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Bioefficacy of new herbicide fluazifop-p-butyl for grassy weed management in groundnut and carry-over effect on succeeding finger millet

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ABSTRACT

Major grassy weed flora observed during 2010 and 2011 mansoon season on red sand loam soil of Bangalore were *Echinochloa colona, Digitaria marginata, Eleusine indica, Dactyloctenium aegyptium* and *Cynodon dactylon*. The new graminicide fluazifop-p-butyl at 134 and 167 g a. i./ha lowered the density and growth of grasses, nutrient uptake by weeds considerably as compared to other treatments. Application of fluazifop-p-butyl 13.4 EC134 to167 g a. i./ha @18-20 DAS gave higher pod yield (1651 to 1531 kg/ha) and was on par with hand weeding (1757 kg/ha), imazethapyr 10 SL 100 g a. i./ha (1574 kg/ha) and pendimethalin 30 EC 750 g a. i./ha @ 3 DAS (1469 kg/ha). Unweeded control significantly lowered pod yield by 39% as compared to hand weeding. Fluazifop-p-butyl at 167 to 335 did not cause phytotoxicity to groundnut and did not leave residual toxicity on succeeding finger millet grown after 155 days of herbicide application during two years of experiment. Thus, herbicides were cheaper, used less energy inputs, lowered nutrient loss, provided higher energy use efficiency and higher B : C than manual weeding.

Key words : Energy productivity, grassy weeds, nutrient loss, pod yield, residual effect

INTRODUCTION

Groundnut is an important oilseed-cum-leguminous crop in India, but its yield is unpredictable. One of the major factors responsible for low productivity of groundnut is the improper management of weeds. Groundnut is grown extensively during **kharif** season under rainfed condition, where it encounters severe weed infestation especially in the early stages. The critical period of weed competition is found to be the first four to eight weeks after sowing (Jat *et al.,* 2011). Groundnut crop is highly susceptible to weed infestation particularly grasses because of its slow growth in the initial stages up to 40 days (Senthil Kumar *et al.*, 2004; Anonymous, 2010), short plant height and underground pod bearing habit. Uncontrolled weed growth reduces groundnut yield to the tune of 76% (Gnanamurthy and Balasubramaniyan, 1998). In agriculture, labour component is becoming scarce, not available at time and prohibitive cost. Chemical use of herbicides forms an excellent alternative to manual weeding. However, pre-emergence application of herbicide may allow the emergence of weeds especially grasses after 25-30 days (Jat *et al.*, 2011). At present, many farmers demand post-emergence herbicides for managing weeds, after seeing their menace and other methods could not limit the weeds' growth. Hence, the present study was initiated during **kharif** 2010 and 2011 at Hebbal, Bangalore to evaluate the performance of graminicides in relation to pre-emergent herbicides.

MATERIALS AND METHODS

A field study was conducted during **kharif** 2010 and 2011 on red sandy loam soil of Hebbal, Bengaluru coming under Eastern Dry Zone of University of Agricultural Sciences, Bengaluru. The soil type was sandy loam with pH of 6.60 and average fertility status of 0.65% OC, available N of 228.0 kg/ha, available P_2O_5 of 24.3 kg/ha and K_2O of 170.0 kg/ha.

The weed management practices included in the bio-efficacy experiment were : (i) fluazifop-p-butyl 13.4 EC at 100, 134 and 167 g a. i./ha, (ii) imazethapyr 10 SL at 100 g a. i./ha, (iii) pendimethalin 30 EC at 750 g

a. i./ha, (iv) quizalofop-p-ethyl 5 EC at 50 g a. i./ha, (v) hand weeding (20 and 35 DAS) and (vi) unweeded control. Pendimethalin was applied three days after sowing using a spray volume of 750 l/ha with WF 72 nozzle, whereas fluazifop-p-butyl, imazethapyr and quizalofop-p-ethyl were applied on 18 DAS in 2010 and 20 DAS in 2011 with spray volume of 500 l/ha by using knap sac sprayer with WF 60 nozzle. The broad leaf weeds were removed from graminicide treated plots (fluazifop-p-butyl and quizalofop-p-ethyl) around 35 days after sowing in order to avoid competition from broad leaf weeds, which were not controlled by the herbicides.

The phytotoxicity experiment consisted of three treatments viz., (i) fluazifop-p-butyl 13.4 EC at 167 g a. i./ha (x dose) and fluazifop-p-butyl 13.4 EC at 335 g a. i/ha (2x dose) 20 DAS and (iii) unsprayed control. The experiment was laid out as randomized complete block design with three replications for bio-efficacy experiment and nine replications for the phytotoxicity experiment. The groundnut cv. TMV-2 was sown at a spacing of 30 x 15 cm with a recommended fertilizer dose of 25 kg N, 75 kg P_2O_5 and 38 kg K_2O/ha. The observations on phytotoxicity by using 0 to 10 scale were made on necrotic symptoms, stunted growth, epinasty symptoms, hyponasty symptoms, wilting and vein clearing. To study the residual effect of fluazifop-p-butyl applied to previous groundnut crop on succeeding finger millet, 155 days after the harvest of groundnut, plots were dug individually, levelled and fertilizer schedule of 100 kg N,50 kg P_2O_5 and 50 kg K_2O_5 was applied before sowing finger millet (GPU-28).

The energy use efficiency over unweeded control has been worked out by using the energy equivalents of herbicides, labour, pod yield and haulm yield (Binning *et al.*, 1983).

$$\text{Energy use efficiency} = \frac{\text{Energy output (MJ/ha)}}{\text{Energy input (MJ/ha)}}$$

Energy Productivity

It is the ratio of yield obtained in groundnut to the energy input used for various weed management treatments (Binning *et al.,* 1983).

$$\text{Energy productivity (kg/MJ/ha)} = \frac{\text{Yield (kg/ha)}}{\text{Energy input (MJ/ha)}}$$

Weed index (WI) was worked out by using the following formula :

$$WI = \frac{\text{Yield of hand weeded plot} - \text{Yield of the treatment plot}}{\text{Yield of hand weeded plot}} \times 100$$

RESULTS AND DISCUSSION

Grassy Weed Flora

Major weed flora observed during both the years in the experimental plot were *Cyperus rotundus* L. (a sedge), *Cynodon dactylon* (L.) Pers., *Digitaria marginata* (Retz.), *Dactyloctenium aegyptium* (L.) Willd, *Eleusine indica* (L.) Gaertn., *Echinochloa colona* (L.) Link., *Eragrostis pilosa* (L.) P. Beauv. and *Setaria glauca* (L.) P. Beauv (among grasses) as also reported in the earlier studies at Hebbal, Bangalore (Jayaram, 2001; Anonymous, 2009, 2010, 2011). Use of fluazifop-p-butyl 134 to 167 g a. i./ha lowered the density of grasses and weed dry weight considerably and compared similar to hand weeding and pendimethalin. Jayaram (2001) and Jat *et al.* (2011) have also observed good control of grassy weeds by using fluazifop-p-butyl 0.25 kg a. i./ha in groundnut (Table 1).

Bio-efficacy

Use of fluazifop-p-butyl 134 to 167 g a. i./ha gave pod yield (1531 to 1651 kg/ha) which was on par with hand weeding (1757 kg/ha), imazethapyr 100 g a. i./ha (1574 kg/ha) and pendimethalin 750 g a. i./ha (1469 kg/ha). All growth and yield components number of pods/plant were higher in herbicide treatments due to lowered grassy weeds' density and dry weight. Unchecked weed growth lowered the leaf area/plant which consequently lowered dry matter production/plant, number of filled pods/plant and pod yield/plant. Thus, weed competition lowered seed yield by 39% as compared to hand weeding due to reduced plant growth and yield components, lowered

Table 1. Major weed flora, weed density and dry weight of grasses observed in groundnut at 45 days and at harvest of groundnut as influenced by weed management practices

Weed management practices (g a. i./ha)	Major weed flora (No./m^2)						Density of grasses (No./m^2)		Dry weight of grasses (g/m^2)	
	EC	Cd	Ei	Dm	Da	Total	45 DAS	At harvest	45 DAS	At harvest
T_1 : Fluazifop-p-butyl 13.4 EC at 100 g	2.0	2.7	0.0	4.0	4.0	15.3	1.25 (16.0)#	1.06 (9.7) #	1.00 (8.3)#	0.84 (5.0)#
T_2 : Fluazifop-p-butyl 13.4 EC at 134 g	0.0	5.3	0.0	3.3	0.0	8.7	1.20 (14.3)	0.77 (4.0)	0.94 (6.8)	0.54 (1.5)
T_3 : Fluazifop-p-butyl 13.4 EC at 167 g	0.0	2.7	0.0	0.0	0.0	2.7	1.16 (13.3)	0.74 (3.7)	0.89 (5.8)	0.51 (1.2)
T_4 : Imazethapyr 10 SL at 100 g	0.0	7.3	6.7	2.0	2.0	21.3	1.30 (18.3)	1.03 (8.7)	1.06 (9.6)	0.75 (3.6)
T_5 : Pendimethalin 30 EC at 750 g	0.7	8.0	0.7	3.3	0.0	12.7	1.33 (20.0)	1.05 (9.3)	0.97 (7.5)	0.82 (4.8)
T_6 : Quizalofop-p-ethyl 5 EC at 50 g	1.3	8.0	3.0	4.3	3.0	20.7	1.23 (15.3)	0.86 (5.3)	1.02 (8.8)	0.87 (5.4)
T_7 : Hand weeding (20 and 35 DAS)	1.3	6.7	0.0	2.0	2.0	12.0	0.66 (3.0)	0.77 (4.0)	0.45 (0.8)	0.59 (1.9)
T_8 : Unweeded control	6.7	5.3	11.3	15.0	13.7	55.3	1.68 (46.0)	1.45 (26.3)	1.69 (47.3)	1.75 (54.4)
S. Em±	----------NA----------						0.07	0.05	0.05	0.04
C. D. (P=0.05)							0.21	0.15	0.14	0.12

NA–Data statistically not analyzed, averaged over two spots/plot and over four replications, #Data within parentheses are original values; data analyzed using log (x+2) transformation; Grasses : Cd–*Cynodon dactylon,* Ei–*Eleusine indica,* Dm–*Digitaria marginata,* Da–*Dactyloctenium aegyptium.* Total grassy weed count includes the density of minor weeds *Setaria glauca* (L.) P. Beauv., *Eragrostis pilosa* (L.) P. Beauv., *Chloris barbata* Sw. and *Echinochloa colona* (L.) Link which are not included in the table. The trend was similar during 2010.

Table 2. Influence of weed management practices on nutrient uptake by weeds, crop and loss in terms of cost of fertilizers (Average of 2010 and 2011)

Weed management practices (g a. i./ha)	Uptake by weeds (kg/ha)			Uptake by crop (kg/ha)			Loss of fertilizer by weeds (Rs./ha)
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	
T_1 : Fluazifop-p-butyl 13.4 EC at 100 g	16.40	6.20	16.42	72.40	11.32	30.90	507
T_2 : Fluazifop-p-butyl 13.4 EC at 134 g	14.07	5.80	14.09	78.00	13.90	33.17	449
T_3 : Fluazifop-p-butyl 13.4 EC at 167 g	13.48	4.60	13.97	79.77	14.72	35.14	407
T_4 : Imazethapyr 10 SL at 100 g	13.00	4.44	13.50	78.93	14.13	35.17	393
T_5 : Pendimethalin 30 EC at 750 g	15.08	5.71	14.63	77.45	13.39	32.87	463
T_6 : Quizalofop-p-ethyl 5 EC at 50 g	15.60	6.12	15.82	75.13	12.10	31.53	490
T_7 : Hand weeding (20 and 35 DAS)	10.63	2.67	10.87	80.73	15.10	35.80	293
T_8 : Unweeded control	28.47	10.10	28.62	43.17	8.43	20.27	863
S. Em±	0.78	0.54	0.76	1.17	0.41	0.88	-
C. D. (P=0.05)	2.35	1.65	2.30	3.55	1.24	2.66	-

nutrient uptake by the crop. Weeds showed higher nutrient uptake to an extent of 2.6 to 2.7 times for N and P_2O_5 uptake and 3.6 times in K_2O uptake in unweeded control as compared to hand weeded control. Unweeded control caused loss of nutrients equivalent to fertilizers cost worth of Rs. 863/ha as compared to Rs. 293/ha in hand weeding and Rs. 393 to 507/ha in herbicide treatments (Table 2). Similar indications of increased loss of nutrient by weed competition were also revealed by Jayarama Reddy (1995), Chaitanya (2009) and Chandolia *et al.* (2010).

Energy input for weed management was

Table 3. Influence of weed management practices on yield parameters, energy use efficiency, weed index and economics in groundnut (Average of 2010 and 2011)

Weed management practices (g a. i./ha)	Pod yield (kg/ha)	No. of filled pods/plant	Weed index (%)	Energy input (MJ/ha)	Total energy output (MJ/ha)	Energy use efficiency	B : C ratio	Net returns (Rs./ha)
T_1 : Fluazifop-p-butyl 13.4 EC at 100 g	1337	21.6	21.4	91.7	61619	326.6	0.81	23301
T_2 : Fluazifop-p-butyl 13.4 EC at 134 g	1531	24.4	12.2	101.6	67238	350.1	1.09	32074
T_3 : Fluazifop-p-butyl 13.4 EC at 167 g	1651	25.6	5.9	111.1	73105	372.9	1.23	36743
T_4 : Imazethapyr 10 SL at 100 g	1574	24.7	6.5	91.7	69578	413.4	1.13	33395
T_5 : Pendimethalin 30 EC at 750 g	1469	22.4	9.9	217.5	65687	156.4	1.10	31423
T_6 : Quizalofop-p-ethyl 5 EC at 50 g	1358	20.8	15.0	77.2	62063	393.7	0.90	26997
T_7 : Hand weeding (20 and 35 DAS)	1757	27.8	0.0	862.4	76995	52.6	1.06	35057
T_8 : Unweeded control	680	9.9	59.9	-	31670	0.0	0.03	863
S. Em±	84	5.54	NA					
C. D. (P=0.05)	254	1.83						

NA–Not analyzed; Energy equivalent of inputs : Human labour–1.96 MJ/h, 1 labour unit (LU) is 8 h working per day, 1 LU–15.68 MJ; groundnut pod–25 MJ/kg, stalk (haulm)–18 MJ/kg, herbicide–290 MJ/kg, herbicide application–LU–4/ha=62.72 MJ/ha. Total energy output–Energy output of pod and haulm yield.

Table 4. Residual effect of fluazifop-p-butyl applied to previous groundnut on initial establishment and growth of succeeding finger millet in summer (Average of 2010 and 2011)

Treatment	Germination (%) 15 DAS	Shoot length (cm)	Root length (cm)	Shoot weight (g)	Root weight (g)	Total dry weight (g)	Grain yield (kg/ha)	Straw yield (kg/ha)
	----------20 DAS----------							
T_1 : Fluazifop-p-butyl 13.4 EC at 167 g	98.0	6.12	5.50	0.65	0.65	2.00	5534	6520
T_2 : Fluazifop-p-butyl 13.4 EC at 335 g	98.5	7.57	6.20	0.60	0.60	2.70	5510	6400
T_3 : Unsprayed control	97.5	6.57	6.63	0.80	0.55	2.40	5800	6480
S. Em±	1.65	0.36	0.30	0.10	0.10	0.20	460	472
C. D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

DAS–Days after sowing, NS : Not Significant. NA–Not analysed, loss of fertilizer is based on the cost of urea, single super phosphate and muriate of potash.

less by using effective herbicides (77.2 to 217.5 MJ/ha) as compared to hand weeding (862.4 MJ/ha) and consequently resulted in higher energy productivity (156.4 to 413.4 as against 52.6 in hand weeding) during both the years of study. This clearly suggested that use of herbicides with good weed control will be cheaper, require less energy input for weeding and higher energy use efficiency as compared to manual weeding, which is expensive, as suggested by Mulik *et al.* (2010) and Chaitanya *et al.* (2010) in groundnut and Deore *et al.* (2008) in soybean. The net return and B : C ratio were higher in fluazifop-p-butyl 167 g a. i./ha (Rs. 36,743/ha and Rs. 1.23/rupee investment) than hand weeding (Rs. 35,057/ ha and Rs. 1.06/rupee investment) owing to lower input cost (Table 3). Thus, herbicides are considered as economical weed management practice in the present day context, of labour shortage, as also spelt out by Patel *et al.* (2006), Chaitanya *et al.* (2010) and Kadlag and Megha (2011) in groundnut.

Phytotoxicity

Application of pre-emergence (pendimethalin 750 g a. i./ha) as well as post-emergence herbicides (fluazifop-p-butyl 100 to 167 g a. i./ha, imazethapyr 100 g a. i./ha and quizalofop-p-ethyl 5 EC 50 g a. i./ha) in the first experiment and post-emergence herbicide (fluazifop-p-butyl 167-335 g a. i./ha) in the second experiment did not show any observable phytotoxicity symptoms (necrotic, epinasty, hyponasty, wilting and vein clearing and stunted growth of seedlings) on groundnut crop during both the years' experiments, as also indicated by Brar and Mehra (1989) in groundnut, Patil *et al.* (1999) in soybean and Robin *et al.* (2012) in wildflower species.

Finger millet was raised as succeeding crop in the same plot after the harvest of groundnut treated with fluazifop-p-butyl at 167 to 335 g a. i./ha i. e. after 155 days of herbicide application. The initial establishment (germination), growth of finger millet (root length, shoot length, dry weight of shoot, root and total number of leaves/plant) and grain yield were unaffected by fluazifop-p-butyl at 167 to 335 g a. i./ha (Table 4). Thus, the carry-over effect of fluazifop-p-butyl applied to previous groundnut did not affect the succeeding finger millet, indicating its safety, as also confirmed by the findings of Douglas *et al.* (1992), Jayarama Reddy (1995) and Deore *et al.* (2009).

CONCLUSION

Thus, fluazifop-p-butyl at 18-20 DAS was found very effective in lowering grassy weeds density, higher pod yield and compared similar to pendimethalin, hand weeding and quizalofop-p-ethyl. The new herbicide at 167-335 g a. i./ha at 20 DAS did not cause any phytotoxicity to groundnut and was found safe to succeeding finger millet crop during 2010 and 2011 at Bangalore on red sandy loam soil.

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