Indian Journal of Agronomy **60** (4): 570–575 (December 2015)

Research Paper

Weed dynamics and productivity of chickpea (*Cicer arietinum*) under pre- and post-emergence application of herbicides

NARENDRA KUMAR[1], K.K. HAZRA[2], S.L. YADAV[3] AND S.S. SINGH[4]

ICAR-Indian Institute of Pulses Research, Kanpur, Uttar Pradesh 208 024

Received : May 2015; Revised accepted : December 2015

ABSTRACT

A field study was conducted during the winter (*rabi*) season of 2011–13 at Kanpur, Uttar Pradesh, to assess the performance of post-emergence application of quizalofop-ethyl in combination with pre-emergence application of pendimethalin on chickpea (*Cicer arietinum* L.). The treatments comprised 5 doses of quizalofop-ethyl (50, 75, 100, 125 and 150 g/ha) in combination with pendimethalin @ 1.25 kg/ha, and pendimethalin @ 1.25 kg/ha followed by (fb) manual weeding. The broad-leaf weeds like *Coronopus dedymus, Melilotus officinalis* and *Chenopodium album* were dominant. In case of grassy weeds, *Phalaris minor* was the most dominant weed. Significant reduction in total weed density and weed dry weight was recorded under application of pendimethalin @ 1.25 kg/ha fb quizalofop-ethyl @ 100–150 g/ha and pendimethalin @ 1.25 kg/ha fb manual weeding. Weed-control indices also showed improvement under these treatments. The poor crop-weed competition due to effective control of weeds under these treatments resulted in higher nodulation and yield. Similarly, higher net returns and benefit: cost ratio were recorded in pendimethalin @1.25 kg/ha fb quizalofop-ethyl @ 125 g/ha.

Key words **:** Chickpea, Herbicide, Nodulation, Post-emergence, Quizalofop-ethyl, Weed dynamics

Chickpea is a leading pulse crop, grown in an area of 8.3 million ha with annual production of 7.7 million tonnes, registering an average productivity of 928 kg/ha (Ministry of Agriculture, 2013). The poor productivity of chickpea is mainly due to competition from diverse weed population (Sharma, 2009; Kumar, 2010). Most weed species can grow faster and taller than the chickpea and inhibits the plant growth by curtailing sunlight, nutrients and moisture; and reduces the grain yield up to 75% (Balyan and Bhan, 1984). So far, pendimethalin was identified as a suitable pre-emergence (PE) herbicide effective against emerging broad-leaf weeds (especially *Chenopodium album*). However, it is not found effective against many other weeds including *Cyperus rotundus* (Kumar and Hazra, 2012). Therefore, pendimethalin along with a manual weeding at 35–40 days after sowing was recommended (Chaudhary *et al*., 2011). Although weed-management practices through manual weeding is effective in weed control, it is uneconomical due to higher costs (Kumar *et al.,* 2010). Use of post-emergence herbicides in combination with pre-emergence may be one of the tools for broad-spectrum weed control. Quizalofop ethyl is recommended in soybean and other leguminous crops to control grassy weeds (Kumar *et al*., 2013). Quizalofop-ethyl in initial screening trials during 2008–10 at Kanpur, Uttar Pradesh, has shown promising results in winter (*rabi*) pulses. Therefore, the present study was proposed to assess the field efficacy of quizalofop-ethyl in combination with pendimethalin in chickpea.

MATERIALS AND METHODS

A field experiment was conducted during the winter (*rabi*) season of 2011–12 and 2012–13 at ICAR-Indian Institute of Pulses Research, Kanpur (26° 27' N, 80° 14' E and 152.4 m above mean sea-level). The climate is tropical sub-humid, receives annual rainfall of 722 mm and mean annual maximum and minimum temperature is 33.0 and 20.0°C respectively. The soils of experimental site comes under taxonomical class Typic Usrtochrept with sandy-loam texture having *p*H 7.8, bulk density 1.44 g/cm^3, low organic carbon content (3.1 g/kg), low in available N (221 kg/ha), and medium in available P (13.2 kg/ha) and K (215 kg/ha).

Treatments comprised 5 different doses of quizalofop-ethyl (50, 75, 100, 125 and 150 g/ha) in combination with pendimethalin @ 1.0 kg/ha (PE) and pendimethalin @ 1.0 kg/ha (PE) fb manual weeding at 30–35 DAS (recommended practice). Weed-free and weedy check plots were also maintained for calculation of weed-control indices. The experiment was laid out in randomized block design

(RBD) with 3 replications. Chickpea variety 'DCP 92-3' was used for the study. Plant-to-plant distance was maintained ~10 cm in a row spacing of 30 cm. Diammonium phosphate (DAP) was applied 100 kg/ha at the time of seedbed preparation as per recommendation. To ensure proper germination, field was prepared after *palewa* irrigation and subsequent irrigation was given as per requirement. Quizalofop-ethyl was applied 25 days after sowing (DAS), whereas pendimethalin was applied as pre-emergence within 24 hr of sowing. Other practices were followed as per recommendation for this region.

An iron square of size 0.25 m^2 (side 0.5 m) was used to take observations on weed population and weed dry weight through random sampling in each plot at 25 (just before application of quizalofop-ethyl), 45, 60 and 90 DAS and at harvesting. The total number of weeds were counted species wise in each plot separately and analyzed after subjecting the original data to square-root transformation ($\sqrt{x + 0.5}$). For dry matter, weeds collected from 0.25 m^2 area were dried under the sun and then in an oven at 70 ^{o}C for 72 h, weighed (g/m^2). Five random plants were selected from each plot at 60 DAS to record observations on nodulation.

Economics of treatments was computed on the basis of prevailing market price of inputs and outputs in Indian rupees under each treatment. The total cost of cultivation of crop was calculated on the basis of different operations performed and materials used for raising the crop including the cost of fertilizers and seeds. The cost of labour incurred in performing different operations was also included. Statistical analysis of the data was done as per the standard analysis of variance technique for the experimental designs following SPSS software based programme, and the treatment means were compared at $P<0.05$ level of probability using t-test and calculating CD values.

RESULTS AND DISCUSSION

Weed density and dry weight

The common weeds present in the experimental fields were *Cyperus rotundus*, *Melilotus officinalis*, *Fumaria parviflora*, *Chenopodium album, Phalaris minor*, and *Coronopus didymus*. The *C. didymus* was most dominant weed with relative density of 66%, followed by *M. officinalis* (6%). However in terms of relative dry weight, *C. didymus* and *M. officinalis* were at par (32% each) followed by *F. parviflora.* The above data showed that broad leaf weeds were dominant at the experimental site.

Significant variation in weed density and weed dry weight was recorded due to different weed-management practices (Table 1). Significantly highest weed density was recorded in weedy check, followed by (fb) pendimethalin @ 1.25 kg /ha fb quizalofop-ethyl @ 75 g/ha, whereas the

Table 1. Weed density, weed dry weight and weed-management indices under different weed-management practices in chickpea

Weed-management practices	Weed density* (numbers/m^2)		Weed dry weight* (kg/ha)		Weed control efficiency$^{\#}$ (%)		Weed control index$^{\#}$ (%)		Weed index$^{\#}$ (%)	
	2011–12	2012–13	2011–12	2012–13	2011–12	2012–13	2011–12	2012–13	2011–12	2012–13
Pendimethalin @ 1.0 kg/ha (PE) fb quizalofop-ethyl @ 50 g/ha (PoE)	179	292	398	539	29.2	37.2	54.6	29.2	34.7	48.6
Pendimethalin @ 1.0 kg/ha (PE) fb quizalofop-ethyl @ 75 g/ha (PoE)	183	305	334	588	27.9	34.3	61.9	22.7	22.5	27.1
Pendimethalin @ 1.0 kg/ha (PE) fb quizalofop-ethyl @ 100 g/ha (PoE)	123	196	296	438	51.3	57.8	66.2	42.4	12.8	33.7
Pendimethalin @ 1.0 kg/ha (PE) fb quizalofop-ethyl @ 125 g/ha (PoE)	118	209	361	344	53.4	55.0	58.8	54.8	5.8	4.4
Pendimethalin @ 1.0 kg/ha (PE) fb quizalofop-ethyl @ 150 g/ha (PoE)	110	196	250	380	56.7	57.8	71.5	50.1	5.3	9.4
Pendimethalin @ 1.25 kg/ha (PE)	178	305	499	730	29.7	34.3	43.0	4.1	22.8	37.6
Pendimethalin @ 1.25 kg/ha (PE) fb manual weeding	39	58	115	91	84.7	87.5	86.8	88.0	8.1	6.4
Weedy check	253	465	876	761						
SEm±	31	44	30	55						
CD (P=0.05)	68	94	65	119						

*Observations recorded at 60 days after sowing; $^{\#}$Weed management indices calculated on mean values lowest in case of pendimethalin @ 1.25 kg/ha fb manual weeding at 40–45 DAS. Among herbicide treatments the lowest weed density was observed in pendimethalin @ 1.25 kg/ha fb quizalofop-ethyl @ 150 g/ha (110 and 196 weeds/m^2 during 2011–12 and 2012–13 respectively) followed by pendimethalin @ 1.25 kg /ha fb quizalofop-ethyl @ 125 g/ha (118 and 196 weeds/m^2 during 2011–12 and 2012–13 respectively). Similarly, significantly highest weed dry weight was observed in weedy check (876 and 761 kg/ha during 2011–12 and 2012–13 respectively) and the lowest in case of pendimethalin @ 1.25 kg/ha fb manual weeding (115 and 91 kg/ha during 2011–12 and 2012–13 respectively). Among herbicide treatments, the lowest weed dry weight was recorded in pendimethalin @ 1.25 kg/ha fb quizalofop-ethyl @ 150 g/ha (250 kg/ha) during 2011–12 and in pendimethalin @ 1.25 kg/ha fb quizalofop-ethyl @ 125 g/ha (334 kg/ha) during 2012–13. Pendimethalin is known to control broad leaf weeds like *C. album* and quizalofop-ethyl for grassy weeds. Thus, reduction in weed density and weed dry weight was recorded with the application of pre-emergence pendimethalin followed by post-emergence quizalofop-ethyl. Chaudhary *et al*. (2011) also reported reduction in weed population and dry weight due to herbicide application.

Species-wise weed density recorded at 60 DAS during 2012–13 is presented in Table 2. Significantly lowest weed density of all weed species was recorded in Pendimethalin @ 1.25 kg/ha fb manual weeding and maximum was under weedy check. However, weed density of *C. rotundus*, *M. officinalis*, *F. parviflora* were at par under different herbicide treatments. Among herbicides, the lowest density of *C. didymus* was recorded under pendimethalin @ 1.25 kg/ha fb quizalofop-ethyl @ 150 g/ha which was at par with pendimethalin @ 1.25 kg/ha fb quizalofop-ethyl @ 100–125 g/ha and significantly higher over rest of the treatments. Generally, *C. didymus* emerges later (20–25 DAS) than chickpea. Thus, wherever crop growth was more, population of *C. didymus* was less. The *P. minor* can be effectively controlled by post-emergence application of quizalofop-ethyl application. Thus, maximum density of *P. minor* (58/m^2) was recorded in weedy check followed by pendimethalin @ 1.25 kg/ha and less under pendimethalin @ 1.25 kg/ha fb quizalofop-ethyl @ 100 to 150 g/ha.

Weed-control indices

Weed-control indices influenced considerably due to weed-management practices. Highest weed-control efficiency (WCE) was recorded in pendimethalin @ 1.25 kg/ha fb manual weeding (84.7 and 87.5% during 2011–12 and 2012–13 respectively). However, among herbicide

Table 2. Weed density (numbers/m^2) under different weed-management treatments in chickpea at 60 days after sowing (DAS) during 2012–13

Weed-management practices	*Cyperus rotundus*	*Melilotus officinalis*	*Fumaria parviflora*	*Coronopus didymus*	*Phalaris minor*	Others	Total
Pendimethalin @ 1.0 kg/ha (PE) fb quizalofop-ethyl @ 50 g/ha (PoE)	4.9 (23)	4.2 (18)	4.4 (19)	13.3 (176)	6.7(45)	3.4(11)	17.1 (292)
Pendimethalin @ 1.0 kg/ha (PE) fb quizalofop-ethyl @ 75 g/ha (PoE)	4.7 (22)	4.2 (17)	4.5 (20)	14.3 (205)	6.0(35)	2.6(7)	17.5 (305)
Pendimethalin @ 1.0 kg/ha (PE) fb quizalofop-ethyl @ 100 g/ha (PoE)	3.9 (15)	4.0 (16)	3.9 (15)	11.9 (140)	3.2(7)	1.3(4)	14.0 (196)
Pendimethalin @ 1.0 kg/ha (PE) fb quizalofop-ethyl @ 125 g/ha (PoE)	4.1 (15)	3.8 (14)	4.1 (17)	12.1 (146)	3.4(11)	2.6(6.3)	14.5 (209)
Pendimethalin @ 1.0 kg/ha (PE) fb quizalofop-ethyl @ 150 g/ha (PoE)	2.9 (8)	4.2 (17)	4.1 (16)	11.5 (133)	3.8(14)	2.9(8)	14.0 (196)
Pendimethalin @ 1.25 kg/ha (PE)	4.6 (19)	3.9 (15)	4.0 (15)	14.3 (204)	6.8(46)	2.5(6)	17.5 (305)
Pendimethalin @ 1.25 kg/ha (PE) fb manual weeding	3.9 (15)	2.9 (8)	2.3 (5)	4.3 (18)	3.2(8)	1.6(4)	7.6 (58)
Weedy check	5.1 (25)	4.2 (18)	4.5 (20)	18.0 (325)	7.6(58)	4.4(19)	21.6 (465)
SEm±	0.4	0.2	0.8	1.6	0.5	0.4	1.4
CD (P=0.05)	0.8	0.5	0.8	3.4	1.1	0.9	3.1

Figures given in parenthesis are original values treatments, the highest WCE was recorded in pendimethalin @ 1.25 kg/ha fb quizalofop-ethyl @ 150 g/ ha, which was at par with pendimethalin @ 1.25 kg/ha fb quizalofop-ethyl @ 100–125 g /ha (Table 1). Similarly, among herbicide treatments, the highest weed-control index (WCI) was recorded in pendimethalin @ 1.25 kg/ha fb quizalofop-ethyl @ 150 g/ha during 2011–12 and pendimethalin @ 1.25 kg/ha *fb* quizalofop-ethyl @ 125 g/ ha during 2012–13. The higher WCI and WCE were mainly due to effective weed control under these treatments.

Weed index (WI) is an indicator of reduction in crop yield due to presence of weeds. The lowest values of WI was recorded under pendimethalin @ 1.25 kg /ha fb quizalofop-ethyl @ 150 g/ha during 2011–12 and pendimethalin @ 1.25 kg/ha fb quizalofop-ethyl @ 125 g/ ha during 2012–13. The lower WI indicates higher yield and vice-versa. Less weeds under pendimethalin @ 1.25 kg/ha fb quizalofop-ethyl @ 100–150 g/ha resulted in poor crop-weed competition and lower WI. Patel *et al.* (2006) and Mudalagiriyappa *et al*. (2013) also reported similar findings.

Nodulation

Mean maximum nodules/plant were recorded with pendimethalin @ 1.25 kg/ha fb quizalofop-ethyl @ 125 g/ ha and the lowest with pendimethalin @ 1.25 kg/ha fb quizalofop-ethyl @ 50 g/ha (Table 3). Similarly, nodules dry weight/plant was highest under pendimethalin @ 1.25 kg/ha fb quizalofop-ethyl @ 125 g/ha (0.902 and 1.083 g/ plant during 2011–12 and 2012–13 respectively) followed by pendimethalin @ 1.25 kg/ha fb manual. The higher nodules/plant and nodules dry weight/plant correspond to lower weed density and weed biomass which led to poor crop-weed competition. Reduction in nodule numbers/ plant was noted with increase in weed density and weed biomass in the study (Fig. 1a, b). Kachhadiya *et al*. (2009) and Mudalagiriyappa *et al*. (2013) also recorded higher nodulation under effective weed-management practices in chickpea.

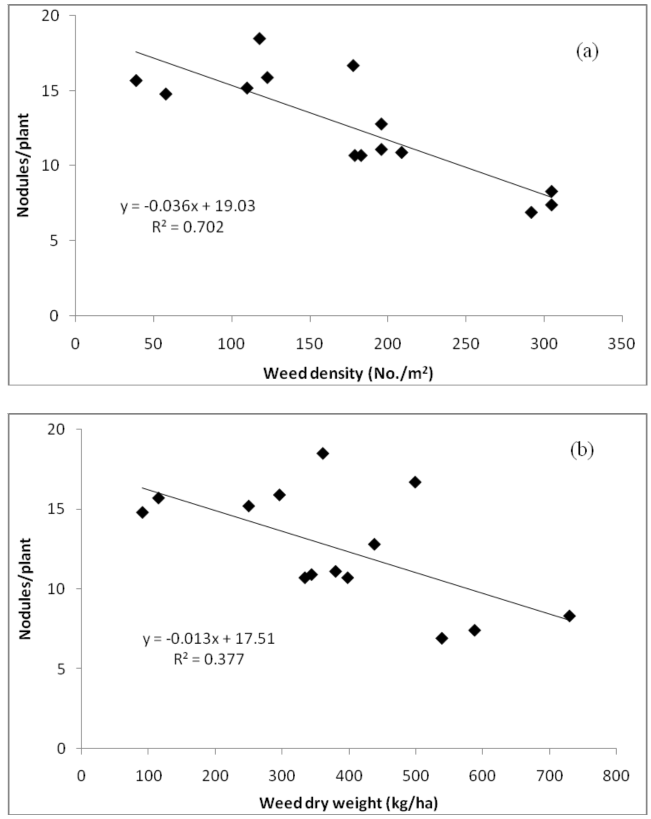

Fig. 1. Relationship between weed densities (a) and weed dry weights (b) with nodulation in chickpea

Grain yield and economics

During 2011–12, the highest grain yield of chickpea was recorded under pendimethalin @ 1.25 kg/ha fb quizalofop-ethyl @ 150 g/ha which was at par with pendimethalin @ 1.25 kg/ha fb quizalofop-ethyl @ 100–125 g/ha and pendimethalin @ 1.25 kg/ha fb manual weeding (Table 3). The significant improvement in chickpea grain yield was recorded owing to application of quizalofop-ethyl @ 100–150 g/ha. During 2012–13, the highest grain yield was recorded with pendimethalin @ 1.25 kg/ha fb quizalofop-ethyl @ 125 g/ha and pendimethalin @ 1.25 kg/ha fb manual weeding. The lowest chickpea grain yield was recorded in pendimethalin @ 1.25 kg/ha fb quizalofop-ethyl @ 50 g/ha. The mean data also revealed that up to 36% improvement in chickpea grain yield can be obtained owing to post-emergence application of quizalofop-ethyl @ 100–150 g/ha in addition to pre-emergence application of pendimethalin @ 1.25 kg/ ha. The higher grain yield under pendimethalin @ 1.25 kg/ ha *fb* quizalofop-ethyl @ 100–150 g/ha was mainly owing to proper growth and development of chickpea under poor crop-weed competition, i.e. less weed population and weed biomass. Negative relationship was shown in Fig. 2a, b among chickpea grain yield and weed density/weed biomass, i.e. chickpea grain yield decreased with increase in weed density and weed biomass. The above results are in line with Sharma (2009) and Mudalagiriyappa *et al*. (2013). The highest net returns and benefit: cost ratio were recorded in pendimethalin @ 1.25 kg/ha fb quizalofop-ethyl @ 125 g/ha during both years. Kachhadiya *et al*. (2009) and Mudalagiriyappa *et al*. (2013) also reported higher returns under herbicide application.

It can be concluded that pendimethalin @ 1.25 kg /ha fb quizalofop-ethyl @ 125 g/ha can be used in chickpea

Table 3. Nodule numbers and dry weight, grain yield and economics in different weed-management practices in chickpea

Weed-management practices	Nodule numbers/plant*		Nodules dry weight* (g/plant)		Grain yield (kg/ha)		Net returns (₹/ha)		Benefit: cost ratio	
	2011–12	2012–13	2011–12	2012–13	2011–12	2012–13	2011–12	2012–13	2011–12	2012–13
Pendimethalin @ 1.0 kg/ha (PE) fb quizalofop-ethyl @ 50 g/ha (PoE)	10.7	6.9	0.633	0.843	907	731	3,862	-1, 418	1.17	0.94
Pendimethalin @ 1.0 kg/ha (PE) fb quizalofop-ethyl @ 75 g/ha (PoE)	10.7	7.4	0.403	0.717	1077	1037	8,138	6, 938	1.34	1.29
Pendimethalin @ 1.0 kg/ha (PE) fb quizalofop-ethyl @ 100 g/ha (PoE)	15.9	12.8	0.705	0.920	1212	1043	11,292	3, 222	1.45	1.23
Pendimethalin @ 1.0 kg/ha (PE) fb quizalofop-ethyl @ 125 g/ha (PoE)	18.5	10.9	0.902	1.083	1310	1360	13,390	14, 890	1.52	1.57
Pendimethalin @ 1.0 kg/ha (PE) fb quizalofop-ethyl @ 150 g/ha (PoE)	15.2	11.1	0.833	0.900	1316	1289	12,570	11, 760	1.47	1.44
Pendimethalin @ 1.25 kg/ha (PE)	16.7	8.3	0.631	0.867	1073	888	10,990	5, 440	1.52	1.26
Pendimethalin @ 1.25 kg/ha (PE) fb manual weeding	15.7	14.8	0.838	1.033	1277	1331	9,710	11, 330	1.34	1.40
SEm±	0.7	0.6	0.045	0.063	76	91	1, 003	1, 045	0.07	0.07
CD (P=0.05)	1.6	1.2	0.096	0.135	162	195	2, 150	2, 241	0.14	0.16

*Recorded at 60 days after sowing

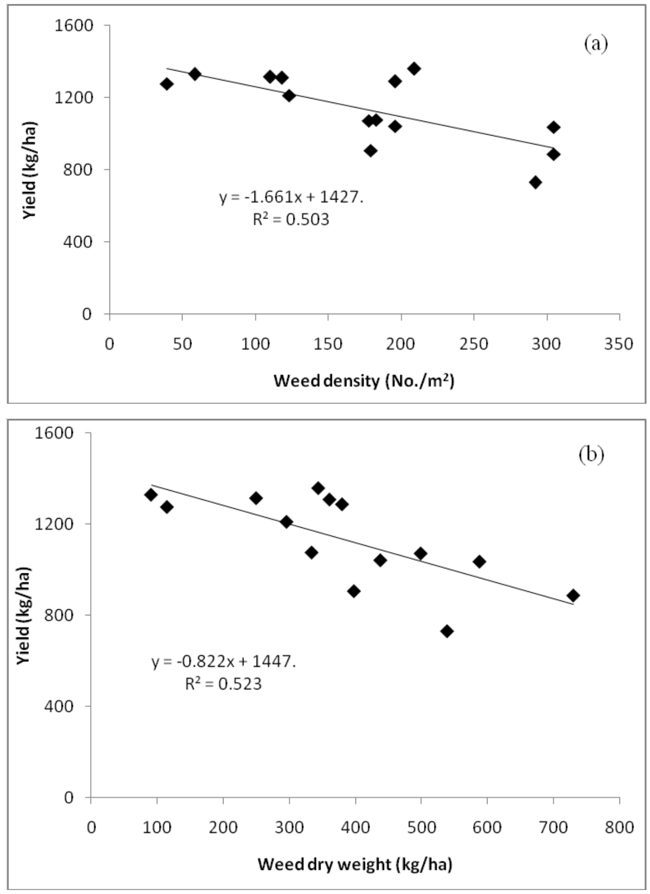

Fig. 2. Relationship between weed densities (a) and weed dry weights (b) with grain yield of chickpea

for effective control of weeds and enhancing productivity.

REFERENCES

Balyan, R.S. and Bhan, V.M. 1984. Promising the herbicides for weed control in chickpea. *Indian Journal of Weed Science* **16**(2): 69–75.

Chaudhary, S.U., Iqbal, J. and Hussain, M. 2011. Weed management in chickpea grown under rice-based cropping system of Punjab. *Crop and Environment* **2**(1): 28–31.

Kachhadiya, S.P., Savaliya, J.J., Bhalu, V.B., Pansuriya, A.G. and Savaliya, S.G. 2009. Evaluation of new herbicides for weed management in chickpea (*Cier arietinum* L.). *Legume Research* **32**(4): 293–97.

Kumar, N. and Hazra, K.K. 2012. Post-emergence Herbicide for *Kharif* and Summer Pulses. *Pulses Newsletter* **23**(4): 5.

Kumar, N., Hazra, K.K., Singh, M.K., Venkatesh, M.S., Kumar, L., Singh, J. and Nadarajan, N. 2013. *Weed-Management Techniques in Pulse Crops*. Indian Institute of Pulses Research, Kanpur, India.

Kumar, N., Mina, B.L., Singh, K.P., Chandra, S., Kumar, M. and Srivastva, A.K. 2010. Weed control for yield and profit maximization in wheat (*Triticum aestivum*) in Indian Himalayas. *Indian Journal of Agronomy* **55**(2): 119–22.

Kumar, N. 2010. *Imazethapyr*: A potential post-emergence herbicide for *kharif* pulses. *Pulses Newsletter* **21**(3): 5.

Ministry of Agriculture. 2013. *Agricultural Statistics at a Glance 2013*, Directorate of Economics and Statistics, Government of India, New Delhi.

Mudalagiriyappa, Panduranga, Chandrashekara, K., Devendrappa, J. and Ambika, D.S. 2013. Performance of new post-emergence herbicides for weed-management in chickpea. *Mysore Journal of Agricultural Science* **47**(2): 333–36.

Patel, B.D., Patel, V.J., Patel, J.B. and Patel, R.B. 2006. Effect of fertilizers and weed management practices on weed control in chickpea *(Cicer arietinum* L.) under middle Gujarat conditions. *Indian Journal of Crop Science* **1**(1–2): 180–83.

Sharma, O.L. 2009. Weed management in chickpea under irrigated conditions of western Rajasthan. *Indian Journal of Weed Science* **41**(3 and 4): 182–84.