Influence of Soil Type on the Adaptation of Groundnut Genotypes

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Abstract

Several trials conducted at ICRISAT Center showed that the performance of groundnut on Vertisols was generally poor compared with that on Alfisols. There was a strong soil type x genotype interaction, suggesting specific varietal adaptation for soil type. Physiological studies revealed that while crop growth rates are greater on Alfisols, they are linearly related to those measured on Vertisols (R = 077). However, pod growth rates and partitioning of dry matter to pods showed a strong soil type x genotype interaction, suggesting that the genotypes developed on the Alfisol may maintain relative ranking for total dry matter on Vertisol, but not necessarily for pod yields.

Resumo

Influencia do tipo de solo na adaptacao dos genotipos de amendoim. Muitos ensaisos conduzidos no ICRISAT centro demostraram que o comportamento do amendoim nos vertisolos foi geralmente pobre comparado com dos alfisolos. Houve forte interagao tipo do solo x genotipo. Sugerindo se variedades especificas para adapta-las ao tipo de solo. Estudos fisiologicos revelaram que enquanto as percentagens de crescimento da cultura sao grandes nos alfisolos elas sao linearmente relacionadas para estas medidas nos vertisolos (R = 077). Porem, a percentagem de crescimento de vagens e participacao de materia seca para vagens demostrou forte interagao tipo de solo x genotipo, sugerindo se que os genotipos cultivados nos alfisolos podem manter relativa categoria para materia seca total nos vertisols, mas nao necessariamente para a producao de vagens.

Introduction

Groundnut *(Arachis hypogaea* L.) is an important cash crop grown on a wide range of soils and climates in the semi-arid tropics (Virmani and Piara Singh 1986). In addition to developing genotypes with tolerance for biotic and abiotic stresses, the adaptation of genotypes to varied environments is one of the major problems faced by groundnut improvement programs (Branch and Hildebrand 1989). Soil fertility problems that are likely to be very diverse and location-specific can be overcome to some extent by use of fertilizers and other amendments. However, the inherent physical properties of soil also vary with soil type (El-Swaify and Caldwell 1991), and are particularly important for groundnut, which has a subterranean fruiting habit.

Although some information is available on the effect of various components of the environment, the nature of the limitations imposed by soil conditions to groundnut growth and yield are not clearly understood, mainly because of climatic factors interacting with the performance of genotypes at different sites. It is therefore important to determine whether high-yielding genotypes developed on one soil type are adapted to other soil types.

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ICRISAT Conference Paper no. CP 812.

Nageswara Rao, R.C., Reddy, L.J., and Nigam, S.N. 1992. Influence of soil type on the adaptation of groundnut genotypes. Pages 15-18 *in* Proceedings of the Fifth Regional Groundnut Workshop for Southern Africa, 9-12 Mar 1992, Lilongwe, Malawi (Nageswara Rao, R.C., and Subruhmanyam, P., cds.). Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

At ICRISAT Center, Alfisols and Vertisols occur in close proximity, thus facilitating the study of crop growth in different soil types but under identical climatic conditions.

Soil Type x Genotype Interaction

Several trials conducted at ICRISAT Center with advanced breeding lines indicated that the performance of groundnut on Vertisols was generally poor compared with that on Alfisols (Table 1). In the trials, the soil type x genotype interaction was significant.

During the 1987 / 88 and 1988 / 89 postrainy seasons, we examined the effect of the two soil types on the growth and yield of four genotypes grown under irrigated and drought-stressed conditions. The four genotypes (ICG 1326, ICGV 87128, ICGV 87160, and ICGV 86635) were subjected to four irrigation regimes.

T_1: Adequate irrigation

T_2: Drought imposed by withholding irrigation during flowering

T_3: Drought imposed by withholding irrigation during pod-set

T_4: Drought imposed by withholding irrigation during pod filling

The three drought regimes (T_2, T_3, and T_4) spanned 25-30 days. Crop growth rates were estimated from plants sampled at 10-day intervals during crop growth.

The pooled data over the two seasons indicate that the total dry matter (TDM) on the Alfisol ranged from 10-12 t ha^{-1} and declined progressively to 6-7 t ha^{-1} as the drought occurred later in the season. However, ICGV 86635 recorded significantly greater TDM on the Alfisol compared with other genotypes in T_1, T_2, and T_3. The mean pod dry matter (PDM) on the Alfisol was 3.5 (±0.5) t ha^{-1} in T_1, and was progressively reduced to 2.0 (±0.5) t ha^{-1} in T_4 with no genotypic variation.

On the Vertisols, the mean TDM was 6.0 (±0.25) t ha^{-1}, although the drought treatments did not significantly affect the dry matter production. However, pod yield ranged from 1.0 to 1.5 t ha^{-1} in T_1 and was reduced to less than 0.5 t ha^{-1} in T_3. ICGV 86635, which had superior pod yield on the Alfisol (more than 3.5 t ha^{-1} in T_1), had the lowest yields on the Vertisol (less than 1 t ha-1), while ICGV 87160 showed superior performance on Vertisols with pod yields about 1.5 (±0.3) t ha^{-1} in T_1. ICGV 87160 was also least influenced by drought.

Table 1. Mean pod yield (t ha^{-1}) of groundnut genotypes from breeding trials grown on Alfisols and Vertisols at ICRISAT Center during the 1987/88, 1988/89, and 1990/91 postrainy seasons (values within brackets indicate the percentage coefficient of variation).

Season	No. of entries	Pod yield (t ha^{-1}) Alfisol	Vertisol	Soil x genotype (F value)
1987/88	4	3.39 ±0.122 (11.6)	1.29 ±0.131 (10.2)	4.86**
1988/89	16	3.81 ±0.154 (7.0)	1.48 ±0.127 (14.9)	6.83**
	25	3.17 ± 0.225 (12.3)	1.06 ±0.148 (24.3)	3.07**
	4	2.02 ±0.092 (15.7)	0.61 ±0.083 (19.1)	8.21**
1990/91	25	3.49 ± 0.178 (8.9)	1.56 ±0.169 (18.8)	4.95**
	16	2.49 ± 0.152 (10.6)	0.81 ±0.144 (30.9)	2.97**
	16	2.52 ±0.212 (14.6)	0.76 ±0.101 (23.0)	3.17**

** $p < 0.01$.

Table 2. The mean crop growth rate (CGR), mean pod growth rate (PGR), and partitioning of dry matter to pods *(p)* of four groundnut genotypes grown on Alfisol and Vertisol at ICRISAT Center during the 1987/88 and 1988/89 postrainy seasons.

		Alfisol			Vertisol		
Treatment	Genotype	CGR ($g\ m^{-2}\ d^{-1}$)	PGR	P	CGR ($g\ m^{-2}\ d^{-1}$)	PGR	P (%)
Control	ICG 1326	13.9	11.2	80	9.2	4.7	54
	ICGV 87128	11.5	9.6	83	8.7	4.7	56
	ICGV 87160	12.1	9.0	75	8.7	5.2	60
	ICGV 86635	16.1	10.9	67	10.9	4.5	43
Early drought							
	ICG 1326	12.9	8.7	66	8.0	3.8	48
	ICGV 87128	10.9	8.1	73	8.6	4.4	56
	ICGV 87160	12.5	9.2	61	9.1	4.5	50
	ICGV 86635	13.8	8.1	58	8.2	3.5	42
Mid-season drought							
	ICG 1326	10.0	7.0	70	6.6	2.6	43
	ICGV 87128	10.1	7.7	76	3.5	2.3	48
	ICGV 87160	9.8	7.2	73	6.8	3.7	55
	ICGV 86635	10.1	7.5	74	6.0	2.5	47
Terminal drought							
	ICG 1326	8.9	6.1	73	5.7	4.0	58
	ICGV 87128	8.1	5.3	65	5.6	3.3	58
	ICGV 87160	8.1	5.1	64	7.0	4,2	61
	ICGV 86635	9.7	6.3	65	7.2	2.9	43
SE		±0.024	±0.011	±2.3	±0.014	±0.091	±2.3

The crop growth rates (CGRs) on the Alfisol were 40% greater than on the Vertisol in T_1 (Table 2). On both soils, the CGRs declined the later the drought occurred in the season. Drought during the pod-filling phase (T_4) reduced PGRs by about 45% on the Alfisol, while the reduction in PGRs on the Vertisol in a similar treatment was only 22%. However, the pod-set phase (T_3) appeared more critical for drought on the Vertisol, where the PGRs declined by more than 40%. Partitioning of dry matter to pods *(p)* was significantly less on the Vertisol, although some genotypes were able to maintain *p* on both the soils.

The correlation of growth rates between the two soil types indicated that the CGR on Alfisol was positively correlated (R = 0.77**) with the CGR on Vertisol, but there was no such relationship for PGR (R = 0.52) and p (R = 0.38) between the two soil types.

These results imply that high-yielding genotypes developed on Alfisols may maintain relative ranking for total dry matter on Vertisols, but not for pod yields. However, it appears that productivity of groundnut can be improved on Vertisols by developing varieties with specific adaptation to this particular soil type.

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Discussion

Ndunguru: Could you expand your work to include climate? Since you have data on both regional and international trials, this would enable us to see how your proposal fits into various agroclimatic zones. Basically, this entails analyzing the data in retrospect

Nageswara Rao: I agree that the results could be expanded. With the GIS system recently installed at ICRISAT Center, we can now analyze international trials and look at the adaptation of genotypes to varied environments with a totally new perspective.

Nigam: The only problem is that we are not getting prompt feedback on information from the international trials that we send to African countries.

Syamasonta: Don't you think it would have been better to include both Virginia and Spanish types in the experiment to obtain more complete varietal information?

Nageswara Rao: In the trials presented, we included only Spanish types. We have not yet included Virginia bunches or runners, although we hope to include them in future work.

Olorunju: Our choice of varieties for different ecological zones has thus far been based on climate, rainfall, etc, without considering the effects of soil. Is it possible that when we introduce the soil factor we may end up with information that contradicts previous findings? Is the soil factor much more important than the other climatic conditions combined?

Nageswara Rao: Soil is an important factor for the adaptation of a crop like groundnut with subterranean fruiting habit. The problem of adaptation becomes important when the breeding program occurs on one type of soil and genotypes are evaluated on other soil types. What I am stressing in my paper is that apart from climatic factors, specific adaptation to soil types should also be considered where applicable.

Freire: Selection for specific adaptation is commonly accepted. But why spend time and money on selection for Vertisols if other crops like soybean or sunflower might be higher yielding, better adapted, and more economically valuable?

Nageswara Rao: Growing other crops in hostile soil environments is one of the options. However, changing of crops at the farmer's level involves considerable time and introduces significant socioeconomic considerations. Specific adaptation of genotypes of the crops already growing in a given environment should therefore be considered.

Chiteka: Specific adaptation creates a problem with seed availability. What information is there concerning soil type distribution across different zones in India and how is this incorporated into the testing sites?

Nageswara Rao: If one is hoping for improvement in yield of groundnut, specific adaptation of cultivars should be considered. In India, the groundnut-growing area is divided into six agroecological zones based on agroclimatic and soil factors. The national trials at the preliminary level are common throughout these zones. Subsequently, however, only entries that perform well are promoted to the advanced trials. The national evaluation system considers both specific and general adaptation, and varieties are released zonewise and nationwide. Scope exists to improve the present system in the light of specific adaptation of cultivars.

Anders: In what season did you conduct these trials and how much importance do you give to soil x season interactions?

Nageswara Rao: All results presented in this paper were obtained during the postrainy seson. We have not yet examined soil x season interactions.