30.

Idapuganti, R.G., Rana, D.S. and Sharma, R. 2005. Influence of integrated weed management on weed control and productivity of soybean (*Glycine max*). *Indian Journal of Weed Science* **37**: 126–128.

Mani, V.S., Malla, M.C., Gautam, K.C. and Bhagwandas. 1973. Weed killing chemicals in potato cultivars. *Indian Farming* **32**(8): 17–18.

Nambi, J. and Sundari, A. 2008. Phytosociological studies of weed flora of groundnut (*Arachis hypogaea* L.) fields in Cuddalore district of Tamilnadu. (In) Proceedings of National Symposium on IAPEA, pp. 122–124.

Patil, B.T., Bhalekar, M.N. and Shinde, K.G. 2013. Weed management in cluster bean (*Cyamopsis tetragonaloba* L.). (In) *Proceedings of National Symposium on Abiotic and Biotic Stress Management in Vegetable Crops*, Indian Institute of Vegetable Research, Varanasi, 12–14 April, pp. 241–258.

Ramakrishna, A., Ong, C.K. and Reddy, S.L.N. 1990. Efficacy of herbicides on the control of weeds in groundnut. *International Arachis Newsletter* **7**: 19–20.

Rathore, V.S., Goyal, R.K., Yadava, N.D., Saxena, A. and Soni, M.L., 2018. Enhancing productivity through water management in hot arid Rajasthan. *Indian Farming* **68**(09): 21–25.

Sanford, J.O. and Hairston, J.E. 1984. Effect of N fertilization on yield, growth and extraction of water by wheat following soybean and sorghum. *Agronomy Journal* **76**: 623–627.

Sangeetha, C. 2010. Evaluation of early post-emergence herbicide in soybean and its residue on succeeding crops. M.Sc. (Agriculture) Thesis, Tamil Nadu Agricultural University, Coimbatore.

Sangwan, M., Singh, S. and Satyavan, S. 2016. Efficacy of imazethapyr applied alone and mixed with pendimethalin or imazamox in cluster bean (*Cyamopsis tetragonoloba*) and their residual effect on mustard (*Brassica juncea*) in two texturally different soils. *Indian Journal of Agricultural Sciences* **86**(2): 256–266.

Sharma, S., Jat, R.A. and Sagarka, B.K. 2015. Effect of weed-management practices on weed dynamics, yield, and economics of groundnut (*Arachis hypogaea*) in black calcareous soil. *Indian Journal of Agronomy* **60**(2): 312–317.

Singh, S.P., Yadav, R.S., Godara, S.L., Kumawat, A. and Birbal. 2019. Herbicidal weed management in groundnut (*Arachis hypogaea*). *Legume Research* **42**(6): 829–833.

Sondhia S., Khankhane, P.J., Singh, P.K. and Sharma, A.R. 2015. Determination of imazethapyr residues in soil and grains after its application to soybean. *Journal of Pesticide Sciences* **40**(3): 106–110.

Vaghasia, P.M. and Nadiyadhara, M.V. 2013. Effect of post-emergence herbicides in groundnut and its residual effect on succeeding crops. *International Journal of Forestry and Crop Improvement* **4**(2): 54–58.

Wesley, J.V., Burke, I.C., Clewis, S.B., Thomas, W.E. and Wilcut, J.W. 2008. Critical period of grass vs. broadleaf weed interference in peanut. *Weed Technology* **22**: 68–73.

Yadav, R.L., Singh, V.K., Dwivedi, B.S. and Shukla, A.K. 2003. Wheat productivity and N use efficiency as influenced by inclusion of cowpea as a grain legume in a rice–wheat system. *Journal of Agricultural Science* **141**: 213–220.

Yadav, R. and Bhullar, M.S. 2014. Residual effects of soybean herbicides on the succeeding winter crops. *Indian Journal of Weed Science* **46**(3): 305–307.