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Research Paper

Effect of pre- and post-emergence herbicides on growth and nutrient uptake of weeds in urdbean (*Vigna mungo*) crop under Shivalik foothills plains of Jammu

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ABSTRACT

A field study was conducted during the summer seasons of 2015 and 2016 at the Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Chatha, Jammu and Kashmir, to study the effect of pre- and post-emergence application of herbicides on nutrients uptake by weeds and blackgram or urdbean [*Vigna mungo* (L.) Hepper] crop. A significant reduction in weed density and weed biomass was observed with 2 hoeing. Further, among the herbicidal treatments, imazethapyr + pendimethalin @ 1,000 g/ha as pre-emergence and imazethapyr + imazamox 80 g/ha as post-emergence significantly reduced the weed density and weed biomass. The lowest nutrient depletion by weeds, highest grain and stover yields and nutrient uptake by urdbean crop were recorded with pre- emergence application of imazethapyr + pendimethalin @ 1,000 g/ha. Thus, pre-emergence application of imazethapyr + pendimethalin @ 1,000 g/ha may be used for effective weed-management for achieving the higher seed yield (786 kg/ha and 743 kg/ha) in urdbean crop, as it provided higher net returns of (₹45,205/ha and 41,364/ha) and benefit: cost ratio of (2.56 and 2.29) to resourceful farmers of sub-tropical conditions of Jammu region.

***Key words*:** Urdbean, Weed management, Nutrient uptake, Benefit: cost ratio

Urdbean is the third most widely produced pulse crop in India after chickpea and pigeonpea. It can be grown during both rainy and summer seasons. Being a short duration crop, it fits well in traditional rice-wheat cropping systems and provides farmers with additional income.

Being a leguminous crop, it plays a major role in nitrogen fixation from 20 to 80 kg/ha (Hayat *et al.,* 2008), thus improving system sustainability. Among the various factors, weed infestation is one of the major constraints in urdbean cultivation and causes 43.2–64.1% yield loss (Rathi *et al.* 2004). Competition with the weeds leads to 50–70% reduction in grain yield of urdbean. Therefore, removal of weeds at appropriate time using a suitable method is essential to obtain high yields of urdbean. Traditional practice of hand-weeding requires dependence on increased number of labours during the peak period of sowing and harvesting and becoming expensive. Timely weeding is most important to minimize the yield losses, and therefore under such circumstances the only effective tool left is to control weeds through the use of chemicals. Management of weeds through the use of chemicals has also been found as effective as realized under manual eradication in urdbean including over and above benefits in saving extra costs involved in use of labour on manual eradication of weeds (Tiwari *et al*., 2018). For controlling weeds in urdbean, number of pre- and post-emergence herbicides have already found their place in cultivation package of urdbean. Hence, keeping the above facts in view, the present investigation was undertaken to assess the performance of herbicidal weed management for providing effective control in urdbean.

MATERIALS AND METHODS

A 2 year field experiment was conducted during the summer seasons of 2015 and 2016 at the research farm of the Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Jammu and Kashmir. The experimental site is located at 32°40 N and 74°58E, with an of 332 m above mean sea-level) in the Shivalik foothills of North-Western Himalayas. The climate of this place is bestowed with hot and dry early summers followed by hot

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and humid monsoon season and cold winters. The soil of the experimental field was sandy clay slightly alkaline in reaction (*p*H 7.81), medium in organic carbon (0.51%), available phosphorus (11.63 kg/ha) and potassium (147.3 kg/ha) and low in available nitrogen (246.5 kg/ha). The experiment was conducted in randomized block design with 3 replications. The treatments comprised of imazethapyr 70 g/ha as pre-emergence, imazethapyr 80 g/ha as pre-emergence, imazethapyr 70 g/ha at 3–4-leaf stage, imazethapyr 80 g/ha at 3–4-leaf stage, imazethapyr + imazamox 70 g/ha as pre-emergence, imazethapyr + imazamox (RM) 80 g/ha as pre-emergence, imazethapyr + imazamox (RM) 70 g/ha at 3–4-leaf stage, imazethapyr + imazamox (RM) 80 g/ha at 3–4-leaf stage, pendimethalin 1,000 g/ha as pre-emergence, imazethapyr + pendimethalin (RM) 1,000 g/ha as pre-emergence, 2 hoeings 15 and 30 DAS, weedy check and weed-free.

Urdbean variety 'Uttara' was sown in April using seed rate of 20 kg/ha. Furrows were opened manually with the help of liners at a specified row-to-row distance of 30 cm and plant-to-plant distance of 10 cm. The crop was grown under assured irrigation without any water stress during crop-growth period and was managed as per regional recommendations of the SKUAST-Jammu. Among the different time of herbicides application, pre-emergence (PE) application was made on next day of sowing and post-emergence (PoE) application was done at 18 DAS (3–4-leaf stage of weeds) by knapsack sprayer fitted with flat-fan nozzle by using 500 litres/ha of water. Weedy check plots remained infested with native population of weeds till harvesting. Data on weed density were recorded from an area enclosed in the quadrate of 0.5 m^2 randomly selected at 2 places in each plot. The data on weed density and weed dry weight thus obtained were subjected to square-root transformation ($\sqrt{x+1}$), as wide variations existed among the treatments before statistical analysis. Among economic parameters, net return per ha was calculated by deducting cultivation cost from gross returns. Benefit: cost (B : C) ratio was calculated. The data obtained on weed count, weed density, yield, nutrient uptake by crop and nutrient removal by weeds were tabulated and subjected to analysis of variance techniques as described by Cochran and Cox (1963).

RESULTS AND DISCUSSION

Weed Studies

The experimental field was mainly infested by weeds including *Cyperus* species, i.e. *Cyperus rotundus* (L.), rice flat sedge *(Cyperus iria* L.), Bermuda grass [*Cynodon dactylon* (L.) Pers.], crab grass [*Digitaria sanguinalis* (L.) Scop.], black nightshade (*Solanum nigrum* L.) native gooseberry (*Physalis minima* L.) and stonebreaker (*Phyllanthus niruri* (L.) during both the years of experimentation (Tables 1 and 2). Among the different weed-management treatments, weed-free treatment significantly reduced the count and dry-matter of all the weed species compared to weedy check at 60 days after sowing (DAS) which recorded the highest values in respect of these parameters. In herbicidal treatments, application of imazethapyr + pendimethalin (RM) @ 1,000 g/ha as pre-emergence significantly reduced the count and dry matter of all the weed species, being statistically at par with imazethapyr + imazamox (RM) @ 80 g/ha at 3–4-leaf stage, imazethapyr @ 80 g/ha at 3–4-leaf stage, imazethapyr + imazamox (RM) @ 70 g/ha at 3–4-leaf stage and imazethapyr @ 70 g/ha at 3–4 leaf stage. The better performance of combination of herbicides was probably due to the synergistic effect of 2 herbicides with same or different modes or sites of action, thus reducing the population as well as dry-matter accumulation of different weed species (Singh *et al.,* 2016). Higher herbicidal efficacy and relatively long-lasting effects of imazethapyr in reducing weed biomass might have happened be owing to broad-spectrum activity of the herbicide, particularly on established weed plants of both narrow and broad-leaf nature and its greater efficiency to retard cell-division of meristems as a result of which weeds succumbed rapidly. The results are in close confirmity with Khairnar *et al.* (2014).

Yield

Seed and stover yields of urdbean exhibited significant variations with respect to different weed management treatments (Table 3). Among the weed-management treatments, weed-free treatment resulted in significantly highest seed and stover yields being statistically at par with 2 hand-hoeing at 15 and 30 DAS. The increase in seed and stover yield of urdbean under weed-free conditions were obviously owing to reduced crop-weed competition, higher weed-control efficiency by providing below-threshold weed situation, resulting in higher yield attributes and finally the higher biological yields. Thus, the crop plants being vigorous efficiently utilized nutrients, moisture, sunlight, space and other input factors hence, gave better yield, whereas the weedy check plots gave significantly lowest yields due to heavy competition for nutrients, moisture and light between the crop and weeds at critical phenophases of crop. Our results confirm the findings of Chand *et al.* (2003), Mirjha *et al.* (2013) and Yadav *et al.* (2015). Among the herbicidal weed-management treatments, significantly highest seed and stover yields were recorded with the application of imazethapyr + pendimethalin (RM) @ 1,000 g/ha as pre-emergence which was statistically at par with (imazethapyr + imazamox (RM) @ 80 g/ha at 3–4-leaf stage, imazethapyr @ 80 g/ha at 3–4-leaf stage,

Table 1. Effect of weed-management practices on density of different weed species in summer urdbean

Treatment	Weed count of Individual species (no./ m^2) at 60 DAS											
	Cyperus spp.		*Cynodon dactylon*		*Digitaria sanguinalis*		*Solanum nigrum*		*Physalis minima*		*Phyllanthus niruri*	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Imazethapyr @ 70 g (pre-emergence)	5.74 (32.00)	5.89 (33.67)	3.91 (14.33)	4.00 (15.00)	3.05 (8.33)	3.21 (9.33)	2.64 (6.00)	2.82 (7.00)	2.44 (5.00)	2.57 (5.67)	2.89 (7.33)	3.00 (8.00)
Imazethapyr @ 80 g (pre-emergence)	5.53 (29.67)	5.63 (30.67)	3.78 (13.33)	3.83 (13.67)	2.92 (7.67)	2.99 (8.00)	2.58 (5.67)	2.71 (6.33)	2.31 (4.33)	2.38 (4.67)	2.77 (6.67)	2.89 (7.33)
Imazethapyr @ 70 g (3–4-leaf stage)	4.12 (16.00)	4.04 (15.33)	3.36 (10.33)	3.41 (10.67)	2.38 (4.67)	2.44 (5.00)	1.91 (2.67)	2.00 (3.00)	1.82 (2.33)	1.91 (2.67)	1.63 (1.67)	1.72 (2.00)
Imazethapyr @ 80 g (3–4-leaf stage)	3.99 (15.00)	3.78 (13.33)	3.05 (8.33)	3.11 (8.67)	2.31 (4.33)	2.38 (4.67)	1.73 (2.00)	1.82 (2.33)	1.73 (2.00)	1.82 (2.33)	1.52 (1.33)	1.52 (1.33)
Imazethapyr + imazamox (RM) @ 70 g (pre-emergence)	5.59 (30.33)	5.71 (31.67)	3.87 (14.00)	3.96 (14.67)	2.99 (8.00)	3.10 (8.67)	2.43 (5.00)	2.56 (5.67)	2.23 (4.00)	2.38 (4.67)	2.77 (6.67)	2.88 (7.33)
Imazethapyr + imazamox (RM) @ 80 g (pre-emergence)	5.44 (28.67)	5.57 (30.00)	3.96 (14.67)	4.04 (15.33)	2.81 (7.00)	2.92 (7.67)	2.51 (5.33)	2.58 (5.67)	2.16 (3.67)	2.08 (3.33)	2.77 (6.67)	2.82 (7.00)
Imazethapyr + imazamox (RM) @ 70 g (3–4-leaf stage)	4.08 (15.67)	4.03 (15.33)	3.55 (11.67)	3.64 (12.33)	2.23 (4.00)	2.31 (4.33)	1.41 (1.00)	1.41 (1.00)	1.52 (1.33)	1.63 (1.67)	1.41 (1.00)	1.72 (2.00)
Imazethapyr + imazamox (RM) @ 80 g (3–4-leaf stage)	3.86 (14.00)	3.83 (13.67)	3.51 (11.33)	3.60 (12.00)	2.08 (3.33)	2.16 (3.67)	1.28 (0.67)	1.41 (1.00)	1.41 (1.00)	1.52 (1.33)	1.52 (1.33)	1.61 (1.67)
Pendimethalin @ 1,000 g (pre-emergence)	5.88 (33.67)	6.02 (35.33)	3.99 (15.00)	4.12 (16.00)	3.15 (9.00)	3.26 (9.67)	2.64 (6.00)	2.76 (6.67)	2.37 (4.67)	2.44 (5.00)	2.94 (7.67)	3.05 (8.33)
Imazethapyr + pendimethalin (RM) @ 1,000 g (pre-emergence)	3.73 (13.00)	3.35 (10.33)	2.90 (7.67)	3.04 (8.33)	1.99 (3.00)	2.07 (3.33)	2.15 (3.67)	2.23 (4.00)	1.72 (2.00)	1.72 (2.00)	1.72 (2.00)	1.80 (2.33)
Hoeing (2) 15 and 30 DAS	3.82 (14.00)	3.91 (14.67)	2.35 (4.67)	2.43 (5.00)	1.91 (2.67)	1.99 (3.00)	1.91 (2.67)	2.00 (3.00)	1.63 (1.67)	1.73 (2.00)	1.63 (1.67)	1.91 (2.67)
Weedy check	7.53 (56.00)	7.65 (57.67)	5.16 (25.67)	5.32 (27.33)	3.60 (12.00)	3.78 (13.33)	3.36 (10.33)	3.55 (11.67)	3.05 (8.33)	3.21 (9.33)	3.46 (11.00)	3.60 (12.00)
Weed-free	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
SEm±	0.22	0.20	0.15	0.12	0.15	0.15	0.11	0.09	0.10	0.10	0.09	0.12
CD (P=0.05)	0.63	0.60	0.44	0.34	0.44	0.43	0.33	0.28	0.29	0.30	0.25	0.35

DAS, Days after sowing

Table 2. Effect of weed-management practices on dry matter of different weed species in summer urdbean

Treatment	Weed dry matter of individual species (g/m^2) at 60 DAS											
	Cyperus spp.		*Cynodon dactylon*		*Digitaria sanguinalis*		*Solanum nigrum*		*Physalis minima*		*Phyllanthus niruri*	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Imazethapyr @ 70 g (pre-emergence)	2.43 (4.96)	2.56 (5.59)	2.15 (3.63)	2.24 (4.03)	2.08 (3.33)	2.18 (3.78)	1.95 (2.79)	2.05 (3.22)	2.02 (3.10)	2.13 (3.57)	1.73 (1.98)	1.79 (2.20)
Imazethapyr @ 80 g (pre-emergence)	2.41 (4.82)	2.53 (5.40)	2.14 (3.57)	2.22 (3.94)	2.02 (3.10)	2.11 (3.47)	1.92 (2.70)	2.03 (3.11)	2.00 (2.99)	2.11 (3.47)	1.71 (1.94)	1.76 (2.09)
Imazethapyr @ 70 g (3–4-leaf stage)	2.10 (3.46)	2.20 (3.90)	2.02 (3.08)	2.10 (3.42)	1.55 (1.43)	1.63 (1.68)	1.79 (2.21)	1.90 (2.60)	1.81 (2.29)	1.91 (2.66)	1.56 (1.43)	1.58 (1.52)
Imazethapyr @ 80 g (3–4-leaf stage)	2.08 (3.31)	2.19 (3.78)	1.99 (2.98)	2.08 (3.31)	1.53 (1.35)	1.60 (1.58)	1.76 (2.10)	1.86 (2.46)	1.76 (2.09)	1.85 (2.44)	1.52 (1.32)	1.56 (1.44)
Imazethapyr + imazamox (RM) @ 70 g (pre-emergence)	2.43 (4.89)	2.55 (5.51)	2.14 (3.59)	2.23 (3.96)	2.05 (3.23)	2.15 (3.62)	1.93 (2.75)	2.03 (3.13)	2.00 (3.01)	2.12 (3.50)	1.75 (2.05)	1.79 (2.20)

Imazethapyr + imazamox (RM) @ 80 g (pre-emergence)	2.40 (4.76)	2.52 (5.36)	2.13 (3.55)	2.22 (3.92)	1.98 (2.92)	2.07 (3.27)	1.90 (2.63)	2.00 (2.99)	1.98 (2.95)	2.06 (3.28)	1.70 (1.91)	1.74 (2.02)
Imazethapyr + imazamox (RM) @ 70 g (3–4-leaf stage)	2.10 (3.41)	2.20 (3.84)	2.01 (3.04)	2.09 (3.36)	1.54 (1.39)	1.61 (1.61)	1.77 (2.15)	1.87 (2.52)	1.77 (2.15)	1.87 (2.52)	1.54 (1.38)	1.57 (1.47)
Imazethapyr + imazamox (RM) @ 80 g (3–4-leaf stage)	2.06 (3.24)	2.16 (3.67)	1.98 (2.93)	2.04 (3.18)	1.40 (1.04)	1.54 (1.38)	1.75 (2.05)	1.84 (2.38)	1.73 (1.99)	1.74 (2.02)	1.50 (1.27)	1.54 (1.37)
Pendimethalin @ 1,000 g (pre-emergence)	2.45 (5.03)	2.58 (5.66)	2.16 (3.69)	2.26 (4.11)	2.10 (3.41)	2.21 (3.89)	1.96 (2.83)	2.07 (3.27)	2.04 (3.16)	2.16 (3.67)	1.77 (2.14)	1.80 (2.26)
Imazethapyr + pendimethalin (RM) @ 1,000 g (pre-emergence)	2.05 (3.21)	2.15 (3.62)	1.88 (2.55)	1.95 (2.81)	1.41 (1.01)	1.46 (1.13)	1.74 (2.02)	1.80 (2.27)	1.71 (1.94)	1.78 (2.18)	1.49 (1.23)	1.52 (1.31)
Hoeing (2) 15 and 30 DAS	1.74 (2.04)	1.81 (2.30)	1.74 (2.04)	1.81 (2.29)	1.22 (0.49)	1.25 (0.57)	1.64 (1.68)	1.71 (1.92)	1.60 (1.55)	1.66 (1.75)	1.39 (0.94)	1.43 (1.04)
Weedy check	3.66 (12.51)	3.87 (14.08)	2.40 (4.77)	2.51 (5.32)	2.45 (5.03)	2.57 (5.63)	2.47 (5.14)	2.61 (5.86)	2.36 (4.58)	2.53 (5.39)	2.45 (5.02)	2.52 (5.38)
Weed-free	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
SEm±	0.09	0.10	0.06	0.06	0.10	0.09	0.05	0.06	0.06	0.07	0.06	0.06
CD (P=0.05)	0.26	0.28	0.18	0.19	0.28	0.26	0.15	0.16	0.18	0.20	0.17	0.18

Table 3. Effect of weed-management practices on yield and economics in summer urdbean

Treatment	Seed yield (kg/ha)		Stover yield (kg/ha)		Net returns (₹10^3/ha)		Benefit: cost ratio	
	2015	2016	2015	2016	2015	2016	2015	2016
Imazethapyr @ 70 g (pre-emergence)	623	581	1,363	1581	33.67	29.31	1.97	1.71
Imazethapyr @ 80 g (pre-emergence)	686	642	1,501	1741	37.91	34.01	2.23	1.96
Imazethapyr @ 70 g (3–4-leaf stage)	730	690	1,814	2105	41.63	38.05	2.48	2.22
Imazethapyr @ 80 g (3–4-leaf stage)	746	695	1,849	2145	42.71	38.25	2.52	2.21
Imazethapyr + imazamox (RM) @ 70 g (pre-emergence)	666	621	1,383	1604	35.99	32.04	2.08	1.81
Imazethapyr + imazamox (RM) @ 80 g (pre-emergence)	688	646	1,615	1874	37.47	33.71	2.13	1.88
Imazethapyr + imazamox (RM) @ 70 g (3–4-leaf stage)	743	690	1,824	2,116	42.15	37.56	2.44	2.13
Imazethapyr + imazamox (RM) @ 80 g (3–4-leaf stage)	759	711	1,877	2,177	43.15	38.97	2.46	2.17
Pendimethalin @ 1,000 g (pre-emergence)	620	565	1,236	1,434	32.72	27.95	1.94	1.62
Imazethapyr + pendimethalin (RM) @ 1,000 g (pre-emergence)	786	743	1,881	2,182	45.21	41.36	2.56	2.29
Hoeing (2) 15 and 30 DAS	820	782	1,905	2,210	43.12	39.70	1.92	1.74
Weedy check	316	297	1,087	1,261	10.28	84.09	0.68	0.55
Weed-free	910	883	2,146	2,490	42.84	40.31	1.43	1.33
SEm±	33	34	81	94	-	-	-	-
CD (P=0.05)	96	100	236	273	-	-	-	-

imazethapyr + imazamox (RM) @ 70 g/ha at 3–4-leaf stage, imazethapyr @ 70 g/ha at 3–4-leaf stage. Application of imazethapyr + pendimethalin (RM) @ 1,000 g/ha as pre-emergence, imazethapyr + imazamox (RM) @ 80 g/ha at 3–4-leaf stage, imazethapyr @ 80 g/ha at 3–4-leaf stage, imazethapyr + imazamox (RM) @ 70 g/ha at 3–4-leaf stage and imazethapyr @ 70 g/ha at 3–4-leaf stage resulted in 148.73, 140.19, 136.08, 135.13 and 131.01% higher seed yield of summer urdbean than weedy-check plots. This might have happened probably due to better control of both grassy as well as broad-leaf weeds during early crop-growth stages and higher nutrient uptake by the crop. Our results confirm the findings of Khairnar *et al.* (2014) and Yadav *et al.* (2015).

Nutrient uptake by crop

Amongst weed the management treatments, significantly higher N, P and K uptake by urdbean crop was recorded in weed-free treatment than weedy check (Table 4). In the herbicidal treatments, an application of imazethapyr + pendimethalin (RM) @ 1,000 g/ha as pre-emergence resulted in significantly highest uptake of N, P and K by grain and stover of urdbean. However, pendimethalin @ 1,000 g/ha as pre-emergence ensued significantly lowest N, P and K uptake by urdbean crop. The possible reason for better nutrient uptake by crop could be attributed to more favourable environment for growth and development of crop plants apparently due to lesser weed competition which led to increased growth of crop and thereby increase in nutrient uptake by accumulation of higher amounts of nutrients in urdbean seeds. Almost a similar trend was observed with respect to NPK uptakes by urdbean stover due to different weed-management treatments. Chhodavadia *et al.* (2013), Komal *et al.* (2015) and Kavad *et al.* (2016) also reported similar results

Nutrient uptake by weeds

The removal of N, P and K by weeds was reduced significantly by various herbicidal interventions and it was found negligible under weed-free treatment, whereas significantly highest N, P and K uptake by weeds was recorded in the weedy check treatment (Table 4). This could possibly be attributed to luxuriant growth of unchecked weeds in weedy check treatment which accumulated higher dry matter and competed dominantly with the crop plants for nutrients. These results corroborate the findings of Kaur *et al.* (2010). Among the herbicidal treatments at different intervals, significantly lowest values of N, P and K uptake by weeds were recorded with the application of imazethapyr + pendimethalin (RM @ 1,000 g/ha as pre-emergence. This is due to fact that, imazethapyr + pendimethalin (RM) @ 1,000 g/ha as pre-emergence showed relatively better efficacy against weeds whose infestation was predominantly lower in these relatively superior herbicidal treatments. Similar findings were made by Komal *et al.* (2015) and Kavad *et al.* (2016).

Economics

The economic feasibility and usefulness of a treatment could be effectively adjudged in terms of benefit: cost ratio and net returns (Table 3). The maximum net returns were obtained from the weed-free plots, followed by treatment of 2 hoeings at 15 and 30 DAS. Amongst the weed-management treatments, the highest net returns were obtained with the application of imazethapyr + pendimethalin (RM) @ 1,000 g/ha as pre-emergence, followed by imazethapyr + imazamox (RM) @ 80 g/ha at 3–4-leaf stage, 2 hoeings @ 15 and 30 DAS and weed-free. Higher seed yield of urdbean might have been responsible for the corresponding higher net returns as compared to weedy-check treatment. Our findings confirm the results of Yadav *et al.* (2015). Also, the highest B : C ratio (2.56) was obtained with an application of imazethapyr + pendimethalin (RM) @ 1,000 g/ha as pre-emergence. Pendimethalin @ 1000 g/ha as pre-emergence recorded significantly lowest benefit: cost (B : C) ratio. Higher B : C ratio and net returns in efficient weed management treatments could be attributed to their higher seed yield which were the major factors that caused variation in net returns and B : C ratio. These results are in conformity with the findings of Kaur *et al.* (2016).

Based on the experimental results obtained from 2 years of study, it can be concluded that imazethapyr + pendimethalin@ 1,000 g as pre-emergence or imazethapyr 80 g at 3–4-leaf stage is suitable for weed control in summer urdbean, as these treatments provide higher seed yield and benefit: cost ratio.

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Table 4. Effect of weed-management practices on nutrient uptake by weeds and summer urdbean

Treatment	Nutrient uptake by grain (kg/ha)						Nutrient uptake by strover (kg/ha)						Nutrient uptake by weeds (kg/ha)					
	N		P		K		N		P		K		N		P		K	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Imazethapyr @ 70 g (pre-emergence)	19.99	18.64	2.05	1.91	14.80	13.79	17.33	20.10	1.92	2.22	13.24	15.36	4.67	5.30	2.03	2.30	3.27	3.71
Imazethapyr @ 80 g (pre-emergence)	22.21	20.79	2.28	2.13	16.44	15.39	19.38	22.48	2.14	2.48	14.81	17.17	4.37	4.92	1.90	2.14	3.06	3.45
Imazethapyr @ 70 g (3–4-leaf stage)	24.29	22.96	2.49	2.35	17.97	16.99	25.07	29.08	2.77	3.21	19.15	22.22	3.10	3.52	1.35	1.53	2.17	2.47
Imazethapyr @ 80 g (3–4-leaf stage)	24.90	23.19	2.55	2.38	18.42	17.16	25.93	30.08	2.87	3.32	19.81	22.98	2.90	3.32	1.26	1.44	2.03	2.32
Imazethapyr + imazamox (RM) @ 70 g (pre-emergence)	21.43	19.98	2.20	2.05	15.86	14.79	17.72	20.55	1.96	2.27	13.54	15.70	4.50	5.06	1.96	2.20	3.15	3.54
Imazethapyr + imazamox (RM) @ 80 g (pre-emergence)	22.32	20.95	2.29	2.15	16.51	15.51	21.16	24.55	2.34	2.71	16.17	18.75	4.25	4.74	1.85	2.06	2.97	3.32
Imazethapyr + imazamox (RM) @ 70 g (3–4-leaf stage)	24.77	23.00	2.54	2.36	18.33	17.02	25.53	29.62	2.82	3.27	19.51	22.63	3.01	3.41	1.31	1.48	2.10	2.39
Imazethapyr + imazamox (RM) @ 80 g (3–4-leaf stage)	25.40	23.80	2.60	2.44	18.80	17.61	26.47	30.70	2.92	3.39	20.22	23.46	2.73	3.07	1.19	1.34	1.91	2.15
Pendimethalin @ 1,000 g (pre-emergence)	19.86	18.10	2.04	1.86	14.70	13.39	15.67	18.18	1.73	2.01	11.97	13.89	4.89	5.52	2.12	2.40	3.42	3.86
Imazethapyr + pendimethalin (RM) @ 1,000 g (pre-emergence)	26.39	24.94	2.71	2.56	19.53	18.45	26.77	31.05	2.96	3.43	20.45	23.73	2.59	2.89	1.13	1.26	1.81	2.02
Hoeing (2) 15 and 30 DAS	27.68	26.39	2.84	2.71	20.48	19.53	27.44	31.83	3.03	3.52	20.97	24.32	1.87	2.10	0.81	0.91	1.31	1.47
Weedy check	9.95	9.36	1.02	0.96	7.36	6.93	13.21	15.32	1.46	1.69	10.09	11.71	9.32	10.49	4.05	4.56	6.52	7.34
Weed-free	30.94	30.02	3.17	3.08	22.90	22.22	31.45	36.48	3.47	4.03	24.03	27.87	–	–	–	–	–	–
SEm±	1.14	1.18	0.12	0.12	0.84	0.87	0.97	1.12	0.11	0.12	0.74	0.86	0.23	0.26	0.10	0.11	0.16	0.18
CD (P=0.05)	3.32	3.43	0.34	0.35	2.46	2.54	2.83	3.28	0.31	0.36	2.16	2.50	0.68	0.76	0.29	0.33	0.47	0.53

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