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Short Research Article

Influence of Pre and Post-emergent Applied Herbicides on Weed Dynamics, Nutrients Uptake and Yield of Pigeonpea (*Cajanus cajan* L.)

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Abstract

Field experiments was conducted during *kharif* season of 2011–12 at G.B. Pant University of Agriculture and Technology, Pantnagar (Uttarakhand), India to study the effect of pre and post-emergent applied herbicides on dynamics of weed flora in the pigeonpea field. The results indicated that the integration of post-emergence application of imazethapyr 75 g a.i. ha^{-1} 10 DAS+quizalofop ethyl 50 g a.i. ha^{-1} PoE 15 DAS followed by 1 HW 50 DAS and tank mix application of imazethapyr 75 g a.i. ha^{-1} +quizalofop ethyl 50 g a.i. ha^{-1} PoE 15 DAS followed by 1 HW 50 DAS proved effective in reducing the density and dry weight of *Echinochloa colona,Cynodon dactylon, Cyperusr otundus* and other weeds species. In over all reducing total weed density and dry weight. It was also found that these herbicides treatments were also effective in reducing NPK uptake by weeds, and increasing the weed control efficiency and weed index. The similar trend was also observed in grain and stover yield of pigeonpea under these treatments. Therefore, it may be concluded that a post-emergence application of imazethapyr 75 g a.i. ha^{-1} 10 DAS+quizalofop ethyl 50 g a.i. ha^{-1} PoE 15 DAS followed by 1 HW 50 DAS, may be an alternative to two or more hand weeding for efficient control of weed flora, reducing nutrient uptake by weeds and achieving more grain yield of pigeonpea.

1. Introduction

In the world, pulses are being grown by 171 countries at the ending of 2010–11; the total area under pulses covered 72.3 mha, which provides about 64.4 mt of pulses production with a productivity of 890 kg ha^{-1}. Worldwide, the highest area under pulses contributed by India (32.24%) followed by Niger (7.00) and Myanmar (5.33). Similarly, the contribution in total production by India is 23.46% followed by Canada 7.93 and China 7.09. However, the France (4219 kg ha^{-1}) followed by Canada (1936 kg ha^{-1}) and USA (1882 kg ha^{-1}) are at the top in pulses productivity. At the ending of 2010–11, it is reported that the contribution of Chickpea to total pulses area are 35%, followed by Pigeonpea 16% and Urdbean 12% (DoAC, 2015). Pigeonpea [*Cajanus cajan* (L.) Millsp.] is one of most important grain legume/pulse crops in the world, mostly being cultivated in Asia with a global area and production of about 85.50% and 83.09% followed by Africa 12.19% and 14.34% and America 2.31% and 2.57% during 2013. The global pigeonpea area, production and productivity in 2013 were 6.22 mha, 4.74 mt and 762.4 kg ha^{-1}, respectively. The major pigeonpea producing countries include India (63.74% of global production), Myanmar (18.98%) and Malawi (6.07%) (FAOSTAT, 2015). India with 4.65 mha area, 3.02 mt of total production and 650.0 kg ha^{-1} of pigeonpea productivity ranks first in the world during 2013. (Pulses Handbook, 2015) Pigeonpea, grown across in the country and also known as *arhar*, *tur*, redgram, is the second most important grain legume/pulse crops of India in terms of acreage and production after chickpea. It has multiple uses and occupies an important place in the prevailing farming systems in the country. Its grains are highly nutritious and rich in protein (21.7%), that constitutes the main source of dietary protein to all vegetarian people, especially in developing countries. It also plays an important role in sustainable agriculture by enriching the soil through biological nitrogen fixation along with deep root system which makes it more suitable for its cultivation under rainfed conditions too. In realizing the yield potential of the crop, sound weed management practices becomes imperative as the weeds start competing fiercely for moisture, nutrients and space with the crop right from the sowing of the crop.

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The magnitude of reduction in yield depends on the nature of weed species, quantum of weed flora, duration of crop-weed competition etc. Ali (1992) reported that yield losses in pigeonpea varied to the tune of 40–60% in different parts of the country due to weeds. Most of the herbicides recommended for pigeonpea are applied as pre-sowing or pre-emergence. These herbicides can keep weeds under check only for early part of the crop season (up to 30–40 days after sowing). (Kaur et al., 2015) revealed that weed infestation in pigeonpea is severe at the initial period during first 6–8 weeks, when the crop requires being kept free from weeds. Moreover, new weed species may emerge at later stages. Several studies showed that two hand weeding 30 and 50 DAS stages gave ahigher yield than herbicides alone. Some herbicides are very costly and applied at higher doses which have an adverse effect on both soil and crop. Supplementing herbicides with hand weeding/ inter-culture gave higher pigeonpea yield than the application of herbicides alone (Maheshwarappa et al., 1994). Several investigations have been carried out in different crops with appropriate herbicides which have been effective at a low dose and also give economic return to the farmers (Mukherjee and Bhattacharya, 1999). Therefore, herbicides use at a lower rate along with other post-emergent herbicides may give good control of weeds and is there by helpful in achieving higher crop yields.

The recent trend in herbicide use is to find out an effective measure with a low and optimum dose of herbicide which will not only reduce the total volume of the product but also makes the application effective for soil and crop health and economically optimum. A limited number of post-emergent herbicides have been tested against the weeds in pigeonpea. But the efficacy and selectivity of these herbicides are yet to be explored in pulse crops. Therefore, the present investigation was imperative to study the effect of pre and post-emergent applied herbicides on the dynamics of weed flora in the pigeonpea field.

2. Materials and Methods

A field experiment was conducted during *kharif* season of 2011−12 at G.B. Pant University of Agriculture and Technology, Pantnagar (Uttarakhand). The soil of the experimental site was sandy loam in texture, medium in organic carbon 0.73%, available nitrogen 320.8 kg ha^{-1}, available phosphorus 19.7 kg ha^{-1} and available potassium 146.2 kg ha^{-1} being slightly alkaline in reaction pH 7.7. Total 10 treatments as T_1–Weedy check, T_2–Alachlor 2 kg a.i. ha^{-1} PE+Paraquat 0.40 kg a.i. ha^{-1} 42 DAS, T_3–Pendimethalin 0.75 kg a.i. ha^{-1} PE followed by 1 HW 50 DAS, T_4–Imazethapyr 75 g a.i. ha^{-1} PoE 15 DAS followed by 1 HW 50 DAS, T_5 - Imazethapyr 75 g a.i. ha^{-1} PoE 10 DAS+Quizalofop ethyl 50 g a.i. ha^{-1} PoE 15 DAS, T_6–Tank mix application of Imazethapyr 75 g a.i. ha^{-1} +Quizalofop ethyl 50 g a.i. ha^{-1} PoE 15 DAS, T_7–T_5 followed by 1 HW 50 DAS, T_8–T_6 followed by 1 HW 50 DAS, T_9–Pendimethalin 0.75 kg a.i. ha^{-1} PE+Imazethapyr 60 g a.i. ha^{-1} PoE 15 DAS and T_{10}–Weed free, were assigned in randomized block design with three replications. The pigeonpea var. Pant Arhar–3 was sown at 60 cm row spacing and 20 cm plant spacing at 15 kg seed ha^{-1} on June 22 and harvested on December 16. Alachlor and pendimethalin were sprayed next day of sowing and imazethapyr, quizalofop ethyl and paraquat were sprayed on 10, 15 and 42 DAS, respectively. However, the application of imazethapyr+quizalofop ethyl was done after tank mixed. Whereas, application of paraquat was done with the help of hood at a spray volume of 500 lit ha^{-1}. A manually operated knapsack sprayer was used for herbicides application. The crop was grown with a standard package of practices for the region. The total rainfall received during the crop season was 1964.2 mm out of which the maximum was received in the month of July. Observations on weeds count (number m^{-2}) was recorded with thehelp of an iron quadrate 0.5×0.5 m^2, placed randomly in each plot at 30 DAS interval and converted to m^{-2}. The data on total weed density and weed dry weight were recorded at different stages of crop growth and were subjected to √X+1 log (X+1) transformation to normalize their distribution. Weeds samples were cut at ground level, and first dried under the sunfor a few days and then in a hot air oven at 65 °C to 70 °C for 48 to 72 hours for recording the dry matter. The data on weed control efficiency were calculated using the maximum weed dry weight stage during the weed growth period irrespective of treatments, and calculated by the following formulae (Mani et al., 1973).

$$WCE=\frac{DWC-DWT}{DWC}\times 100$$

Where, WCE=Weed control efficiency, DWT=Dry weight of weeds in treated plot, DWC=Dry weight of weeds in theunweeded control plot. The Weed index was calculated by using the formula given by Gill and Kumar, 1969.

$$WI=\frac{YHW-Yt}{YHW}\times 100$$

Where, WI=Weed index, YHW=Average yield of thecrop in weed free plot, Yt=Average yield of thecrop in theplot under other weed control treatment. The relative efficacy of pre and post emergent herbicides was studied in terms of weed species, weeds density, and weed dry weight, weed control efficiency, and weed index and pigeonpea grain yield. The data for different parameters were statistically analyzed by (Gomez and Gomez, 1984). The mean differences were computed at 5% level of significance.

3. Results and Discussion

3.1. Weeds associated with pigeonpea crop

Weed flora of the experimental site was collected and identified. There were following dominant annual weeds florain the experimental field during *kharif* season under Pantnagar conditions. *Echinochloa colona* (L.) Link. (*Jangli* rice) locally known as *Sawan, Eleusine indica* (L.) (Goose grass) locally known as *Jagali Mandua*, *Digitaria sanguinalis* (L.) (large crabgrass) locally known as *Tackrighas,* belongs to grassy weeds of Poaceae family, Broad leaves weeds like *Commelina benghalensis* (day flower) locally known as *Kansara* or *Kankana,* belongs to Commelinaceae family, *Celosia argentea* (L.) (White cock's comb) locally known as *Safed murga* belongs to Amaranthaceae family, and *Mollugo pentaphylla* (L.) (Indian chickweed) belongs to Molluginaceae family and perennial weeds namely *Cynodon dactylon* (L.) Pers. (Bermuda grass) locally known as *Doobghas*, *Sorghum halepense* (L.) Pers. (Johnson grass) locally known as *Baru* or *Banchari,* belongs to grassy weeds of Poaceae family, and *Cyperus iria* (L.) (Rice flat sedge) locally known as *Chhatri Wala Motha,Cyperus rotundus* (L.) (Purple nut sedge) locally known as Motha, belongs to sedges weeds of Cyperaceae family.

Out of these weed spp. identified so far only *Echinochloa colona*, *Cynodon dactylon* and *Cyperus rotundus* were most predominant under weedy condition accounting for 45.5, 18.7 and 11.2% contribution of the total weed population, respectively during whole crop growth periods (Table 1 and Figure 1). These data show that these three weeds were the major weeds in the pigeonpea field under Pantnagar conditions. The dominance of these weeds in pigeonpea field has also been reported by Singh et al. (1998), from Pantnagar.

3.2. Effect on weeds dynamics

The data regarding the weeds population species wise at 90

Table 1: Species wise density and dry matter accumulation of the major weeds as influenced by different weed management practices at maximum weeds dry weight accumulation stage (90 DAS)

	Species wise weeds density (Numbers of weeds m^{-2})					Species wise dry matter accumulation in weeds (g m^{-2})				
Treatment	*Echinochloa colona*	*Cynodon-dactylon*	*Cyperus-rotundus*	Other weeds species	Total number of weeds	*Echinochloa colona*	*Cynodon dactylon*	*Cyperus rotundus*	Other weeds species	Total dry matter accumulation
T_1	6.34 (565)	5.51 (247)	4.59 (97)	5.47 (236)	7.04 (1145)	5.81 (332.67)	4.25 (69.33)	3.85 (46.33)	4.79 (119.67)	6.35 (568.70)
T_2	5.13 (167)	4.40 (81)	3.37 (28)	4.74 (114)	5.97 (390)	4.91 (134.33)	3.61 (36.00)	3.52 (33.00)	4.12 (60.67)	5.58 (264.00)
T_3	5.10 (163)	4.31 (73)	3.33 (27)	4.54 (93)	5.88 (356)	4.79 (119.00)	3.50 (32.00)	3.46 (31.00)	4.07 (58.00)	5.48 (240.00)
T_4	5.25 (190)	4.52 (91)	3.61 (36)	4.95 (140)	6.13 (457)	5.14 (170.00)	3.81 (44.33)	3.83 (45.33)	4.41 (81.67)	5.84 (341.30)
T_5	4.61 (100)	4.24 (68)	3.24 (25)	4.47 (86)	5.63 (279)	4.49 (88.33)	3.42 (29.67)	3.37 (28.33)	4.00 (53.67)	5.30 (200.00)
T_6	5.05 (156)	4.47 (87)	3.46 (31)	4.87 (129)	6.00 (403)	5.22 (184.67)	3.70 (39.67)	3.57 (35.00)	4.22 (67.33)	5.79 (326.70)
T_7	4.44 (84)	2.84 (17)	3.04 (20)	4.09 (59)	5.20 (180)	4.28 (71.33)	3.24 (24.67)	3.10 (21.33)	3.86 (46.67)	5.11 (164.00)
T_8	4.46 (86)	3.11 (22)	3.13 (22)	4.23 (68)	5.29 (198)	4.42 (82.00)	3.33 (27.00)	3.23 (24.33)	3.94 (50.67)	5.23 (184.00)
T_9	5.44 (229)	4.70 (109)	3.64 (37)	5.09 (162)	6.29 (537)	5.26 (192.33)	3.98 (52.33)	3.87 (47.00)	4.45 (84.33)	5.93 (375.30)
T_{10}	0.00 (0)	1.39 (3)	0.00 (0)	2.39 (10)	2.70 (14)	0.00 (0.00)	0.46 (1.00)	0.00 (0.00)	1.33 (3.00)	1.47 (4.00)
SEm±	0.03	0.06	0.06	0.04	0.03	0.02	0.16	0.07	0.05	0.12
CD (p=0.05)	0.10	0.19	0.19	0.11	0.08	0.06	0.48	0.20	0.16	0.35

*Transformed values as log (X+1); **Original values in parentheses

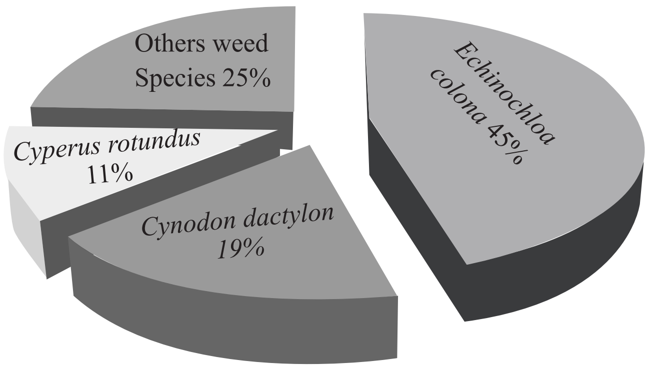

Figure 1: Percentage composition of the major weed species in the weedy treatment of pifeopea field

DAS stage of crop growth are showing (Table 1) and it was revealed that the differences in the population of *Echinochloa colona,Cynodon dactylon, Cyperus rotundus* and other weeds species due to weed control treatments were significantly highest in the case of the weedy check. However, significant reductions in the population of theses weed species were recorded in all the treatments as compared to the weedy-check. Among the weed management practices, herbicidal treatment, T_7 (imazethapyr 75 g a.i. ha^{-1} PoE 10 DAS+quizalofop ethyl 50 g a.i. ha^{-1} PoE 15 DAS followed by 1 HW 50 DAS) caused a significant reduction in *Echinochloa colona, Cynodon dactylon, Cyperus rotundus* and other weeds species population over rest of the herbicidal treatments. However, the density of *Cyperus rotundus* remained on a par with T_8 (tank mix application of imazethapyr 75 g a.i. ha^{-1} +quizalofop ethyl 50 g a.i. ha^{-1} PoE 15 DAS followed by 1 HW 50 DAS) which did not differ significantly. In the case of the total weed population, significantly lower weed density was recorded under weed-free which might have been attributed to better control of weeds by hand weeding at the critical stages of competition. These findings corroborate the results obtained by Dhaker et al. (2010). Among the herbicides treatments, T_7 (imazethapyr 75 g a.i. ha^{-1} PoE 10 DAS+quizalofop ethyl 50 g a.i. ha^{-1} PoE 15 DAS followed by 1 HW 50 DAS) caused asignificant reduction in total weed population over rest of the treatments except weed free.

Post-emergence application of T_7 (imazethapyr 75 g a.i. ha^{-1} PoE 10 DAS+quizalofop ethyl 50 g a.i. ha^{-1} PoE 15 DAS followed by 1 HW 50 DAS) proved to be superior over other herbicidal treatments used in the experiment. Imazethapyr is an imidazole compound used as aselective herbicide in a variety of crops. The compound has residual effect extending from a week to several months depending on herbicide dose. Findings also show that it is a broad-spectrum herbicide which kills both kinds of grass and broad-leaved weeds very effectively. Many researchers have reported lower weed densities in pigeonpea and similar crops with the use of herbicides like alachlor (Reddy et al., 2007), pendimethalin (Singh et al., 2010b; Singh et al., 2010a; Yadav and Singh, 2009; Rao, 2000), quizalofop-ethyl (Meena et al., 2011), imazethapyr (Dhaker et al., 2010).

The data regarding the total and species wise weeds dry matter unit area^{-1} basis at maximum weed stages of crop growth (Table 1) shows that the herbicidal treatments T_7 (imazethapyr 75 g a.i. ha^{-1} PoE 10 DAS+quizalofop ethyl 50 g a.i. ha^{-1} PoE 15 DAS followed by 1 HW 50 DAS) reduced the dry matter accumulation in *Echinochloa colona* significantly over the other treatments. However, the dry matter production of *Cynodon dactylon, Cyperus rotundus,* other weeds species andtotal weeds dry matter production under the herbicidal treatments T_7 (imazethapyr 75 g a.i. ha^{-1} PoE 10 DAS+quizalofop ethyl 50 g a.i. ha^{-1} PoE 15 DAS followed by 1 HW 50 DAS) reduced significantly over the other treatments except T_8 (tank mix application of imazethapyr 75 g a.i. ha^{-1}+quizalofop ethyl 50 g a.i. ha^{-1} PoE 15 DAS followed by 1 HW 50 DAS) which remained on a par.

It was observed that weed dry matter is a better parameter to measure the crop-weeds competition than weed number since it precisely measures the quantum of growth-related factors utilized by the weeds, similar opinion had been expressed by Bhanmurthy and Subramanian (1989). In addition, the treatments T_7 (imazethapyr 75 g a.i. ha^{-1} PoE 10 DAS+quiz Alo fop ethyl 50 g a.i. ha^{-1} PoE 15 DAS followed by 1 HW 50 DAS) recorded low population and dry matter of weeds as compared to other treatments upto 90 days of crop growth, which is considered as a critical crop-weed competition period for pigeonpea. A weed free environment at theinitial stage of crop growth till the critical period of the crop-weed competition or flowering initiation in crop facilitated thegood growth of crop by offering least competition for water, nutrients, light and space with weeds which ultimately reflected on yield. Furthermore, the apprehension can be made that upto 90 DAS, weeds did not attain much growth and subsequently the crop canopy development was sufficient enough to smother the weeds which emerged of the later stages of crop growth. These results are in close conformity with those of Ramasamy et al. (1996).

3.3. *Effect on pigeonpea yield*

The data on grain yield ha^{-1} (Table 2), revealed that the weed free plot recorded the maximum grain yield ha^{-1} being significantly superior over all the treatments except T_7 (imazethapyr 75 g a.i. ha^{-1} PoE 10 DAS+quizalofop ethyl 50 g a.i. ha^{-1} PoE 15 DAS followed by 1 HW 50 DAS) and T_8 (tank mix application of imazethapyr 75 g a.i. ha^{-1}+quizalofop ethyl 50 g a.i. ha^{-1} PoE 15 DAS followed by 1 HW 50 DAS) which was statistically on a par with each other. However, among the various herbicides treatments, T_7 (imazethapyr 75 g a.i. ha^{-1} PoE 10 DAS+quizalofop ethyl 50 g a.i. ha^{-1} PoE 15 DAS followed by 1 HW 50 DAS) produced the maximum grain yield, than all the other remaining herbicides treatments. The grain yield of pigeonpea was severely reduced due to the crop–weed competition. On an average, there was 37.04% reduction in the grain yield in weedy as compared to weed-free condition. The yield variation in the present study due to various weed management practices are in close conformity with those of Ali (1992); Kumar et al. (2000); Kandasamy (1999). All the weed management practices produced significantly more grain yield of pigeonpea than weedy check. T_8 (tank mix application of imazethapyr 75 g a.i. ha^{-1}+quizalofop ethyl 50 g a.i. ha^{-1} PoE 15 DAS followed by 1 HW 50 DAS). Higher grain yield under these treatments might be attributed to better weed control efficiency and weed index (Table 2).

The data on stover yields ha^{-1} revealed that the weed-free treatment recorded the maximum stover yield ha^{-1} which was significantly higher over all the herbicides treatments except T_7 (imazethapyr 75 g a.i. ha^{-1} PoE 10 DAS+quizalofop ethyl 50 g a.i. ha^{-1} PoE 15 DAS followed by 1 HW 50 DAS), T_8 (tank mix application of imazethapyr 75 g a.i. ha^{-1}+quizalofop ethyl 50 g a.i. ha^{-1} PoE 15 DAS followed by 1 HW 50 DAS), and T_5 (imazethapyr 75 g a.i. ha^{-1}PoE 10 DAS+quizalofop ethyl 50 g a.i. ha^{-1} PoE 15 DAS) which were statistically on a par with each other. Among the various herbicides treatments, T_7 (imazethapyr 75 g a.i. ha^{-1} PoE 10 DAS+quizalofop ethyl 50 g a.i. ha^{-1} PoE 15 DAS followed by 1 HW 50 DAS) produced the maximum stover yields being significantly superior over all the treatments except T_8 (tank mix application of imazethapyr 75 g a.i. ha^{-1}+quizalofop ethyl 50 g a.i. ha^{-1} PoE 15 DAS followed by 1 HW on 50 DAS), T_5 (imazethapyr 75 g a.i. ha^{-1} PoE 10 DAS+quizalofop ethyl 50 g a.i. ha^{-1} PoE 15 DAS) and T_3 (pendimethalin 0.75 kg a.i. ha^{-1} P.E. followed by 1 HW 50 DAS) which did not differ significantly. The weedy check plot remained significantly inferior in comparison with all the other treatments.

3.4. *Effect on weed control efficiency and weed index*

The WCE, obviously, remained highest in weed free plot. As for as the weed management practices are concerned, the treatments T_7 (imazethapyr 75 g a.i. ha^{-1} PoE 10 DAS+quizalofop ethyl 50 g a.i. ha^{-1} PoE 15 DAS followed by 1 HW 50 DAS) came up with the highest weed control efficiency being significantly superior to the other weed management practices except T_8 (tank mix application of imazethapyr 75 g a.i. ha^{-1}+quizalofop ethyl 50 g a.i. ha^{-1} PoE 15 DAS followed by 1 HW 50 DAS) which did not differ significantly. Differences in WI were influenced significantly due to different weed management practices. In an obvious rationale, the weed index remained maximum in the weedy check, and the weed management combinations T_7 (imazethapyr 75 g a.i. ha^{-1} PoE 10 DAS+quizalofop ethyl 50 g a.i. ha^{-1} PoE 15 DAS followed by 1 HW 50 DAS), T_8 (tank mix application of imazethapyr 75 g a.i. ha^{-1}+quizalofop ethyl 50 g a.i. ha^{-1} PoE 15 DAS followed by 1 HW 50 DAS) and T_5 (imazethapyr 75 g a.i. ha^{-1} PoE 10 DAS+quizalofop ethyl 50 g a.i. ha^{-1} PoE 15 DAS) remained significantly superior in terms of the WI transformation values.

3.5. *Effect of NPK uptake by weed*

The uptake of N, P and K in weeds were remained significantly

Table 2: Effect of various weed management practices on pigeonpea yield, weed control efficiency, weed index and NPK uptake by weeds, during crop growth period

Treatment	Yield (kg ha^{-1})		WCE (%)	WI (%)	NPK uptake (kg ha^{-1}) by weeds		
	Grain yield	Stover yield			N	P	K
T_1	1217	5375	0.00 (0.00)	3.61 (36.47)	4.29 (71.94)	2.67 (13.44)	4.61 (99.60)
T_2	1508	7002	4.00 (53.53)	2.99 (21.00)	3.46 (30.82)	1.93 (5.87)	3.80 (43.86)
T_3	1567	7563	4.07 (57.75)	2.86 (18.26)	3.36 (27.68)	1.81 (5.13)	3.70 (39.62)
T_4	1501	6833	3.71 (39.91)	2.90 (21.27)	3.71 (39.90)	2.17 (7.74)	4.06 (56.86)
T_5	1600	7897	4.19 (64.79)	2.41 (16.33)	3.16 (22.58)	1.65 (4.20)	3.52 (32.90)
T_6	1508	6835	3.77 (42.49)	3.03 (21.49)	3.67 (38.14)	2.14 (7.51)	4.03 (54.97)
T_7	1750	8621	4.28 (71.13)	2.21 (9.59)	2.96 (18.25)	1.47 (3.33)	3.24 (24.44)
T_8	1700	8305	4.23 (67.61)	2.44 (11.78)	3.06 (20.42)	1.57 (3.80)	3.43 (30.05)
T_9	1508	7017	3.55 (33.80)	2.29 (20.21)	3.84 (45.62)	2.28 (8.78)	4.18 (64.30)
T_{10}	1933	9185	4.61 (99.29)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
SEm±	95	437	0.01	0.39	0.04	0.03	0.03
CD (p=0.05)	283	1298	0.04	1.17	0.13	0.09	0.08

*Transformed values as log (X+1); **Original values in parentheses the maximum in case of the weedy check. Among the various weed management practices T_7 (imazethapyr 75 g a.i. ha^{-1} PoE 10 DAS+quizalofop ethyl 50 g a.i. ha^{-1} PoE 15 DAS followed by 1 HW 50 DAS) Recorded lowest N, P and K uptake by weeds being significantly superior over all the other treatments except T_8 (tank mix application of imazethapyr 75 g a.i. ha^{-1} +quizalofop ethyl 50 g a.i. ha^{-1} PoE 15 DAS followed by 1 HW 50 DAS) which did not differ significantly in case of N uptake, only. The newly developed post-emergence broad-spectrum herbicides for the selective control of annual and perennial weeds in broad-leaved crop kills weeds by inhibiting the enzyme acetohydroxy acid synthetase (AHAS), which involved in the synthesis of three branches chain aliphatic amino acids viz., leucine, isoleucine and valine. This inhibition causes a disruption in protein synthesis, which leads to an interference in DNA synthesis and cell growth. Foliar applications of these herbicides quickly absorbed and readily translocated throughout the plant system. Visual symptoms include early chlorosis/necrosis of the younger plant tissues followed by a progressive collapse of the remaining foliage and subsequent death within a few weeks of application. In addition to top-killing activity, these herbicides are also effective in controlling root system regrowth of several perennial grass species. These compound has residual effect extending from a week to several months which also control the later stages weed flora of crop effectively and therefore, reduced nutrients uptake by weeds from crop field, and ultimately increased nutrient use efficiency of crop. The similar mode of action of these herbicides have also been reported by Anon (1985).

4. Conclusion

Post-emergence application of imazethapyr 75 g a.i. ha^{-1} 10 DAS+quizalofop ethyl 50 g a.i. ha^{-1} PoE 15 DAS followed by 1 HW 50 DAS may be an alternative to two or more hand weeding for efficient control of weed flora, reducing nutrient removal by weeds and achieving more grain yield of pigeonpea during *kharif* season.

5. References

Ali, M., 1992. Weeds are a great threat to rainy season pulses. Indian Farming 42(5), 27, 29–30.

Anon, 1985. Assure grass herbicide, Tech. Bull. Du Pont., U.S.A. (E689718/85) 1–6.

Bhanmurthy, V.B., Subramanian, S., 1989. Adoption of new parameters, gram dry competition for weed control study. Indian Journal of Agricultural Sciences 59, 800–801.

Dhaker, S.C., Mundra, S.L., Nepalia, V., 2010. Effect of weed management and sulphur nutrition on productivity of soybean [*Glycine max* (L.) Merrill]. Indian Journal of Weed Science 42(3 & 4), 232–234.

DoAC, 2015. Status paper on pulses, directorate of pulses development, Department of Agriculture & Cooperation, Ministry of Agriculture, Government of India, New Delhi. Available from http://farmer.gov.in/imagedefault/pestanddiseasescrops/pulses.pdf. Accessed on accessed on July 2016.

FAOSTAT, 2015. Food and Agricultural Organization Statistics. Available from http://faostat.fao.org/site/339/default.aspx. Accessed on July 2016.

Gill, G.S., Kumar, V., 1969. Weed index: a new method for reporting weed control traits. Indian Journal of Agronomy 16(2), 96–98.

Gomez, A.K., Gomez, A.A., 1984. Statistical Procedure for Agricultural Research. International Rice Research Institute., Los Banos, Philippines.

Kandasamy, O.S., 1999. Effect of herbicides with and without manual weeding on weeds and yield of rainfed pigeonpea [*Cajanus cajan* (L.) Millisp.]. Legume Research 22(3), 172–176.

Kaur, R., Rishi Raj, Das, T.K., Shekhawat, K., Singh, R., Choudhary, A.K., 2015. Weed management in pigeonpea-based cropping systems. Indian Journal of Weed Science 47(3), 267–276.

Kumar, P., Saraf, C.S., Singh, R., Chander, S., 2000. Effect of weed management and sulphur fertilization on weeds and yield in green gram and black gram intercropping system. Indian Journal of Weed Science 32(1 & 2), 25–30.

Maheswarappa, H.P., Srinivasan, G., Nanjappa, H.V., 1994. Effect of integrated weed management practices in nutrient removal by weeds in pigeonpea. Journal of Maharashtra Agriculture University 19(3), 453–454.

Mani, V.S., Mola, M.L., Gautam, K.C., Bhagwn, D., 1973. Weed killing chemicals in potato cultivation. Indian Farming 17(1), 17–18.

Meena, B., Sagarka, B.K., Pisal, R.R., 2011. Impact of some herbicides and cultural practices on weed and crop parameter in *kharif* pigeonpea [*Cajanus cajan* (L.) Millsp.]. Legume research 34(1), 55–58.

Mukherjee, P.K., Bhattacharya, S.P., 1999. Comparative study of bio-efficacy between new generation micro-herbicide and traditional voluminous herbicide on transplanted rice culture. Annals of Agricultural Sciences 20(4), 509–511.

Pulses Handbook, 2015. Foretell Business Solutions Pvt. Ltd. Available from http://commodityindia.com/mailer/Pulses_handbook_2015_EBook.pdf. Accessed on July 2016, Page 17.

Ramasamy, M., Srinivasan, K.,Vairavan, K., 1996. Weed management in pigeonpea+groundnut intercropping system. The Madras Agricultural Journal 83(5), 298–300.

Rao, V.S., 2000. Principles of weed science. Second edition, Oxford, and IBH. Publishing Company Private Limited. New Delhi, 71–73.

Reddy, M.M., Madhavilatha, A., Rao, L.J., 2007. Integrated weed management in pigeonpea (*Cajanus cajan*)–soybean (*Glycine max*) intercropping system in Vertisol under rainfed conditions. Indian Journal of Agriculture Science 77, 177–178.

Singh, G., Hari Ram, Sekhon, H.S., Navneet Aggarwal, Buttar, G.S., Kulvir Singh, Harpreet Kaur,Veena Khanna, 2010b. Bioefficacy of pendimethalin for the control of weeds in pigeonpea [*Cajanus cajan* (L.) millsp.]. Journal of Research Punjab Agricultural University 47(3 & 4), 121–126.

Singh, G., Navneet Aggarwal, Hari Ram, 2010a. Effect of Row Spacing and Weed Management Practices on Weeds, Growth and Yield of Pigeonpea [*Cajanus cajan* (L.) Millsp.]. Indian Journal of Weed Science 42(3&4), 241–243.

Singh, V.K., Singh, N.P., Sharma, B.B., Sahu, J.P., 1998. Effect of planting methods and weed-control practice on weed management and productivity of pigeonpea (*Cajanus cajan*) in foothills region. Indian Journal of Agronomy 4(3), 685–688.

Yadav, M.K., Singh, R.S., 2009. Effect of nitrogen levels and weed management practices on pigeonpea (*Cajanus cajan*) and rice (*Oryza sativa*) intercropping system under ridge-furrow planting system, The Indian Journal of Agricultural Sciences 79(4), 268–272.

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