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TECHNOLOGICAL PROGRESS AND CROP PRODUCTION IN JAMAICA
1968 to 1976

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Introduction

The land/man ratio in Jamaica was estimated to be six (6) acres of arable land per agricultural worker in 1975 (3). This ratio is likely to become smaller over time, since the agricultural labor force is increasing at a faster rate than available arable lands. Given this low land/man ratio, we are more directly interested in maximizing output per unit of the relatively scarce land resources, rather than maximizing output per man.

In this paper, a long-term increase in productivity (per acre) will be used as the criterion for measuring technological progress in crop production in Jamaica. Recognizing that most of the increases in productivity (per acre) result from the expanded use of improved biological and chemical inputs, this criterion essentially measures the rate of progress in the availability and use of improved biological and chemical technologies.

This paper is divided into three sections. The first section examines the productivity trends for the principal crop industries--food-crops, sugar-cane and bananas--in order to evaluate the question of technological progress in crop production. The second section examines the productivity levels in crop production in order to evaluate the potential for technological improvement. The actual productivities obtained in Jamaica are compared with (a) those expected under recommended production techniques, (b) those obtained under special farm programs, and (c) those obtained in other Caribbean territories with similar climatic conditions. The third section compares the trends and levels of productivity on small-scale and large-scale farms in order to determine whether there was any relationship between technological progress and farm size.

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1. Productivity Trends in Crop Production

Productivity growth rates for food-crops, sugar-cane and bananas are presented in Table 1. Food-crop productivities increased by 1.69 per cent per annum during the period 1968-1976; however, most of the increases occurred during the pre-1972 period which recorded a growth rate of 3.87 per cent per annum. Productivities declined by 0.38 per cent per annum during the post-1972 period. These data reveal that there was evidence of rapid technological progress in the food-crop industry during the pre-1972 period; however, most of these gains were lost during the post-1972 period.

Productivity growth rates for sugar-cane and bananas compared unfavorably with those observed for the food-crop industry. This probably resulted from the policy emphasis on domestic agriculture relative to export agriculture. During the period 1970 to 1976, sugar-cane and banana productivities declined by an average of 2.1 per cent and 8.8 per cent per annum respectively.

TABLE 1
Productivity Growth Rates for the Principal
Crop Industries, 1968-1976

Crop Industries	Compound Annual Growth Rates (Per Cent)		
	1968-1976	1968-1972	1972-1976
Food-Crops	+1.69	+3.76	-0.38
Sugar Cane	-2.10*	-3.50*	-1.90
Bananas	-8.80*	+10.30*	-10.60

*These data were computed from 1970.

Source: (i) Statistical Yearbook of Jamaica, Department of Statistics, 1976.
(ii) Annual Report, Ministry of Agriculture, Jamaica, 1975.
(iii) Banana Board, Kingston, Jamaica

Sugar-cane productivities recorded a higher annual decline during the pre-1972 period relative to the post-1972 period, while banana productivities recorded a positive growth rate during the pre-1972 period and a negative growth rate during the post-1972 period.

It is interesting to note that each of the principal crop industries--food-crops, sugar-cane and bananas--recorded a decline in productivity growth rates during the post-1972 period. This may have resulted from the foreign exchange problems which the Jamaican economy experienced during this period; consequently, the imports of improved biological, chemical and mechanical technologies were severely restricted. It is also conceivable, however, that declining productivities in any crop industry may be due to a high incidence of new pests and diseases, rather than an actual decline in the use of improved biological and chemical technologies.

A more detailed picture of the technological problems in the food-crop industry is provided by the data in Table 2. Five of the ten commodity groups--legumes, condiments, plantains, Irish potatoes and yams--recorded negative productivity growth rates during the period 1968 to 1976. Moreover, the relative decline in productivity growth rates observed for the food-crop industry during the post-1972 period was also observed for most of the commodity groups except cereals (corn), vegetables and condiments.

Productivity increases for corn were due to the expanded use of improved hybrid corn varieties and fertilizer which were made available to farmers through a government subsidy. The increases in corn productivity were therefore a result of improvements in both the quantity and quality of inputs used in corn production. This provides an excellent example of the potential for promoting agricultural development in Jamaica through investments to improve the quantities and qualities of the inputs utilized.

It is not certain whether the relative increases in productivity growth rates for vegetables and condiments during the post-1972 period were due to improvements in the quantities or qualities of inputs, or both; however, it is believed that the import substitution policies for food products may have succeeded in stimulating both the production and productivities of condiments and vegetables, to the extent that domestic market prices rose sufficiently to induce producers to expand production. This was observed for onion prices and production.

TABLE 2

GROWTH IN PRODUCTIVITY PER ACRE OF FOOD CROPS HARVESTED
JAMAICA, 1968-1976

COMMODITIES	COMPOUND ANNUAL GROWTH RATES (PER CENT)			RANK
	1968-1976	1968-1972	1972-1976	
Legumes	-2.26	-3.45	-3.07	9
Vegetables	1.31	-2.15	2.27	5
Condiments	-4.44	-14.98	-0.41	10
Fruits	2.40	6.43	1.30	3
Cereals (corn)	8.16	5.37	17.50	1
Plantains	-1.64	2.92	-4.29	7
Irish Potatoes	-1.91	4.08	-4.12	8
Sweet Potatoes	1.51	3.77	1.37	4
Yams	-0.28	0.85	-1.23	6
Other Tubers	3.35	5.68	1.98	2
ALL ITEMS	1.69	3.87	-0.38	

SOURCE: Statistical Yearbook of Jamaica, 1976

It is also conceivable that productivity increases in any enterprise may be merely due to improvements in production techniques, with the input quantities and qualities remaining unchanged. In any event, the exact sources of productivity increases could only be determined if data were available on the quantities and qualities of inputs utilized. These data are suggested for future collection.

2. Productivity Levels in Crop Production

In this section, productivity levels are evaluated in order to determine the potential for technological improvement in crop production. The actual productivities obtained in Jamaica are compared with (a) those expected under recommended production techniques, (b) those obtained under special farm programs, and (c) those obtained in other Caribbean territories with similar climatic conditions.

(a) Actual vs Expected Productivities

In Table 3, the highest productivities obtained for some of the more important commodities are compared with the minimum productivities expected under recommended production techniques. Recommended production techniques refer to the general procedures outlined in the Extension bulletin prepared by the Ministry of Agriculture. Productivity levels considered by Agronomists to be attainable are also reported. Productivity levels which are lower than the minimum expected are considered to be absolutely low, while those which are lower than the attainable levels are considered to be relatively low.

The highest productivities recorded for most of the commodities--except onions and Irish Potatoes--were lower than the minimum expected, and can therefore be considered as absolutely low. Compared to the attainable productivities, however, the highest productivities obtained for onions and Irish Potatoes can be considered as relatively low.

TABLE 3

HIGHEST PRODUCTIVITIES OBTAINED FOR SELECTED FOOD CROPS AS A
PERCENTAGE OF EXPECTED PRODUCTIVITIES UNDER RECOMMENDED
PRODUCTION TECHNIQUES,¹ JAMAICA, 1968-1976
(SHORT TONS PER ACRE)

Commodities	Highest Produc- tivities	Expected Productivities		Highest as A % of Expected Produc- tivities	
		Minimum	Attainable	Minimum	Attainable
Red Peas	0.32	0.40	1.15	80%	28%
Gungo Peas	0.34	0.60	n.a.	57%	-
Cabbage	3.99	6.00	n.a.	67%	-
Carrots	3.80	5.00	8.00	76%	48%
Tomatoes	4.29	5.00	n.a.	86%	-
Onions	4.92	4.00	8.00	123%	62%
Corn	0.82	1.00	2.80	82%	29%
Plantains	4.63	n.a.	n.a.	-	-
Irish Potatoes	4.71	3.75	7.00	126%	67%
Sweet Potatoes	3.70	4.00	n. a.	93%	-
Yams (negro)	7.00	8.00	16.00	88%	-
Cassava	4.07	8.00	n.a.	51%	-

- SOURCE: ¹ Recommended production techniques refer to the procedures outlined in the Extension bulletin prepared by the Ministry of Agriculture.
- (i) Statistical Yearbook of Jamaica, 1976
 - (ii) Personal interview with Mr. C. Clemetson, Agronomist, Department of Crops and Soils, Ministry of Agriculture.
 - (iii) Personal interview with Dr. H. Payne, Agronomist Caribbean Agricultural Development Institute, U.W.I. Mona.
 - (iv) Handbook for Credit Officers, Vol. 1 Crop Husbandry Guide, Jamaica Development Bank.

An ANOV test was conducted to determine the significance of the differences between the highest productivities and the minimum expected productivities. The results of this test are presented in Table 4.

TABLE 4
Analysis of Variance

	Sum of Squares	Degrees of Freedom	Mean Square	F-Ratio
Category Means	3.75	1	3.75	F = 0.65
Within	114.61	20	5.73	F .95 (1.20) = 4.35
Total	118.37	21		

The computed F-value of 0.65 was less than the Tabled F-value of 4.35. The differences in the means of the highest productivities and the minimum expected productivities were not statistically significant at the 5 per cent level; however, there may still be many opportunities for technological improvement in the food-crop industry, considering that the comparison was made between the highest productivities obtained and the minimum productivities expected under recommended production techniques.

(b) Productivities Under Special Farm Programs

A further evaluation of the productivity levels obtained in Jamaica and the opportunities for technological improvement can be made by examining the effects of the Self-Supporting Farmers Development Program (SSFDP). This was essentially a supervised credit program for small farmers with farms between 5 to 25 acres in size.

Table 4 provides data on the productivity levels for selected commodities before and after the program. The national average productivity levels for these commodities are also provided. All of the food-crop commodities recorded productivity increases after the program. These increases ranged from 39 per cent for cassava to 532 per cent for guno peas. The results of an ANNOV test to determine the significance of the productivity differences before and after the program are presented in Table 5.

TABLE 4
CHANGES IN PRODUCTIVITY PER ACRE FOR SELECTED COMMODITIES BEFORE AND AFTER LOANS,
S.S.F.D.P., JAMAICA, 1970-1976

Commodities	Productivity Before Loan (tons/acre)	Productivity After Loan (tons/acre)	Per Cent Change in Productivity Per Acre (%)	National Average Productivity, 1972-1976 tons/acre	After Loan productivity as a Per Cent of National Average (%)
Gungo Peas	0.31	1.96	532	0.30	653
Cabbage	1.90	4.10	116	3.42	120
Carrots	1.60	3.00	88	3.41	88
Tomatoes	1.90	3.90	105	3.71	105
Irish Potatoes	1.30	3.50	169	3.73	94
Sweet Potatoes	1.70	2.60	53	3.48	75
Yams (Negro)	1.50	4.00	167	5.02	80
Cassava	3.80	5.30	39	3.83	138

SOURCE: S.S.F.D.P. Socio-Economic Evaluation Report,
December 1977.

TABLE 5
Analysis of Variance

	Sum of Squares	Degrees of Freedom	Mean Square	F - Ratio
Category Means	12.88	1	12.88	F = 12.88
Within	14.03	14	1.00	F .95 (1.14) = 4.60
Total	26.91	15		

The computed F-value of 12.88 exceeded the Tabled F-value of 4.60. The differences in the mean productivities before and after the program were therefore statistically significant at the 5 per cent level. This result confirms that there are tremendous opportunities for promoting technological progress in the food-crop industry through increased investments in improved inputs, including management.

The productivities obtained after the program were also compared with the national average productivities. Four of the commodities--gungo peas, cabbage, tomatoes and cassava -- recorded productivities which were higher than the national average. The results of an ANOV test to determine the significance of the differences between the mean productivity after the loan and the national average productivity are presented in Table 6.

TABLE 6
Analysis of Variance

	Sum of Squares	Degrees of Freedom	Mean Square	F-Ratio
Category Means	0.14	1	0.14	F = 0.09
Within	19.81	14	1.42	F .95 (1.14) = 4.60
Total	19.95	15		

The computed F-value of 0.09 was less than the Tabled F-value of 4.60. The differences in the mean productivities after the program and the national average productivities were not statistically significant at the 5 per cent level. This result suggests that programs for promoting technological progress in the food-crop industry should be more productive if targeted to farms of similar characteristics to those in the SSFDP.

(c) International Productivity Comparisons

Another evaluation of the productivity levels obtained in Jamaica can be made by a comparison with the productivities obtained in other Caribbean territories with similar climatic conditions. This external comparison also serves as a test of the realism and feasibility of the internal criteria--minimum and attainable expected productivities--which were used earlier for evaluating productivity levels.

The countries selected for comparison with Jamaica were Barbados, Cuba, Guadeloupe, Haiti and Trinidad. These countries ranked highly among the more productive Caribbean territories with respect to the commodities selected for comparison.

Productivity data for the selected territories are presented in Table 7. The following conclusions can be derived from an analysis of the data in Table 7.

- (i) The average productivities for the selected territories were similar to, and in many cases higher than, the minimum productivities expected in Jamaica under recommended production techniques. This confirms the realism and feasibility of the minimum expected productivities;
- (ii) for all the commodities studied, the productivities obtained in Jamaica were lower than the average obtained for the selected territories. This confirms the findings that productivities in Jamaica were absolutely low;
- (iii) inadequate data on attainable productivities in Jamaica (Table 3) did not permit a satisfactory appraisal of this productivity criterion; however, a comparison of the highest productivities obtained in Jamaica (Table 3) with the highest obtained in the selected Caribbean

TABLE 7
PRODUCTIVITY COMPARISONS OF SELECTED FOOD CROPS IN SELECTED CARIBBEAN TERRITORIES,
1970-75
(SHORT TONS PER ACRE)

Commodities	Barbados	Cuba	Guade- loupe	Haiti	Trinidad	Jamaica	Average for all terri- tories	Jamaica as a Per cent of the Highest Territory
Gungo Peas ¹	-	-	-	0.24 ^f	0.75	0.31	0.43	41%
Cabbage ²	2.62	6.38 ^f	6.75	4.60	11.51	3.15	5.84	27%
Carrots ²	3.13 ^f	-	4.46	-	11.90	3.15	5.66	26%
Tomatoes ²	2.81 ^f	2.58 ^f	5.37	9.45 ^f	6.14	3.70	5.01	39%
Onions ²	5.08 ^f	2.83 ^f	-	3.83 ^f	-	3.49	3.81	69%
Corn ¹	1.41 ^f	0.43 ^f	0.87	0.47 ^f	1.46	0.65	0.88	45%
Irish Potatoes	-	4.91 ^f	3.37	6.33 ^f	-	3.70	4.58	58%
Sweet Potatoes	3.87 ^f	1.71 ^f	6.13	2.23 ^f	4.31	3.43	3.61	56%
Yams ¹	6.09 ^f	-	-	10.71 ^f	7.04	5.09	7.23	48%
Cassava ¹	11.81 ^f	2.98 ^f	4.60	1.91 ^f	5.40	3.70	5.07	31%

f: F.A.O. Estimate

¹ Average Yields for the period 1973 to 1975.

² Average Yields for the period 1970 to 1975.

SOURCE: F. A. O. Production Yearbook, Volume 29, 1975.

territories (Table 7) reveals that, for many commodities, attainable productivities in excess of 50 per cent of their highest productivities were feasible. This implies a significant technological gap between Jamaica and the other Caribbean territories with respect to these commodities.

The results of an ANOV test to determine the significance of the differences between the means of the highest productivities in Jamaica and the other Caribbean territories are provided in Table 8 below:

TABLE 8
Analysis of Variance

	Sum of Squares	Degrees of Freedom	Mean Square	F - Ratio
Category Means	70.28	1	70.28	F = 6.56
Within	192.79	18	10.71	F _{.95} (1.18 = 4.41)
Total	263.07	19		

The computed F-value of 6.56 exceeded the Tabled F-value of 4.41. The differences in the means of the highest productivities between Jamaica and the other Caribbean territories were statistically significant at the 5 per cent level. Jamaica can therefore benefit from the production techniques employed in gungo peas, cabbage, carrot and corn production in Trinidad; onion and cassava production in Barbados; sweet-potato production in Guadeloupe; and tomato, Irish potato, and yam production in Haiti.

3. Productivity and Farm Size

The final section of this paper is concerned with the relationship between technological progress and farm size. Productivity trends and levels on large-scale and small-scale farms in the sugar-cane industry will be compared. This industry is selected since it provides the best dichotomy

between small-scale and large-scale farming.

Table 9 provides data on sugar-cane and sugar productivities for estates and farmers. The data for farmers represent a combination of small-scale and medium-scale farms usually less than 100 acres in size, most of which are less than 25 acres. Estates are usually in excess of 500 acres.

During the period 1972 to 1976, sugar-cane productivities on the estates declined by 4.79 per cent per annum, while sugar productivities declined by 2.82 per cent per annum. On the other hand, sugar-cane productivities on the small and medium farms increased by 1.94 per cent per annum, while sugar productivities increased by 3.51 per cent per annum. These data reveal an apparent technological decline on the estates and a technological improvement on the small and medium farms. Perhaps, the declining productivities on the estates were due to a high incidence of new pests and diseases rather than an actual decline in the use of improved biological and chemical technologies.

On the average, sugar-cane and sugar productivities were higher on the estates than on the small and medium farms. Estates recorded sugar-cane and sugar productivities of 27.67 tons and 2.72 tons per acre respectively. While the small and medium farms recorded productivities of 24.82 tons and 2.44 tons per acre respectively. These data suggest a higher level of technology on the estates.

TABLE 9
SUGAR-CANE PRODUCTIVITIES, CONVERSION RATIOS, AND SUGAR PRODUCTIVITIES; FARMERS AND
ESTATES, JAMAICA, 1972-76

Years	Sugar Cane Productivities (tons cane/acre harvested)		Conversion Ratios (tons cane/ton sugar) 96 °		Sugar Productivities (tons sugar/acre harvested)	
	Estate	Farmers	Estate	Farmers	Estate	Farmers
1972	31.00	23.30	10.59	10.49	2.92	2.22
1973	29.95	24.53	10.47	10.47	2.86	2.34
1974	28.00	25.00	10.01	10.10	2.79	2.47
1975	18.80	26.65	9.71	9.88	1.93	2.69
1976	30.61	24.61	9.91	10.00	3.08	2.46
Average 1972-76	27-67	24.82	10.14	10.19	2.72	2.44

Source: (i) Economic Survey, Jamaica, 1976.
(ii) Annual Reports, All Island Jamaica Cane-Farmers
Association, 1971-1976.

The results of two ANOV test to determine the significance of the differences between the mean sugar-cane and sugar productivities on the small and large farms are presented in Tables 10 and 11.

TABLE 10
Analysis of Variance
(Sugar-Cane Productivities)

	Sum of Squares	Degrees of Freedom	Mean Square	F - Ratio
Category Means	20.37	1	20.37	F = 1.49
Within	109.53	8	13.69	F _{.95} (1.8) = 5.32
Total	129.90	9		

The computed F-value of 1.49 was less than the Tabled F-value of 5.32. This implies that the differences between the mean sugar-cane productivities on the small and large farms were not statistically significant at the 5 per cent level.

TABLE 11
Analysis of Variance
(Sugar Productivities)

	Sum of Squares	Degrees of Freedom	Mean Square	F - Ratio
Category Means	3.19	1	3.19	F - 26.58
Within	0.94	8	0.12	F _{.95} (1.8) = 5.32
Total	4.13	9		

The computed F-value of 26.58 exceeded the Tabled F-value of 5.32. The differences between the mean sugar-productivities on the small and large farms were statistically significant at the 5 per cent level. These results suggest that the large farms were utilizing better sugar-cane varieties than the small and medium farms, i.e., varieties with a higher sugar content. The large farms were therefore more advanced in the use of improved biological technologies.

Summary and Conclusion

Given the low land/man ratio in the Jamaican economy, maximizing output per acre was thought to be more critical than maximizing output per man. A long-term increase in productivity (per acre) was therefore used as the criterion for measuring technological progress in crop production.

Evidence of technological decline in the principal crop industries were provided by the negative productivity growth rates recorded for sugar-cane and bananas during the period 1968 to 1976, and for food-crops during the post-1972 period. There was also evidence of technological decline for most of the principal food-crop commodity groups, except cereals (corn), vegetables and condiments (onions) during the post-1972 period.

It was suggested that most of the declining productivity in the food-crop industry during the post-1972 period was due to a relative decline in the use of improved biological and chemical technologies. This suggestion was supported by the rapid productivity increases observed for corn as a result of a government subsidy on improved hybrid corn and fertilizer. There was some evidence that increasing onion productivities were also due to the higher domestic market prices resulting from the import substitution policies; however, it is suggested that policies to achieve rapid productivity growth in the food-crop industry should also include programs which make the improved technologies more readily available to farmers.

An examination of the productivity levels obtained in Jamaica revealed that productivities were low when compared with (a) the minimum expected under recommended production techniques, and (b) the levels obtained in other Caribbean territories with similar climatic conditions. Opportunities for increasing productivities through increased investments in improved technologies were again confirmed by the results of the Self-Supporting Farmers Development Program--which recorded significant productivity increases after the Program.

An examination of the productivity trends and levels on the small/medium and large-scale farms in the sugar industry revealed an apparent technological decline on the large-scale farms and a technological improvement on the small and medium farms; however, there was a significant difference between the sugar productivities on the small/medium and large farms, implying that the large farms employed a higher level of biological technologies. It was suggested that the declining productivities on the estates were probably due to a high incidence of new pests and diseases rather than an actual decline in the use of improved biological and chemical technologies.

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