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Effect of weed-management practices on nutrient depletion by weeds, yield and economics of winter-irrigated cotton (*Gossypium hirsutum*)

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ABSTRACT

A field experiment was conducted on sandy-loam soils during winter seasons of 2001–02 and 2002–03 at Bhubaneshwar, to explore effective weed management in irrigated cotton. *Eleusine indica* L. *Dactyloctenium aegyptium* (L.) Beauv., *Digitaria sanguinalis* L., *Cynodon dactylon* L. Pers. *Cyperus rotundus* L., *Cyperus iria* L., *Ageratum conyzoides* L., *Heliotropium indicum* L. and *Gnaphalum indicum* L. were the major weed flora in the unweeded control plot. Post-emergence directed spray of paraquat dichloride @ 0.2 kg/ha at 30 days after sowing with follow up hand-weeding at 60 days after sowing recorded the lowest weed population, maximum weed-control efficiency, highest plant height, leaf-area index, number of sympodia, bolls/plant and boll weight, and significantly increased seed-cotton yield, net return, benefit : cost ratio with maximum NPK uptake compared to other weed control and unweeded control due to lesser weed competition. It was followed by pre-emergence spray of alachlor @ 1.0 kg/ha at 3 days after sowing with a hand-weeding at 40 days after sowing, Weeds if not controlled within 60 days after sowing, could deplete NPK to the extent of 87.1, 17.9 and 61.7 kg/ha at 90 days after sowing.

Key words : Economics, NPK depletion, Seed-cotton yield, Weed control, Winter irrigated cotton

The productivity of cotton in Orissa is very low because the entire cotton area of the state is rainfed, low in soil fertility, affected by heavy infestation of weeds and attack of bollworm during peak square, flowering and boll-development stages. As cotton is a day neutral, indeterminate forced, annual plant, the non-traditional rice-fallows of coastal Orissa could be a potential area for winter irrigated cotton cultivation because of better availability of bright sunshine, relative humidity and crop-management practices. Among different production constraints, weeds pose serious problems if not controlled within 60 days of crop growth because of its slow initial growth, causing significant yield loss, estimated to vary from 40 to 85% under different location specific agroclimatic conditions (Brar and Brar, 1992). Keeping this in view, an attempt was made to find out a profitable weed-management practice for winter irrigated cotton cultivation in rice fallows of coastal Orissa.

MATERIALS AND METHODS

A field experiment was conducted at Bhubaneshwar during the winter season of 2001–02 and 2002–03 in sandy-loam soil, having pH 5.7, organic carbon 0.39%, and available N, P and K 234.0, 9.0 and 167.4 kg/ha respectively. The experiment using 'MCU 5' cotton was laid out in randomized block design with ten treatments having 3 replications. The crop was sown on 30 October during both the years with 60 cm × 45 cm spacing. The weed-control treatments were T_1, post-emergence directed spray of paraquat dichloride @ 0.2 kg/ha at 30 days after sowing (DAS); T_2, post-emergence directed spray of paraquat dichloride @ 0.3 kg/ha at 30 DAS; T_3, post-emergence directed spray of paraquat dichloride @ 0.4 kg/ha at 30 DAS; T_4, pre-planting soil application with incorporation of fluchloralin @ 0.8 kg/ha, T_5, pre-emergence spray of alachlor @ 1.0 kg/ha at 3 DAS; T_6, post-emergence directed spray of paraquat dichloride @ 3.0 kg/ha at 30 DAS with follow-up hand-weeding at 60 DAS; T_7, pre-planting soil application with incorporation of fluchloralin @ 0.8 kg/ha with follow-up hand-weeding at 40 DAS; T_8, pre-emergence spray of alachlor @ 1.0 kg/ha at 3 DAS with follow-up hand-weeding at 40 DAS; T_9, 2 hand-weedings at 20 and 40 DAS; and T_{10}, unweeded control. A uniform recommended fertilizer dose of 120 kg N, 17.2 kg P and 33.2 K was applied to all the treatments. The crop was grown under irrigated condition with need-based plant-

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protection measures. Weed flora, crop growth and seed cotton yield were recorded. Weed population was counted in m^2 at 90 DAS during both the years and their dry weights from the same area were subjected to square root and log transformation to normalize their distribution respectively. Nitrogen, phosphorus and potassium contents in weeds and cotton were analysed 90 DAS during both the years and their uptake were calculated from their respective elemental concentration and dry-matter accumulation at their respective growth stages. Economics of all weed-control treatments was worked out on the basis of prevailing input cost and market price of cotton. Weed-control efficiency and weed index were also worked out to assess the efficiency of different weed-control treatments.

RESULTS AND DISCUSSION

Weeds

The total weed flora of the experimental unweeded control plot at 90 DAS during both the years consisted of 22 different species of weeds, of which 6 belong to grasses, 2 to sedges and 14 to broad-leaf weeds with their relative weed density values of 25.4, 18.0 and 56.6% respectively. The total weed density was 404/m^2 with absolute density of 102.7, 72.8, and 228.5 of grasses, sedges and broad-leaf weeds/m^2 respectively. The experimental field comprised *Eleusine indica, Dactyloctenium aegyptium, Digitaria sanguinalis* and *Cynodon dactylon* among grasses *Cyperus rotundus, Cyperus iria* as sedges; and *Ageratum conyzoides, Heliotropium indicum, Gynaphalum indicum, Acanthospermum hispidum* and *Borreria hispida* as dominant broad-leaf weeds weeds.

Different weed-control treatments significantly reduced weed density and their dry weights compared to unweeded control. The unweeded control recorded the highest weed population and their dry weights (Table 1). The weeds in control plot continued their growth till maturity of the crop, indicating the need for their timely weed control. Post-emergence directed spray of paraquat dichloride @ 0.2 kg/ha at 30 DAS with a follow-up hand- weeding at 60 days after sowing significantly reduced both weed population and their dry matter to a wide spectrum of weeds comprising grasses, sedges and broad leaf at 90 DAS with highest weed-control efficiency (Table 2). Paraquat dichloride being a non-selective contact herbicide, caused the mortality of weeds by the directed spray, and the subsequent follow-up hand-weeding was highly effective in checking the further regeneration and growth of weeds under congenial soil-moisture conditions, confirming the results of Singh *et al.* (1992). Among the other herbicidal applications, pre-emergence application of alachlor @ 1.0

Table 1. Effect of weed-management practices on weed population at 90 days after sowing in winter-irrigated cotton

Treatment	Weed population/m^2							
	Grasses		Sedges		Broad-leaf weeds		Total	
	2001–02	2002–03	2001–02	2002–03	2001–02	2002–03	2001–02	2002–03
T_1	7.9*	26.5*	15.8*	22.0*	48.4*	54.6*	72.1*	103.1*
	(2.90)**	(5.16)**	(4.02)**	(4.74)**	(6.98)**	(7.42)**	(8.51)**	(10.15)**
T_2	8.13	17.5	10.5	17.7	28.5	40.2	47.1	75.4
	(2.93)	(4.21)	(3.31)	(4.22)	(5.37)	(6.37)	(6.88)	(8.71)
T_3	6.16	13.4	7.5	11.5	21.3	32.5	33.3	57.4
	(2.55)	(3.69)	(2.82)	(3.46)	(4.08)	(5.74)	(5.80)	(7.60)
T_4	40.9	44.9	30.8	32.2	71.7	77.7	143.4	154.8
	(6.44)	(6.72)	(5.58)	(5.75)	(8.49)	(8.83)	(11.92)	(12.48)
T_5	31.5	31.7	21.7	24.5	78.6	86.6	131.9	142.8
	(5.64)	(5.67)	(4.72)	(4.99)	(8.89)	(9.33)	(11.52)	(11.98)
T_6	9.8	8.6	14.6	4.9	45.3	15.1	69.7	28.6
	(3.20)	(3.02)	(3.88)	(2.33)	(6.76)	(3.94)	(8.36)	(5.40)
T_7	12.0	21.5	15.9	18.7	30.50	31.7	58.4	71.9
	(3.53)	(4.68)	(4.05)	(4.38)	(5.56)	(5.66)	(7.66)	(8.47)
T_8	13.7	19.6	9.5	13.7	23.6	26.8	46.8	60.1
	(3.77)	(4.47)	(3.16)	(3.77)	(4.90)	(5.22)	(6.87)	(7.54)
T_9	26.8	40.0	34.6	31.7	57.5	78.3	111.8	145.0
	(5.22)	(6.36)	(5.92)	(5.66)	(7.61)	(8.58)	(10.92)	(12.08)
T_{10}	92.2	102.7	90.6	72.8	207.4	228.5	390.2	404.0
	(9.61)	(10.14)	(9.54)	(8.56)	(14.41)	(15.12)	(19.76)	(20.10)
SEm±	0.22	0.31	0.20	0.24	0.43	0.42	0.56	0.34
CD (P=0.05)	0.67	0.92	0.61	0.73	1.28	1.26	1.67	1.03

* Original values; ** Figures in parentheses are square-root transformed values $\sqrt{x + 0.05}$

kg/ha with a hand-weeding 40 days after sowing (T_8), pre-planting soil application with incorporation of fluchloralin @ 0.8 kg/ha with a hand-weeding 40 days after sowing (T_7) and post-emergence directed spray of paraquat dichloride @ 0.4 kg/ha at 30 DAS (T_3) were also found effective with respect to weed-control efficiency 90 DAS and remained statistically at par with one another. Hand-weeding twice at 20 and 40 DAS (T_9) and other herbicidal treatments (T_1, T_2, T_4 and T_5) were found ineffective in containing the weed growth and their dry matter due to gradual regeneration of uncontrolled weeds under favourable soil moisture environment under irrigated condition. Post-emergence directed spray of Paraquate dichloride @ 0.2 kg/ha at 30 days after sowing with a follow-up hand-weeding 60 days after sowing (T_6) also significantly reduced the depletion of N, P and K (Table 2) by the weeds at up to 80.7, 16.2 and 57.2 kg/ha, respectively, 90 days after sowing during 2002–03 due to lowest weed population and their dry weight compared to unweeded control plot and were significantly less than that of other weed-control treatments respectively. This confirms the results of Singh and Brar (1990). This result significantly facilitated highest N, P and K uptake by the cotton crop at 90 DAS to 105.4, 21.4 and 98.3 kg/ha during 2002–03 compared to unweeded control (T_{10}) and remained statistically at par with that of other weed-control treatments like T_8, T_7 and T_3, respectively, due to increased dry matter of cotton caused by less weed competition as reflected in the higher weed-control efficiencies (Chander *et al.*, 1994) under these weed-control treatments compared to that of unweeded control.

Cotton

Different weed-control treatments significantly affected plant height, leaf-area index, sympodia, bolls/plant, boll weight and seed-cotton yield (Table 3) compared to that of unweeded control plot. Post-emergence directed spray of paraquat dichloride @ 0.2 kg/ha at 30 days after sowing with follow-up hand-weeding 60 days after sowing (T_6) significantly increased plant height, leaf-area index, number of sympodia, bolls/plant and boll weight resulted in the highest seed-cotton yield during both the years followed by pre-emergence application of alachlor @ 1.0 kg/ha at 3 days after sowing with a follow-up hand-weeding 40 days after sowing (T_8) and pre-planting soil application with incorporation of fluchloralin @ 0.8 kg/ha with a follow-

Table 2. Effected of weed-management practice on weed dry weight (kg/ha), weed-control efficiency, nutrient depletion by weed and uptake by winter irrigated cotton 90 days after sowing during 2001–02 and 2002–03 cropping seasons

Treatment	Total weed dry matter		Weed control efficiency (%)		Nutrient depletion by weeds (kg/ha)						Nutrient uptake by cotton (kg/ha)					
					2001–02			2002–03			2001–02			2002–03		
	2001–02	2002–03	2001–02	2002–03	N	P	K	N	P	K	N	P	K	N	P	K
T_1	1,437 * (3.15)**	1,647* (3.21)**	55.4	51.9	12.8	1.3	17.8	21.3	4.2	26.8	39.9	7.3	37.4	140.9	29.8	116.8
T_2	1,278 (3.10)	1,512 (3.17)	60.3	55.9	11.6	1.0	15.6	18.3	3.0	23.6	43.4	7.9	42.4	144.4	35.7	132.9
T_3	743 (2.87)	952 (2.97)	76.9	72.2	9.6	0.9	13.5	14.2	2.5	20.9	48.9	8.7	43.7	158.0	40.9	151.6
T_4	1,089 (3.03)	1,324 (3.12)	66.2	61.3	12.4	1.0	11.8	19.8	4.1	18.3	47.7	6.8	38.8	121.0	29.2	112.7
T_5	993 (2.99)	1,213 (3.08)	69.1	64.6	12.2	1.1	10.1	17.1	3.3	13.9	49.3	7.5	39.4	127.3	29.1	114.4
T_6	394 (2.59)	621 (2.79)	87.8	81.8	12.4	1.2	16.9	6.4	1.7	4.5	42.9	7.2	36.7	180.2	40.0	105.8
T_7	544 (2.73)	814 (2.91)	83.1	76.2	7.9	0.8	8.7	13.9	1.8	8.9	53.9	9.8	42.2	157.8	37.0	154.8
T_8	496 (2.69)	689 (2.83)	84.6	79.4	6.3	0.6	7.4	12.7	1.6	6.3	61.4	10.3	45.2	171.7	38.9	158.5
T_9	793 (2.89)	1125 (3.05)	77.6	67.2	6.7	0.5	6.5	5.7	4.1	16.9	62.5	9.6	41.9	128.9	30.9	125.1
T_{10}	3224 (3.50)	3429 (3.53)	0	0	58.0	5.7	41.3	87.1	17.9	61.7	29.6	6.9	19.7	74.8	18.6	67.5
SEm±	0.03	0.02			1.93	0.18	0.67	0.79	0.33	1.29	2.36	0.22	1.83	9.04	1.61	8.08
CD (P=0.05)	0.09	0.08			5.74	0.55	1.99	2.35	0.99	3.87	7.02	0.67	5.44	27.90	4.10	23.20

* Original values; ** figures in parantheses are log transformed [log (x+1)] values

Table 3. Effect of weed-management practices on growth parameters, seed-cotton yield and economics of winter-irrigated cotton (mean of 2001-02 and 2002-03)

Treatment	Plant height (cm)	Leaf area index	No. of sympodia/ plant	Bolls/ plant	Boll weight (g)	Seed-cotton yield (kg/ha)	Net returns (Rs/ha)	Benefit : cost ratio
T_1	91.9	3.62	12.4	13.7	4.0	834	6,445	1.48
T_2	92.4	3.90	14.2	14.1	4.2	993	10,110	1.75
T_3	99.6	4.01	14.8	14.6	4.3	1,269	16,545	2.21
T_4	89.5	3.79	13.6	12.9	4.0	1,034	10,812	1.78
T_5	93.6	3.86	14.0	13.6	4.2	1,126	13,014	1.94
T_6	104.2	4.14	16.9	16.6	4.4	1,487	20,704	2.41
T_7	94.5	4.04	16.0	14.9	4.2	1,292	15,940	2.08
T_8	103.6	4.12	16.7	16.0	4.2	1,398	18,474	2.25
T_9	88.6	3.97	14.7	15.3	4.0	1,184	13,532	1.93
T_{10}	72.2	1.62	10.7	7.8	3.9	597	1,190	1.09
SEm±	1.44	0.07	0.66	0.57	0.15	51	750	
CD (P=0.05)	4.29	0.22	1.96	1.71	0.41	155	2,250	

up hand-weeding 40 days after sowing (T_7) with 149, 134 and 116% increase in seed-cotton yield over unweeded control on pooled result basis. The unweeded control plot recorded significantly lowest seed-cotton yield and highest weed index (60%) due to severe weed infestation. The follow-up hand-weeding after herbicide application is the most important reason for higher yields, as it effectively removed both chemically uncontrolled weeds and the regenerated weeds growth, providing efficient control of weeds for the entire cropping season.

Economic viability

All the treatments for weed control had better economics over the unweeded control (Table 3). Post-emergence directed spray of Paraquate dichloride @ 0.2 kg/ha at 30 days after sowing with a follow-up hand-weeding 60 days after sowing accrued significantly highest net return of Rs 20,704/ha with a maximum benefit : cost ratio of 2:41 due to its season-long effective control of weeds appropriated with better growth parameters, yield attributes resulting in highest seed-cotton yield compared with rest of the weed-control treatments. However, the other weed-control treatments like T_8 (pre-emergence spray of alachlor @ 1.0 kg/ha at 3 DAS with follow-up hand-weeding at 40 DAS); T_7 (pre-planting soil application with incorporation of fluchloralin @ 0.8 kg/ha with follow-up hand-weeding at 40 DAS) and T_3, (post-emergence directed spray of paraquat dichloride @ 0.4 kg/ha at 30 DAS) were also found economically viable to control weeds in winter irrigated cotton in rice-fallows of coastal Orissa.

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