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Weed and fertility management effects on grain yield and economics of finger millet following groundnut

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ABSTRACT

The field experiment was conducted during *Kharif* 2010 with finger millet Hebbal, Bengaluru. The finger millet crop was grown followed by groundnut during summer and continued up to 2014. The pooled data of five years of finger millet crop from 2010 to 2014 during *Kharif* indicated that application of butachlor at 0.75 kg/ha more or less gave similar grain yield (3.12 t/ha) to hand weeding twice (3.52 t/ha) due to good control of weeds. Continuous application of alachlor 1.0 kg /ha in groundnut and 2,4-D sodium salt 0.75 kg/ha in finger millet paved way for dominance of grasses particularly *Digitaria marginata*, *Dactyloctenium aegyptium* and *Echinochloa colona*, whereas pendimethalin treated plots showed higher emergence of *Commelina benghalensis*. A saving in weeding cost to an extent of ` 6,810 to ` 6,980/ha in finger millet was realized by using herbicides as compared to hand weeding. None of the herbicides affected the establishment, growth and yield of succeeding crops over the past five years, in spite of herbicides being applied continuously on the same piece of land.

Key words: Finger Millet, Groundnut, Long term herbicide usage, Weed shift

Finger millet (*Eleusine coracana* (L.)) ranks third in importance among millets in the country in both area (1.27 million ha) and production (1.91 million tonnes) after sorghum and pearl millet. It is commonly being called as *ragi* in Karnataka and it is one of the major staple foods of farming communities of Southern Karnataka. Apart from human consumption, straw is also used as fodder for the live stocks and green straw is suitable for making silage. Higher food production could be achieved by increasing the productivity of different cropping systems using improved technologies and increased cropping intensity both in rainfed and irrigated farming. Weeds are one of the major constraints in the production of finger millet. Even though, weed management strategies have been developed for finger millet and groundnut crops, the weed management strategies for finger millet-groundnut cropping system are limited. The earlier studies indicated that change in cropping system like transplanted finger millet followed by pulses have reduced the menace of *Cyperus rotundus* with concomitant increase in the density of *Portulaca oleracea* and *Digitaria marginata* (Anonymous 1998). By following transplanted finger millet - groundnut system, the density of *C. rotundus* was lowered in finger millet crop after the harvest of groundnut as a result of digging of plants at the time of harvest (Anonymous 1998, Kumara 2004). The usage of recommended herbicide(s) for the first crop in a sequence should not cause any residual effect on the succeeding crop or vice-versa. There is a need to document the shift in weed flora in a cropping system involving cereals, pulse/oilseed crops. In addition, integration of FYM along with recommended fertilizer application appeared to sustain the productivity of crops. Therefore, the effect of weed management practices along with fertility levels in cropping system of groundnut-finger millet on shifting of weed flora, yield and economics was studied.

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MATERIALS AND METHODS

The field experiment was initiated during *Kharif*, 2010 with finger millet as first crop followed by groundnut during summer as the second crop at the Main Research Station, Hebbal, Bengaluru under the jurisdiction of the University of Agricultural Sciences, Bengaluru. The soil type of the experimental site was red sandy loam with average fertility level. The finger millet - groundnut cropping system was followed from 2010 to 2014 on the same piece of land. In finger millet three weed management practices were tried, *viz.*W1- Butachlor 0.75 kg/ha (pre- emergence, within 3 days after planting, DAP), W2 - 2, 4-D NA salt 0.75 kg/ha (post-emergence, 15 DAP), *viz.* butachlor 0.75 kg/ha, 2,4-D sodium and hand weeding twice (20 and 40 DAP) which were compared with two sources of fertility levels, *viz.*

75% NPK through fertilizer + 25% N supplied through FYM, and 100% NPK supplied through fertilizers only. The gross and net plot sizes were 9.0 x 4.5 m and 8.4 x 3.9 m, respectively. Finger millet cv. *'GPU-28'* was grown as *Kharif* crop from 2010 to 2014 with a recommended fertilizer dose of 100 kg N, 50 kg P_2O_5 and 50 kg K_2O per hectare at a common spacing of 22.5 x 15 cm. As per treatment, species-wise weed density was counted at 30, 60 and at 90 DAP in 50 x 50 cm quadrant randomly at two spots per treatment, apart from taking dry weight of weeds (category-wise; sedge, grasses and broad leaf weeds). The overall grain and straw yield of finger millet obtained during 2010 to 2014 with pooled analysis of these five years have been presented in the Table 4. The weed density and dry weight of weeds - sedge, grass and broad-leaf weeds at 30, 60 and at 90 DAP were analyzed using transformation of square root of ($\sqrt{x + 1}$) and log ($\sqrt{x + 2}$), depending on the variability and presented in Table 1-3. The weed shift and the economics of weed management were also worked out.

RESULTS AND DISCUSSION

Weed flora

The major weed species found in the finger millet experimental plots were *C. rotundus,* (sedge), *Cynadon dactylon, Digitaria marginata, Dactyloctenium aegyptium, Echinochloa colona* (grasses); *Commelina benghalensis, Lagascea mollis, Ageratum conyzoides, Spilanthus acmella, Amaranthus viridis* and *Euphorbia hirta* (broad-leaf weeds). Among different categories, grasses were recorded in higher number followed by broad-leaf weeds and sedges during 30 and 60 days after planting and at harvest in finger millet crop. Similar findings have been reported by Kumar (2004).

Weed density and weed dry weight

The data pertaining to weed density and dry weight recorded at 30, 60 and at 90 DAP as influenced by weed management practices and sources of nutrients in transplanted finger millet is presented in Table 1, 2 and 3. Weed management practices significantly influenced the weed density and dry weight at all stages of finger millet crop. Butachlor 0.75 kg/ha as pre-emergence had significantly reduced the density of grasses followed by sedges and broad-leaf weeds, whereas 2,4-D sodium salt 0.75 kg/h as post- emergence application significantly controlled sedges and broad leaf weeds followed by grasses at 30 and 60 days after planting. Hand weeding at 20 and 40 DAP resulted in significantly lower weed density and dry weight as compared to the application of herbicides. Among herbicides, application of butachlor as pre-emergence herbicide at 1.0 kg/ha resulted in lower grass density whereas post-emergence application of 2,4-D sodium salt at 0.75 kg/ha resulted in lower sedge and broad-

Table 1. Effect of weed management practices on weed density at 30 and 60 DAP in finger millet in finger millet-groundnut cropping system

Treatment	At 30 DAS				At 60 DAS			
	Sedges	Grass	Broad-leaf	Total	Sedges	Grass	Broad-leaf	Total
Weed management								
Butachlor 0.75 kg/ha + with OM	(20.3)2.21	(11.5)3.08	(29)4.24	(60.8)1.74	(26.3)2.78	(19.7)1.80	(42.20)4.43	(88.8)1.90
2,4-D Sodium salt 0.75 kg/ha + with OM	(17.1)2.42	(34)5.62	(16.1)3.09	(67.2)1.79	(15.3)2.23	(49.0)2.40	(17.81)2.64	(82.1)1.83
Hand weeding + with OM	(6.70)1.51	(7.40)2.52	(13.1)2.80	(27.1)1.31	(12.3)2.12	(12.0)1.36	(18.03)2.69	(43.0)1.52
Butachlor 0.75 kg/ha - without OM	(19.9)2.38	(10.1)3.11	(27.9)4.25	(58)1.75	(25.7)2.78	(19.5)1.70	(40.75)4.27	(86.4)1.87
2,4-D sodium salt 0.75 kg/ha - without OM	(18)2.57	(34.2)5.95	(18.8)3.27	(71)1.83	(17.1)2.42	(44.5)2.49	(20.90)2.74	(83.2)1.85
Hand weeding - without OM	(7.45)1.56	(8.30)2.50	(13.3)2.81	(29.0)1.34	(11.4)2.12	(13.5)1.35	(20.22)2.73	(45.2)1.53
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Fertility level								
75% NPK+25% N through FYM	(14.7)2.05	(17.6)3.74	(19.3)3.38	(51.7)1.61	(18)2.38	(27.8)1.85	(26.01)3.25	(71.1)1.75
100% NPK	(15.1)2.17	(17.5)3.85	(20)3.44	(52.6)1.64	(18.1)2.44	(26.5)1.85	(27.29)3.25	(71.5)1.75
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Weed management								
Butachlor	(20.1)2.30	(10.8)3.09	(28.4)4.24	(59.4)1.75	(26.1)2.78	(19.8)1.75	(41.48)4.35	(87.3)1.88
2,4-D sodium salt	(17.5)2.50	(34.1)5.78	(17.4)3.18	(69.1)1.81	(16.2)2.33	(46.9)2.44	(19.35)2.69	(82.5)1.84
Hand weeding- 20 and 40 DAP	(7.08)1.54	(7.85)2.51	(13.1)2.81	(28.1)1.33	(11.9)2.12	(13.1)1.36	(19.12)2.71	(44.2)1.52
LSD (P=0.05)	0.20	0.30	0.51	0.07	0.26	0.20	0.33	0.05

OM: Organic matter; Figures in the parentheses are the original values.

Table 2. Effect of weed management practices on weed density and weed dry weight at 90 DAP in finger millet in finger millet groundnut cropping system

Treatment	Weeds' density (no./m^2) at 90DAS				Weeds' dry weight(g/m^2) at 90DAS			
	Sedge	Grass	Broad-leaf	Total	Sedge	Grass	Broad-leaf	Total
Weed management								
Butachlor 0.75 kg/ha + with OM	(27.3)2.56	(34.6)3.14	(44.7)3.32	(106.6)2.01	(17.1)4.12	(26.6)2.45	(39.7)3.15	(83.6)1.88
2,4-D Sodium salt 0.75 kg/ha + with OM	(18.6)1.91	(59.6)3.96	(30.8)2.93	(109.1)2.02	(10.5)3.16	(52.9)3.37	(21.4)2.38	(84.9)1.88
Hand weeding + with OM	(19.7)2.14	(27.2)2.89	(36.6)2.99	(83.5)1.90	(10.2)3.17	(17.5)2.30	(26.8)2.61	(54.6)1.70
Butachlor 0.75 kg/ha - without OM	(24.6)2.43	(39.6)3.16	(39.6)3.20	(103.9)2.00	(14.5)3.76	(31.2)2.51	(34)3.03	(79.8)1.87
2,4-D sodium salt 0.75 kg/ha - without OM	(22.8)2.22	(62.3)4.05	(31.2)2.83	(116.4)2.05	(12.9)3.54	(56.2)3.47	(21.7)2.29	(90.9)1.92
Hand weeding - without OM	(18.3)2.07	(23.3)2.54	(34.8)2.92	(76.4)1.87	(9.4)3.08	(14.4)1.98	(24.7)2.53	(48.6)1.66
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Fertility level								
75% NPK+25% N through FYM	(21.9)2.20	(40.5)3.33	(37.3)3.08	(99.7)1.98	(12.6)3.48	(32.3)2.71	(29.3)2.72	(74.3)1.82
100% NPK	(21.9)2.24	(41.7)3.25	(35.2)2.98	(98.9)1.97	(12.3)3.46	(34.0)2.65	(26.8)2.61	(73.1)1.82
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Weed management								
Butachlor 0.75 kg/ha	(25.9)2.49	(37.1)3.15	(42.1)3.26	(105.2)2.00	(15.8)3.94	(28.9)2.48	(36.8)3.09	(81.7)1.88
2,4-D sodium salt	(20.7)2.07	(61.0)4.01	(31.0)2.88	(112.7)2.04	(11.7)3.35	(54.6)3.42	(21.5)2.33	(87.9)1.90
Hand weeding- 20 and 40 DAP	(19.0)2.11	(25.2)2.71	(35.7)2.96	(79.9)1.88	(9.8)3.12	(15.9)2.14	(25.8)2.57	(51.6)1.68
LSD (P=0.05)	0.34	0.30	0.28	0.06	NS	0.21	NS	NS

OM: Organic matter; Figures in the parentheses are the original values.

Table 3. Effect of weed management practices on weed dry weight at 30 and 60 DAP in finger millet in finger millet-groundnut cropping system

Treatment	Weeds dry matter (g/m^2) at 30 DAS				Weeds dry weight (g/m^2) at 60 DAS			
	Sedge	Grass	Broad-leaf	Total	Sedge	Grass	Broad-leaf	Total
Weed management								
Butachlor 0.75 kg/ha + with OM	(5.39)2.13	(3.13)1.58	(12.59)3.30	(21.11)4.11	(12.68)3.55	(7.76)2.57	(23.19)4.29	(43.63)2.99
2,4-D Sodium salt 0.75 kg/ha + with OM	(4.04)1.92	(12.59)3.09	(2.29)1.65	(18.91)3.79	(5.29)2.40	(28.61)4.73	(4.43)1.96	(38.33)2.70
Hand weeding + with OM	(0.57)1.13	(0.91)1.22	(1.16)1.41	(3.24)1.65	(2.44)1.84	(3.62)1.78	(4.79)1.97	(10.8)1.56
Butachlor 0.75 kg/ha - without OM	(5.29)2.17	(2.46)1.58	(12.66)3.44	(20.41)4.24	(11.7)3.49	(7.53)2.44	(22.4)4.12	(41.7)2.92
2,4-D sodium salt 0.75 kg/ha - without OM	(4.16)1.97	(12.14)3.21	(2.81)1.72	(19.1)3.94	(5.95)2.52	(26.65)4.71	(5.70)2.12	(38.3)2.75
Hand weeding - without OM	(0.70)1.13	(1.12)1.21	(1.79)1.42	(3.60)1.66	(2.18)1.77	(3.69)1.84	(5.18)1.94	(11.1)1.53
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Fertility level								
75% NPK+25% N through FYM	(3.33)1.73	(5.54)1.96	(5.54)2.12	(14.2)3.18	(6.80)2.60	(13.33)3.03	(10.0)2.74	(30.94)2.42
100% NPK	(3.38)1.76	(5.24)2.00	(5.75)2.19	(14.7)3.28	(6.64)2.59	(12.62)3.00	(11.0)2.73	(30.37)2.40
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Weed management								
Butachlor 0.75 kg/ha	(5.34)2.15	(2.79)1.58	(12.62)3.37	(20.7)4.18	(12.2)3.52	(7.65)2.51	(22.81)4.21	(42.7)2.96
2,4-D sodium salt	(4.10)1.95	(12.6)3.15	(2.55)1.68	(19.1)3.86	(5.62)2.46	(27.6)4.72	(5.07)2.04	(38.3)2.73
Hand weeding- 20 and 40 DAP	(0.63)1.13	(1.10)1.21	(1.77)1.41	(3.42)1.66	(2.31)1.80	(3.65)1.81	(4.99)1.95	(10.9)1.55
LSD (P=0.05)	0.13	0.14	0.25	0.28	0.32	0.21	0.21	0.14

leaf density but higher grass density which compete with finger millet during the early stages of crop growth. Sources of fertility and their interaction with weed management practices did not differ significantly.

Change in weed flora due to long term use of herbicides

During *Kharif*, 1999, population of grasses, sedge and broad leaf weeds were almost similar in all the three weed management practices. After sixteen

Table 4. Effect of weed management practices on pod and straw yield in finger millet in finger millet-groundnut cropping system

Treatment	Pooled data of 5 years	
	Pod yield (t/ha)	Straw yield (t/ha)
Weed Management		
Butachlor 0.75 kg/ha + with OM	3.11	4.84
2,4-D Sodium salt 0.75 kg/ha + with OM	2.64	4.14
Hand weeding + with OM	3.45	5.18
Butachlor 0.75 kg/ha - without OM	3.13	4.89
2,4-D Sodium salt 0.75 kg/ha - without OM	2.63	4.07
Hand weeding - without OM	3.58	5.52
LSD (P = 0.05)	NS	NS
Fertility level		
75% NPK fertilizer + 25% FYM (0.25%)	3.07	4.72
100% NPK fertilizer only	3.12	4.83
LSD (P = 0.05)	NS	NS
Weed Management		
Butachlor 0.75 kg/ha	3.12	4.86
2,4-D sodium salt	2.63	4.12
Hand Weeding- 20 & 40 DAP	3.52	5.35
LSD (P=0.05)	0.21	0.22

years of detailed study, it is evident that continuous application butachlor has brought down the grass density substantially from 74.4/m^2 in 1999 to 13.3/m^2 in 2014 (Table 7). Similarly, application of 2, 4-D sodium salt has reduced the broad leaf weed density from 36.4/m^2 in 1999 to 2.8/m^2 in 2014. Continuous removal of weeds by manual weeding had reduced the weed density of all the three categories very effectively from a total weed count of 130.4/m^2 in 1999 to 14.1/m^2 in 2014. The results are in conformity with the results obtained by Channa *et al*. (2000).

Grain yield

Over five years (2010 to 2014), the grain yield of finger millet applied with fertilizer gave only yield (3.12 t/ha) which was on par with the finger millet receiving both fertilizer and FYM (3.07 t/ha). Among weed control treatments, grain yield obtained in plot treated with butachlor (3.12 t/ha) was similar to hand weeding twice (3.52 t/ha) and these were significantly superior to 2, 4-D Sodium salt (2.63 t/ha) owing to good control of grasses, as the latter treatment was effective on broad leaf weeds (Table 4). The interaction effect was non-significant.

Table 5. Long term effect of herbicides on soil physico-chemical properties in finger millet production in finger millet-groundnut cropping system

Treatment	pH	EC Ds/M	BD g/cc	OC %	P_2O_5 (kg/ha)	K_2O (kg/ha)
2,4-D sodium salt 0.75 kg/ha + FYM	6.64	0.07	1.36	0.61	88.0	172.4
2,4-D sodium salt 0.75 kg/ha without FYM	6.32	0.09	1.40	0.51	92.7	169.1
Butachlor 0.75 kg/ha + FYM	6.31	0.08	1.38	0.54	86.6	160.8
Butachlor 0.75 kg/ha + without FYM	6.41	0.07	1.33	0.50	95.0	178.0
Hand weeding + FYM	6.30	0.06	1.39	0.60	91.2	178.3
Hand weeding without FYM	6.31	0.08	1.41	0.62	87.9	162.3
Initial soil value (1999)	6.10	0.03	1.25	0.60	56.0	136.0

Initial soil value refers to the soil data at the time of start of the experiment *i.e., Kharif,* 1999.

Table 6. Economics of weed management practices in finger millet production in finger millet-groundnut cropping system

Finger millet (*Kharif*, 2014)		
Treatment	Cost of weed management (x10^3 `/ha)	Savings over hand weeding (x10^3 `/ha)
Butachlor 0.75 kg/ha	1.05	6.15
2,4-D sodium salt 80 WP 0.75 kg/ha	0.96	6.24
Hand weeding (and 45 DAP)	7.20	--

Cost of herbicides: Butachlor 50 EC Rs. 225/- litre, 2,4-D sodium salt 80 WP - ` 360/- per kilogram, application cost – ` 600/- per ha, cost of labour – ` 200/- per day(for men), ` 150/- (for women) per dayof eight hours work.

Butachlor and hand weeding treatments gave higher grain yield at both sources of fertility than 2,4-D Sodium salt treatment. Similar indications of weed control by using herbicides have been observed by Kumara (2004).

Economics of weed management

In finger millet, use of butachlor 0.75 kg/ha - 3 DAP (` 1,050/ha) and 2,4-D sodium salt 0.75 kg/ha - 15 DAP (` 960/ha) was cheaper than two hand weeding, amounting to ` 7,200/ha. Thus, a saving in weeding cost to an extent of ` 6,150 to ` 6,240/ha was observed though it gave comparable yield to butachlor (Table 6). This suggested that herbicides are economical and cost effective in managing weeds right from the initial stages as compared to hand

Table 7. Change in the weed flora due to weed management practices in finger millet during *Kharif*, 1999 to 2014 in finger millet–groundnut system

Treatment	Density of major category of weeds/m^2							
	Initial year – 1999 (30 DAP - First crop)				Final year - 2014 (30 DAP – sixteenth crop sequence) (thirty first crop in the system)			
	Sedge	Grass	Broad-leaf	Total	Sedge	Grass	Broad-leaf	Total
Weed management								
Butachlor 0.75 kg/ha + with OM	30.8	79.2	41.2	151.2	13.0	14.5	29.0	56.5
2,4-D Sodium salt 0.75 kg/ha + with OM	27.2	80.4	35.6	143.2	5.3	30.0	3.0	38.3
Hand weeding + with OM	23.2	68.4	34.0	125.6	3.3	5.0	6.0	14.3
Butachlor 0.75 kg/ha - without OM	34.0	70.0	54.8	158.8	11.7	12.0	23.5	47.2
2,4-D sodium salt 0.75 kg/ha - without OM	29.2	64.4	37.2	130.4	5.0	34.0	2.5	41.5
Hand weeding - without OM	30.4	59.6	44.8	134.8	4.3	4.5	5.0	13.8
Fertility level								
75% NPK + 25% N through FYM	27.2	76.0	36.8	140.0	7.2	16.5	12.7	36.4
100% NPK	31.2	64.8	45.6	141.6	7.0	16.8	10.3	34.2
Weed management								
Butachlor 0.75 kg/ha	32.4	74.4	48.0	154.8	12.4	13.3	26.3	51.9
2,4-D sodium salt 0.75 kg/ha	28.4	72.8	36.4	137.6	5.2	32.0	2.8	39.9
Hand weeding- 20 and 40 DAP	26.8	64.0	39.6	130.4	3.8	4.8	5.5	14.1

W1 : Butachlor 0.75 kg (pre-em.), W2 : 2,4-D sodium salt 80 WP 0.75 kg/ha (post-em.), W3 : Hand weeding (20 and 45 DAP); F1 :75% NPK through fertilizer + 25 % N through FYM, F2 : 100% NPK through fertilizers only; OM = Organic matter,100% NPK = 25 kg N,75 kg P_2O_5,38 kg K_2O per ha

weeding. Gnanamurthy and Balasubramaniyan (1998) and Kumars (2004) also obtained similar benefits in their studies.

Long term effect of herbicides on soil physico-chemical properties

The change in the physico-chemical properties of the soil due to long term application of herbicides was also studied after the harvest of crop finger millet during *Kharif* 2014 (Table 5). Continuous use of 2,4-D sodium salt or butachlor in finger millet did not affect the soil physico-chemical properties, *viz*. pH, EC, bulk density, organic carbon, contents of P_2O_5 and K_2O when compared to initial values over a period of sixteen years from 1999 to 2014. Compared to initial values, the values of these properties were slightly higher in the treatments indicating no adverse effect of herbicides applied continuously. Further, application of FYM slightly increased the organic carbon over fertilizer application alone. The continuous application of fertilizers increased the P_2O_5 and K_2O contents in the soil as compared to initial values. Phosphorus build up was slightly more in fertilizer applied plots than FYM applied plots. Similar findings were reported by Ramamoorthy *et al*. (2009).

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