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Efficacy of herbicides on yield and economics of summer groundnut as well as residual effect on succeeding crops

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Abstract
The present investigation was conducted to evaluate the efficacy of herbicides on yield and economics of summer groundnut as well as residual effect on succeeding crops during two consecutive summer season of 2018 and 2019 at College of Agriculture, Anand Agricultural University, Jabugam, Gujarat Oxyfluorfen, quizalofop-ethyl, imazethapyr, imazethapyr + imazamox (premix) and fluazifop-p-butyl + fomesafen (premix) were tested as alone, with integration as well as sequential application in comparison with IC *fb* HW at 20 and 40 DAS and weedy check in randomized block design with three replications. All the weed management practices significantly reduced the density and dry biomass of weeds and increased the pod yield of groundnut. Results revealed that Oxyfluorfen 180 g/ha PE *fb* IC + HW at 40 DAS provide effective control of weeds at all the intervals with higher pod and haulm yields as well as net return and BC ratio of groundnut followed by Oxyfluorfen 180 g/ha PE *fb* Imazethapyr 100 g/ha PoE, IC *fb* HW at 20 and 40 DAS, oxyfluorfen 180 g/ha PE *fb* Imazethapyr + Imazamox 70 g/ha PoE (premix) and fluazifop-p-butyl + fomesafen 250 g/ha EPoE (premix) *fb* IC + HW at 40 DAS. The plant stand, plant height and dry matter production of cotton, maize and green gram were not affected by the application of any herbicides in applied in preceding summer groundnut.

Keywords: Herbicides, Seed, Haulm, Weed dry weight (WDW)

Introduction
In field condition, infestation of weed is an important limiting factor in producing potential yield of any crops. Groundnut (*Arachishypogaea* L.) is an important oil seed crop of India and particular of Gujarat. Due to slow initial growth with poor competitive ability, groundnut heavily infested with weed which leads to huge loss of yield. Priya *et al*. (2013) [4] reported that groundnut crop is highly susceptible to weed infestation because of its slow growth during its initial crop growth stages up to 40 days. Further, Sasikala *et al*. (2006) [5] reported that weed infestation in summer groundnut is one of the main factors for loss in yields to the tune of 17-84 per cent. At present various new formulations of pre emergence and post emergence pre mix herbicide are available in the market which provides broad spectrum weed control. Sometimes herbicide become effective in controlling weeds but the cost of certain herbicides may be very high because the basic ingredients for manufacturing such type of herbicides are imported from the other countries. Hence, it necessary to know the effectiveness of applied herbicides on weeds as well as their cost effectiveness so that overall cost of cultivation can be reduce which help in increase in net return. Herbicides applied for weed control may or may not be persist in the soil for a longer period and it may differ from agro-climatic conditions. The main aim of application of herbicide is to control the weeds but may lead to accumulation of residue in soil which may causes considerable damage to the succeeding crops hence, it is necessary to determine whether herbicide may persist in the soil for a longer time or not. For that bioassay is a major tool for determination of herbicide residues present in the soil. Beside this, bioassay is cheap and easy method to determine their residual effect on succeeding crops by growing sensitive crops in previously treated plot. Meager information is available on the efficacy of pre and post emergence herbicides applied in summer groundnut for weed control as well as their carry over effect on succeeding crops. Considering above in view, the present experiment was conducted to study the efficacy pre and post emergence application of Oxyfluorfen, Imazethapyr, Imazethapyr + Imazamox, quizalofop-ethyl and fluazifop-p-butyl +

fomesafen and their residual effect on succeeding crops.

Materials and methods

A field experiment was conducted to study the efficacy of herbicides on yield and economics of summer groundnut as well as residual effect on succeeding crops summer season of the year 2018 and 2019 at College of Agriculture, Anand Agricultural University, Jabugam on loamy sand soil. The soil of the experimental field was low in available nitrogen and medium in available phosphorous and high in potassium. Twelve weed management practices consisted of Oxyfluorfen 180 g/ha PE *fb* IC + HW at 40 DAS, Oxyfluorfen 180 g/ha PE *fb* Imazethapyr 100 g/ha PoE, Oxyfluorfen 180 g/ha PE *fb* Imazethapyr + imazamox 70 g/ha PoE (premix), quizalofop-ethyl 50 g/ha EPoE *fb* IC + HW at 40 DAS, Imazethapyr 100 g/ha EPoE *fb* IC + HW at 40 DAS, imazethapyr 150 g/ha PoE, Imazethapyr + Imazamox 70 g/ha PoE (premix), imazethapyr + imazamox 70 g/ha EPoE (premix) *fb* HW at 40 DAS, fluazifop-p-butyl + fomesafen 250 g/ha PoE (premix), fluazifop-p-butyl + fomesafen 250 g/ha EPoE (premix) *fb* IC + HW at 40 DAS, IC *fb* HW at 20 and 40 DAS and weedy check were laid out in randomized block design with three replications. Groundnut cv. TG 37 were sown on third and first week of February, 2018 and 2019, respectively keeping spacing of 30 x 10 cm by using seed rate of 120 kg/ha. The crop was harvested on 1 and 7 June, 2018 and 2019, respectively. The crop was fertilizer with recommended rate of fertilizer with 25 kg N and 50 kg P_2O_5/ha in the form of urea and single super phosphate, respectively as a basal dose. The rest of the recommended package of practices was adopted to raise the crop. Pre-and post-emergence herbicides were applied by using battery operated knapsack sprayer fitted with flat-fan nozzle by mixing in 500 liter of water/ha as per treatments. Density and dry weight of weeds were recorded at 30, 60 DAS and at harvest. Economics was worked as per the prevailing market price. Residual effect of tested herbicides in groundnut was done on succeeding cotton, maize and green gram grown in the same plot without disturbing the previous field lay-out. Seeds of respective crop were keeping the recommended spacing. All the recommended package of practices was followed in each succeeding crops. Observations on crop growth parameters viz., plant stand at 15 DAS (no/m row length), plant height (cm) at 30 DAS and plant dry matter (g/plant) at 30 DAS was recorded. Data on various observations recorded during the experimental period was statistically analysed as per the standard procedure developed by Cochran and Cox (1957) [1].

Results and discussion

Weed flora

Major weed flora observed in the experimental plots were *Eleusine indica* (24.1%), *Dactyloctenium aegyptium* (15.0%), *Eragrostis major* (9.28%) and *Digitaria sanguinalis* (4.81%) in monocot weeds category whereas, *Trianthema monogyna* (21.5%) *Phyllanthus niruri* (18.0%), *Digera arvensis* (2.40%) and *Amaranthus viridis* (2.18%) in dicot weed category indicating their dominance and competitiveness in summer groundnut during both the years of experimentation.

Effect on weed

Among weed management practices, IC *fb* HW at 20 and 40 DAS was provided complete control of weeds at 30 DAS hence, no dry biomass was recorded. Application of Oxyfluorfen 180 g/ha PE *fb* imazethapyr 100 g/ha PoE and Oxyfluorfen 180 g/ha PE *fb* imazethapyr + imazamox 70 g/ha PoE (pre mix) at 30 DAS recorded significantly lower density and dry biomass of weeds during both the year. At 60 DAS, density of weeds was recorded minimum under application of Imazethapyr 100 g/ha EPoE *fb* IC + HW at 40 DAS but it was at par with Oxyfluorfen 180 g/ha PE *fb* Imazethapyr 100 g/ha PoE and Oxyfluorfen 180 g/ha PE *fb* Imazethapyr + Imazamox 70 g/ha PoE (pre-mix) at 30 DAS during both the year. Pre emergence application of Oxyfluorfen prevented the germinating weeds during the initial stage of the crops and later germinated weeds were managed by mechanical methods this leads to season long weed free situation. Better weed control with integration weed management in groundnut was also observed by Poonia *et al*. (2016) [2]. However, dry biomass of weeds was recorded significantly the lowest under application of Imazethapyr 100 g/ha EPoE *fb* IC + HW at 40 DAS. Pre emergence application of Oxyfluorfen 180 g/ha PE *fb* IC + HW at 40 DAS, Oxyfluorfen 180 g/ha PE *fb* imazethapyr 100 g/ha PoE and fluazifop-p-butyl + fomesafen 250 g/ha EPoE (premix) *fb* IC + HW at 40 DAS maintain their effectiveness for a longer period by providing significantly lower density and dry biomass of weeds during both the year at harvest. Further, it was observed that alone application of imazethapyr 100 g/ha PoE and fluazifop-p-butyl + fomesafen 250 g/ha PoE (premix) found poor in reducing density and dry biomass of weeds as compared to inclusion of IC + HW at 40 DAS in both the treatment. However, all these herbicide treatments recorded significantly lower density and dry biomass of weeds as compared to weedy check. Effectiveness of Oxyfluorfen as pre emergence was also reported by Vora *et al*. (2019) [7].

Yield and economics

Results revealed pod and haulm yields of groundnut was recorded significantly higher under pre emergence application of Oxyfluorfen 180 g/ha PE *fb* IC + HW at 40 Das but it was at par with Oxyfluorfen 180 g/ha PE *fb* imazethapyr 100 g/ha PoE, IC *fb* HW at 20 and 40 DAS, Oxyfluorfen 180 g/ha PE *fb* imazethapyr + imazamox 70 g/ha PoE (premix), fluazifop-p-butyl + fomesafen 250 g/ha EPoE (premix) *fb* IC + HW at 40 DAS, imazethapyr 100 g/ha EPoE *fb* IC + HW at 40 DAS, imazethapyr + imazamox 70 g/ha EPoE (premix) *fb* HW at 40 DAS. Higher yields under above treatments may be due to lower density and dry biomass Biomass of weeds leads to reduce the crop-weed competition which provides congenial condition for better growth of the crops by utilization of available nutrients, moisture, light and space throughout the growing season. The results are in accordance with the results of Poonia *et al*. (2016) and Vora *et al*. (2019) [2, 7]. Significantly the lowest pod and haulm yields were recorded under weedy check treatment.

Among different weed management practices, pre emergence Oxyfluorfen 180 g/ha PE *fb* IC + HW at 40 DAS was recorded higher gross return (`2,07,011 /ha) and net return (`2,02,799/ha) followed by Oxyfluorfen 180 g/ha PE *fb* imazethapyr 100 g/ha PoE. However, benefit cost ratio, of 3.24 and 3.22 were achieved under pre emergence application of Oxyfluorfen 180 g/ha PE *fb* imazethapyr 100 g/ha PoE and Oxyfluorfen 180 g/ha PE *fb* IC + HW at 40 DAS, respectively. Higher net return and B:C ratio was obtained due to effective management of weeds at crucial stages of the crop with adopting integration of pre-and post-emergence herbicides along with Inter cultivation and hand weeding, which resulted in higher pod yield with reduced cost of cultivation in comparison to other premix herbicides applied with integration and farmers practices. Further, IC *fb* HW at

20 and 40 DAS recorded lower BC ratio might be due to higher additional cost of cultivation.

Succeeding crops

Data presented in Table 3 indicated that application of Oxyfluorfen, imazethapyr + imazamox, quizalofop-ethyl, imazethapyr and fluazifop-p-butyl + fomesafen applied to groundnut did not show any significant differences in terms of plant stand, plant height and plant dry biomass of cotton, maize and green gram recorded at 30 DAS. This indicates that there was no any carry over/residual effect of applied herbicides in preceding groundnut crop was observed on succeeding crops. This may be due to sufficient time was available after application of different herbicides to groundnut for detoxification of the applied herbicides. Hence, all the tested herbicides used in groundnut for weed control with a tested rate are safe for growing of succeeding cotton, maize and green gram. Priya *et al*. (2017) [3] also reported that Oxyfluorfen herbicide to be secure on succeeding crops. The results are in accordance with the finding of Yadav and Bhullar (2014) [6].

Table 1: Density and dry biomass of weeds as influenced by weed management practices in summer groundnut

Treatment	Weed density at 30 DAS (no./m^2)	Weed dry biomass at 30 DAS (g/m^2)		Weed density at 60 DAS (no./m^2)		Weed dry biomass at 60 DAS (g/m^2)			Weed density at harvest (no./m^2)	Weed dry biomass at harvest (g/m^2)		
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
T1: Oxyfluorfen 180 g/ha PE *fb* IC + HW at 40 DAS	9.74^{f} (95.0)	6.47^{g} (41.0)	5.29^{g} (27.0)	3.53^{ef} (11.5)	6.83^{fg} (46.0)	6.16^{g} (37.3)	6.27^{efg} (38.4)	6.66^{defg} (43.5)	6.80^{d} (45.3)	6.19^{h} (37.3)	10.7^{e} (114)	10.0^{e} (101)
T2: Oxyfluorfen 180 g/ha PE *fb* imazethapyr 100 g/ha PoE	9.64^{f} (93.0)	5.95^{g} (34.7)	5.42^{g} (28.4)	3.57^{ef} (11.8)	7.80^{efg} (60.0)	6.96^{fg} (47.7)	7.44^{e} (54.5)	5.86^{efg} (33.6)	7.34^{d} (53.3)	6.56^{fgh} (42.7)	10.9^{e} (119)	10.4^{e} (107)
T3: Oxyfluorfen 180 g/ha PE *fb* imazethapyr + imazamox 70 g/ha PoE (premix)	9.28^{f} (85.3)	6.48^{g} (41.7)	5.56^{g} (29.9)	3.23^{ef} (9.49)	8.38^{ef} (69.7)	6.20^{g} (37.7)	8.98^{d} (80.3)	6.91^{def} (46.9)	8.29^{cd} (68.0)	8.13^{defg} (66.7)	11.7^{e} (136)	10.7^{e} (114)
T4: Quizalofop-ethyl 50 g/ha EPoE *fb* IC + HW at 40 DAS	19.5^{d} (378)	16.9^{e} (284)	7.89^{def} (61.2)	3.69^{ef} (12.6)	9.46^{de} (89.3)	12.2^{cd} (149)	6.72^{efg} (44.2)	6.09^{efg} (36.2)	8.11^{cd} (65.3)	6.67^{cdef} (74.7)	12.1^{de} (146)	11.6^{e} (135)
T5: Imazethapyr 100 g/ha EPoE *fb*IC + HW at 40 DAS	19.9^{d} (396)	10.6^{f} (113)	8.09^{de} (64.5)	3.75^{e} (13.1)	5.70^{g} (32.0)	5.82^{g} (33.3)	4.98^{h} (23.9)	4.62^{h} (20.5)	8.10^{cd} (64.7)	6.69^{fgh} (44.0)	11.9^{de} (142)	12.0^{de} (143)
T6: Imazethapyr 150 g/ha PoE	23.2^{c} (538)	19.0^{cd} (359)	10.8^{b} (116)	5.32^{b} (27.3)	14.9^{c} (221)	13.7^{c} (189)	14.5^{c} (209)	13.6^{c} (183)	10.2^{ab} (104)	9.56^{bcd} (90.7)	15.6^{c} (242)	15.1^{c} (226)
T7: Imazethapyr + imazamox 70 g/ha PoE (premix)	23.0^{c} (531)	19.5^{c} (381)	8.85^{c} (77.4)	4.70^{cd} (21.1)	18.6^{b} (347)	15.9^{b} (254)	16.9^{b} (283)	17.5^{b} (307)	11.1^{a} (121)	9.98^{bc} (98.7)	18.3^{b} (334)	19.7^{ab} (390)
T8: Imazethapyr + imazamox 70 g/ha EPoE (premix) *fb* HW at 40 DAS	22.9^{c} (526)	17.6^{de} (308)	8.22^{cd} (66.7)	4.26^{d} (17.1)	10.3^{de} (106)	7.78^{fg} (61.0)	6.09^{g} (36.2)	5.54^{gh} (29.7)	9.08^{bc} (82.7)	8.76^{cde} (76.0)	12.9^{de} (167)	11.6^{e} (135)
T9: Fluazifop-p-butyl + fomesafen 250 g/ha PoE (premix)	25.5^{b} (648)	23.4^{b} (546)	10.9^{b} (119)	5.18^{bc} (25.8)	18.9^{b} (357)	14.1^{bc} (197)	17.7^{b} (313)	17.6^{b} (308)	10.7^{a} (113)	11.1^{ab} (124)	18.9^{b} (356)	18.8^{b} (355)
T10: Fluazifop-p-butyl + fomesafen 250 g/ha EPoE (premix) *fb* IC + HW at 40 DAS	12.5^{e} (155)	10.3^{f} (106)	5.12^{g} (25.2)	3.29^{ef} (9.85)	7.73^{efg} (59.0)	8.69^{ef} (76.0)	6.66^{efg} (43.5)	6.91^{de} (46.8)	7.57^{d} (57.3)	7.67^{efgh} (58.7)	11.4^{e} (130)	11.2^{e} (125)
T11: IC *fb* HW at 20 and 40 DAS	1.00^{g} (0.00)	1.00^{h} (0.00)	1.00^{h} (0.00)	1.00^{g} (0.00)	11.7^{d} (139)	11.5^{de} (132)	7.28^{ef} (52.3)	7.36^{d} (53.6)	6.89^{d} (46.7)	7.80^{efgh} (60.0)	13.8^{cd} (190)	14.0^{cd} (196)
T12: Weedy check	31.6^{a} (1000)	28.8^{a} (831)	13.6^{a} (184)	6.20^{a} (37.6)	28.5^{a} (813)	22.5^{a} (506)	22.5^{a} (503)	22.1^{a} (488)	11.4^{a} (128)	11.9^{a} (141)	21.7^{a} (470)	21.6^{a} (469)
S. Em ±	0.63	0.57	0.21	0.15	0.72	0.61	0.34	0.35	0.43	0.52	0.57	0.70
F test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
CV%	6.3	7.1	4.7	6.6	10.1	9.7	5.7	6.1	8.5	11.0	7.0	8.7

Note: Data subjected to √(X+1) transformation. Figures in parentheses are means of original values. Treatment means with the letter/ letters in common are not significant by Duncan's New Multiple Range Test at 5% level of significance

Table 2: Yield and economics of groundnut as influenced by integrated weed management (Mean of two years)

Treatment	Pod yield (t/ha)	Haulm yield (t/ha)	Gross return (`/ha)	Additional cost over control (`/ha)	Cost of cultivation (`/ha)	Net return (`/ha)	B:C
T1: Oxyfluorfen 180 g/ha PE *fb* IC + HW at 40 DAS	3.99[a]	5.95[a]	207011	6260	64205	142806	3.22
T2: Oxyfluorfen 180 g/ha PE *fb* imazethapyr 100 g/ha PoE	3.91[a]	5.80[a]	202799	4624	62569	140230	3.24
T3: Oxyfluorfen 180 g/ha PE *fb* imazethapyr + imazamox 70 g/ha PoE (premix)	3.77[a]	5.65[a]	195653	5299	63244	132409	3.09
T4: Quizalofop-ethyl 50 g/ha EPoE *fb* IC + HW at 40 DAS	2.87[bc]	4.70[bc]	149743	7860	65805	83938	2.28
T5: Imazethapyr 100 g/ha EPoE *fb* IC + HW at 40 DAS	3.69[ab]	5.43[ab]	191301	6726	64671	126630	2.96
T6: Imazethapyr 150 g/ha PoE	1.82[d]	3.54[d]	96078	2750	60695	35383	1.58
T7: Imazethapyr + imazamox 70 g/ha PoE (premix)	1.13[e]	2.19[e]	59637	2775	60720	-1083	0.98
T8: Imazethapyr + imazamox 70 g/ha EPoE (premix) *fb* HW at 40 DAS	3.14[bc]	4.71[bc]	162966	7225	65170	97796	2.50
T9: Fluazifop-p-butyl + fomesafen 250 g/ha PoE (premix)	1.05[e]	1.65[e]	54645	2925	60870	-6225	0.90
T10: Fluazifop-p-butyl + fomesafen 250 g/ha EPoE (premix) *fb* IC + HW at 40 DAS	3.75[a]	5.55[a]	194475	7017	64962	129513	2.99
T11: IC *fb* HW at 20 and 40 DAS	3.81[a]	5.84[a]	197989	12100	70045	127944	2.83
T12: Weedy check	0.385[f]	0.905[f]	20637	-	57945	-37309	0.36
S. Em.+	0.13	0.20	-	-	-	-	-
F test	**Sig.**	**Sig.**	-	-	-	-	-
CV%	10.9	12.0	-	-	-	-	-

Note: Data subjected to $\sqrt{(x+1)}$ transformation. Figures in parentheses are means of original values. Treatment means with the letter/ letters in common are not significant by Duncan's New Multiple Range Test at 5% level of significance

Table 3: Growth parameters of succeeding crops as influenced by integrated weed management practices followed in preceding groundnut crop (Bio assay study) (Mean of two years)

Treatment	Plant stand at 15 DAS (No./m row length)			Plant height at 30 DAS (cm)			Plant dry biomass at 30 DAS (g/plant)		
	Cotton	Maize	Greengram	Cotton	Maize	Greengram	Cotton	Maize	Greengram
T1: Oxyfluorfen 180 g/ha PE *fb* IC + HW at 40 DAS	2.85	4.25	8.87	22.0	76.7	24.5	5.09	9.76	1.79
T2: Oxyfluorfen 180 g/ha PE *fb* imazethapyr 100 g/ha PoE	2.97	4.28	8.58	22.4	75.7	24.6	5.19	9.51	1.67
T3: Oxyfluorfen 180 g/ha PE *fb* imazethapyr + imazamox 70 g/ha PoE (premix)	2.90	4.22	8.68	22.7	74.1	24.4	5.00	9.41	1.68
T4: Quizalofop-ethyl 50 g/ha EPoE *fb* IC + HW at 40 DAS	2.88	4.25	8.53	22.5	75.3	25.4	5.04	9.42	1.76
T5: Imazethapyr 100 g/ha EPoE *fb* IC + HW at 40 DAS	2.90	4.22	8.73	23.5	76.1	25.3	5.24	9.83	1.86
T6: Imazethapyr 150 g/ha PoE	2.87	4.22	8.82	23.9	73.6	24.8	5.05	9.52	1.79
T7: Imazethapyr + imazamox 70 g/ha PoE (premix)	2.98	4.25	8.73	23.6	73.3	26.1	5.19	9.28	1.65
T8: Imazethapyr + imazamox 70 g/ha EPoE (premix) *fb* HW at 40 DAS	2.90	4.23	8.60	23.7	73.6	25.4	5.17	9.58	1.72
T9: Fluazifop-p-butyl + fomesafen 250 g/ha PoE (premix)	2.85	4.22	8.68	21.9	74.4	24.8	5.04	9.81	1.71
T10: Fluazifop-p-butyl + fomesafen 250 g/ha EPoE (premix) *fb* IC + HW at 40 DAS	3.03	4.18	8.70	22.5	74.4	25.9	5.07	9.86	1.74
T11: IC *fb* HW at 20 and 40 DAS	3.13	4.32	8.87	22.3	76.1	25.8	5.30	10.1	1.83
T12: Weedy check	3.10	4.32	8.72	23.4	71.6	25.6	5.07	9.32	1.65
S. Em.+	0.09	0.16	0.29	1.17	2.54	1.07	0.23	0.32	0.09
F test	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV%	7.9	10.3	9.0	13.7	9.29	11.4	12.5	8.94	12.6

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