Response of cotton to NP fertilizers and cropping sequences on irrigated vertisols of the Rahad Scheme

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Abstract

Field experiments were conducted at Rahad Research Station in seasons 1986-87, 1987-88, 1991-92, 1992-93 and 1993-94 to investigate the response of cotton (*G. hirsutum*) to NP fertilizers in varying cropping sequences. Results revealed that yield differences due to 3N were not significant as compared to 1N and 2N. Response to phosphorus application at 1P and 2P were also not significant as compared to the control. Accordingly, N-fertilizers in the range of 43-86 kg N/ha (1N-2N) are recommended for *G. hirsutum* to cater for both the low input approach at 1N and the aging recommendation of 2N for the anticipated yield maximization. Neither phosphorus nor the high rate of N (3N) application are recommended for cotton (*G. hirsutum*) based on the evidence presented in this paper.

Introduction

Up to the last century, Cotton had been the mainstay of the Sudan economy with a sizeable contribution amounting to more than 40% of the Sudan total exports earnings. Today, however, cotton shares less than 5% of the foreign export earnings and was subjected to crucial challenges such as stagnating low average yield of 420 kg lint/ha as compared to the world average of 635 kg lint/ha, escalating costs of production. Low cotton prices, inefficient pest management, stickiness, subsidies in the developed countries, diminishing finances and competition from other crops that sometimes challenged the merits of continuing cotton cultivation. Hence, it had once been said: "Growing cotton is harvesting poverty".

Nitrogen had been commercially applied at 3N for cotton preceded by sorghum in the Northern section of the Rahad Scheme. This was based on the work of Burhan (1970) with Egyptian cotton in the Gezira, who found that as a precursor to cotton, cotton has the most depressing effect on yield, followed by sorghum, fallow and lubia and that in all rotations there was an increase in yield due to 3N application. Moreover, as a result of recommending phosphorous to wheat in Rahad (Babiker and Abdalla, 1991), many farmers are of the opinion that phosphorus application to cotton would also increase the productivity. However, earlier report of the NPK experiment showed that response to Phosphorus was erratic (Burhan and Mansi, 1970).

If cotton industry is to prosper and achieve competitiveness in the global economy, significant improvements in productivity and tangible reduction in the production cost must be made. In practice, however, it is difficult to improve the long-term average yield of 4-5 kantars/fed, whereas the possibility of lowering the production cost particularly that of fertilizers is there. The objective of this study is therefore to optimize the use of N, quantify the response to 3N and phosphorus in varying cropping sequences.

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Material and methods

Field experiments were conducted at Rahad Research Station for five seasons (1986-87, 1987-88, 1991-92, 1992-93 and 1993-94). The physical and chemical properties of the soil of the experimental site were described by Babiker and Abdalla (1991). The percent soil physical components are 2.4, 14.6, 10.2 and 72.8 for coarse sand, fine sand, silt and clay, respectively, and the chemical properties are:-

$NaHCO_3$ (ppm)	8.0
Total –N (ppm)	588
O.C. (%)	0.51
PH	8.4
NO_3-N (ppm)	33
EC(mmho/cm)	0.7
ESP %	4

Three field experiments were executed. The objective of experiment I and II is to find out how the variation in cropping sequence affects the response of the variety Shambat-B to rate of N-fertilizer. On the other hand, experiment III aimed at assessing the response of cotton to phosphorus and nitrogen fertilizers. The details of the experiments were as follows:

Experiment I

This experiment was conducted in seasons 1986-87 and 1987-88. It consisted of 10 treatments in factorial combinations of 5 rates of nitrogen (0N, 1N, 2N, 3N and 4N) and 2 dates of application (at sowing and 4-5 weeks later). Nitrogen was applied in form of urea, where 0N, 1N, 2N, 3N and 4N representing 0, 43, 86, 129 and 172 kg of urea per feddan. The plot size was 36 m^2. The cropping sequence was groundnut-cotton.

Experiment II

Treatments were the same as in experiment I, except that the cropping sequence was sorghum-cotton.

Experiment III

This study was conducted in seasons 1991-92, 1992-93 and 1993-94 at the Rahad Research Station. For all these seasons, cotton was preceded by sorghum. There were 12 treatments in factorial combinations of three levels of triple super phosphate viz. 0P, 1P and 2P, and 4 levels of N viz. 0N, 1N, 2N and 3N in RCBD with 4 replications. Plot size was 6 rows × 10 m × 0.8 m and net area was 4 rows × 9 × 0.8 m. Both fertilizers were side-dressed at sowing. Other cultural practices were as recommended by ARTC.

Results

Experiment I and II

Results for season 1986-87 indicated that seed cotton yield differences (Table 1) due to treatments in the groundnut-cotton sequence were of lower magnitude as compared to the sorghum–cotton sequence. The same trend was observed in season 1987-88 (Table 1). On average, seed cotton yield increases due to 1N, 2N, 3N and 4 N were 4, 9, 11 and 10 percent, respectively in the groundnut-cotton sequence. The

corresponding percent increases for sorghum-cotton sequence were 13 ,19 , 21 and 23, respectively (Table 2). However, in both cropping sequences differences between 1N, 2N, 3N and 4N were not significant. Difference in seed cotton yield due to time of nitrogen application were mostly insignificant (Tables 1). Sizeable yield increase was recorded for season 1986-87 as compared to that of 1987-88 for both cropping sequences (Table 2).

Experiment III

Results from three seasons indicated significant yield differences due to N application, but differences due to phosphorus or P×N interactions were not significant (Table 3). On average, yield increases in response to rates of N were 20, 25 and 29 percent for 1N, 2N and 3N, respectively (Table 4). However, differences between the rates 1N, 2N and 3N were not significant, except in season 1992-93, where 1N significantly out yielded 2N. The lowest seed cotton yield was obtained in season 1992-93 as compared to the other two seasons (1991-92 and 1993-94). Differences due to P application for seasons 1991-92, 1992-93 and 1993-94 were small and insignificant (Table 5).

Discussion

On average, the response of cotton. preceded by groundnut, to nitrogen was small as compared to that of sorghum. This may be attributed to the high level of total N and $N0_3$–N associated with groundnut being a precursor crop (Babiker et al, 1999). However, data for both cropping sequences indicated that yield differences between levels of N-fertilizer 1N, 2N, 3N and 4N were not significant. This was supported by the more recent experimentation. Accordingly, application of 3N to cotton (*G. hirsutum*) is not appropriate, regardless of the cropping sequence. However, the recommendation of 3N made by Burhan (1971) was for the *G. barbadense* being a long duration cotton (245 days), may not be true for Acala (150-180 days). Moreover, (Burhan, 1971) emphasized the need for scattered trials throughout the Gezira to verify the pattern of fertilizer response. Hence, the 3N recommendation was based on the findings that seed cotton yield from 0N, 1N, 2N, 3N and 4N were 4.08, 5.3, 6.11, 6.81 and 7.25 kantar/fed, respectively as obtained in the Gezira Research Farm. In the Rahad Scheme, however, 3N was commercially implemented throughout the Northern Section, with no yield increases being exhibited in the sorghum-cotton cropping sequence. Instead, rank growth and high pest infestation were observed. Therefore, based on the experimentation reported in this paper and the supported field observations, the application of 3N to cotton preceded by sorghum was abandoned.

Despite the present blanket recommendation of 2N, i.e. at 86 kg N/ha for *G. hirsutum* cotton, results obtained herein revealed that in four out of the five seasons tested, no significant differences in yields between 1N, 2N, and 3N were found. However, the effect of season was predominant, hence, seed cotton yields of more than 10 kantars/fed were obtained with 0N in seasons 1991-92 and 1993-94 as compared to 9.4 kantar/fed with 3N for season 1992-93. This was in agreement with yield fluctuation studies due to interactions between biotic and abiotic factors (Burhan, 1968). Thus, for yield maximization in response to N-fertilizer application at 86 kg N/ha, efficient pest management and perfection of cultural practices need to be granted as a prerequisite for such a high yield environment. In practice, however, the average yields are stagnating, whereas production cost are escalating. Therefore, the insignificant differences between 1N, 2N and 3N, suggest that 1N (43 kg N/ha) can be an alternative

recommendation depending on the projected yield levels in a low input approach where the chances of yield maximization were not eminent. Such approach will be enhanced via the new release of the prospective short duration varieties (140-150 day). The insignificant responses due to phosphors fertilizer were in agreement with (Burhan and Mansi, 1970). This was also in support of Peters and Fadul, (1961) who suggested that there was sufficient phosphorus for normal development of variety Acala 4-42 at Gezira.

Recommendations

Based on the evidence presented in this paper, the following recommendations are proposed:

1. Application of nitrogen fertilizer is to be recommended for cotton (*G. hirsutum*) in the range of 43-86 kg N/ha, i.e. 1N-2N, targeting both the low (1N) and the high (2N) input depending on the projected yield levels.
2. Data obtained does not justify phosphorus application for the Upland cotton (*G. hirsutum*).

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Table 1. Effect of rate and time of N-application on seed cotton yield (kg/ha) of variety Shambat-B in a groundnut-cotton and sorghum-cotton cropping sequence in 1986-87 and 1987-88.

N rate	1986-87						1987-88					
	Ground-cotton			Sorghum-cotton			Groundnut-cotton			Sorghum-cotton		
	At sowing	4-5 wks after	Mean	At sowing	4-5 wks after	Mean	At sowing	4-5 wks after	Mean	At sowing	4-5 wks after	Mean
		(±91)	**(±64)**		(±176)	(±122)		(±140)	(±98)		(±190)	(±135)
0N	2775	3147	3046 b	2775	2876	2826b	2403	2403	2403 a	2335	3406	2369 b
1N	3012	3181	3130ab	3012	3452	3232a	2640	2470	2555ab	3707	3572	2640ab
2N	3046	3282	3232 a	3046	3519	3283a	2707	2741	2758 a	2876	2944	2910 a
3N	3147	3282	3282 a	3147	3621	3384a	2707	2809	2758 a	2944	2876	2910 a
4N	3181	3113	3147ab	3181	3655	3418a	2876	2809	2842 a	2944	3012	2978 a
Mean	3032 (±41)	3201		3032 (±78)	3425		2667 (±62)	2646		2761 (±85)	2762	

Table 2. Main effect of nitrogen rate on seed cotton yield (kg/ha) and increase (%) in Groundnut-Cotton and Sorghum-cotton cropping sequences in (1986-87 and 1987-88).

Rate of N-fertilizer	Groundnut-Cotton					Sorghum- Cotton				
	1986-87	1987-88	Mean	NUE	Increase (%)	1986-87	1987-88	Mean	NUE	Increase (%)
-----	(±64)	(±98)	------	-----	-----	(±122)	(±135)	------	----	---
0 N	3046 b	2403 b	2725	0	0	2826 b	2369 b	2598	0	0
1 N	3130 ab	2555 ab	2843	2.7	4	3232 a	2640 ab	2936	8	13
2 N	3232 a	2724 a	2978	2.9	9	3283 a	2910 a	3097	6	19
3 N	3282 a	2758 a	3020	2.3	11	3384 a	2910 a	3147	4	21
4 N	3147 ab	2842 a	2995	1.6	10	3418 a	2978 a	3198	3	23
Mean	3167	2656	2912	-----	------	3229	2761	2995	-----	------

Table 3. Effect of NP fertilizers and their interactions on seed cotton yield (kg/ha) of Barac(67)B in seasons 1991-92, 1993-93 and 1993-94

Fertlizer	Season 1991-92					Season 1992-93					Season 1993-94				
	0N	1N	2N	3N	Mean	0N	1N	2N	3N	Mean	0N	1N	2N	3N	Mean
			(±274)		(±137)			(±188)		(±94)			(±201)		(±99)
0P	3147	3899	3929	3838	3703	2007	2217	2900	3046	2542	3452	4027	4128	4061	3917
1P	3528	4151	4017	4195	3973	2078	2734	3046	3181	2760	3384	3993	4061	4332	3943
2P	3632	4355	4084	4084	4039	1939	2629	3117	3323	2752	3452	3824	3993	4162	3858
Mean	3436	4135	4010	4039		2008	2527	3021	3183		3429	3948	4061	4185	
			(±158)					(±108)					(±116)		

Table 4. Main effect of N-fertilizers on seed cotton (kg/ha) of variety Barac(67)B for seasons 1991-92, 1992-93 and 1993-94 (sorghum-cotton sequence).

N rate	1991-92	1992-93	1993-94	Mean	NUE	Increase (%)
0N	3436 b	2008 c	3429 b	2958	0	0
	(10.2)	(5.9)	(10.1)	(8.7)		
1N	4135 a	2527 b	3948 a	3537	11	20
	(12.2)	(7.5)	(11.7)	(10.5)		
2N	4010 a	3021 a	4061 a	3697	9	25
	(11.9)	(8.9)	(12.0)	(10.9)		
3N	4039 a	3184 a	4185 a	3802	7	29
	(12)	**(9.4)**	**(12.4)**	**(11.2)**		
S.E(±)	158	108	116			
Mean	3905	2685	3906			
	(11.6)	**(7.9)**	**(11.6)**			

Values between parentheses are seed cotton in kantar/fed

Table 5. Main effect of P-fertilizers on seed cotton (kg/ha) of variety Barac(67)B for seasons 1991-1992, 1992-93 and 1993-94 (sorghum-cotton sequence).

P rate	1991-92	1992-93	1993-94	Mean	Increase %
0P	3703	2543	3917	3388	0
1P	3973	2760	3943	3559	5
2P	4039	2752	3858	3550	5
Mean	3905	2685	3906		
S.E(±)	137	94	99		