Indian Journal of Weed Science **53**(3): 269–274, 2021

Print ISSN 0253-8040 Online ISSN 0974-8164

Effective and profitable weed management in rainy season groundnut grown under arid zone of Rajasthan

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Article information

DOI: 10.5958/0974-8164.2021.00049.6

Type of article: Research article

Received : 9 May 2021
Revised : 23 September 2021
Accepted : 25 September 2021

KEYWORDS
Groundnut

Imazethapyr

Pendimethalin

Pod Yield

Weed control efficiency

Weed management

ABSTRACT

A field study was conducted under arid climatic conditions at Agricultural Research Station, Mandor, Jodhpur, Rajasthan, India, during rainy season (*Kharif*) of 2018, 2019 and 2020. The aim of this study was to identify effective and profitable weed management practices in groundnut for managing weeds and improve groundnut productivity. The weed density and biomass were reduced significantly with hand weeding twice at 20 and 40 days after sowing (DAS). Next best treatment was pendimethalin 30 EC + imazethapyr 2 EC (ready mix) 1.0 kg/ha pre-emergence application (PE) followed by (*fb*) manual weeding at 30 DAS. The highest weed control efficiency (87.48%) and herbicide efficiency index (4.66%) were also recorded with manual weeding twice at 20 and 40 DAS. Next best treatment was pendimethalin + imazethapyr (ready mix) 1.0 kg/ha PE *fb* manual weeding at 30 DAS in terms of lower weed density and biomass, higher weed control efficiency and herbicide efficiency index. The groundnut pod (2.12 t/ha) and haulm yield (3.89 t/ha) were highest with manual weeding twice at 20-40 DAS. All the weed management treatments did not influence the oil content. The highest net returns (₹ 36033 /ha) and B: C ratio (1.57) were obtained with pendimethalin 1.0 kg/ha PE *fb* imazethapyr 75 g/ha post-emergence application (PoE) at 20 DAS.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is an important oilseed crop of India. It is second most important source of vegetable oil in the world (Guchi 2015). In India, groundnut was cultivated in about 4.9-million-hectare area during 2019-20 with a total production of 10.1 million tonnes and average productivity of 2.06 tonnes per hectare (Government of India 2021). Yield loss in groundnut due to weed infestation ranged from 74 to 92% (Jat *et al.* 2011). Critical period for crop-weed competition in groundnut was reported up to 40-60 DAS and weed free environment during this period registered higher pod yield (Geetha *et al.* 2017). The initial growth (generally 6 weeks) of groundnut and its inter row area covering by its canopy is relatively slow which facilitates maximum weed growth and making weeds strongly compete with the crop causing significant reduction in groundnut yield (Shanwad *et al.* 2011). Besides, weeds compete for growth resources (underground space, water, nutrient and light) with the crop, hinder pegging, pod development and make harvesting of groundnut cumbersome (Regar 2017). Hand weeding is an effective method but it is more laborious and expensive (Kalhapure *et al.* 2013, Rao and Chauhan 2015). Chemical control method is quick, more efficient, time and labour-saving method (Kumar 2009). However, there are some harmful effects including the environmental pollutions, animal and human risks as well as impacts on non-target organisms. Selective herbicides control limited weed species but may not be useful on complex of weed flora. The pre-emergence herbicides application (PE) may control weeds for a limited period and late emerging weeds escape from PE, which may need application of post-emergence herbicides application (PoE). There is ample scope for managing weeds by herbicides integration with other weed management methods (Rao and Nagamani 2010, Yaduraju *et al.* 2015). Recently many pre-mix herbicides are available in the market which may be used for effective control of complex of weed flora associated with groundnut. Thus, the present study was conducted to identify effective and economically viable combinations of chemical and cultural methods of weed management for enhancing the groundnut productivity in the arid zone of Rajasthan.

MATERIALS AND METHODS

A field experiment was carried out during three consecutive rainy seasons (*Kharif*) of 2018, 2019 and 2020 at Agricultural Research Station, Mandor (Agriculture University, Jodhpur, Rajasthan, India) located at 26°15 to 26°45 N latitude, 73°E to 73°29 E longitude and 242.6 m above mean sea level. The climate of the area is sub-tropical which received an average annual rainfall of 350 mm. The maximum and minimum temperature was 39.7°C, 18.1°C; 40.8°C, 14.9°C and 39.7°C, 20.3°C during the crop growth in three consecutive years (**Figure 1**). The soil of experimental site was sandy loam in texture with pH 8.2, organic carbon 0.13, available nitrogen (174 kg/ ha), phosphorus (22 kg/ha) and potassium (325 kg/ ha). Groundnut variety *HNG-69* was sown on 30 June in 2018, 28 June in 2019 and 24 June in 2020. The seeds were sown manually by using 80 kg/ha seed rate with a row spacing of 30 cm and plant spacing of 10 cm. The crop duration was 143, 140 and 141 days during the three respective years of study.

There were nine treatments namely pendimethalin 1.0 kg/ha PE; pendimethalin 30 EC + imazethapyr 2 EC 1.0 kg/ha (ready-mix) PE; pendimethalin 1.0 kg/ha PE followed by (*fb*) quizalofop –p-ethyl 50 g/ha at 20 days after seeding (DAS); pendimethalin 30 EC + imazethapyr 2 EC 1.0 kg/ha (ready-mix) PE *fb* quizalofop –p-ethyl 50 g/ha at 20 DAS; pendimethalin 1.0 kg/ha PE *fb* imazethapyr 75 g/ha at 20 DAS; pendimethalin 1.0 kg/ ha PE *fb* manual weeding at 30 DAS; pendimethalin 30 EC + imazethapyr 2 EC 1.0 kg/ha (ready-mix) PE *fb* manual weeding at 30 DAS; manual weeding twice at 20 and 40 DAS and weedy check. The plot size of each treatment was 18 m^2 (5 x 3.6 m^2). The randomized block design with three replications was used. Herbicides were applied by using knapsack sprayer fitted with flat fan nozzle at spray volume of 500 L/ha. The recommended dose of fertilizers for groundnut was 15 kg N, 60 kg P and 250 kg gypsum/ ha. The whole quantity of N and P was applied using urea and single superphosphate at the time of sowing of groundnut. Gypsum was applied in two equal splits, one at basal and another at the time of earthing up on 40 DAS. Plant protection measures, harvesting and other management practices were adopted according to standard recommendations. The observations on branches/plant and pods/plant were recorded manually for five randomly selected representative plants from each plot of each replication separately. The oil in groundnut was estimated by using Clevenger's apparatus (AOAC, 1990). Shelling percentage, weed control efficiency (WCE), weed index (WI), herbicide efficiency index and (HEI) was calculated by using the standard formula. Total weed density (number/m^2) and weed dry biomass (g/m^2) were recorded at harvest for each treatment by using a quadrat of 0.5 x 0.5 m (0.25 m^2) size and expressed as number or g/m^2. Data on weed density and biomass were transformed using ($\sqrt{(x+0.5)}$ for comparison among treatments. The experimental data recorded in various observations were statistically analyzed in accordance with the 'Analysis of Variance' technique as described by Panse and Sukhatme (1985). The least significant difference (LSD) was calculated for the comparison among treatments where ever the variance ratio (F test) was found significant at 5% level of probability. To elucidate the nature and magnitude of treatments effects, summary tables with LSD ($p<0.05$) were prepared.

RESULTS AND DISCUSSION

Effect of weed management treatments on weeds

Weed flora in the experimental field consisted of grassy weeds: *Cynodon dactylon, Dactyloctenium aegyptium* and *Eragrostis minor;* broad-leaved weeds: *Amaranthus viridis, Celosia argentea, Chorchorus trilocularis, Digera arvensis, Phyllanthus niruri, Portulaca oleracea* and *Tribulu sterristris*. *Cyperus rotundus and Cyprus esculentus* were dominant sedge weeds during all the three years of experimentation. However, broad-leaved weeds were dominant over grassy and sedge weeds.

The weedy check treatment had the highest weed density and biomass, weed index and lowest WCE and HEI (**Table 1**). The hand-weeding twice at 20 and 40 DAS recorded significantly lowest weed density and was at par with pendimethalin + imazethapyr (ready-mix) 1.0 kg/ha PE *fb* manual weeding at 30 DAS. On pooled data basis, hand-weeding twice at 20 and 40 DAS has reduced weed density at harvest by 87.9 % as compare to the weedy check. Among herbicide treatments, integration of manual weeding at 30 DAS integrated with pendimethalin + imazethapyr (ready-mix) 1.0 kg/ha PE reduced weed density at harvest stage by 85.42 % in comparison with weedy check plot (**Table 1**). Similar pattern was also observed with weed biomass. Lower weed biomass (29.3 g/m^2) was recorded with pendimethalin + imazethapyr (ready-mix) 1.0 kg/ha PE manual weeding at 30 DAS. The biomass in this effective treatment was 85.24, 56.52 and 38.18 % lower than that recorded with weedy check, pendimethalin 1.0 kg/ha PE, pendimethalin +

imazethapyr 1.0 kg/ha (ready-mix) PE and was at par to pendimethalin 1.0 kg/ha PE *fb* manual weeding at 30 DAS (**Table 1**). Venkateshwara *et al*. (2020) also observed significantly lower weed density and biomass with pendimethalin + imazethapyr (ready-mix) 1.0 kg/ha PE *fb* manual weeding at 30 DAS.

The highest WCE and HEI were achieved in manual weeding twice at 20-40 DAS (87.48% and 4.66). The next best was pendimethalin + imazethapyr (ready-mix) 1.0 kg/ha PE *fb* manual weeding at 30 DAS (85.24 and 3.85%), pendimethalin 1.0 kg/ha PE *fb* manual weeding at 30 DAS (83.60% and 3.40) and pendimethalin 1.0 kg/ha PE *fb* imazethapyr 75 g/ha at 20 DAS (82.34% and 3.12) (**Table 1**). These results were in agreement with Parthipan (2020). The pendimethalin + imazethapyr (ready-mix) 1.0 kg/ha PRE resulted in better control of grasses, sedges and broad-leaved weeds by inhibiting weeds root and shoot growth resulting in less crop-weed competition during early stages of the crop growth and later the weed growth was checked by manual weeding at 25-30 DAS. Pawar *et al*. (2018) reported that pendimethalin 1.5 kg/ha (PE) + imazethapyr 0.075 kg/ha at 20-30 DAS was found effective in controlling weeds that shows higher weed control efficiency and lowest weed index.

Weed index is indirectly correlated to the decrease in yield due to higher weed density and biomass. Minimum reduction in pod yield of groundnut due to least weed competition was found in two hand-weeding at 20 and 40 DAS (0.00%). Next lowest weed index (3.99%) was with pendimethalin + imazethapyr 1.0 kg/ha (ready-mix) PE *fb* manual weeding at 30 DAS (3.78%), pendimethalin 1.0 kg/ha PE + manual weeding at 30 DAS (5.91%) and pendimethalin 1.0 kg/ha PE + imazethapyr 75 g/ha at 20 DAS (7.33%). These results were in agreement with findings of Regar *et al*. (2021) and Thorat *et al*. (2020). The treatment two hand-weeding at 20 and 40 DAS recorded minimum weed index which reflected that the lowest weed index results in highest yield of groundnut due lower weed crop competition. All the herbicides showed minimum value as compared to hand weeding twice at 20 and 40 DAS in context to herbicide efficiency index (HEI).

Effect on groundnut growth and yield parameters

All weed management treatments significantly increased the growth and yield parameters *viz*. branches/plant, number of pods/plant and seed index (g) (**Table 2**). The groundnut plant population was not affected by any of weed management treatments while it was significantly affected due to weeds in weedy check treatment. Maximum number of branches/plants was obtained with manual weeding twice at 20-40 DAS, which was at par with pendimethalin + imazethapyr (ready-mix) 1.0 kg/ha PE *fb* manual weeding at 30 DAS and pendimethalin 1.0 kg/ha PE *fb* manual weeding at 30 DAS. Application of pendimethalin + imazethapyr (ready-mix) 1.0 kg/ha PE *fb* manual weeding at 30 DAS caused significantly increased in number of branches/ plant by 12.30% over pendimethalin + imazethapyr 1.0 kg/ha (ready-mix) PE; 5.79% over pendimethalin 1.0 kg/ha PE *fb* imazethapyr 75 g/ha at 20 DAS and 46% over weedy check.

Significantly highest pods/plant was recorded with manual weeding twice at 20-40 DAS and it was at par with pendimethalin + imazethapyr (ready-mix)

Table 1. Effect of weed management treatments on weed density, weed biomass, weed control efficiency, weed index and herbicides efficiency index at harvest in *Kharif* groundnut (pooled data of three years).

Treatment	Weed density (no./m^2)	Weed biomass (g/m^2)	Weed control efficiency (%)	Weed index (%)	Herbicide efficiency index (%)
Pendimethalin 1.0 kg/ha pre-emergence (PE)	4.6 (21.3)	8.0 (67.4)	66.05	33.70	1.10
Pendimethalin 30 EC + imazethapyr (ready-mix) 1.0 kg/ha PE	3.8 (15.1)	6.7 (47.4)	76.15	18.15	2.06
Pendimethalin 1.0 kg/ha PE *fb* quizalofop-p-ethyl 50 g/ha at 20 DAS	4.3 (18.7)	7.6 (59.5)	70.03	29.02	1.38
Pendimethalin + imazethapyr (ready-mix) 1.0 kg/ha PE *fb* quizalofop-p-ethyl 50 g/ha at 20 DAS	3.6 (13.3)	6.4 (42.5)	78.62	14.18	2.41
Pendimethalin 1.0 kg/ha PE *fb* imazethapyr 75 g/ha at 20 DAS	3.1 (9.6)	5.8 (35.1)	82.34	7.33	3.12
Pendimethalin 1.0 kg/ha PE *fb* MW at 30 DAS	2.9 (8.6)	5.6 (32.6)	83.60	5.91	3.40
Pendimethalin + imazethapyr 1.0 kg/ha PE *fb* MW at 30 DAS	2.6 (7.2)	5.3 (29.3)	85.24	3.78	3.85
Manual weeding (MW) twice at 20-40 DAS	2.4 (6.0)	4.9 (24.9)	87.48	0.00	4.66
Weedy check	6.9 (49.4)	13.8 (198.6)	-	58.46	0.00
LSD (p=0.05)	0.26	0.40			

LSD, least significant difference at the 5% level of significance; DAS-days after sowing; the figures in parentheses are original values of weed density and weed dry weight transformed to square root transformation.

1.0 kg/ha PE *fb* manual weeding at 30 DAS, pendimethalin 1.0 kg/ha PE *fb* manual weeding at 30 DAS and pendimethalin 1.0 kg/ha PE *fb* imazethapyr 75 g/ha at 20 DAS (**Table 2**). Weed-free environment created by these treatments facilitated better plant growth and development, flowering, peg initiation and entry into the soil, pod formation and development which lead to increase number of mature pods/plant (Manickam *et al*. 2000, Mishra *et al*. 2020).

Highest seed index was recorded with manual weeding twice at 20-40 DAS (44.1 g) and pendimethalin + imazethapyr 1.0 kg/ha (ready-mix) PE *fb* manual weeding at 25-30 DAS **(**43.6 g**)**. This is might be due to better control of weeds from the initial stage by pendimethalin + imazethapyr (ready-mix) 1.0 kg/ha PE *fb* hand-weeding at 30 DAS as evident by less weed density and biomass. 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 (Suseendran *et al*. 2019), resulting to higher rate of supply of carbohydrates which leading to higher increase in growth parameters. Lower weed density also provides ample space for growth of root and nodulation in groundnut (Devi Dayal 2004).

Effect on groundnut pod yield, haulm yield, shelling% and oil content

The yield and shelling% of groundnut significantly influenced by different weed management treatments (**Table 2 and 3**). The application of pendimethalin 1.0 kg/ha PE + imazethapyr 75 g/ha at 20 DAS increased the pod yield by 123.1% over weedy check. However, it was at par with pendimethalin 1.0 kg/ha PE *fb* manual weeding at 30 DAS and pendimethalin + imazethapyr (ready-mix) 1.0 kg/ha PE *fb* manual weeding at 30 DAS. These results were in conformity with findings of Sharma *et al*. (2015), Parthipan (2020) and Mathukia *et al.* (2017).

Highest shelling percentage and haulm yield were recorded with two manual weeding at 20-40 DAS (followed by pendimethalin + imazethapyr

Table 2. Effect of weed management practices on plant growth, yield attributes, shelling and oil content of *Kharif* groundnut (pooled data of three years).

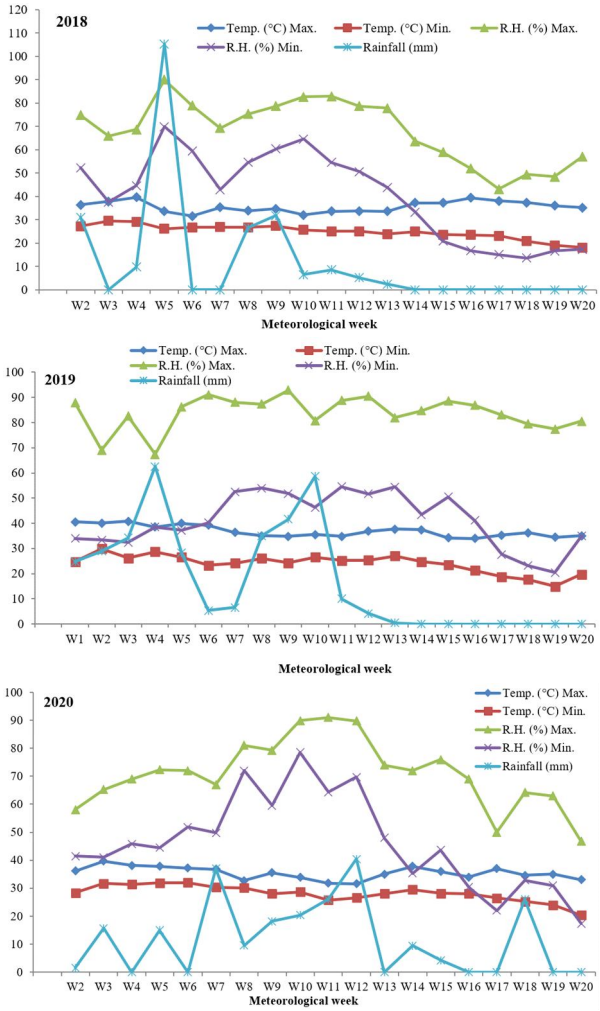
Treatment	Final plant population (000/ha)	Branches /plant	Pods/ plant	Seed index (g)	Shelling (%)	Oil content (%)
Pendimethalin 1.0 kg/ha pre-emergence (PE)	295.1	6.3	14.2	41.5	69.2	48.3
Pendimethalin 30 EC + imazethapyr (ready-mix) 1.0 kg/ha PE	298.8	6.5	16.4	42.1	70.3	48.3
Pendimethalin 1.0 kg/ha PE *fb* quizalofop-p-ethyl 50 g/ha at 20 DAS	306.9	6.4	14.8	42.0	69.4	48.1
Pendimethalin + imazethapyr 1.0 kg/ha PE *fb* quizalofop-p-ethyl 50 g/ha at 20 DAS	305.5	6.8	17.0	42.4	70.2	47.2
Pendimethalin 1.0 kg/ha PE *fb* imazethapyr 75 g/ha at 20 DAS	296.9	6.9	17.8	42.6	71.0	47.3
Pendimethalin 1.0 kg/ha PE *fb* MW at 30 DAS	296.6	7.2	18.7	43.2	70.5	48.5
Pendimethalin + imazethapyr 1.0 kg/ha PE *fb* MW at 30 DAS	308.4	7.3	19.3	43.6	71.6	47.2
Manual weeding (MW) twice at 20-40 DAS	292.9	7.4	20.0	44.1	72.7	47.3
Weedy check	246.1	5.0	11.2	40.7	67.6	47.7
LSD (p=0.05)	15.9	0.3	0.95	1.4	-	-

LSD, least significant difference at the 5% level of significance; DAS-days after sowing

Table 3. Effect of weed management practices on pod yield and haulm yield of *Kharif* groundnut

Treatment	Pod yield (t/ha)				Haulm yield (t/ha)			
	2018	2019	2020	Pooled	2018	2019	2020	Pooled
Pendimethalin 1.0 kg/ha pre-emergence (PE)	1.44	1.52	1.25	1.40	2.92	3.36	2.59	2.95
Pendimethalin 30 EC + imazethapyr (ready-mix) 1.0 kg/ha PE	1.60	2.05	1.54	1.73	3.19	3.60	3.04	3.27
Pendimethalin 1.0 kg/ha PE *fb* quizalofop-p-ethyl 50 g/ha at 20 DAS	1.58	1.62	1.31	1.50	3.13	3.30	2.64	3.02
Pendimethalin + imazethapyr 1.0 kg/ha PE *fb* quizalofop-p-ethyl 50 g/ha at 20 DAS	1.70	2.09	1.67	1.82	3.32	4.11	3.00	3.48
Pendimethalin 1.0 kg/ha PE *fb* imazethapyr 75 g/ha at 20 DAS	1.73	2.44	1.71	1.96	3.45	4.54	3.05	3.68
Pendimethalin 1.0 kg/ha PE *fb* MW at 30 DAS	1.77	2.46	1.74	1.99	3.40	4.55	3.13	3.70
Pendimethalin + imazethapyr 1.0 kg/ha PE *fb* MW at 30 DAS	1.81	2.50	1.80	2.04	3.30	4.64	3.24	3.73
Manual weeding (MW) twice at 20-40 DAS	1.85	2.64	1.86	2.12	3.34	4.91	3.40	3.89
Weedy check	0.84	1.04	0.76	0.88	1.79	2.25	1.84	1.97
LSD (p=0.05)	0.21	0.24	0.26	0.094	0.44	0.63	0.39	0.19

LSD, least significant difference at the 5% level of significance; DAS-days after sowing



W_1: June 18 - June 24; W_2: June 25 - July 1; W_3: July 2-8; W_4: July 9-15; W_5: July 16-22; W_6: July 23-29; W_7: July 30 - August 5; W_8: August 6-12; W_9: August 13-19; W_{10}: August 20-26; W_{11}: August 27- September 2; W_{12}: September 3-9; W_{13}: September 10-16; W_{14}: September 17-23; W_{15}: September 24-30; W_{16}: October 1-7; W_{17}: October 8-14; W_{18}: October 15-21; W_{19}: October 22-28; W_{20}: October 29-November 4

Figure 1. Weather parameters of *Kharif* season during three consecutive years (2018, 2019 and 2020)

(ready-mix) 1.0 kg/ha PE *fb* manual weeding at 30 DAS in pooled data (**Table 2 and Table 3**). Similar observations were made by Kumar *et al.* (2013). Oil content in kernel was not influenced by different weed-management practices (**Table 2**) as reported by Adhikary *et al.* (2016). However, the per cent increase in oil content was found higher in case of pendimethalin 1.0 kg/ha PE *fb* manual weeding at 30 DAS as compared to other treatments.

Economics

All the weed management treatments recorded higher net returns and B:C ratio than weedy check (**Table 4**). Among herbicide-based treatments, higher net returns (₹ 36,033 /ha) and B:C (1.57) ratio was recorded with pendimethalin 1.0 kg/ha PE *fb* imazethapyr 75 g/ha at 20 DAS. Next best was pendimethalin + imazethapyr (ready-mix) 1.0 kg/ha PE *fb* manual weeding at 30 DAS (₹ 34,435 /ha and 1.50) on pooled basis. This was due to higher pod yield and minimum cost of cultivation of groundnut crop than two manual weeding at 20-40 DAS whose cost of cultivation was more due to the higher human labour involved and their higher wages cost. The cost was reduced in herbicidal treatments which gave effective control of weeds while minimizing human labours use. Parthipan (2020) also reported the effective weed management and improved returns in groundnut with pendimethalin + imazethapyr (ready-mix) 1.0 kg/ha as PE *fb* hand weeding at 30 DAS.

It was concluded that pre-emergence application of pendimethalin 1.0 kg/ha followed by imazethapyr 75 g/ha at 20 DAS could be adopted for effective and economic management of weeds with higher productivity of groundnut in arid climatic conditions of Rajasthan.

Table 4. Effect of weed management practices on economics of *Kharif* groundnut (pooled data of three years)

Treatment	Gross returns ($x10^3$ ₹/ha)	Net returns ($x10^3$ ₹/ha)	B:C Ratio
Pendimethalin 1.0 kg/ha pre-emergence (PE)	71.26	10.53	1.17
Pendimethalin 30 EC + imazethapyr (ready-mix) 1.0 kg/ha PE	88.04	26.77	1.44
Pendimethalin 1.0 kg/ha PE *fb* quizalofop-p-ethyl 50 g/ha at 20 DAS	76.23	14.40	1.23
Pendimethalin + imazethapyr 1.0 kg/ha PE *fb* quizalofop-p-ethyl 50 g/ha at 20 DAS	92.38	30.01	1.48
Pendimethalin 1.0 kg/ha PE *fb* imazethapyr 75 g/ha at 20 DAS	99.74	36.03	1.57
Pendimethalin 1.0 kg/ha PE *fb* MW at 30 DAS	101.25	32.67	1.48
Pendimethalin + imazethapyr 1.0 kg/ha PE *fb* MW at 30 DAS	103.56	34.44	1.50
Manual weeding (MW) twice at 20-40 DAS	107.65	34.78	1.48
Weedy check	44.66	-14.11	0.76
LSD (p=0.05)	4.81	-	-

LSD, least significant difference at the 5% level of significance; DAS-days after sowing

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