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Impact of Imidazolinones on Weeds in Pigeon Pea (*Cajanus cajan* L.)

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ABSTRACT

Background: Among various biotic factors limiting pigeon pea yield, weeds are of prime importance which can causes seed yield losses up to 80 per cent. Therefore current study aims to evaluate the impact of imidazolinones on weeds in pigeon pea (*Cajanus cajan* L.).

Methods: The experiment was laid out in randomized block design using eighteen treatments replicated thrice. To control the weeds in pigeon pea, imidazolinones alone and its combination with pendimethalin were applied and rest other cultural practices for cultivation of pigeon pea were adopted according to the package and practices of CCA HAU, Hisar.

Result: Among all weed controls treatments, two hoeing at 40 and 70 DAS found most effective to control all kind of weeds. PRE application of imidazolinones was comparatively more effective than POE application. Among different weed species, *Cynodon dactylon* was not controlled by any of the herbicide treatment and PRE application of pendimethalin @ 1000 g/ha did not control *Digera arvensis* and *Cyperus rotundus.* Whereas, PRE application of pendimethalin + imazethapyr @ 1000 + 75 g/ha provided best control of total weeds leads to lowest nutrient uptake by weeds. Therefore, PRE application of pendimethalin + imazethapyr @ 1000 + 75 g/ha proved to be an effective and a profitable alternative to the existing recommendation (two hoeing at 25 and 45 DAS) of weed control in pigeon pea in Haryana locality.

Key words: Imidazolinones, Nutrient uptake, Pendimethalin + imazethapyr, Pigeon pea, Weeds.

INTRODUCTION

In addition to food security 'nutritional security' has now become an emerging global issue which is haunting the researchers. Among pulse crops, pigeon pea (*Cajanus cajan* L.) is one of the most important pulse crops of India after chick pea used for food, feed and fuel. It is also known as Arhar, Red gram, Tur, No eye pea, Gungopea and Congopea (Prasad *et al*. 2006). In India, the area under pulses is 29.45 million hectares with a production of 23.13 million tonnes during 2016-17 (Anonymous, 2018a). The per capita availability of pulses has dwindled down from 60 g/capita/day in 1951 to 43 g/capita/day in 2016 as against World Health Organization recommendation of 80 g/capita/day (Anonymous, 2018b). Thus, there is an urgent need to increase the production to meet the increasing demand by improving the production technologies appropriately.

Among various biotic factors limiting pigeon pea yield, weeds are of prime importance which can causes seed yield losses up to 80 per cent (Talnikar *et al*., 2008). Pigeon pea is cultivated in rainy season (*kharif*) in India. Rainy season, slow initial growth and sowing at wider spacing of pigeon pea encourage rapid growth and severe infestation of weeds. Hence, initial period of 6-8 weeks of pigeon pea are critical in terms of crop weed competition for resources *i.e*. water, sunlight, space, nutrient *etc*., which may eventually reduce the seed yield (Channappagoudar and Biradar, 2007). Therefore, weed management is an important key factor for reducing the crop with competition for resources especially for nutrients.

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Imazethapyr and imazethapyr + imazamox are imidazolinone herbicide which are absorbed both by the roots and the shoots and can effectively control a broad spectrum of weeds (Saltoni *et al.,* 2004). These inhibit the plastid enzyme acetolactate syntheses (ALS) in plants which catalyses the first step in the biosynthesis of essential branched chain amino acids (valine, leucine, isoleucine). The ALS inhibitors thus stop cell-division and reduce carbohydrate translocation in the susceptible plants (Das, 2008).

Imazethapyr, an herbicide of imidazolinones group has been registered for soybean, groundnut and other legumes (Herbicides Handbook, 2002) found effective to control of grassy as well as broad leaved weeds when either applied

in alone or in combination with pendimethalin in black gram (Kumar *et al*., 2015) and in green gram (Punia *et al*., 2015).

Therefore, taking into consideration the all above facts a field experiment was conducted to study the impact of imidazolinones alone and in combination on different weed species and nutrient uptake by weeds in pigeon pea.

MATERIALS AND METHODS

The present field experiment was conducted at Agronomy Research Farm, CCS Haryana Agricultural University, Hisar, India during 2017-18 and 2018-19. Geographically, Hisar is situated at 29°10′N latitude, 75°46′E longitude and at an altitude of 215.2 meters above mean sea level. The climate of Hisar is semi-arid characterized by hot and dry summer and severe cold during winter season. Texture of the soil of experimental field was sandy-loam and it is slightly alkaline in reaction. The fertility status of soil was medium in organic carbon, medium in available nitrogen and phosphorus but high in available potassium. The experiment was laid out in randomized block design using eighteen treatment combinations *viz*., T_1- imazethapyr @ 75 g/ha as PRE, T_2- imazethapyr @ 100 g/ha as PRE, T_3- imazethapyr @ 75 g/ha at 45 DAS, T_4- imazethapyr @ 100 g/ha at 45 DAS, T_5- imazethapyr + imazamox (RM) @ 70 g/ha as PRE, T_6- imazethapyr + imazamox (RM) @ 100 g/ha as PRE, T_7- imazethapyr + imazamox (RM) @ 70 g/ha at 45 DAS, T_8- imazethapyr + imazamox (RM) @ 100 g/ha at 45 DAS, T_9- pendimethalin + imazethapyr @ 750 + 50 g/ha as PRE, T_{10}- pendimethalin + imazethapyr @ 1000 + 50 g/ha as PRE, T_{11}- pendimethalin + imazethapyr @ 750 + 65 g/ha as PRE, T_{12}- pendimethalin + imazethapyr @ 1000 + 65 g/ha as PRE, T_{13}- pendimethalin + imazethapyr @ 750 +75 g/ha as PRE, T_{14}- pendimethalin + imazethapyr @ 1000 + 75 g/ha as PRE, T_{15}- pendimethalin @ 1000 g/ha as PRE, T_{16}- weed free, T_{17}- weedy check and T_{18}- two hoeing at 40 and 70 DAS, replicated thrice. The experimental field was properly prepared in the first week of June during both the years. Field was ploughed twice with tractor drawn cultivator after harvest of the previous crop to crush clods. A uniform basal dose of 20 kg nitrogen and 40 kg phosphorus/ha was applied through DAP and urea, at the time of field preparation. On well prepared field, seeds of the pigeon pea crop variety 'Paras' @ 15 kg/ha were sown by seed cum fertilizers drill. All agronomic practices as per recommendation of CCS HAU, Hisar were performed irrespective of the treatments.

In pigeon pea crop, imazethapyr, imazethapyr + imazamox (RM), pendimethalin + imazethapyr and pendimethalin, were applied as pre emergence (PRE) spray to the soil surface as per treatment on the day of sowing and, imazethapyr, imazethapyr + imazamox (RM) were applied as post emergence (POE) at 45 DAS. Herbicides were applied with the aid of manually operated powered with 12V chargeable battery of 16 liters tank capacity 'V-dyut Delux a product of ASPEE' knapsack sprayer fitted with flat fan nozzle using 600 liters of water per hectare for precise and uniform application of herbicides and sufficient moisture was maintained in the soil at the time of application.

The associated weeds which were collected with the help of 0.25 square meter quadrate at 30 DAS and 60 DAS were removed species wise from two places in each plot. These samples of individual weed species were kept in paper bags or wrap into used newspaper and first sun dried and thereafter dried in oven at 65±5°C till constant weight achieved. Then dried weed samples were weighted and the dry weight of different weeds species and total weeds were expresses in g/m^2. Nitrogen, phosphorus and potassium content in seeds and stalk of pigeon pea were analyzed by micro Kjeldahl, Ammonium-vanadomolybdo phosphoric acid yellow color and Flame emission spectrometric method, respectively. Nitrogen, phosphorus and potassium uptake (kg/ha) by weed plant was worked out by multiplying the dry matter accumulation by weeds (kg/ha) with their respective nitrogen, phosphorus and potassium contents.

Original data were subject to square root transformation before statistical analysis. The data obtained on various observations were tabulated and subjected to statistical analysis by using the techniques of the analysis of variance (ANOVA) as suggested by Panse and Sukhatme (1967). To estimate the average response to given treatment combined analysis of both years data were performed in 'The SAS System 9.3'.

RESULTS AND DISCUSSION

Experimental field was infested with different kind of weeds such as *Echinochloa colona*, *Cynodon dactylon*, *Dactyloctenium aegyptium* and *Digitaria sanguinalis* among grassy weeds; *Trianthema portulacastrum* and *Digera arvensis* among BLWs; and *Cyperus rotundus* in sedges. Among all weed controls treatments, two hoeing employed at 40 and 70 DAS found most effective to control all kind of weeds. Among all of the herbicides used in study, PRE application of pendimethalin + imazethapyr @ 1000 + 75 g/ha provided best results in control of total weeds. Whereas POE application of imidazolinones were not proved to give satisfactory results as were obtained from PRE application of imidazolinones alone and in combination with pendimethalin in terms of dry matter accumulation by weeds and nutrient uptake by weeds.

Dry matter accumulation by grassy weeds

The perusal of pooled data of two years presented in Table 1 reveals that all of the herbicides applied alone and in combination either used as PRE or POE (45 DAS) significantly reduced the dry matter accumulation by *Echinochloa colona* over weedy check. At 30 DAS, PRE application of pendimethalin + imazethapyr @ 1000 + 75 g/ha (T_{14}), pendimethalin + imazethapyr @ 750 +75 g/ha (T_{13}) and pendimethalin + imazethapyr @ 1000 + 65 g/ha (T_{12}) significantly reduced the dry matter accumulation by *Echinochloa colona* over weedy check (T_{17}) which gave almost *Echinochloa colona* free condition statistically at par with weed free (T_{16}). But at 60 DAS, none of the herbicides

Table 1: Effect of imidazolinones alone and in combination on dry matter accumulation (g/m^2) of different grassy weed species in pigeon pea (Pooled data of two years).

Treatments	*Echinochloa colona*		*Cynodon dactylon*		*Dactyloctenium aegyptium*		*Digitaria sanguinalis*	
	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS
T_1	1.98^{cb} (2.92)	3.58^{dc} (11.81)	1.35^{ba} (0.88)	2.12^{ba} (3.99)	1.99^{cb} (3.04)	3.36^{fed} (10.46)	2.09^{cb} (3.38)	3.43^{ed} (10.86)
T_2	1.56^{ced} (1.44)	2.73^{dfge} (6.46)	1.4^{ba} (0.97)	2.18^{a} (4.04)	1.47^{ed} (1.18)	2.67^{feg} (6.17)	1.49^{fgh} (1.23)	2.57^{hfg} (5.69)
T_3	4.21^{a} (16.74)	5.29^{b} (27.26)	1.44^{a} (1.12)	2.12^{ba} (3.71)	3.95^{a} (14.72)	4.83^{b} (22.32)	4.04^{a} (15.32)	4.97^{b} (23.83)
T_4	4.23^{a} (17.04)	3.9^{c} (14.19)	1.37^{ba} (0.91)	2.06^{bac}(3.55)	4.02^{a} (15.19)	4.66^{cb} (20.78)	4.1^{a} (15.86)	4.71^{b} (21.35)
T_5	2.13^{b} (3.54)	3.9^{c} (14.27)	1.4^{ba} (1.01)	2.12^{ba} (3.83)	2.22^{b} (3.97)	3.66^{ced} (12.44)	2.25^{b} (4.08)	3.73^{d} (12.99)
T_6	1.83^{cebd}(2.39)	3.07^{dfce} (8.64)	1.36^{ba} (0.88)	2.21^{a} (4.13)	1.62^{cd} (1.64)	2.87^{feg} (7.23)	1.69^{fgde} (1.87)	2.81^{efg} (7.1)
T_7	4.2^{a} (16.61)	5.0^{4b} (24.47)	1.42^{a} (1.02)	2.19^{a} (4.18)	3.9^{a} (14.25)	4.52^{cb} (19.83)	4.08^{a} (15.78)	4.83^{b} (22.36)
T_8	4.19^{a} (16.63)	3.49^{dc} (11.22)	1.4b^{a} (1.02)	2.18^{a} (4.12)	3.88^{a} (14.1)	4.37^{cbd} (18.25)	4.05^{a} (15.56)	4.58^{cb} (20.04)
T_9	1.93^{cbd} (2.84)	3.16^{dce} (9.19)	1.41^{a} (1.02)	2.21^{a} (4.1)	1.79^{cbd} (2.21)	3.01^{feg} (8.26)	1.83^{cde} (2.39)	3^{ef} (8.02)
T_{10}	1.75^{cebd}(2.16)	3.05^{dfce} (8.64)	1.37^{ba} (0.91)	2.22^{a} (4.22)	1^{e} (0)	2.89^{feg} (7.66)	1.71^{fde} (1.94)	2.91^{ef} (7.49)
T_{11}	1.64^{cebd}(1.69)	2.81^{dfge} (6.9)	1.37^{ba} (0.92)	2.19^{a} (4.05)	1.34^{ed} (0.87)	2.72^{feg} (6.66)	1.56^{fghe} (1.45)	2.63^{hfg} (5.93)
T_{12}	1.52^{cefd} (1.33)	2.56^{fge} (5.62)	1.41^{a} (1.03)	2.23^{a} (4.53)	1.02^{e} (0.04)	2.47^{fhg} (5.25)	1.56^{fghe} (1.44)	2.39^{hfg} (4.72)
T_{13}	1.42^{efd} (1.02)	2.28^{fg} (4.2)	1.4^{ba} (1)	2.24^{a} (4.35)	1.11^{e} (0.26)	2.32^{hg} (4.58)	1.39^{gh} (0.92)	2.25^{hg} (4.1)
T_{14}	1.36^{ef} (0.86)	1.95^{hg} (3.3)	1.36^{ba} (0.89)	2.19^{a} (4.22)	1^{e} (0)	1.55^{ih} (2.02)	1.31^{h} (0.73)	1.99^{h} (3.02)
T_{15}	1.96^{cbd} (2.84)	3.24^{dce} (9.97)	1.44^{a} (1.13)	2.27^{a} (4.25)	1^{e} (0)	3.04^{feg} (8.93)	1.91^{cd} (2.65)	3.97^{cd} (15.26)
T_{16}	1^{f} (0)	1^{i} (0)	1^{b} (0)	1^{c} (0)	1^{e} (0)	1^{i} (0)	1^{i} (0)	1^{i} (0)
T_{17}	4.2^{a} (17.16)	7.28^{a} (53.23)	1.4^{a} (0.99)	2.22^{a} (4.33)	3.85^{a} (14.24)	6.46^{a} (42.32)	4^{a} (15.04)	6.97^{a} (48.48)
T_{18}	4.16^{a} (16.56)	1.22^{hi} (0.53)	1.4^{a} (1.01)	1.06^{bc} (0.13)	3.95^{a} (14.93)	1.04^{i} (0.08)	4.12^{a} (16.06)	1.22^{i} (0.49)

Original data given in parenthesis were subjected to square root ($\sqrt{x+1}$) transformation before analysis.

Mean values with atleast one same letter are not significantly different.

Table 2: Effect of imidazolinones alone and in combination on dry matter accumulation (g/m^2) of different broad leaf, sedges weeds species and total weed (Pooled data of two years).

Treatments	*Trianthema portulacastrum*		*Digera arvensis*		*Cyperus rotundus*		Total weed	
	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS
T_1	2^{cb} (3.02)	3.11^{ed} (8.75)	1.87^{cb} (2.54)	2.97^{ed} (8)	1.12^{cbd} (0.26)	1.41^{dce} (1)	4.11^{dc} (16.04)	7.43^{fg} (54.87)
T_2	1.58^{ed} (1.49)	2.55^{gf} (5.54)	1.55^{ced} (1.4)	2.64^{egdf} (5.99)	1.08^{ced} (0.16)	1.31^{dfce} (0.71)	2.97^{fgh} (7.87)	5.95^{hi} (34.61)
T_3	4.34^{a} (17.82)	4.58^{cb} (20.02)	4.21^{a} (16.95)	4.34^{b} (17.92)	1.57^{a} (1.48)	1.82^{b} (2.33)	9.22^{a} (84.15)	10.87^{b} (117.38)
T_4	4.32^{a} (17.66)	4.23^{c} (16.9)	4.2^{a} (16.84)	3.85^{cb} (13.84)	1.56^{a} (1.44)	1.57^{c} (1.46)	9.26^{a} (84.95)	9.64^{cbd} (92.07)
T_5	2.17^{b} (3.7)	3.41^{d} (10.68)	2^{b} (3.01)	3.26^{cd} (9.92)	1.2^{b} (0.44)	1.5^{dc} (1.24)	4.55^{c} (19.76)	8.14^{fe} (65.38)
T_6	1.73^{cd} (1.98)	2.74^{ef} (6.56)	1.7^{cbd} (1.92)	2.83^{edf} (7.01)	1.15^{cb} (0.32)	1.34^{dfce} (0.81)	3.46^{fe} (11.01)	6.5^{hg} (41.48)
T_7	4.35^{a} (17.93)	4.68^{b} (20.89)	4.19^{a} (16.58)	4.15^{b} (16.3)	1.55^{a} (1.42)	1.82^{b} (2.31)	9.19^{a} (83.6)	10.55^{cb} (110.34)
T_8	4.4^{a} (18.35)	4.19^{c} (16.74)	4.14^{a} (16.12)	3.86^{cb} (13.98)	1.53^{a} (1.34)	1.55^{c} (1.41)	9.16^{a} (83.13)	9.29^{ced} (85.77)
T_9	1.88^{cbd} (2.56)	2.82^{ef} (6.95)	1.85^{cb} (2.56)	2.69^{egdf} (6.32)	1.12^{cbd} (0.26)	1.34^{dfce} (0.81)	3.8^{de} (13.83)	6.64^{hg} (43.66)
T_{10}	1.75^{cd} (2.09)	2.75^{ef} (6.59)	1.79^{cbd} (2.3)	2.52^{egf} (5.42)	1.12^{cbd} (0.25)	1.3^{dfce} (0.7)	3.21^{fg} (9.64)	6.4^{hg} (40.71)
T_{11}	1.62^{ed} (1.62)	2.51^{gf} (5.3)	1.61^{cbd} (1.68)	2.41^{eghf} (5.02)	1.11^{cbd} (0.24)	1.28^{dfe} (0.64)	3.06^{fg} (8.47)	5.95^{hi} (34.49)
T_{12}	1.55^{ed} (1.4)	2.26^{g} (4.09)	1.69^{cbd} (2.12)	2.19^{ghf} (3.97)	1.07^{ced} (0.15)	1.2^{fge} (0.44)	2.88^{gh} (7.51)	5.43^{hi} (28.63)
T_{13}	1.35^{e} (0.9)	1.48^{h} (1.32)	1.42^{ed} (1.07)	2.05^{gh} (3.21)	1.04^{ed} (0.08)	1.17^{fge} (0.37)	2.45^{ih} (5.25)	4.77^{ji} (22.12)
T_{14}	1^{f} (0)	1^{i} (0)	1.22^{fe} (0.57)	1.8^{ih} (2.29)	1.03^{ed} (0.06)	1.09^{fg} (0.19)	2.01^{i} (3.12)	4^{j} (15.03)
T_{15}	2.05^{cb} (3.2)	2.97^{e} (7.81)	4.2^{a} (16.67)	5.71^{a} (31.87)	1.58^{a} (1.52)	2.3^{a} (4.42)	5.38^{b} (28.01)	9.07^{ed} (82.51)
T_{16}	1^{f} (0)	1^{i} (0)	1^{f} (0)	1^{j} (0)	1^{e} (0)	1^{g} (0)	1^{j} (0)	1^{k} (0)
T_{17}	4.65^{a} (20.9)	6.47^{a} (41.27)	4.16^{a} (16.57)	6.03^{a} (36.16)	1.58^{a} (1.52)	2.33^{a} (4.51)	9.31^{a} (86.42)	15.09^{a} (230.3)
T_{18}	4.42^{a} (18.54)	1.21^{ih} (0.47)	4.22^{a} (17.01)	1.33^{ij} (0.87)	1.55^{a} (1.42)	1.02^{g} (0.05)	9.3^{a} (85.53)	1.87^{k} (2.61)

Original data given in parenthesis were subjected to square root ($\sqrt{x+1}$) transformation before analysis.

Mean values with atleast one same letter are not significantly different.

Table 3: Effect of imidazolinones alone and in combination on nutrient uptake by weeds in pigeon pea (Pooled data of two years).

Treatments	Nitrogen uptake (kg/ha)		Phosphorus uptake (kg/ha)		Potassium uptake (kg/ha)		Total NPK uptake (kg/ha)	
	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS
T_1	1.85^{dc} (2.46)	3.01^{gf} (8.18)	1.23^{dc} (0.51)	1.65^{gf} (1.74)	1.87^{dc} (2.49)	3.04^{gf} (8.36)	2.53^{dc} (5.46)	4.36^{ef} (18.28)
T_2	1.47^{fg} (1.17)	2.47^{jhi} (5.12)	1.11^{ghfe} (0.24)	1.43^{ih} (1.06)	1.47^{fg} (1.17)	2.46^{jhi} (5.07)	1.89^{fgh} (2.58)	3.49^{gh} (11.25)
T_3	3.73^{a} (12.95)	4.31^{b} (17.59)	1.95^{a} (2.8)	2.22^{b} (3.91)	3.83^{a} (13.71)	4.43^{b} (18.66)	5.51^{a} (29.46)	6.41^{b} (40.17)
T_4	3.75^{a} (13.08)	3.84^{cd} (13.76)	1.96^{a} (2.86)	2^{cd} (3)	3.85^{a} (13.87)	3.95^{cd} (14.58)	5.55^{a} (29.82)	5.69^{cb} (31.35)
T_5	2.01^{c} (3.04)	3.27^{ef} (9.72)	1.28^{c} (0.64)	1.75^{ef} (2.06)	2.02^{c} (3.1)	3.33^{ef} (10.09)	2.79^{c} (6.78)	4.78^{ed} (21.88)
T_6	1.64^{fe} (1.68)	2.67^{ghi} (6.18)	1.16^{dfe} (0.35)	1.52^{gh} (1.31)	1.64^{fe} (1.71)	2.69^{ghi} (6.29)	2.17^{fe} (3.74)	3.83^{gf} (13.78)
T_7	3.72^{a} (12.86)	4.19^{cb} (16.53)	1.94^{a} (2.77)	2.16^{cb} (3.66)	3.82^{a} (13.57)	4.31^{cb} (17.55)	5.49^{a} (29.19)	6.22^{b} (37.73)
T_8	3.71^{a} (12.79)	3.71^{ed} (12.81)	1.93^{a} (2.72)	1.94^{ed} (2.78)	3.8^{a} (13.46)	3.8^{d} (13.52)	5.47^{a} (28.97)	5.48^{cd} (29.11)
T_9	1.75^{de} (2.12)	2.73^{gh} (6.51)	1.2^{dce} (0.43)	1.53^{gh} (1.35)	1.75^{de} (2.09)	2.73^{gh} (6.53)	2.35^{de} (4.65)	3.9^{gf} (14.39)
T_{10}	1.56^{fe} (1.47)	2.63^{ghi} (6.03)	1.14^{gfe} (0.3)	1.5^{gh} (1.25)	1.55^{fe} (1.45)	2.62^{ghi} (5.96)	2.03^{fg} (3.21)	3.74^{gf} (13.24)
T_{11}	1.51^{fg} (1.29)	2.46^{jhi} (5.07)	1.12^{ghfe} (0.26)	1.43^{ih} (1.04)	1.5^{fg} (1.26)	2.44^{jhi} (4.99)	1.94^{fg} (2.81)	3.47^{gh} (11.11)
T_{12}	1.44^{fg} (1.1)	2.26^{ji} (4.15)	1.11^{ghf} (0.23)	1.36^{ihj} (0.85)	1.45^{fg} (1.11)	2.26^{ji} (4.14)	1.84^{gh} (2.43)	3.17^{gh} (9.14)
T_{13}	1.32^{hg} (0.76)	2.02^{jk} (3.14)	1.08^{ghi} (0.16)	1.29^{ij} (0.66)	1.32^{hg} (0.77)	2.03^{jk} (3.17)	1.62^{ih} (1.69)	2.8^{ih} (6.97)
T_{14}	1.2^{h} (0.44)	1.76^{k} (2.12)	1.05^{hi} (0.09)	1.2^{kj} (0.44)	1.2^{h} (0.46)	1.77^{k} (2.15)	1.41^{i} (0.99)	2.39^{i} (4.7)
T_{15}	2.3^{b} (4.31)	3.62^{ed} (12.32)	1.38^{b} (0.91)	1.91^{ed} (2.69)	2.33^{b} (4.45)	3.71^{ed} (12.98)	3.26^{b} (9.66)	5.34^{cd} (27.99)
T_{16}	1^{i} (0)	1^{l} (0)	1^{i} (0)	1^{l} (0)	1^{i} (0)	1^{l} (0)	1^{j} (0)	1^{j} (0)
T_{17}	3.77^{a} (13.37)	5.92^{a} (34.55)	1.98^{a} (2.96)	2.94^{a} (7.79)	3.88^{a} (14.16)	6.1^{a} (36.76)	5.58^{a} (30.48)	8.88^{a} (79.11)
T_{18}	3.77^{a} (13.23)	1.16^{l} (0.36)	1.98^{a} (2.93)	1.04^{lk} (0.08)	3.88^{a} (14.06)	1.17^{l} (0.37)	5.58^{a} (30.23)	1.34^{j} (0.81)

Original data given in parenthesis were subjected to square root ($\sqrt{x+1}$) transformation before analysis.

Mean values with atleast one same letter are not significantly different.

was found much effective to kept the field almost *Echinochloa colona* free condition as obtained from weed free (T_{18}) except hoeing *i.e*. two hoeing at 40 and 70 DAS (T_{18}) provided the weed free condition. None of the herbicides applied alone and in combination either used as PRE or POE (45 DAS) found effective to reduce the dry matter accumulation by *Cynodon dactylon* significantly at any stage. Obviously two hoeing at 40 and 70 DAS (T_{18}) gave best control of *Cynodon dactylon* to tune with weed free condition.

Pooled data presented in Table 1 shows that at 30 and 60 DAS, all of the herbicides applied alone and in combination either used as PRE or POE (45 DAS) significantly reduced the dry matter accumulation by *Dactyloctenium aegyptium* over weedy check. At 30 DAS alone application of imazethapyr @ 100 g/ha as PRE (T_2) and combined application of pendimethalin + imazethapyr as PRE (at either doses) except lowest combination of dose *i.e*. 750 + 50 g/ha (T_9) significantly reduced the dry matter accumulation by *Dactyloctenium aegyptium* over weedy check (T_{17}) which gave almost *Dactyloctenium aegyptium* free condition statistically at par with weed free (T_{16}). Whereas at 60 DAS, none of the herbicides treatment except T_{14} was found much effective to kept the field almost *Dactyloctenium aegyptium* free condition as obtained from weed free (T_{16}) except hoeing *i.e*. two hoeing at 40 and 70 DAS (T_{18}) provided the weed free condition.

All of the herbicides applied alone and in combination either used as PRE or POE (45 DAS) significantly reduced the dry matter accumulation by *Digitaria sanguinalis* over weedy check. But none of the herbicides was found much effective to kept the field almost *Digitaria sanguinalis* free as obtained from weed free plot (T_{18}). However at 60 DAS, hoeing *i.e*. two hoeing at 40 and 70 DAS (T_{18}) provided the weed free condition.

Dry matter accumulation by BLWs, sedges and total weed

The perusal of pooled data of two years presented in Table 2 reveals that at 30 and 60 DAS, all of the herbicides applied alone and in combination either used as PRE or POE (45 DAS) significantly reduced the dry matter accumulation by *Trianthema portulacastrum* over weedy check (T_{17}). But none of the herbicides except PRE application of pendimethalin + imazethapyr @ 1000 + 75 g/ha (T_{14}) was found effective to kept the field almost *Trianthema portulacastrum* free as obtained from weed free plot (T_{18}).

At 30 and 60 DAS, all of the herbicides except PRE application of pendimethalin @ 1000 g/ha (T_{15}), applied alone and in combination either used as PRE or POE (45 DAS) significantly reduced the dry matter accumulation by *Digera arvensis* over weedy check (T_{17}). At 30 DAS, PRE application of pendimethalin + imazethapyr @ 1000 + 75 g/ha (T_{14}) significantly reduced the dry matter accumulation by *Digera arvensis* to kept the field almost *Digera arvensis* free as obtained from weed free plot (T_{18}). Similarly at 30 and 60 DAS, all of the herbicides except pendimethalin @ 1000 g/ha as PRE (T_{15}) applied alone and in combination either used as PRE or POE (45 DAS) significantly reduced the dry matter accumulation by *Cyperus rotundus* over weedy check (T_{17}). At 30 DAS, alone application of imazethapyr @ 100 g/ha as PRE (T_2) and combined PRE application of pendimethalin + imazethapyr either at 1000 + 65 g/ha (T_{12}), 750 + 75 g/ha (T_{13}) and 1000 + 75 g/ha (T_{14}) significantly reduced the dry matter accumulation by *Cyperus rotundus* over weedy check to gave almost *Cyperus rotundus* free condition as obtained from weed free plot (T_{18}). Whereas at 60 DAS, dry matter accumulation by *Cyperus rotundus* was reduced significantly by combined PRE application of pendimethalin + imazethapyr either at 1000 + 65 g/ha (T_{12}), 750 + 75 g/ha(T_{13}) and 1000 + 75 g/ha (T_{14}) to tune with *Cyperus rotundus* free condition. At 30 and 60 DAS, all of the herbicides applied alone and in combination either used as PRE or POE (45 DAS) significantly reduced the dry matter accumulation by total weeds over weedy check (T_{17}). But none of the weed management treatment except hoeing *i.e*. two hoeing at 40 and 70 DAS (T_{18}) was found much effective to keep the field almost total weed free as obtained from weed free plot (T_{18}). These results on different species are tune with the findings of Kumar *et al.* (2015), Punia *et al.* (2015) and Gupta *et al*. (2017) who found combined PRE application of pendimethalin + imazethapyr significantly reduced the dry matter accumulation by total weeds.

Nutrient uptake by weeds

The perusal of pooled data of two years presented in Table 3 reveals that all of the herbicides applied alone and in combination either used as PRE or POE (45 DAS) significantly reduced the nitrogen, phosphorus, potassium and total NPK uptake by weeds over weedy check (T_{18}). At 30 DAS, PRE application of pendimethalin + imazethapyr either @ 750 + 75 g/ha (T_{13}) and @ 1000 + 75 g/ha (T_{14}) significantly reduced the phosphorus uptake by weeds over weedy check provided the results as such as obtained weed free plot (T_{18}). Obviously at 60 DAS, hoeing *i.e*. two hoeing at 40 and 70 DAS (T_{18}) significantly reduced the nutrient uptake by weeds over weedy check. Among all of the herbicides treatments, PRE application of pendimethalin + imazethapyr @ 1000 + 75 g/ha provided excellent control of total weeds that reduced the total dry matter accumulation by weeds leads to lowest nutrient uptake by weeds. Similarly, Chavan *et al.* (2016) observed significant reduction in nutrient uptake by weeds by application of herbicides over weedy check.

CONCLUSION

Keeping the field weed free *via* hoeing is laborious, time consuming and costlier weed management practice. In pigeon pea which is a rainy season crop in Haryana. It is not possible to employee hoeing in rainy condition. Among different weed species, *Cynodon dactylon* was not controlled by any of the herbicide treatment and PRE application of pendimethalin @ 1000 g/ha did not control *Digera arvensis*

and *Cyperus rotundus*. Whereas, PRE application of pendimethalin + imazethapyr @ 1000 + 75 g/ha provided excellent control of total weeds leads to lowest nutrient uptake by weeds. Therefore, chemical weed control with PRE application of pendimethalin + imazethapyr @ 1000 + 75 g/ha may be an effective and a profitable alternative to the existing recommendation (two hoeing at 25 and 45 DAS) of manual weed control in pigeon pea in Haryana locality.

Conflict of interest: None.

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