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NITROGEN HARVEST INDEX IN RELATION TO PRODUCTIVITY IN GROUNDNUT (*ARACHIS HYPOGAEA* L.)

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ABSTRACT

Twelve lines derived from three single crosses were used to evaluate the role of the two characters, nitrogen harvest index (NHI) and total nitrogen percentage (TN) in selection or producivity in groundnut (*Arachis hypogaea* L). The selected lines could be differentiated either by the breeding process, intermating or selfing, through which they were evolved or by their high or low yield levels. There was significant variation among the lines for TN and NHI. NHI was positively and significantly correlated with pod yield. NHI and TN together could identify the yield status of all the lines correctly. The mean values of NHI and TN were much higher in high yielding lines compared to the values of their superior progenitor parent. The reverse was true for low yielding lines. The results suggest that nitrogen harvest index is an important parameter to reckon with in programmes of yield improvement in groundnut.

Key words: *Arachis hypogaea*; Nitrogen harvest index; Yield; Nitrogen content.

INTRODUCTION

Parameters relevant to nitrogen fixation are particularly important in programmes aiming at improving productivity of self-pollinated legumes like groundnut (*Arachis hypoguea* L.). Nitrogenase activity is one such parameter and is usually taken to be a direct measure of nitrogen fixation.

As estimated *in situ* acetylene reduction technique, it is vitiated by a number of variable factors like soil moisture incubation temperature, diurnal variation and light intensity (Nambiar and Dart, 1983). Total available nitrogen (TN) ranks as an alternative since it was reported to have a direct association with nitrogenase activity (Mytton, 1983) and had also high positive correlation with grain yield (Desai and Bhatia, 1978 in durum wheat, Westermann and Kolar, 1978 in common been, Ronis et al., 1985 in soybean), Likewise, nitrogen harvest index (NHI) is another parameter reported to have high positive correlation with yield (Paccaud et al., 1985 in winter wheat, Brunner and Zapata, 1984 in field bean).

It would therefore be of interest to examine the availability of genetic variation for NHI and TN in consciously selected lines of groundnut which were differentiated either by the breeding process through which they were evolved or by their (high or low) yield levels. Using this experimental material, and an attempt is made to evaluate the role of NHI and TN in yield improvement.

MATERIALS AND METHODS

Lines generated from there crosses were used for the study. The crosses had a highly adapted *Virginia* bunch cultivar, Robut 33-1 as female and one of the accessions,

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chico, NC AC 17090 or PI 298115 as male parent. Lines were generated from each cross by one generation of intermating followed by natural self-pollination (IM) or by natural self-pollination alone (SF). From each category, one high (H) and one low (L) yielding line was chosen. The yield was assessed by a joint score across pod yield, shelling percentage and 100-kernel weight following the method of Arunachalam and Bandyopadhyay (1984). A total of 12 lines provided the experimental material (Table 1). They were grown with their 4 progenitor parents and two checks, NFG 3 and NFG 7 in a randomised block design with 4 replications. The plot size was a row of 10m length with plants spaced 10cm and rows 60cm apart. The crop was grown under normal agronomic practices and plant protection measures. 30 kg N and 50 kg P_2O_5 per hectare were applied as basal dressing and 250kg gypsum per hectare at pegging stage. Observations were made on random samples of six plants per plot. Nitrogen per cent was estimated by microkjeldahl method. Plant samples dried to constant temperature were ground to a fine powder; a homogeneous sample of 500mg was used to estimated total N percentage. Total N was calculated as total N% X dry weight of the plant. N percentage in pod walls and kernels was similarly estimated to provide pod N kernel N using which NHI 1 and NHI 2 were computed as follows:

TABLE 1. Material selected for studies on nitrogen harvest index in groundnut.

Cross	Yield potential	Lines	
		IM	SF
Robut 33-1 ×	High	(*) RCEH	RCAH
Chico	Low	RCEL	RCAL
Robut 33-1 ×	High	R9EH	R9AH
NC Ac 17090	Low	R9EL	R9AL
Robut 33-1 ×	High	R5EH	R5AH
PI 298115	Low	R5EL	R5AL

(*)XCodes used in the text.

$$\text{NHI} = \frac{\text{Kernel N}}{\text{Pod N}} \times 100$$

$$\text{NHI } 2 \quad \frac{\text{Total N}}{\text{Pod N}} \times 100$$

In addition, pod yield, shelling percentage and 100-kernel weight were also measured. The yield potential of the lines was judged by a score across the direct yield components, pod yield, shelling percentage and 100-kernel weight, following the method of Arunachalam and Bandyopadhyay (1984). The lines were assigned a performance status-High or Low, based on the scores. The utility of nitrogen harvest index and/or total nitrogen percentage in judging the performance (yield) status was

TABLE 2. ANOVA (mean squares) for various characters in groundnut

Source	d.f.		[a]Total N	[b]Nitrogen harvest index		[a]Pod yield	[b]shelling	[b]100-kernel
	a	b	(g/plant)	1	2	(g/plant)	percentage	weight (g)
Entries	17	17	16245.42*	37.40*	236.60*	15.22*	23.45*	31.47*
Lines	11	11	8763.42	19.90	177.90*	14.38*	12.66	18.85
Parents	3	3	27355.26*	96.55*	511.08*	19.09*	60.56*	73.81*
Checks	1	1	29016.83	37.07	170.24	16.85*	21.58	28.36
Rest	2	2	34845.94*	45.07	180.88*	13.15*	28.08*	38.91*
Error	51	17	8755.26	10.53	42.56	3.01	6.56	9.09

a = Based on 4 replications; b = Based on 2 replications;

TABLE 3. Mean values of various lines for some characters in groundnut.

Progenitor cross	Identity of line	Total nitrogen (g/plant)	Nitrogen harvest index		Pod yield (g/plant)	Shelling percentage	100 kernel weight (g)
			1	2			
Robut 33-1 × Chico	RCAH	448.8b	88.9a	59.8b	4.3ab	67.0a	44.7b
	RCAL	281.3a	89.1a	53.9b	2.9a	65.0a	31.8a
	RCEH	408.5ab	88.8a	53.3b	6.3b	68.1a	51.7c
	RCEL	327.0ab	88.8a	35.1a	4.2ab	65.9a	38.8b
Robut 33-1 × PI 298115	R5AL	430.3a	88.0a	40.5a	6.0a	68.6a	47.4a
	R5EH	459.8a	89.1a	50.3a	6.9a	68.4a	44.1a
	R5EL	457.0a	86.6a	41.3a	5.3a	66.8a	42.7a
Robut 33-1 × NC AC 17090	R9AL	337.3a	83.5a	23.0a	2.5a	65.3a	31.8a
	R9EH	412.0a	89.0a	48.6b	5.2b	68.4a	46.5c
	R9EL	357.3a	87.4a	41.2b	6.6b	65.4a	38.6b
C.D. at 5%		132.8	6.9	13.8	2.5	5.4	6.4

Values carrying the same letters are not significantly different.

TABLE 4. Mean values of IM and SF, High and Low lines for some characters in groundnut

Progenitor cross	Identity	Total nitrogen (g/plant)	Nitrogen harvest index		Pod yield (g/plant)	Sheling percentage	100-kernel weight (g)
			1	2			
Robut 33-1 × Chico	IM	367.8a	88.8a	56.9b	5.3b	67.0	45.2b
	SF	365.0a	89.0a	44.2a	3.6a	66.0a	38.3a
	High	428.6b	88.8a	56.6b	5.3b	67.5a	48.2b
	Low	304.2a	88.9a	44.5a	3.6a	65.4a	35.3a
Robut 33-1 × PI 298115	IM	458.5a	87.8a	45.8a	6.1a	67.2a	43.4a
	SF	415.4a	86.9a	44.5a	5.8a	66.1a	42.1a
	High	443.8a	87.5a	49.4a	6.2a	66.1a	45.0b
	Low	430.1a	87.3a	40.9a	5.7a	67.7a	40.5a
Robut 33-1 × NC Ac 17090	IM	421.1a	88.8b	44.9b	5.9b	66.9a	42.6b
	SF	384.6b	84.0a	31.3a	3.0a	65.4a	38.1a
	High	458.5b	86.1a	44.1b	4.4a	67.0a	45.5b
	Low	347.3a	86.0a	32.1a	4.6a	65.3a	[illegible]5.2a
C.D. at 5%		93.9	4.8	9.7	1.7	3.8	4.5

Values carryng identical letters are not significantly different.

evaluated by comparing the percentage of lines in which the status assigned by a particular set of characters agreed with the performance status.

The yield status of the 12 lines was assessed in two successive rainy seasons. The status remained stable only for 10 lines (except R5 AH and R9 AH). They were only considered, therefore, for drawing inferences.

RESULTS AND DISCUSSION

There was substantial variation among progenitor parents for all the characters (Table 2). The variation among lines was significant for pod yield, 100-kernel weight and nitrogen harvest index 2. The high variation among parents might be explained by the differences between the adapted cultivar, Robut 33-1, on the one hand and the three male parents which were germplasm accessions with comparatively low, yield performance, on the other.

Differences among lines derived from Robut 33-1 × Chico were observed for TN, NHI 2, pod yield and 100-kernel weight and in those from Robut 33-1 × NC Ac 17090 for the latter three traits. Lines derived from Robut 33-1 × PI 298115 failed to show differences (Table 3). Similar results were also observed, in general between 1M and SF or between High and Low lines derived from the above two crosses (Table 4).

Total nitrogen singly or in combination with nitrogen harvest index 10 could assess the High or Low performance status of all the 10 lines correctly (Table 5). Nitrogen harvest index 2 was only next in priority in the correct identification of yield status. The predictive ability of nitrogen harvest index would partly be explained by its significant correlation with pod yield and shelling percentage (Table 6) among others.

TABLE 5. Efficiency of various character combinations in predicting the yield status of 10 lines.

Character set	Number of lnes in which there was agreement
Total nitrogen	10
Total nitrogen + Nitrogen harvest index 1	10
Nitrogen harvest index 1	8
Total nitrogen + Nitrogen harvest index 2	8
Nitrogen harvest index 2	6

TABLE 6. Significant (at 5% level) correlation coefficients (r) between characters measured in groundnut.

Character combination	r
Pod yield – Nitrogen harvest index 1	0.64
Pod yield – Shelling percentage	0.64
Pod yield – Nitrogen harvest index 2	0.59
Total nitrogen - 100-kernel weight	0.67
Shelling percentage – Nitrogen harvest index 1	0.67
Shelling percentage – Nitrogen harvest index 2	0.54

The direct association of total nitrogen and nitrogen harvest index with pod yield was clearly brought out (Table 7) in their range of values between high and low yielders. Lines with high yield status and values higher than those of the better parent, Robut 33-1 for those characters; similarly lines with low yield status recorded values lower than those of Robut 33-1 (Table 7).

TABLE 7. Maximum and minimum values observed for nitrogen harvest index and total nitrogen in 12 lines and their progenitor parents in groundnut.

Mean Value		Total nitrogen (g/plant)		Nitrogen harvest index			
				1		2	
Maximum		RCAH	449	(*))		RCAH	60
		R5EH	460	R5EH	89	R5EH	50
		R9EH	412	R9EH	89	R9EH	49
Minimum		RCAL	281	(*)		RCEL	35
		R5AL	430	R5EL	87	R5AL	40
		R9AL	337	R9AL	85	R9AL	23
Significant	Robut 33-1 X Chico		+	—		+	
differences	Robut 33-1 × PI 298115		—	—		—	
in populations							
derived from	Robut 33-1 × NC Ac 17090		+	—		—	
Parents	Robut 33-1		477		85		45
.	Chico		140		90		59
	PI 298115		426		75		25
	NC Ac 17090		394		77		28

(*) NHI 1 values for all the populations derived from Robut 33-1 × Chico = 89.

Nitrogen accumulation is an important parameter in N metabolism which can be used as a criterion for selection particularly because it is indicative of biological nitrogen fixation (Mytton *et al.*, 1984). Genetic variation for N accumulation has been reported in many crops including groundnut (Williams, 1979). Nitrogen harvest index takes into account both nitrogen percentage and dry matter. It has also been reported to have constently high correlation with seed yield (Jeppson *et al.*, 1978). Nitrogen harvest index is the result of cumulative effects of a number genetically controlled activities and their interaction with environment, a reason why it can be used as an effective criterion of selection (Cregan and Van Berkum, 1984). The result that there was high agreement between yield status of lines and the status given by nitrogen harvest index 1 and total nitrogen (Table 5) was earlier obtained in other crops as well.

For instance, a re-analysis of the data on soybean from Jeppson *et al.* (1978) could show that the status allotted by total nitrogen per cent agreed with that given by grain yield in 11 and that allotted by nitrogen harvest index in 9 out of 13 genotypes. In a similar re-analysis of data on winter wheat from McNeal *et al* (1968), the status given by total nitrogen agreed in 4 out of 7 genotypes (Radhakrishna, 1986). The low agreement per cent in wheat could be explained by the low relevance of nitrogen fixation in that crop.

Further nitrogen harvest index was found to be correlated with yield and its direct components (Table 6), a result that had also been reported in other crops like soybean (Jeppson *et al.*, 1978) and *Vicia faba* (Brunner and Zapata, 1984). In addition, its correlation with harvest index was also found positive in those reports. That nitrogen harvest index can be stable over years and takes into consideration with nitrogen percentage and dry matter are reasons weighty enough to suggest the use of nitrogen harvest index with advantage in programmes of yield improvement in legumes like groundnut.

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