Madras Agric. J., 100 (1-3): 123-126, March 2013
https://doi.org/10.29321/MAJ.10.001253

Influence of Imazethapyr on Weed Control and Yield of Groundnut and its Residual Effect on Succeeding Sunflower and Pearl Millet

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A field investigation was carried out at Agricultural Research Station, Bhavanisagar of Tamil Nadu Agricultural University, during *kharif* 2009 and 2010 to evaluate the new formulation of imazethapyr (10% SL) on weed control in groundnut and its residual effect on succeeding crops. Based on two years field experimentation, it was found that early post emergence application of imazethapyr (10% SL) at 200 g ha^{-1} gave significantly lower total weed density, weed dry weight and higher weed control efficiency at all the stages. Application of new formulation of imazethapyr (10% SL) at 100 g ha^{-1} as early post emergence herbicide kept the weed density and dry weight below the economic threshold level and increased the pod yield (1602 and 1900 kg ha^{-1}) and this was on par with 150 g ha^{-1} (1580 and 1854 kg ha^{-1}) in groundnut. Succeeding crops like sunflower and pearl millet sown immediately after the harvest of groundnut was not affected by the residue of new formulation of imazethapyr at all different doses.

Key words: weed density, weed control efficiency, yield, succeeding crops.

Groundnut (*Arachis hypogaea* L.), the "*King"* of oilseeds, popularly known as "*Wonder nut* " and "*Poor man's cashew nut"* is the sixth most important oilseed crop of the world. In the National scenario, Tamil Nadu shares 8.59 per cent in area and 11.44 per cent in production of the crop (Agricultural Statistics, 2009). One of the major constraints in groundnut production is the weed menace and losses caused by weeds are more than any other causes like insects, diseases and nematodes. Gnanamurthy and Balasubramaniyan (1998) reported that yield of groundnut was reduced by 70 per cent if when the weed cover was more than 50 per cent. Pre-plant or pre-emergence chemical weed management using selective herbicides like fluchloralin and pendimethalin followed by one hand weeding is a common practice in groundnut and most research works confirm this (Walia *et al.,* 2007). However, disturbing the soil during manual weeding, in the early stages, exposes the groundnut crop to new flushes of weeds. These late emerging weeds seriously affect the pegging and pod development and disrupt digging and harvesting operations and difficult to strip the pods from vines. Apart from competition for nutrients and other inputs, these late emerging weeds infest the land with weed seeds and make the land less productive in the subsequent seasons (Kanagam, 2003). There also exists another situation wherein the pre-emergence application could not be done owing to continuous rains or for other reasons. Early post-emergence herbicides offer great scope to tide over these situations. This warrants development of early post-emergence herbicides in order to effectively manage the late emerging weeds. Beneath these backdrops, newer formulation of herbicides is coming in the market with wide spectrum of weed control efficiency. The early post emergence of new herbicide formulations imazethapyr (10% SL) are to be evaluated for their bio-efficacy of controlling wide range of weed flora, better crop growth and yield of groundnut.

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Materials and Methods

With a view to determine the residual effect of herbicide applied to *kharif groundnut* on succeeding *rabi* sunflower and pearlmillet crops, the present study was carried out during *kharif* season of 2009 and 2010 at Agricultural Research Station, Bhavanisagar, Tamil Nadu Agricultural University. The soil was red sandy loam in texture with low in available nitrogen (221 kg ha^{-1}), medium in available phosphorus (16.2 kg ha^{-1}) and high in available potassium (288 kg ha^{-1}) with pH of 7.5. The experiment was laid out in randomized complete block design with twelve treatments and replicated thrice. The treatments consisted of five doses of imazethapyr 10% SL (50, 75, 100, 150 and 200 g ha^{-1}) followed by one hand weeding at 45 days after sowing (DAS). The different doses of imazethapyr were compared with the recommended herbicide pendimethalin at 0.75 kg ha^{-1} in combination with either hand weeding or imazethapyr at 50 g ha^{-1} at

2-3 leaf stage of weeds or one weeding with star weeder or layby application of pendimenthalin at 45 DAS, hand weeding twice at 25 and 45 DAS, unweeded control and a weed free check. The *kharif* groundnut variety CO 2 and VRI 2 was sown manually at a spacing of 30 x 10 cm at 125 kg ha^{-1} of seed during first week of June 2009 and 2010. The experimental field was irrigated immediately after sowing. Life irrigation was given three days after sowing and subsequent irrigations were given as and when required. Weeding was done as per the treatment schedule. In order to study crop -weed competition, hand weeding was done once in seven days in the weed free treatment. In the treatment on hand weeding twice, hand weeding was given at 25 and 45 days after sowing. Herbicide treatment plots were applied with pendimethalin 30% EC at 0.75 kg a.i. ha^{-1} as pre-emergence spray on 3 DAS and new formulation of imazethapyr 10% SL was sprayed at 2-3 leaf stage of weeds (15 DAS) as early post emergence followed by a hand weeding and earthing upon 45 DAS. Layby application of pendimethalin 30% EC at 0.75 kg ha^{-1} was given 45 DAS. Calculated quantity of herbicides with a spray fluid of 500 liters ha^{-1} was sprayed uniformly over the plots using knapsack sprayer fitted with fan type nozzle (WFN 40) on 3, 15 and 45 DAS. In mechanically weeded plots, one weeding was given 45 DAS with star weeder in between rows and weeds within the rows were removed manually. A fertilizer schedule of 17:34:54 kg NPK ha^{-1} in the form of urea, single super phosphate and muriate of potash, respectively were applied to all plots uniformly in lines and incorporated at the time of sowing. The entire dose of NPK was applied as basal. Gypsum at the rate of 400 kg ha^{-1} was applied in two equal splits, one at basal (200 kg ha^{-1}) and another at the time of earthing up (200 kg ha^{-1}) at 45 DAS. The crop was harvested on second week of September during both the years. After harvesting of the groundnut crop, to know the residual effect of herbicides, without disturbing the layout, each plot was manually prepared for sowing of succeeding crops. Seven rows of each succeeding sunflower (CO 4) and pearl millet CO (Cu) 9 were sown in each plot in *rabi* season. The germination percentage, plant height, dry weight of plants and yield of sunflower and pearl millet crops were recorded and data were used for analysis.

Results and Discussion

Effect on weeds

Weed flora of the experimental field consisted of eleven species of broad-leaved weeds, five species of grasses and a sedge. Among the different weed species, the major broad-leaved weeds *consisted of Boerhaavia diffusa, Parthenium hysterophorous, Acalypha indica* and *Amaranthus viridis* followed by grassy weeds like *Dactyloctenium aegyptium, Acrachne racemosa, Bracharia reptans* and *Chloris barbata* and sedge (*Cyperus rotundus*).

Early post-emergence application of new formulation of imazethapyr at 100, 150 and 200 g ha^{-1} followed by one hand weeding on 45 DAS resulted in effective control of broad leaved weeds, grasses and to some extent sedge due to its broad spectrum action. Thus, broad leaved and grassy

Table 1. Effect of different weed management practices on total weed density in groundnut

Treatment	Total weed density (No. m^{-2})					
	kharif 2009			*kharif* 2010		
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS
T_1 : EPOE imaze. 10 % SL at 50 g ha^{-1} *fb* HW at 45 DAS	19.79 (136.01)	21.33 (158.01)	11.10 (36.67)	8.51 (70.43)	10.02 (98.33)	6.19 (36.32)
T_2 : EPOE imaze. 10 % SL at 75 g ha^{-1} *fb* HW at 45 DAS	17.33 (96.66)	18.58 (114.33)	10.31 (30.00)	7.81 (59.02)	8.98 (78.67)	4.90 (22.00)
T_3 : EPOE imaze. 10 % SL at 100 g ha^{-1} *fb* HW at 45 DAS	10.99 (35.00)	9.57 (24.66)	7.28 (11.99)	5.48 (27.99)	5.20 (25.00)	3.21 (8.33)
T_4 : EPOE imaze. 10 % SL at 150 g ha^{-1} *fb* HW at 45 DAS	9.18 (23.99)	7.81 (14.33)	6.65 (9.33)	4.51 (18.33)	4.47 (18.01)	2.77 (5.66)
T_5 : EPOE imaze. 10 % SL at 200 g ha^{-1} *fb* HW at 45 DAS	8.65 (21.67)	6.24 (7.00)	6.26 (7.66)	3.70 (11.67)	3.37 (9.33)	1.41 (1.00)
T_6 : PE pendi. at 0.75 kg ha^{-1} *fb* HW at 45 DAS	14.22 (62.33)	16.76 (87.67)	9.80 (26.33)	8.25 (66.10)	10.90 (116.78)	3.51 (10.34)
T_7 : PE pendi. at 0.75kg ha^{-1} *fb* imaze. at 50g ha^{-1}	10.71 (39.33)	12.02 (48.33)	8.14 (16.66)	4.82 (21.23)	5.76 (31.17)	2.89 (6.33)
T_8 : PE Pendi. at 0.75kg ha^{-1} *fb* star weeder weeding on 45 DAS	14.50 (65.00)	16.54 (85.34)	14.74 (68.33)	8.48 (69.87)	11.35 (126.72)	5.94 (33.33)
T_9 : PE Pendi. at 0.75 kg ha^{-1} *fb* layby pendi. at 0.75 kg ha^{-1} on 45 DAS	13.88 (58.67)	16.24 (82.00)	7.69 (14.00)	8.01 (62.20)	11.36 (126.96)	2.83 (6.00)
T_{10} : HW twice on 25 and 45 DAS	5.73 (5.00)	10.57 (32.00)	7.53 (13.00)	3.13 (7.80)	5.03 (23.34)	2.71 (5.33)
T_{11} : Unweeded control	23.61 (190.01)	26.12 (240.67)	12.67 (48.67)	16.60 (273.46)	20.12 (402.66)	8.43 (69.00)
T_{12} : Weed free check	5.73 (5.00)	4.97 (2.33)	5.20 (3.00)	1.73 (1.00)	2.00 (2.00)	2.00 (2.00)
SEd	1.35	1.49	0.90	0.73	0.90	0.73
CD (P=0.05)	3.46	3.09	2.26	1.51	1.86	1.83

Figures in parenthesis are original values; EPOE – Early post-emergence; PE – Pre-emergence; Imaze – Imazethapyr; HW - Hand weeding; Pendi - Pendimethalin

weeds were effectively controlled with the herbicide. Application of imazethapyr at 200 g ha^{-1} resulted in the weed control of more than 90 per cent of weeds, but the herbicide inhibited the crop growth. Noticeable reduction of nearly 90 per cent of broad leaved weeds and grassy weeds in soybean with the application of imazethapyr at 100 and 150 g ha^{-1} as early post-emergence was reported by Sangeetha (2010). The left over weeds were controlled by manual weeding on 45 DAS. Several research findings showed that imazethapyr has successfully controlled broad leaved weeds and

Table 2. Effect of weed management methods on pod yield, weed index and weed control efficiency of groundnut

Treatment	*kharif* 2009				*kharif* 2010			
	Pod yield (kg ha^{-1})	Weed Index (%)	WCE (%) 30 DAS	WCE (%) 45 DAS	Pod yield (kg ha^{-1})	Weed Index (%)	WCE (%) 30 DAS	WCE (%) 45 DAS
T_1 : EPOE imaze. 10 % SL at 50 g ha^{-1} *fb* HW at 45 DAS	900	50.7	22.8	40.8	1014	45.4	65.5	71.5
T_2 : EPOE imaze. 10 % SL at 75 g ha^{-1} *fb* HW at 45 DAS	1133	37.0	37.4	55.0	1296	31.3	72.7	75.1
T_3 : EPOE imaze. 10 % SL at 100 g ha^{-1} *fb* HW at 45 DAS	1602	2.8	82.8	93.3	1900	7.6	93.1	96.7
T_4 : EPOE imaze. 10 % SL at 150 g ha^{-1} *fb* HW at 45 DAS	1580	9.8	87.3	96.5	1854	4.1	94.8	97.5
T_5 : EPOE imaze. 10 % SL at 200 g ha^{-1} *fb* HW at 45 DAS	1142	33.5	91.3	98.4	1368	30.7	97.0	98.8
T_6 : PE pendi. at 0.75 kg ha^{-1} *fb* HW at 45 DAS	1420	13.8	61.4	73.7	1630	20.7	76.2	66.8
T_7 : PE pendi. at 0.75kg ha^{-1} *fb* imaze. at 50g ha^{-1}	1470	16.1	83.0	86.9	1725	10.8	93.8	92.9
T_8 : PE Pendi. at 0.75kg ha^{-1} *fb* star weeder weeding on 45 DAS	1224	30.7	67.5	66.0	1424	25.7	75.9	67.2
T_9 : PE Pendi. at 0.75 kg ha^{-1} *fb* layby pendi. at 0.75 kg ha^{-1} on 45 DAS	1380	20.9	68.5	64.8	1626	16.3	76.6	65.2
T_{10} : HW twice on 25 and 45 DAS	1486	12.0	96.9	87.9	1810	9.8	97.8	94.7
T_{11} : Unweeded control	800	59.4	-	-	834	51.5	-	-
T_{12} : Weed free check	1648	0.0	98.3	99.4	2056	0.0	99.7	99.7
SEd	63	-			75	-		
CD (P=0.05)	158	-			187	-		

EPOE – Early post-emergence; PE – Pre-emergence; Imaze – Imazethapyr; HW - Hand weeding; Pendi - Pendimethalin

grassy weeds in groundnut (Dubey *et al.,* 2010) and soybean (Lambade *et al.*, 2008). Early post-emergence application of imazethapyr most effectively decreased the number of annual broad leaved weeds and grassy weeds in soyabean and blackgram as reported by Singh (2009) and Veeraputhiran *et al.* (2008) lend support to the present findings.

Effect on crop

In groundnut, among the weed control treatments, early post-emergence application of imazethapyr at 100 g ha^{-1} recorded higher pod yield (1602 and 1900 kg ha^{-1}) during 2009 and 2010 respectively, due to better control of weeds at critical stages thus providing favourable environment for better growth and development leading to enhanced pod yield of groundnut. The percentage increase over unweeded control during *kharif* 2009 and 2010 was 56.3 and 60.5. This might be due to translocation and accumulation of photosynthates to pods and kernels which resulted in appreciable increase in the yield attributing characters in groundnut. This treatment was comparable with early post emergence application of imazethapyr at 150 g ha^{-1} with a pod yield of (1580 and 1854 kg ha^{-1}) during both the years. Hand weeding twice on 25 and 45 DAS and application of pendimethalin at 0.75 kg ha^{-1} followed by hand weeding at 45 DAS were the next best treatments compared to new formulation of imazethapyr at 50, 75 and 200 g ha^{-1} and recorded higher pod yield.

Weed free check and herbicide treatments had provided favourable environment to the groundnut during its critical periods of growth which in turn resulted in enhanced yield attributing characters like number of pegs plant^{-1}, matured pods plant^{-1}, peg to pod per cent and shelling percentage. These might be due to low level of weed competition at critical phases of crop growth (upto 60 DAS) which favoured the groundnut crop to utilize the available resources

Table 3. Residual effect of imazethapyr on the germination (%) and dry matter production (kg ha^{-1}) of succeeding crops of groundnut

Treatment	Sunflower						Pearl millet					
	rabi 2009			*rabi* 2010			*rabi* 2009			*rabi* 2010		
	Germ* (%)	DMP 30DAS	DMP 60 DAS	Germ* (%)	DMP 30 DAS	DMP 60 DAS	Germ* (%)	DMP 30 DAS	DMP 60 DAS	Germ* (%)	DMP 30	DMP 60 DAS
T_1 : EPOE imaze. 10 % SL at 50 g ha^{-1} *fb* HW at 45 DAS	86.3	56.8	145.5	82.3	65.4	146.2	94.3	75.4	193.4	89.3	81.5	210.6
T_2 : EPOE imaze. 10 % SL at 75 g ha^{-1} *fb* HW at 45 DAS	89.7	59.3	149.6	80.3	60.2	147.4	95.0	75.8	194.8	92.7	79.1	216.4
T_3 : EPOE imaze. 10 % SL at 100 g ha^{-1} *fb* HW at 45 DAS	89.3	63.5	152.3	86.0	61.8	147.6	93.7	77.2	191.4	94.3	76.9	219.5
T_4 : EPOE imaze. 10 % SL at 150 g ha^{-1} *fb* HW at 45 DAS	88.0	63.2	151.0	87.7	62.8	145.8	94.3	78.3	181.6	88.7	78.2	214.8
T_5 : EPOE imaze. 10 % SL at 200 g ha^{-1} *fb* HW at 45 DAS	86.7	53.9	138.1	84.7	63.4	142.4	95.0	72.2	184.5	90.3	76.4	213.0
T_6 : PE pendi. at 0.75 kg ha^{-1} *fb* HW at 45 DAS	86.3	62.3	136.1	83.3	59.8	143.4	96.0	72.6	182.4	96.7	73.9	216.7
T_7 : PE pendi. at 0.75kg ha^{-1} *fb* imaze. at 50g ha^{-1}	85.0	53.6	141.3	84.0	62.5	144.3	92.3	72.5	184.7	94.3	78.2	200.8
T_8 : PE Pendi. at 0.75kg ha^{-1} *fb* star weeder weeding on 45 DAS	89.3	59.3	133.0	82.3	63.4	139.5	95.7	71.3	184.7	89.0	70.5	206.5
T_9 : PE Pendi. at 0.75 kg ha^{-1} *fb* layby pendi. at 0.75 kg ha^{-1} on 45 DAS	87.0	57.3	132.3	87.3	61.0	139.3	95.3	70.7	186.7	87.7	80.6	209.4
T_{10} : HW twice on 25 and 45 DAS	89.3	58.3	141.7	88.0	60.9	140.4	96.3	69.3	180.6	89.3	83.5	206.2
T_{11} : Unweeded control	87.7	56.8	145.5	86.7	65.8	140.6	94.7	78.5	188.5	92.0	76.5	200.8
T_{12} : Weed free check	86.3	59.3	150.5	82.3	62.5	135.5	93.0	76.3	190.6	95.7	79.1	207.4
SEd	-	6.0	14.6	-	6.4	10.2	-	7.5	18.9	-	8.0	21.3
CD (P=0.05)	-	NS	NS	-	NS	NS	-	NS	NS	-	NS	NS

EPOE – Early post-emergence; PE – Pre-emergence; Imaze – Imazethapyr; HW - Hand weeding; Pendi - Pendimethalin; *Data statistically not analysedDMP – Dry matter production

Table 4. Residual effect of imazethapyr on yield (kg ha^{-1}) of succeeding crops of groundnut

Treatment	Sunflower				Pearl millet			
	rabi 2009		*rabi* 2010		*rabi* 2009		*rabi* 2010	
	Grain	Stalk	Grain	Stalk	Grain	Stover	Grain	Stover
T_1 : EPOE imaze. 10 % SL at 50 g ha^{-1} *fb* HW at 45 DAS	1455	1695	1490	2186	1625	2357	1702	2784
T_2 : EPOE imaze. 10 % SL at 75 g ha^{-1} *fb* HW at 45 DAS	1434	1807	1461	2248	1542	2512	1735	2683
T_3 : EPOE imaze. 10 % SL at 100 g ha^{-1} *fb* HW at 45 DAS	1486	1878	1564	2298	1754	2995	1798	2994
T_4 : EPOE imaze. 10 % SL at 150 g ha^{-1} *fb* HW at 45 DAS	1460	1794	1486	2246	1626	2638	1754	2875
T_5 : EPOE imaze. 10 % SL at 200 g ha^{-1} *fb* HW at 45 DAS	1463	1612	1473	2284	1710	2448	1764	2576
T_6 : PE pendi. at 0.75 kg ha^{-1} *fb* HW at 45 DAS	1426	1761	1498	2290	1645	2975	1738	2984
T_7 : PE pendi. at 0.75kg ha^{-1} *fb* imaze. at 50g ha^{-1}	1418	1857	1459	2156	1655	2618	1751	2537
T_8 : PE Pendi. at 0.75kg ha^{-1} *fb* star weeder weeding on 45 DAS	1450	1714	1502	2147	1630	2900	1764	2845
T_9 : PE Pendi. at 0.75 kg ha^{-1} *fb* layby pendi. at 0.75 kg ha^{-1} on 45 DAS	1439	1704	1526	2268	1685	2944	1714	2686
T_{10} : HW twice on 25 and 45 DAS	1482	1860	1550	2294	1740	2984	1769	2835
T_{11} : Unweeded control	1442	1787	1474	2160	1635	2864	1706	2586
T_{12} : Weed free check	1465	1849	1590	2288	1665	2990	1745	2734
SEd	55	94	82	122	63	275	57	324
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

EPOE – Early post-emergence; PE – Pre-emergence; Imaze – Imazethapyr; HW - Hand weeding; Pendi - Pendimethalin

to the maximum extent, which ultimately reflected on higher growth and yield attributing characters. The results are in accordance with the findings of Kalaiselvi *et al.* (1998) and Manickam *et al.* (2000) who have reported that the efficient utilization of soil moisture and nutrients and earthing up operation created a favourable condition for the development of gynophores into the soil which leads to maximum number of pegs and matured pods in groundnut.

Bioassay Study

Results revealed that germination of succeeding sunflower and pearl millet recorded at 10 DAS was not significantly affected by residual effect of herbicide applied to irrigated groundnut. The plant stand of sunflower ranged from 85 to 90 per cent and pearl millet from 87 to 96 per cent under all the treatments at 10 DAS. Further, plant height and dry weight of plants recorded at 30, 60 and 90 DAS were also unaffected due to residual effect of different doses of imazethapyr applied in groundnut. Yield of sunflower and pearl millet showed no distinct variation due to different dose of imazethapyr. This result is in line with the results of Sangeetha (2010) who reported that, the early post-emergence application of imazethapyr in soyabean at higher doses of 200 g ha^{-1} did not leave any residue in the soil and there was no toxic effect to the succeeding crops of sunflower and pearl millet. It might be shown that new formulation of imazethapyr with different doses could be very effective against most of the broad leaved and grassy weeds in groundnut. But residual toxicity of imazethapyr cannot be ruled out on sensitive crops such as sunflower and pearl millet in rotation.

Conclusion

The results indicated that early post-emergence application of imazethapyr (10% SL) at 100 g ha^{-1} can keep the weed density and dry weight reasonably at lower level and enhance the productivity of groundnut. The new formulation of early post emergence application of imazethapyr at 50, 75, 100, 150 and 200 g ha^{-1} and pre-emergence application of pendimethalin at 0.75 kg ha^{-1} applied in groundnut was found to be safe on the succeeding crops and this might be due to detoxification of herbicides in soil and do not adversely affect the growth and yield of the succeeding crops in terms of plant height, dry matter production and grain yield of the succeeding sunflower and pearl millet crops.

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Received: August 10, 2012; Accepted: November 8, 2012