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Original Research Article

Residues Studies of Pendimethalin and Other Herbicides in Pigeonpea Field Through Bioassay Technique

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A B S T R A C T

Field experiment was conducted during 2012 and 2013 in the Research Area of College Farm, Navsari Agricultural University, Navsari to study the effect of residual behavior of pendimethalin applied in pigeonpea on succeeding greengram crop grown in rotation. Residual effect of pendimethalin was assessed by conducting bioassay studies on greengram in a randomized block design with three plant population levels 83,333 plants/ha (P_1)' 55,555 plants/ha (P_2) and 41,666 plants/ha (P_3) and eight weed management practices *viz.* (W_1) Unweeded control, (W_2) Weed free (HW at 20 and 40 DAS), (W_3) Pendimethalin @ 1 kg ha^{-1} as pre-emergence (PE), (W_4) Imazethapyr @ 75 g ha^{-1} (POE) at 20 DAS, (W_5) Quizalofop ethyl @ 40 g ha^{-1} (POE) at 20 DAS, (W_6) Pendimethalin @ 1 kg ha^{-1} (PE) + Imazethapyr @ 75 g ha^{-1} (POE) at 40 DAS, (W_7) Pendimethalin @ 1 kg ha^{-1} (PE) + Quizalofop ethyl @ 40 g ha^{-1} (POE) at 40 DAS and (W_8) Pendimethalin @ 1 kg ha^{-1} + hand weeding at 40 DAS were evaluated in factorial randomized block design with three replications. After harvest of pigeonpea, greengram crop was planted after slight disking without disturbing the original layout. pendimethalin applied in pigeonpea was found to persist even after 35 days after its application in pigeonpea and its residues in the soil medium do not caused phytotoxicity to succeeding crop of greengram. Plant population, plant height, number of branches per plant, dry matter weight and yield of greengram were non-significantly by pendimethalin. The residual effect of pendimethalin on greengram was not found to be significant. Neither the growth parameters nor the yield of greengram were not affected significantly by plant populations in wheat. Therefore, it can be inferred that increasing plant populations not helped in degradation of pendimethalin and greengram should be planted in rotation with pigeonpea where pendimethalin has been applied in pigeonpea.

Keywords

Pendimethalin, Herbicides, Pigeonpea, Bioassay

Introduction

Herbicides have become obligatory for increasing the agricultural production and to maintain the non-cropped area free from weeds and pests. In general, herbicides are formulated in such a way that they degrade from the environment after completion of their intended work, but a few of them persist in the environment and pose a serious hazard to the succeeding crop and also to the surroundings.

Pendimethalin, a dinitroanilines group of herbicides, is used for selective control of complex weed flora in pigeonpea. The use of herbicides offers selective and economic control of weeds from the beginning and

gives the crop an advantage of a good start and competitive superiority. In India, soil pH is high (around 8.0), organic matter content is low, rainfall is less, temperature is high and soil moisture content. These conditions are entirely different than those prevailing in most of the western countries where these herbicides have been used and research work on their persistence has been studied. So, entirely different persistence behaviour can be expected under West Indian climatic conditions. Therefore, it is essential to study the persistence behaviour of pendimethalin in our soils before making any sound recommendation for farmers' use.

In the light of these considerations, present study was planned to study the effect of plant population levels on persistence of pendimethalin in soil and its residual effect on succeeding greengram crop when applied in pigeonpea.

Materials and Methods

To study the effect of plant populations on persistence of pendimethalin applied in pigeonpea and its residual effect on succeeding greengram crop, field experiment was conducted during two consecutive *rabi* seasons of 2012 and 2013 at College Farm, Navsari Agricultural University, Navsari Campus, Navsari. The study involved twenty-four treatment combinations consisting of three plant populations *viz.* 83,333 plants/ha (P_1)' 55,555 plants/ha (P_2) and 41,666 plants/ha (P_3) and eight weed management practices *viz.* (W_1) Unweeded control, (W_2) Weed free (HW at 20 and 40 DAS), (W_3) Pendimethalin @ 1 kg ha^{-1} as pre-emergence (PE), (W_4) Imazethapyr @ 75 g ha^{-1} (POE) at 20 DAS, (W_5) Quizalofop ethyl @ 40 g ha^{-1} (POE) at 20 DAS, (W_6) Pendimethalin @ 1 kg ha^{-1} (PE) + Imazethapyr @ 75 g ha^{-1} (POE) at 40 DAS, (W_7) Pendimethalin @ 1 kg ha^{-1} (PE) + Quizalofop ethyl @ 40 g ha^{-1} (POE) at 40 DAS and (W_8) Pendimethalin @ 1 kg ha^{-1} + hand weeding at 40 DAS with three replications. The soil was watered to field capacity when necessary. Data on germination, plant height and dry weight of plant were recorded. For recording dry matter, plants were removed from the base and first sun dried and then in oven at 60ºC till constant weight was obtained.

The test crops chosen were greengram. Soil samples were taken at the time of harvest of crop from 0-15 and 15-30 cm soil depths. The dry matter of test crops was recorded at 30 days after sowing. All other agronomic practices except herbicide application were adopted as per university recommendations. Herbicide as per treatments was applied with a knapsack sprayer by using 500 l water/ha. Data on weed density, dry matter accumulation by weeds at 60 DAS and at harvest were recorded and WCE (%) was calculated based on dry matter accumulation by weeds at 60 DAS and at harvest. At harvesting, data on grain yield and various yield attributes were recorded.

Field bioassay

In order to study the residual effect of pendimethalin on succeeding grengram crop, after the harvest of pigeonpea, field was irrigated and disked slightly. Greengram variety Meha was planted on March 20, 2013 and March 21, 2014, during the first and second year, respectively, without disturbing the original layout. Greengram crop was raised as per recommended package of practices. To study the residual effect of pendimethalin on greengram, data on number of plants/metre row length, plant height, dry matter production and yield were recorded. All the data recorded were analyzed by ANOVA method as suggested by Cochran and Cox (1957).

Results and Discussion

Effect of herbicides in pigeonpea

During 2006, weed flora of the clusterbean field consisted mainly of*Echinochloa crusgalli* L. and *Cynodon doctylon* L. among monocot; *Cyperus rotundus* L. among sedges; and *Amaranthus viridis L., Digera arvensis and Portulaca oleracea, Physalis minima, Euphorbia hirta, Corchorus olitorus and Alternenthara sessili* among dicot weeds. The effect of plant population on monocots at 30 DAS was found to be non-significant. While, significant effect in pooled results in dicot and sedges weeds and total weed population (Table 1). Numerically lower values of monocots, dicots, sedges and total weed population were recorded under plant population of 83,333 plant/ha. Similar trend was followed in case of dry weight of weeds at 40 DAS and harvest. However, significantly higher weed population and dry weight of weeds were recorded with plant population of 41,666 plant/ha. This might be due to more space in lower plant population, which leads to luxurious growth of weeds in these treatments resulted in the higher dry matter accumulation by weeds, while higher plant population recorded lowest weeds dry weight due to better crop stand in higher plant population leads to smothering effect on weeds growth.

As regard weed management, weed free (HW at 20 & 40 DAS) (W_2) did not crub the density of weeds because weeding was done at 20 days after sowing, whereas dry weight of weeds at 60 days after sowing and at harvest was significantly lowest with this treatment. However, marked reduction in density was observed in plot receiving pre-emergence application of Pendimethalin 1.0 kg/ha coupled with hand weeding at 40 DAS (W_8) followed by application of pre-emergence Pendimethalin 1.0 kg/ha followed by Quizalofop ethyl @ 40 g ha^{-1} (POE) at 40 DAS (W_7) and proved superior rest other treatment. Weed control efficiency and weed index varied appreciably under various weed management practices. Both indices indicated the efficiency of weed control treatments. Identical increase in weed control efficiency was noted with treatment weeds free check through two hand weeding at 20 and 40 days after sowing (W_2) followed by Pendimethalin 1.0 kg/ha coupled with hand weeding at 40 DAS (W_8) and Pendimethalin 1.0 kg/ha followed by Quizalofop ethyl @ 40 g ha^{-1} (POE) at 40 DAS (W_7), respectively. Contrary to this lowest weed index was observed with weed free check (W_2) followed by Pendimethalin 1.0 kg/ha + hand weeding (W_4) and Pendimethalin 1.0 kg/ha followed by Quizalofop ethyl @ 40 g ha^{-1} (POE) at 40 DAS (W_7)**.** This is due to lower weed population and reduces dry matter production of weeds during initial stage and effective control of later emerged weeds through hand weeding which ultimately provided weeds free environment to pigeonpea crop.

All herbicide treatments proved very effective against weeds (Table 1 and 2). All the treatments of plant population differed significantly from each other and independent in their pronounced effect on pods per plant, seeds per pod and test weight. Plant population of 41,666 plants/ha proved its superiority by producing higher pods per plant, seeds per pod and test weight compared to other treatments. While significantly the lowest value recorded under the higher plant population of 83,333 plants/ha. The better development of various yield attributes in lower to medium plant population levels might be due to low degree of inter plant competition for moisture, nutrients and solar energy reflecting in higher vegetative growth.

Table.1 Weed population/m^2 dry weight of weeds at 40 DAS and at harvest, weed control efficiency and weed index in pigeonpea influenced by various treatments of plant population and weed management (Pooled)

Treatments	Weed population at 30 DAS				Dry weight of total weeds		WCE (%)		WI (%)
	Monocot	Dicot	Sedges	Total	At 40 DAS	At harvest	At 40 DAS	At harvest	
Plant population (P)									
P_1 : 83,333 plants ha^{-1} (60cm x 20cm)	3.34 (11.00)	2.67 (7.13)	2.86 (9.11)	4.54 (25.36)	16.66 (306.56)	17.81 (348.71)	-	-	-
P_2 : 55,555 plants ha^{-1} (90cm x 20cm)	3.47 (11.86)	3.01 (8.95)	3.30 (11.42)	4.89 (29.87)	18.09 (350.59)	19.03 (389.54)	-	-	-
P_3 : 41,666 plants ha^{-1} (120cm x 20cm)	3.50 (12.14)	3.07 (9.34)	3.36 (11.82)	4.96 (30.86)	18.65 (370.50)	19.48 (407.05)	-	-	-
S.Em.±	0.06	0.06	0.06	0.07	0.23	0.20	-	-	-
C.D. (P=0.05)	NS	0.16	0.17	0.20	0.65	0.57	-	-	-
Weed management practices (W)									
W_1 : Unweeded control	4.41 (19.10)	3.94 (15.08)	5.42 (29.05)	6.32 (57.24)	28.85 (840.28)	30.02 (908.22)	-	-	59.37
W_2 : Weed free (HW at 20 & 40 DAS)	2.81 (7.58)	2.04 (3.92)	2.17 (4.62)	3.72 (15.16)	11.85 (142.14)	13.78 (189.64)	83.08	79.11	-
W_3 : Pendimethalin @ 1 kg ha^{-1} (PE)	3.44 (11.51)	2.83 (7.78)	3.08 (9.24)	4.74 (26.62)	17.82 (319.71)	19.92 (398.28)	61.95	56.14	17.94
W_4 : Imazethapyr @ 75 g ha^{-1} (POE) at 20 DAS	3.64 (12.84)	3.14 (9.55)	3.44 (11.56)	5.11 (31.57)	20.11 (404.89)	21.98 (483.42)	51.81	46.77	28.10
W_5 : Quizalofop ethyl @ 40 g ha^{-1} (POE) at 20 DAS	3.44 (11.49)	3.34 (10.81)	3.60 (12.63)	5.12 (32.32)	18.73 (352.12)	20.73 (430.73)	58.09	52.57	25.18
W_6 : W_3 + Imazethapyr @ 75 g ha^{-1} (POE) at 40 DAS	3.47 (11.63)	2.64 (6.61)	2.52 (6.12)	4.59 (23.10)	15.69 (248.27)	15.28 (235.80)	70.45	74.02	10.18
W_7 : W_3 + Quizalofop ethyl @ 40 g ha^{-1} (POE) at 40 DAS	3.22 (10.00)	2.81 (7.57)	2.78 (7.55)	4.54 (23.56)	14.85 (222.26)	14.42 (209.80)	73.54	76.89	8.75
W_8 : Pendimethalin @ 1 kg ha^{-1} (PE) + HW at 40 DAS	3.07 (9.16)	2.59 (6.48)	2.36 (5.51)	4.26 (20.01)	14.52 (210.75)	14.08 (198.27)	74.91	78.16	4.92
S.Em.±	0.10	0.10	0.10	0.12	0.38	0.33	-	-	-
C.D. (P=0.05)	0.18	0.16	0.17	0.20	0.65	0.57	-	-	-
C.V. %	12.66	13.85	9.08	8.12	9.01	7.44	-	-	-
Interaction	NS	NS	NS	NS	NS	NS	-	-	-
Note: Figure in parenthesis refers to actual weed population and those outside are $\sqrt{X+0.5}$ transformed values									

Table.2 Growth and yield attributes of pigeonpea at harvest by various treatments of plant population and weed management (Pooled)

Treatments	Plant height (cm)	Dry matter production (g plant^{-1})	No. of pods plant^{-1}	No. of seeds pods^{-1}	Test weight (g)	Grain yield (kg/ha)	Stalk yield (kg/ha)
Plant population (P)							
P_1 : 83,333 plants ha^{-1} (60cm x 20cm)	100.52	54.03	79.87	3.63	109.58	868	2442
P_2 : 55,555 plants ha^{-1} (90cm x 20cm)	90.02	60.47	87.84	3.57	110.34	993	2621
P_3 : 41,666 plants ha^{-1} (120cm x 20cm)	86.33	63.26	92.84	3.72	110.55	1043	2734
S.Em.±	1.39	0.69	1.32	0.07	1.15	14.63	33.30
C.D. (P=0.05)	3.90	1.95	3.72	NS	NS	41.15	93.69
Weed management practices (W)							
W_1 : Unweeded control	70.93	38.19	55.55	2.94	105.63	487	1503
W_2 : Weed free (HW at 20 & 40 DAS)	100.96	67.93	101.14	3.91	111.78	1200	3319
W_3 : Pendimethalin @ 1 kg ha^{-1} (PE)	94.07	62.07	88.89	3.68	111.29	984	2385
W_4 : Imazethapyr @ 75 g ha^{-1} (POE) at 20 DAS	91.25	55.04	79.34	3.56	109.73	862	2082
W_5 : Quizalofop ethyl @ 40 g ha^{-1} (POE) at 20 DAS	92.53	59.14	82.60	3.63	109.73	898	2165
W_6 : W_3 + Imazethapyr @ 75 g ha^{-1} (POE) at 40 DAS	93.21	62.69	94.51	3.78	109.92	1077	3064
W_7 : W_3 + Quizalofop ethyl @ 40 g ha^{-1} (POE) at 40 DAS	96.69	63.62	95.90	3.75	111.41	1095	3114
W_8 : Pendimethalin @ 1 kg ha^{-1} (PE) + HW at 40 DAS	98.69	65.36	96.87	3.89	111.77	1141	3163
S.Em.±	2.26	1.13	2.16	0.12	1.89	23.88	54.38
C.D. (P=0.05)	3.90	1.95	3.72	0.20	NS	41.15	93.69
C.V. %	10.40	8.12	10.54	13.60	7.26	10.47	8.88
Interaction	NS	NS	NS	NS	NS	NS	NS

Table.3 Residual effect of plant population and weed management practices applied in pigeonpea on succeeding greengram (Pooled)

Treatments	Plant stand (per metre row length)	Plant height at harvest (cm)	Dry matter production at 60 DAS (g plant^{-1})	No. of pods plant^{-1}	Grain yield (kg/ha)	Straw yield (kg/ha)
Plant population (P)						
P_1 : 83,333 plants ha^{-1} (60cm x 20cm)	10.37	55.69	14.00	9.68	569	860
P_2 : 55,555 plants ha^{-1} (90cm x 20cm)	10.42	56.24	13.92	9.79	580	879
P_3 : 41,666 plants ha^{-1} (120cm x 20cm)	10.58	56.90	14.75	10.01	591	895
S.Em.±	0.16	0.91	0.20	0.16	10.96	16.98
C.D. (P=0.05)	NS	NS	0.56	NS	NS	NS
Weed management practices (W)						
W_1 : Unweeded control	10.17	54.63	13.47	9.49	557	845
W_2 : Weed free (HW at 20 & 40 DAS)	10.56	57.18	14.53	10.27	596	897
W_3 : Pendimethalin @ 1 kg ha^{-1} (PE)	10.44	56.17	14.24	9.76	578	876
W_4 : Imazethapyr @ 75 g ha^{-1} (POE) at 20 DAS	10.37	55.80	14.23	9.69	575	871
W_5 : Quizalofop ethyl @ 40 g ha^{-1} (POE) at 20 DAS	10.38	55.84	13.95	9.70	575	871
W_6 : W_3 + Imazethapyr @ 75 g ha^{-1} (POE) at 40 DAS	10.59	56.84	14.52	9.91	586	888
W_7 : W_3 + Quizalofop ethyl @ 40 g ha^{-1} (POE) at 40 DAS	10.61	56.97	14.51	9.93	588	891
W_8 : Pendimethalin @ 1 kg ha^{-1} (PE) + HW at 40 DAS	10.55	56.81	14.32	9.87	584	886
S.Em.±	0.26	1.49	0.33	0.26	17.90	27.72
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS
C.V. %	10.51	11.22	9.77	11.06	13.10	13.40
Interaction	NS	NS	NS	NS	NS	NS

Moreover, because of low degree of intra-plant competition, adequate supply of photo-synthates might be resulted in better development of sink. Similar findings were also reported, by Pavan *et al.,* (2011) and Sarita *et al.,* (2012). Data further reveled that plant population exerted their significant effect on grain yield and stalk yield being maximum (1043 and 2734 kg/ha, respectively) and minimum (868 and 2442 kg/ha, respectively) with plant popula-tion of 41,666 plants/ha and 83,333 plants/ha, respectively. Moreover, plant population of 55,555 plants/ha and 41,666 plants/ha were found equally effective and significantly superior to plant population of 83,333 plants/ha in case of grain and stalk yield. Though the higher values for almost all the yield attributes were observed under lower plant population of 41,666 plants/ha, it could not compensate the yield loss due to lower plant stand compared to higher plant geometry. Hence medium and lower plant population of 55,555 plants /ha and 41,666 plants /ha increased the grain yield by 14.45 and 20.12% respectively while stalk yield by 7.33 and 11.93% respectively over plant population of 83,333 plants/ha. These findings are in agreement with those of Parameswari, *et al.,* (2003).

Weed free check proved its superiority by producing the pods per plant and seeds per pod with higher value compared to other treatments but statistically differ with treatments but test weight did not differ significantly. Pendimethalin 1 kg/ha as pre-emergence + H.W. at 40 DAS, Pendimethalin 1kg /ha as pre-emergence + quizalofop-ethyl @ 40 g/ha (POE) at 40 DAS for test weight (Table 2). While, unweeded control (W_1) noted significantly the lowest value of all yield attributes. This may be due least competition offered by weeds for nutrients and moisture at crucial growth stages under this treatment ultimately improved all yield attributes besides increased rate of N, P and K ab-sorption cumulatively helped the crop plants to produce more surface area for high photosynthetic rate as well as maximum translocation of photosynthates from source to sink, subsequently resulted in improvement of all yield attributes. Because of synergist effect among the yield at-tributes, they benefited each other. These findings are in accordance with those of Latha and Nadarajan (2010). Ultimately the pronouncing effect of all said growth parameter reflect on grain and stalk yield and treatments Weed free (HW at 20 & 40 DAS) and pendimethalin 1 kg/ha as pre-emergence + H.W. at 40 DAS were on par for grain yield (1200 and 1141 kg/ha, respectively) and stalk (3319 and 3163 kg/ha, respectively) yield per hectare, respectively, but significantly superior to the rest of the weed management practices. Significantly the lowest value of grain and stalk yield of 487 and 1503 kg/ha, respectively was recorded with weedy check treatment.

Residual effect of herbicides applied in pigeonpea on succeeding greengram

Herbicides applied in pigeonpea did not show any kind of phytotoxicity on any of the succeeding greengram crop. Post-emergence application of quizalofop-ethyl 40 g/ha and pre-emergence application of pendimethalin 1000 g/ha used in pigeonpea also did not show any residual effect on germination, plant height as well as seed/grain yield of these crops as evident from the data presented in (Table 3). The mean grain and straw yield of green gram ranged between 557 to 596 kg/ha and 845 to 897 kg/ha, respectively. It might be due to enhanced microbial degradation of these herbicides due to congenial condition occurred between time of herbicide application and planting of

greengram in Rabi seasons of 2012 and 2013. So, on the basis of two years' study, it can be summarized that Pendimethalin at 1000 g/ha, Quizalofop-ethyl at 40 g/ha and imazethapyr at 75 g/ha applied at POE 20 DAS can be safely used for weed control in pigeonpea if greengram was planted as succeeding crop.

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