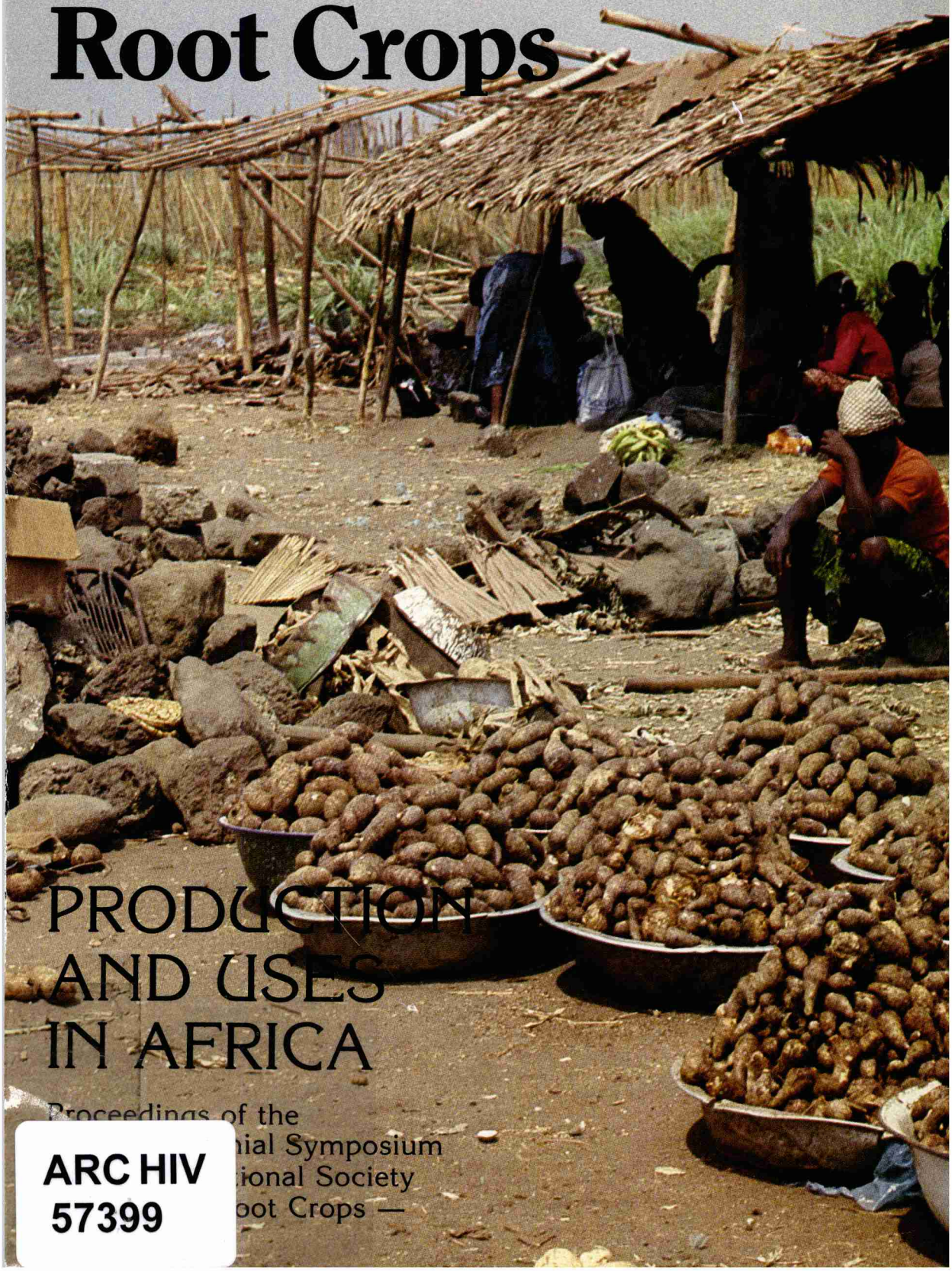
Tropical Root Crops



PRODUCTION AND USES IN AFRICA

Proceedings of the
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The International Society for Tropical Root Crops — Africa Branch was created in 1978 to stimulate research, production, and utilization of root and tuber crops in Africa and the adjacent islands. The activities include encouragement of training and extension, organization of workshops and symposia, exchange of genetic materials, and facilitation of contacts between personnel working with root and tuber crops. The Society's headquarters are at the International Institute of Tropical Agriculture in Ibadan, Nigeria, but its executive council comprises eminent root and tuber researchers from national programs throughout the continent.

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TROPICAL ROOT CROPS: PRODUCTION AND USES IN AFRICA

Abstract

A mixture of original research, updates on procedures, literature reviews, and survey reports, this document resulted from the second symposium of the International Society for Tropical Root Crops — Africa Branch, with 77 participants from 16 countries. The focus was cassava, yams, cocoyams, and sweet potatoes, from the perspectives of breeders, agronomists, soil specialists, plant pathologists, entomologists, nutritionists, food technologists, etc. Learning from past successes and failures, many of the researchers directed their efforts toward problems obstructing progress in reaching improved production and use of root crops and attempted to view, realistically, the context in which their results would be applied.

Résumé

Résultats de recherches récentes, mises à jour sur les méthodes de recherche, revues de publications et rapports de sondages sont contenus dans ce document issu du Deuxième symposium de la Société internationale pour les plantes-racines tropicales — Direction Afrique, qui a réuni 77 participants de 16 pays. Des communications sur le manioc, le taro, le yam et la patate douce ont été présentées par des phytosélectionneurs, des agronomes, des pédologues, des phytopathologistes, des entomologistes et des spécialistes de la nutrition et des aliments, entre autres. Tirant leçon de leurs succès et de leurs échecs, beaucoup de ces chercheurs ont dirigé leurs efforts vers la solution des problèmes qui entravent l'augmentation de la production et de la consommation des plantes-racines et ont tenté de considérer d'un œil réaliste le contexte qui sera celui de l'application de leurs recherches.

Resumen

Una mezcla de investigaciones originales, actualizaciones de procedimientos, reseñas de literatura e informes de encuestas, este documento es el resultado del segundo simposio de la Sociedad Internacional de Raíces Tropicales, Filial Africana, que contó con 77 participantes de 16 países. El simposio se centró en la yuca, el ñame, el cocoñame y las batatas, desde la perspectiva de los fitomejoradores, los agrónomos, los especialistas en suelos, los patólogos vegetales, los entomólogos, los nutricionistas, los tecnólogos alimenticios, etc. A partir de los éxitos y fracasos anteriores, muchos de los investigadores encaminaron sus esfuerzos hacia los problemas que obstaculizan el avance para lograr una producción y un uso mejorados de las raíces y trataron de obtener una visión realista del contexto en que los resultados pueden ser aplicados.

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TROPICAL ROOT CROPS:
PRODUCTION AND USES IN AFRICA

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PROCEEDINGS OF THE SECOND TRIENNIAL SYMPOSIUM OF THE INTERNATIONAL SOCIETY FOR TROPICAL ROOT CROPS — AFRICA BRANCH HELD IN DOUALA, CAMEROON, 14 – 19 AUGUST 1983

CONTENTS

GENETIC PARAMETERS OF CASSAVA

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We investigated six diverse cassava populations grown during 1979–80 and 1980–81 at the International Institute of Tropical Agriculture (IITA), Ibadan, to estimate genetic parameters for 22 traits of cassava. The data, when analyzed, revealed that: considerable variation existed both within and between the populations for most of the characters; the coefficients of variation for phenotype and genotype were largest for root yield (85% and 62%, respectively), quite large for the roots per plant and root size (60% and 40%), moderate for harvest index and total number of branches (45% and 30%, respectively), and low (less than 30% and 15%) for stem girth, canopy width, and plant height at harvest. Heritability estimates as well as expected genetic gain also varied considerably. On average, root yield and number of roots showed moderately high heritability (50%) and high expected response to selection (88% and 64%, respectively). Relatively high heritability values were obtained for harvest index (49%) and dry-matter content (52%), but they were associated with expected genetic gains of only 50% and 29%, respectively. Agronomic traits such as stem girth, canopy width, and plant height at harvest showed moderate-to-low heritability values (32–42%) associated with low expected genetic advance (15–18%).

Cassava breeding programs have been primarily based on selection for yield and have not included physiological or morphological characters in selection procedures. It would, therefore, be useful to have a quantitative statement of the relative importance of heredity and environment in determining the expression of characters.

In asexually reproduced plants, like cassava, any combination of genetic factors that yields a superior genotype can be used through clonal propagation. In such circumstances, all genetic variability can be used and heritability estimates have meaning (Hanson 1963).

This study was initiated to estimate certain genetic parameters of various cassava traits. Heritability is in most cases taken as a valid statistic for describing the relative variability inherent in a character and must represent a practical concept to have utility in plant breeding. The expected response to selection under a particular selection scheme supplies the practical information the breeder desires, and heritability estimates provide important information regarding advances that may be expected from selection. High heritability indicates that selection of desirable genotypes on the basis of phenotypic performance is likely to be effective.

MATERIALS AND METHODS

We conducted two separate field studies using different cassava populations at the International Institute of Tropical Agriculture (IITA), Ibadan. One, conducted during the 1979 growing cycle, utilized two genetically broad-based composites — A from African sources and B from Latin America and India, 45 and 42 genotypes, respectively. The other study conducted during the 1980 growing cycle, utilized mature cuttings of seedlings from four segregating F_1 families produced from crosses between Isunikankiyan × 58308 (35 offspring), TMS 30395 × Isunikankiyan (35 offspring), 58308 × 60506 (25 offspring), and 60506 × TMS 30395 (20 offspring). Both studies were harvested at 12 months; the experimental design was a randomized complete block, with four replications. In each replication, for each genotype, four stem cuttings were planted in single rows, 1 m × 1 m. Observations were made on 22 traits.

Coefficients of variation (CV — %) were com-

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Table 1. Phenotypic (PCV) and genotypic (GCV) coefficients (%) of variation of characters of six cassava populations.

	A		B		Families from Isun. × 58308		30395 × Isun.		58308 × 60506		60506 × 30395		Mean	
Character	PCV	GCV	PCV	GCV	PCV	GCV	PCV	GCV	PCV	GCV	PCV	GCV	PCV	GCV
Root yield	115.92	88.50	119.27	83.19	65.67	45.63	52.31	36.08	103.19	87.40	50.44	30.17	84.48	61.83
Roots/stand	98.46	72.17	99.90	68.99	43.44	26.04	34.46	21.66	48.84	43.66	34.30	24.11	59.90	42.77
Root size	88.24	29.41	77.11	48.77	61.49	27.50	41.67	26.35	74.43	52.63	40.00	40.00	63.82	37.44
Harvest index	64.28	45.46	78.57	55.56	35.71	22.59	37.04	23.42	40.00	40.00	35.71	15.97	48.55	33.83
Dry matter, roots	13.16	8.22	15.84	10.94	11.80	9.50	10.27	7.18	11.77	8.45	12.29	9.57	12.52	8.98
Starch	22.85	13.16	25.11	14.13	33.88	24.56	30.91	18.75	21.96	15.78	19.02	10.67	25.62	16.18
HCN														
Roots	40.02	33.79	34.99	22.87	38.41	21.25	38.57	12.78	39.21	22.96	57.88	24.30	41.51	22.99
Leaves	28.90	15.97	27.46	16.98	17.81	10.47	22.12	11.95	20.25	12.33	24.76	12.00	23.55	13.28
Nodes/stand	33.07	24.55	38.80	31.60	39.15	31.20	33.92	26.51	37.24	31.59	31.67	24.31	35.64	28.29
Branching height	34.35	26.85	46.85	39.53	43.20	32.98	41.84	33.09	47.42	39.61	38.40	27.36	42.01	33.24
Flowering														
Age	21.64	12.49	30.13	24.84	19.56	16.76	18.63	12.73	30.72	28.63	22.06	18.93	23.79	19.06
Height	33.09	22.68	39.55	31.13	35.40	29.99	37.04	29.82	44.76	40.90	32.43	27.46	37.05	30.33
Resistance														
CMD	34.88	24.78	32.26	22.81	20.64	14.69	23.64	18.78	30.72	22.76	17.56	13.00	26.62	19.47
CBB	35.47	18.02	35.05	21.70	29.51	10.43	26.77	5.47	35.58	20.86	30.04	10.01	32.07	14.42
Angle of forked branches														
1st	16.52	8.47	11.82	8.16	15.07	10.05	12.35	9.45	13.63	7.50	11.00	6.85	13.40	8.41
2nd	13.66	8.03	11.17	6.75	11.94	7.62	14.59	9.28	14.06	8.35	9.93	7.32	12.56	7.90
Stem girth	26.80	14.00	21.28	13.13	18.96	11.49	12.04	6.16	16.07	12.07	15.22	12.20	18.40	11.58
Height at harvest	26.46	16.43	18.98	12.03	17.97	11.67	11.52	6.71	21.83	16.36	11.84	3.65	18.10	11.14
Canopy width	35.09	17.92	33.08	13.73	27.73	17.45	22.44	11.98	26.96	13.66	23.17	17.31	28.08	15.34
1st forked branches/stand	20.58	9.60	20.24	9.44	19.68	11.36	20.08	4.10	21.07	7.15	24.49	14.72	21.02	9.40
Branches/stand	49.95	32.70	38.60	24.40	45.59	26.11	31.04	19.93	57.87	49.23	39.91	18.45	43.83	28.47
Stems/stand	39.93	17.86	47.11	23.11	34.40	19.39	37.83	25.66	33.16	21.98	28.00	19.34	36.74	21.22

Table 2. Broad-sense heritability (h^2) in % and expected response to selection (R) (% of mean and i = 5%) of cassava traits in six cassava populations.

					Families from									
	A		B		Isun. × 58308		30395 × Isun.		58308 × 60506		60506 × 30395		Average	
Character	h^2	R	h^2	R	h^2	R	h^2	R	h^2	R	h^2	R	h^2	R
Root yield	44.63	106.56	47.78	117.65	48.06	65.24	47.47	51.03	71.79	152.80	35.66	37.20	49.23	88.41
Roots/plant	53.80	109.03	47.66	98.37	35.95	32.22	39.43	28.04	79.86	80.32	48.48	34.59	50.86	63.76
Root size	14.44	26.47	38.15	62.07	24.14	30.44	40.00	41.67	57.14	89.47	38.46	32.00	35.39	47.02
Harvest index	41.44	54.88	54.38	88.01	44.49	32.70	50.00	38.15	75.00	61.80	28.75	21.15	49.00	49.45
Dry matter, roots	38.99	105.68	47.71	15.56	64.81	15.76	48.93	10.35	51.52	12.50	60.72	15.38	52.11	29.21
Starch	33.20	17.00	32.46	15.90	52.57	24.43	37.30	14.70	48.97	15.78	31.47	12.33	39.33	16.69
HCN														
Roots	71.26	58.75	42.74	30.80	30.62	24.23	10.97	8.72	34.27	27.68	17.63	21.02	34.58	28.53
Leaves	30.53	18.17	38.27	21.65	34.60	12.69	29.15	13.29	37.06	15.46	23.47	11.97	32.18	15.54
Nodes/plant	55.12	37.55	66.31	53.00	63.50	51.21	61.06	42.67	71.97	55.20	58.92	38.44	62.81	46.35
Branching height	61.10	43.24	71.22	68.73	58.29	51.87	62.53	53.90	69.77	68.16	50.78	40.17	62.28	54.35
Flowering														
Age	33.32	13.35	67.98	36.92	73.35	37.49	46.67	20.78	86.89	47.62	73.66	34.56	63.63	31.79
Height	46.96	32.01	61.98	50.49	71.75	52.33	64.82	49.46	83.49	76.98	71.72	47.91	66.79	51.53
Resistance														
CMD	50.70	36.43	49.52	32.91	50.27	21.37	62.79	30.58	54.91	36.94	53.79	19.46	53.66	29.62
CBB	25.34	18.52	38.21	27.59	10.21	6.21	2.89	15.94	33.03	24.21	11.85	7.33	20.66	16.63
Angle of forked branches														
1st	26.29	8.95	47.67	11.60	44.44	13.80	58.60	14.90	30.24	8.49	38.76	8.78	41.00	11.09
2nd	34.57	9.73	36.50	8.40	40.74	10.02	40.91	12.23	35.30	10.22	55.08	11.27	40.52	10.31
Stem girth	27.30	15.07	40.46	17.74	36.72	14.24	26.35	6.54	56.12	18.58	63.93	20.06	41.81	15.38
Height	38.54	21.01	40.15	15.70	42.20	15.62	33.90	8.05	56.18	25.26	9.52	23.22	36.75	18.14
Canopy width	26.08	18.85	17.24	11.75	39.61	22.63	28.50	13.17	25.67	14.26	55.80	26.63	32.15	17.32
1st forked branches/stand	20.30	8.61	19.26	8.03	32.92	13.34	5.74	2.37	12.09	5.25	35.44	17.88	20.96	9.25
Branches/stand	42.84	44.08	39.95	31.77	32.79	30.79	41.22	26.36	72.36	86.27	21.37	17.57	41.76	39.47
Stems/stand	19.47	16.02	23.27	21.58	32.08	22.73	46.15	35.96	44.13	30.14	10.96	6.32	29.34	22.29

puted as suggested by Burton (1952): $100\sigma/\bar{X}$ where σ is the standard deviation and $\bar{X}$ is the mean of the trait. Broad-sense heritability (h^2) was estimated as $h^2 = \sigma^2g/\sigma^2p$ where σ^2g is the genotypic variance and σ^2p is the phenotypic variance (Allard 1960). Response to selection (R) was predicted as $ih^2\sigma p$ where i is the standardized selection differential at 5%, h^2 is the heritability, and σp is the phenotypic standard deviation.

Results and Discussion

Among the various characters studied (Tables 1 and 2), root yield, on average, had the largest phenotypic and genotypic CV (85% and 62% respectively); dry matter in roots and angle of second forking branches had the least phenotypic (about 13%) and genotypic (9% and 8% respectively) CV. Although phenotypic CV for root size (64%) was somewhat higher than that for number of roots (60%), the opposite was true for genotypic CV. The phenotypic and genotypic values were smaller for stem girth (18% and 12% respectively); plant height at harvest (18% and 11% respectively); and canopy width (28% and 15% respectively).

Heritability and genetic advance for the different characters studied varied considerably (Table 2). Moderately high heritability associated with high genetic advance was observed for root yield, number of roots/plant, and branching height in most of the populations. Aggarwal and Kang (1976) observed high genetic gain associated with high heritability values for some characters in horse gram and postulated additive gene control for these characters. Additive genes are probably also operating in cassava for such traits, and, consequently, direct selection, applied on the traits, can be expected to produce worthwhile results.

Moderate-to-high heritability in characters such as plant height at flowering, number of days to flowering, harvest index, resistance to cassava mosaic disease, and dry matter in roots was associated with relatively lower genetic gain, indicating a somewhat limited scope for further improvement by selection. The low expected genetic gain for these characters, despite their high heritability, mainly reflected their low genotypic CV. Some characters such as stem girth, plant height at harvest, and canopy width had low heritability values associated with low expected genetic gain. A large proportion of the variability observed in these traits was caused by environment.

Root size showed fairly low heritability (35%), with a sizable expected genetic gain of 47%, indicating the possibility of significant progress in improvement through selection and supporting the findings from another study at IITA in which heritability for root size was estimated to be 37% (IITA 1975).

The additive portion of the genotypic variance for some of the characters may be small, but this possibility is not important if selection is being done on clonal material because the nonadditive portion can be fixed vegetatively (Hanson 1963). As genetic advance in cassava is measured by the potential of clonal types, estimation of heritability as in this study could be quite useful for plant-breeding programs.