Indian Journal of Agronomy **60** (2): 312–317 (June 2015)

Research Paper

Effect of weed-management practices on weed dynamics, yield, and economics of groundnut (*Arachis hypogaea*) in black calcareous soil

SATYAKUMARI SHARMA[1], RAM A. JAT[2] AND B.K. SAGARKA[3]

College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat 362 001

Received : December 2014; Revised accepted : June 2015

ABSTRACT

A field experiment was conducted during the rainy (*kharif*) seasons of 2012 and 2013 on Vertisols at Junagadh, Gujarat to study the effects of pre-and post-emergence herbicides, alone or integrated with manual/mechanical weeding on weed pressure, productivity and economic returns of *kharif* groundnut (*Arachis hypogaea* L.). Pendimethalin @ 0.9 kg/ha as pre-emergence (PE) + imazethapyr @ 75 g/ha as post-emergence (PoE) herbicides 20 days after sowing (DAS) resulted in significantly higher growth attributes, yield attributes and yield, quality parameters, and net returns over the unweeded control, and was found at par with hand-weeding and inter-culturing at 20 and 40 DAS, and pendimethalin @ 0.9 kg/ha as pre-emergence + hand-weeding and inter-culturing at 40 DAS. However, significantly highest NPK in soil after crop harvest was recorded with oxadiargyl @ 90 g/ha as PoE at 20 DAS + hand-weeding and inter-culturing at 40 DAS.

Key words: Groundnut, Herbicide, Weed management

Globally, India ranks first in area under groundnut cultivation and second in production after China. In India, groundnut is grown on 5.29 million ha area, with production of 6.65 million tonnes of nuts-in-shell and productivity of 1,243 kg/ha (average of 2010–11 to 2012–13) (DAC, 2013). Gujarat with 1.59 million ha area and 2.28 million tonnes of nuts-in-shell ranks first in area and production of groundnut in the country. Most of the groundnut in Gujarat is grown in Saurashtra region on Vertisols as a rainfed crop during the rainy (*kharif*) season. Though groundnut is a hardy crop, it shows high tolerance to abiotic stresses, particularly susceptible to weed preponderance due to its smaller canopy, wider spacing between the rows (45–60 cm in Gujarat), and initial slow growth (Devi Dayal, 2004). Weeds may cause yield losses as high as 70% in groundnut (Devi Dayal, 2004; Jat *et al*., 2011). Weeds compete for water, nutrients, solar radiation, and underground space, and hinder pegging as well. Besides, weeds when not controlled effectively lead to heavy pod loss during harvesting by intermingling with and breaking pods from plants. In Gujarat, interculturing by bullock/mini-tractor-drawn implements followed by manual weeding in the intra-row zone has been the common practice of weed management in groundnut. However, now-a-days farmers are showing increasing interest in the use of herbicides for controlling weeds with the urge of reducing cost of cultivation owing to shortage of and high cost of labour (Savu *et al*., 2005). Herbicides provide effective weed control when field is not ready for mechanical/manual weeding due to rainfall. Besides, 45–50 days after sowing when pegging starts mechanical interculturing should be avoided, and in that case use of post-emergence herbicides is the only viable option to control weeds. Though pre-emergence herbicides are widely used in groundnut by farmers in Gujarat, use of post-emergence herbicides is not very common. Therefore, the present investigation was undertaken with the objective of finding suitability of different pre- and post-emergence herbicides and their doses for groundnut, so that practically convenient and economically feasible strategy for weed management can be developed for the *kharif* groundnut.

MATERIALS AND METHODS

An experimental was conducted at Junagadh Agricultural University, Junagadh (21.5° N' and 70.5° E') in Gujarat during the rainy (*kharif*) seasons of 2012 and 2013. The area has typically sub-tropical climate with fairly cool and dry winter, hot and dry summer, and warm and moderately humid rainy season. The total rainfall received during the crop-growth period was 342 mm during

[1]**Corresponding author Email**: satya.sharma77@yahoo.com
[1]Ph.D. Student, [3]Professor and Head, Department of Agronomy; [2]Senior Scientist (Agronomy), Directorate of Groundnut Research, Junagadh, Gujarat 362 001

2012 and 1,047.1 mm during 2013 with fairly good distribution. The maximum and minimum temperature during the crop-growth period ranged between 29.9˚C to 37.7˚C and 17.6˚C to 27.2˚C during 2012 and 28.5˚C and 35.2˚C and 19.0˚C to 26.0˚C during 2013. The soil was silt clay (43% clay) in texture and slightly alkaline in reaction (*p*H 8.01) with electric conductivity 0.31 dS/m, low in available N (241.2 kg/ha), and medium in available P (22.4 kg/ha) and available K (242.2 kg/ha). A combination of 12 treatments, viz. pendimethalin 30% EC @ 0.9 kg/ha PE + hand-weeding and inter-culturing at 40 days after sowing (DAS), pendimethalin 38.7% CS @ 0.75 kg/ha as pre-plant-incorporation (PPI) + hand-weeding and interculturing 40 DAS, oxyfluorfen @ 0.24 kg/ha PE + hand-weeding and interculturing 40 DAS, quizalofop-ethyl @ 40 g/ha PoE at 20 DAS + hand-weeding and interculturing 40 DAS, pendimethalin 30% EC @ 0.9 kg/ha PE + quizalofop-ethyl @ 40 g/ha PoE at 20 DAS, imazethapyr @ 75 g/ha PoE at 20 DAS + hand-weeding and interculturing 40 DAS, pendimethalin 30% EC @ 0.9 kg/ha PE + imazethapyr @ 75 g/ha PoE at 20 DAS, oxadiargyl @ 90 g/ha PoE at 20 DAS + hand-weeding and interculturing at 40 DAS, propaquizafop @ 90 g/ha PoE at 20 DAS + hand-weeding and interculturing 40 DAS, hand-weeding and interculturing at 20 and 40 DAS, weed-free and unweeded control, were tested in a randomized block design and replicated thrice. Herbicides were applied using spray volume of 500 litres/ha. Groundnut 'GG 20' was sown at 60 cm × 10 cm spacing on July 11 in 2012 and June 26 in 2013. The recommended dose of fertilizers, i.e. 12.5 kg N/ha and 25 kg P_2O_5/ha was applied before sowing in the seed row zone. Nitrogen and P_2O_5 were applied through urea and single superphosphate, respectively. The initial plant stand was counted 15 days after sowing. The chlorophyll content was measured using SPAD meter from second fully-expanded leaf from top 5 plants in each plot and values were averaged to get mean value for each plot. To calculate weed-control efficiency (WCE), weed index (WI) and herbicide efficiency index (HEI) following formulae were used:

$$\text{WCE (\%)} = \frac{\text{DWC} - \text{DWT}}{\text{DWC}} \times 100$$

where, WCE, Weed control efficiency;

DWT, dry weight of weeds in treated plot;

DWC, dry weight of weeds in unweeded control plot.

$$\text{WI (\%)} = \frac{Y_{HW} - Y_t}{Y_{HW}} \times 100$$

where, WI, Weed index;

Y_{HW}, Average yield of crop in weed-free plot;

Y_t, Average yield of crop in plot under other weed-control treatment.

$$\text{HEI} = \frac{Y_t - Y_c}{Y_c} \times 100$$

where, HEI, herbicide-efficiency index; Y_t, yield from treated plot; Y_c, yield from unweeded control plot.

RESULTS AND DISCUSSION

Weeds

Weed flora in the experimental field consisted of monocot weeds, viz. *Cynodon dactylon* (L.) Pers (9.68 and 10.38%), *Aeluropus villosus* L. (7.81 and 8.31%), *Brachiaria* spp. (5.78 and 6.24%), *Indigofera glandulosa* L. (4.24 and 5.04%), *Panicum colonum* L. (4.22 and 4.69%) and *Asphodelus tenuifolius (*L.) Cav. (3.56 and 4.98%); dicot weeds, viz. *Digera arvensis* Forsk aal and (11.22 and 6.45%), *Euphorbia hirta* L. (9.03 and 8.02%), *Amaranthus viridis* L. (7.87 and 8.55%), *Leucas aspera* (Wild.) Spreng (4.91 and 5.44%), *Boerhavia diffusa* L. (4.33 and 5.12%), *Commelina benghalensis* L. (4.71 and 3.98%), *Portulaca oleracea* L. (3.79 and 3.91%), *Physalis minima* L. (2.98 and 3.16%) and *Parthenium hysterophorus* (1.01 and 0.50%); and sedge weed *Cyperus rotundus* L. (14.86 and 15.23%) during both the years of study.

All the treatments were found to reduce significantly population density of monocot, dicot and sedge weeds 30 days after sowing (DAS) and harvesting as compared to unweeded control. After weed-free control, hand-weeding and interculturing at 20 and 40 DAS was found to have significantly lowest weed density as compared to unweeded control and was at par with pendimethalin 30% EC @ 0.9 kg/ha PE + hand-weeding and interculturing at 40 DAS, and pendimethalin 30% EC @ 0.9 kg/ha PE + imazethapyr @ 75 g/ha PoE at 20 DAS (except at harvest for sedges) at 30 DAS and harvest for monocot, dicot and sedge weeds (Table 1). Hand-weeding and interculturing at 20 and 40 DAS reduced weed density of monocots by 66.74 and 65.81%, dicots by 75.65 and 72.81% and sedges by 60.50 and 67.89% at 30 DAS and harvesting, respectively, compared to the unweeded control. Similarly, pendimethalin 30% EC @ 0.9 kg/ha PE + imazethapyr @ 75 g/ha PoE at 20 DAS reduced density of monocot weeds by 62.74 and 63.04%, dicot weeds by 73.91 and 71.17% and sedge weeds by 59.55 and 60.36% at 30 DAS and harvesting respectively, compared to unweeded control. Our results support the findings of Kalhapure *et al*. (2013), who reported that pendimethalin 1.5 kg/ha as PE + imazethapyr 0.15 kg/ha as PoE + 1 hand-weeding at 40 DAS was at par with weed free control in controlling the weed density in groundnut. According to them, pre-emergence application of pendimethalin prevents emergence of

Table 1. Effect of different weed-management practices on weed count at 30 DAS and at harvest, weed-control efficiency and weed-index (pooled over 2 years)

Treatment	Monocot weeds/m²		Dicot weeds/m²		Sedge weeds/m²		Weed control efficiency (5)	Weed index (%)
	30 DAS	Harvest	30 DAS	Harvest	30 DAS	Harvest		
Pendimethalin 30% EC @ 0.900 kg/ha PE + HW and IC at 40 DAS	1.67(2.32)	2.03(3.73)	2.15(4.14)	2.43(5.60)	1.28(1.14)	1.69(2.37)	84.3	3.9
Pendimethalin 38.7% CS @ 0.750 kg/ha PPI + HW and IC at 40 DAS	2.46(5.56)	2.54(5.78)	2.52(5.90)	2.70(6.81)	1.48(1.71)	2.47(5.64)	76.1	18.4
Oxyfluorfen @ 0.240 kg/ha PE + HW and IC at 40 DAS	2.64(6.50)	2.49(6.02)	2.74(7.03)	3.49(11.80)	1.52(1.83)	2.54(6.07)	72.1	20.2
Quizalofop-ethyl @ 40 g/ha PoE at 20 DAS + HW and IC at 40 DAS	3.12(9.29)	2.34(5.08)	3.25(10.05)	3.46(11.57)	1.55(1.91)	2.91(8.05)	68.7	13.2
Pendimethalin 30% EC @ 0.900 kg/ha PE + quizalofop-ethyl @ 40 g/ha PoE at 20 DAS	2.44(5.73)	2.70(6.66)	3.53(12.00)	2.86(7.68)	1.63(2.19)	2.26(4.77)	68.6	10.7
Imazethapyr @ 75 g/ha PoE at 20 DAS + HW and IC at 40 DAS	1.68(2.33)	2.51(5.74)	2.15(4.17)	2.70(6.81)	1.48(1.62)	2.59(6.25)	71.2	13.9
Pendimethalin 30% EC @ 0.900 kg/ha PE + imazethapyr @ 75 g/ha PoE at 20 DAS	1.68(2.33)	1.87(2.93)	2.10(3.74)	2.47(5.69)	1.27(1.11)	1.76(2.62)	84.5	3.3
Oxadiargyl @ 90 g/ha PoE at 20 DAS + HW and IC at 40 DAS	3.09(9.10)	3.01(8.76)	3.94(15.09)	4.09(16.27)	1.76(2.58)	3.16(9.53)	65.9	23.6
Propaquizafop @ 90 g/ha PoE at 20 DAS + HW and IC at 40 DAS	2.40(4.51)	2.08(3.71)	2.43(5.47)	2.41(5.31)	1.31(1.22)	2.43(4.79)	82.5	6.0
HW and IC at 20 and 40 DAS	1.50(1.74)	1.73(2.55)	1.96(3.37)	2.33(4.98)	1.24(1.03)	1.43(1.58)	87.2	5.2
Weed-free	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	100.0	0.0
Unweeded control	4.51(19.91)	5.06(25.41)	8.05(63.15)	8.57(73.00)	3.14(9.38)	4.44(19.17)	00	50.2
SEm±	0.10	0.13	0.10	0.10	0.05	0.11	–	–
CD (P=0.05)	0.29	0.36	0.28	0.27	0.15	0.32	–	–

PE, Pre-emergence; PoE, post-emergence; HW, hand-weeding; IC, interculturing, DAS, days after sowing; CS, capsule suspension and EC, emulsifiable concentration
$\sqrt{x+0.5}$ transformation, Figure in parentheses are original values

monocot and grassy weeds by inhibiting root and shoot growth, while imazethapyr inhibit sacetolactate synthase (ALS) or acetohydroxy acid synthase (AHAS) in broad-leaf weeds which causes destruction of these weeds at 3–4 leaf stage.

Hand-weeding and interculturing at 20 and 40 DAS followed by pendimethalin 30% EC @ 0.9 kg/ha as PE + imazethapyr @ 75 g/ha as PoE at 20 DAS, and pendimethalin 30% EC @ 0.9 kg/ha as PE + hand-weeding and interculturing at 40 DAS was found to have the highest weed-control efficiency. However, pendimethalin 30% EC @ 0.9 kg/ha as PE + imazethapyr @ 75 g/ha as PoE at 20 DAS followed by pendimethalin 30% EC @ 0.9 kg/ha as PE + hand-weeding and interculturing at 40 DAS, and hand-weeding and interculturing at 20 and 40 DAS resulted in the lowest weed index. Kalhapure *et al*. (2013) also reported higher weed-control efficiency (WCE) and lower weed index with pendimethalin 1.5 kg/ha as PE + imazethapyr 0.15 kg/ha as PoE + 1 hand-weeding at 40 DAS. Dubey and Gangwar (2012) found higher weed-control efficiency and lower weed index with post-emergence application of imazethapyr and 2 hand-weedings in groundnut. The lowest weed-control efficiency and the highest weed-index percentage were recorded in oxadiargyl @ 90 g/ha PoE at 20 DAS + hand-weeding and interculturing at 40 DAS.

Growth attributes

The results revealed that all the weed-control measures including weed-free control significantly improved the growth parameters, except plant population, over unweeded control. Pendimethalin 30% EC @ 0.9 kg/ha as PE + imazethapyr @ 75 g/ha as PoE at 20 DAS, and hand-weeding and interculturing at 20 and 40 DAS had almost equal effects on plant height, branches/plant, dry-matter, and leaf chlorophyll content, and were at par with weed-free control (Table 2). Pendimethalin 30% EC @ 0.9 kg/ha as PE + hand-weeding and interculturing at 40 DAS was also at par with hand-weeding and interculturing at 20 and 40 DAS to affect plant height, dry-matter accumulation at 60 DAS and harvesting, and leaf chlorophyll content. This is attributed to better control of weeds from the initial stage by pre-emergence application of pendimethalin 30% EC @ 0.9 kg/ha as PE and later supplemented with post-emergence application of imazethapyr or hand-weeding and interculturing as evident by less count (Table 2) and dry weight of weeds (data not given here). The timely and effective control of weeds is expected to have better availability of moisture, nutrients and solar radiation to the crop plants, thereby increasing total chlorophyll content, photosynthetic rate and nitrate reductase activity (Channappagoudar *et al.* 2008), leading to higher supply of carbohydrates which resulted in higher increase in growth attributes than unweeded control. Less weed population also provides ample space for root growth and nodulation in groundnut (Devi Dayal, 2004).

Yield attributes and yield

Yields attributes, except harvest index, and yield was significantly affected by weed-control measures (Table 3). Among the weed-control measures, hand-weeding and interculturing at 20 and 40 DAS recorded significantly highest number of pegs/plant, mature pods/plant, 100-seed weight, shelling %, and haulm yield, and the lowest immature pods/plant compared to the unweeded control, and was at par with pendimethalin 30% EC @ 0.9 kg/ha as PE + imazethapyr @ 75 g/ha as PoE at 20 DAS and weed-free control. Pendimethalin 30% EC @ 0.9 kg/ha as PE + hand-weeding and interculturing at 40 DAS was also at par with hand-weeding and interculturing at 20 and 40 DAS, and weed-free control in its effect on pegs/plant, mature pods/plant, shelling %, and haulm yield. After weed-free control, pendimethalin 30% EC @ 0.9 kg/ha as PE + imazethapyr @ 75 g/ha as PoE at 20 DAS was recorded significantly highest pod yield among all the weed-control measures compared to unweeded control and was on a par with weed-free control, hand-weeding and interculturing at 20 and 40 DAS, and pendimethalin 30% EC @ 0.9 kg/ha as PE + hand-weeding and interculturing at 40 DAS. Weed-free control, pendimethalin 30% EC @ 0.9 kg/ha as PE + imazethapyr @ 75 g/ha as PoE at 20 DAS, and pendimethalin 30% EC @ 0.9 kg/ha as PE + hand-weeding and interculturing at 40 DAS resulted in 100.6, 94.3 and 92.69% higher pod yield, respectively, compared to unweeded control. These results are in conformity with the findings of Kalhapure (2013), and Kamble *et al*. (2003). Weed-free environment facilitates better growth and development of plants, flowering, peginitiation and entry into the soil, pod formation and development, and harvesting which tends to increase mature pods/plant, kernel weight and consequently pod yield/ha.

Quality parameters

Protein and oil content in kernel were significantly influenced by different weed-management practices (Table 4). Among all the weed-control practices, hand-weeding and interculturing at 20 and 40 DAS recorded significantly highest oil and protein content than unweeded control, and on a par with pendimethalin 30% EC @ 0.9 kg/ha as PE + imazethapyr @ 75 g/ha as PoE at 20 DAS, pendimethalin 30% EC @ 0.9 kg/ha as PE + hand-weeding and interculturing 40 DAS, and weed-free control. The effective weed control owing to these treatments led to higher nutrient uptake, and consequently higher oil and protein content compared to unweeded control. These results support the findings of Zid (2006), who reported that maximum oil and protein content in kernel of groundnut was recorded with application of pendimethalin 30% EC @ 0.8

Table 2. Effect of different weed-management practices on growth attributes and leaf chlorophyll content (pooled over 2 years)

Treatment	Plant height at harvest (cm)	Branches/ plant at harvest	Dry matter accumulation (g)			Leaf chlorophyll content (mg/g)
			30 DAS	60 DAS	Harvest	
Pendimethalin 30% EC @ 0.900 kg/ha PE + HW and IC at 40 DAS	33.0	6.4	6.3	19.3	26.3	0.98
Pendimethalin 38.7% CS @ 0.750 kg/ha PPI + HW and IC at 40 DAS	31.0	5.9	6.0	18.5	24.9	0.97
Oxyfluorfen @ 0.240 kg/ha PE + HW and IC at 40 DAS	30.5	5.8	6.0	17.5	24.2	0.85
Quizalofop-ethyl @ 40 g/ha PoE at 20 DAS + HW and IC at 40 DAS	31.0	5.8	5.9	18.1	25.2	0.92
Pendimethalin 30% EC @ 0.900 kg/ha PE + quizalofop-ethyl @ 40 g/ha PoE at 20 DAS	30.1	6.2	6.1	18.7	25.3	0.98
Imazethapyr @ 75 g/ha PoE at 20 DAS + HW and IC at 40 DAS	30.5	5.7	6.0	17.3	24.9	0.92
Pendimethalin 30% EC @ 0.900 kg/ha PE + imazethapyr @ 75 g/ha PoE at 20 DAS	33.1	7.0	6.7	19.5	26.5	1.07
Oxadiargyl @ 90 g/ha PoE at 20 DAS + HW and IC at 40 DAS	30.2	5.8	5.7	15.6	23.0	0.87
Propaquizafop @ 90 g/ha PoE at 20 DAS + HW and IC at 40 DAS	31.9	6.2	6.5	19.2	26.4	1.01
HW and IC at 20 and 40 DAS	33.1	6.6	6.7	19.5	26.3	1.08
Weed-free	34.7	7.3	7.2	20.1	27.7	1.15
Unweeded control	27.0	4.3	4.8	12.2	15.1	0.69
SEm±	0.6	0.3	0.2	0.3	0.5	0.02
CD (P=0.05)	1.8	0.7	0.6	0.9	1.6	0.08

PE, Pre-emergence; PoE, post-emergence; HW, hand-weeding; IC, interculturing, DAS, days after sowing; CS, capsule suspension and EC, emulsifiable concentration

Table 3. Effect of different weed-management practices on yield attributes and yields (pooled over 2 years)

Treatment	Per plant			100-seed weight (g)	Shelling turn-out (%)	Yield at harvest (kg/ha)		Harvest index
	Pegs/ plant	Mature pods/plant	Immature pods/plant			Pod	Haulm	
Pendimethalin 30% EC @ 0.900 kg/ha PE + HW and IC at 40 DAS	24.8	7.4	3.0	44.2	70.9	1,624	2,494	39.4
Pendimethalin 38.7% CS @ 0.750 kg/ha PPI + HW and IC at 40 DAS	22.9	6.7	3.3	41.8	68.6	1,377	2,316	37.2
Oxyfluorfen @ 0.240 kg/ha PE + HW and IC at 40 DAS	20.8	6.6	3.6	40.2	68.7	1,351	2,228	37.5
Quizalofop-ethyl @ 40 g/ha PoE at 20 DAS + HW and IC at 40 DAS	23.4	6.4	3.4	40.4	68.7	1,468	2,301	38.9
Pendimethalin 30% EC @ 0.900 kg/ha PE + quizalofop-ethyl @ 40 g/ha PoE at 20 DAS	23.6	6.8	2.7	41.8	68.1	1,508	2,388	38.5
Imazethapyr @ 75 g/ha PoE at 20 DAS + HW and IC at 40 DAS	23.8	6.9	3.5	41.3	67.7	1,456	2,256	39.2
Pendimethalin 30% EC @ 0.900 kg/ha PE + imazethapyr @ 75 g/ha PoE at 20 DAS	23.9	7.7	2.4	44.3	71.0	1,638	2,490	39.6
Oxadiargyl @ 90 g/ha PoE at 20 DAS + HW and IC at 40 DAS	23.5	5.7	3.6	38.9	67.7	1,281	2,157	37.3
Propaquizafop @ 90 g/ha PoE at 20 DAS + HW and IC at 40 DAS	23.2	7.5	2.6	43.8	70.8	1591	2,499	38.9
HW and IC at 20 and 40 DAS	26.0	8.2	1.9	44.9	71.2	1,603	2,505	39.0
Weed-free	24.9	8.2	1.6	46.2	72.9	1,691	2,592	39.5
Unweeded control	14.9	2.9	4.2	33.0	58.1	843	1,271	39.8
SEm±	0.7	0.3	0.1	0.7	0.72	42.91	35.71	0.9
CD (P=0.05)	2.0	0.9	0.4	1.9	2.07	122	102	NS

PE, Pre-emergence; POE, post-emergence; HW, hand-weeding; IC, interculturing, DAS, days after sowing; CS, capsule suspension and EC, emulsifiable concentration

kg/ha PE + imazethapyr 2% EC @ 0.8 kg/ha PoE + hand-weeding and interculturing at 30 DAS.

Soil-nutrient status

Available N, P, and K in soil after harvesting of groundnut were significantly affected by different weed-management practices (Table 4). The highest available N, P and K in the soil after harvesting of the crop was recorded under oxadiargyl @ 90 g/ha as PoE at 20 DAS + hand-weeding and interculturing at 40 DAS, which remained statistically at par with application of pendimethalin 38.7% CS @ 0.75 kg/ha as PPI + hand-weeding and interculturing at 40 DAS, and oxyfluorfen @ 0.24 kg/haas PE + hand-weeding and interculturing at 40 DAS. This may be owing to lesser pod and haulm yields under these treatments and consequently lower nutrient uptake by crop, whereas the treatments like hand-weeding and interculturing at 20 and 40 DAS, pendimethalin 30% EC @ 0.9 kg/ha as PE + imazethapyr, pendimethalin 30% EC @ 0.9 kg/ha as PE + hand-weeding and interculturing at 40 DAS and weed-free control which had relatively higher pod and haulm yield were found to have lower NPK content in soil mainly owing to higher nutrient uptake by crop. The significantly lowest NPK in soil was found under unweeded control. These results confirm the findings of Chaudhari *et al*. (2007).

Economics

Pendimethalin 30% EC @ 0.9 kg/ha as PE + imazethapyr @ 75 g/ha as PoE at 20 DAS resulted in the highest net returns, followed by weed-free control, pendimethalin 30% EC @ 0.9 kg/ha as PE + hand-weeding and interculturing at 40 DAS, and hand-weeding and interculturing at 20 and 40 DAS (Table 4). The unweeded control gave the lowest net returns. Similarly, pendimethalin 30% EC @ 0.9 kg/ha as PE + imazethapyr @ 75 g/ha as PoE at 20 DAS recorded the highest benefit: cost ratio (2.56), followed by pendimethalin 30% EC @ 0.9 kg/ha as PE + hand-weeding and interculturing at 40 DAS, and hand-weeding and interculturing at 20 and 40 DAS. Kalhapure (2013) also reported the highest net returns and benefit: cost ratio with pendimethalin @ 1.5 kg/ha as PE + imazethapyr @ 0.15 kg/ha as PoE + hand-weeding at 40 DAS.

Thus, pre-emergence application of pendimethalin 30% EC @ 0.9 kg/ha followed by post-emergence application of imazethapyr @ 75 g/ha or pre-emergence application of pendimethalin 30% EC @ 0.9 kg/ha, followed by hand-weeding and interculturing at 40 DAS or hand-weedings and interculturing at 20 and 40 DAS can be used to get higher productivity and economic returns in *kharif* groundnut in Saurashtra region of Gujarat.

Table 4. Effect of weed-management practices on quality parameters, soil-nutrient status, and economics of groundnut (pooled over 2 years)

Treatment	Protein (%)	Oil (%)	Nutrient status in soil after harvest (kg/ha)			Net returns	Benefit: cost
			N	P	K	(×10³₹/ha)	ratio
Pendimethalin 30% EC @ 0.900 kg/ha PE + HW and IC at 40 DAS	26.3	48.0	181.3	16.6	192.7	37.2	2.47
Pendimethalin 38.7% CS @ 0.750 kg/ha PPI + HW and IC at 40 DAS	25.8	46.3	188.2	18.0	198.6	28.6	2.13
Oxyfluorfen @ 0.240 kg/ha PE + HW and IC at 40 DAS	25.7	44.5	187.9	17.7	198.9	26.9	2.05
Quizalofop-ethyl @ 40 g/ha PoE at 20 DAS + HW and IC at 40 DAS	26.0	45.8	184.4	16.9	196.9	31.9	2.28
Pendimethalin 30% EC @ 0.900 kg/ha PE + quizalofop-ethyl @ 40 g/ha PoE at 20 DAS	25.8	46.9	184.5	15.9	193.3	34.1	2.40
Imazethapyr @ 75 g/ha PoE at 20 DAS + HW and IC at 40 DAS	26.0	46.2	189.2	17.5	198.0	31.0	2.23
Pendimethalin 30% EC @ 0.900 kg/ha PE + imazethapyr @ 75 g/ha PoE at 20 DAS	26.5	48.0	180.0	16.7	191.8	38.4	2.56
Oxadiargyl @ 90 g/ha PoE at 20 DAS + HW and IC at 40 DAS	25.4	44.0	192.1	18.3	200.1	24.9	1.98
Propaquizafop @ 90 g/ha PoE at 20 DAS + HW and IC at 40 DAS	26.2	48.0	181.9	16.5	192.4	36.2	2.42
HW and IC at 20 and 40 DAS	26.4	48.1	181.5	17.0	193.2	36.9	2.47
Weed-free	26.7	49.4	179.2	17.6	193.0	37.8	2.38
Unweeded control	24.0	40.1	173.1	11.1	188.2	11.2	1.53
SEm±	0.2	0.6	3.3	0.3	1.0	–	–
CD (P=0.05)	0.5	1.6	10.3	0.8	3.0	–	–

PE, Pre-emergence; PoE, post-emergence; HW, hand-weeding; IC, interculturing, DAS, days after sowing; CS, capsule suspension and EC, emulsifiable concentration

REFERENCES

Channappagoudar, B.B., Koti, R.V., Biradar, N.R., and Bharmagoudar, T.D. 2008. Influence of herbicides on physiological and biochemical parameters in radish. *Karnataka Journal of Agricultural Science* **21**(1): 8–11.

Chaudhari, A.P., Gaikwad, C.B., Tiwari, T.K., Nikam, A.S.,Bhende, S.N. and Bagwan, I.R. 2007. Effect of weed control on nutrient uptake, weed weight and yield of groundnut. *International Journal of Agricultural Sciences* **3**(1): 193–95.

Devi Dayal. 2004. Weed management in groundnut. (In) *Groundnut Research in India*, pp. 248–59, Basu, M.S. and Singh, N.B. (Eds). CABI, Wallingford, UK.

DAC, 2013. Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Government of India, New Delhi.

Dubey, M. and Gangwar, S. 2012. Effect of chemical weedcontrol of imazethapyr (pursuit) in groundnut var. 'TG 24'. *Plant Archives* **12**(2): 675–77.

Jat, R.S., Meena, H.N., Singh, A.L., Surya, J.N. and Misra, J.B. 2011. Weed management in groundnut (*Arachis hypogaea* L.) in India–a review. *Agricultural Review* **32**(3): 155–71.

Kalhapure, A.H., Shete, B.T. and Bodake, P.S. 2013. Integration of chemical and cultural methods for weed management in groundnut. *Indian Journal of Weed Science* **45**(2): 116–19.

Kamble, A.B., Chavan, N.R., Bhilare, R.L. and Pathan, S.H. 2003. Integrated weed management in *kharif* groundnut. *Journal of Maharashtra Agricultural Universities* **28**(1): 52–53.

Savu, R.M., Choubey, N.K., Shrivastava, G.K. and Tiwari, N. 2005. Effect of chemical weed control on nitrogen uptake, weed weight and yield of groundnut under Chhattisgarh plains. *Environment and Ecology* **23**(3): 400–02.

Zid, M.Z. 2006. Efficacy of herbicides in pre-monsoon groundnut (*Arachis hypogaea* L.). *M.Sc. (Agric.) Thesis,* Department of Agronomy, Junagadh Agricultural University, Junagadh, Gujarat.