THE ROLE OF RESEARCH IN MODERNIZATION OF AGRICULTURE WITH SPECIAL REFERENCE TO FERTILIZATION

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Israel's success

Agricultural research in Israel is the basis of this paper. In Israel there was no agricultural tradition, land and water was limited and the agricultural worker had aspirations for a standard of living at least equal to that of the industrial and services workers. Improvement of agricultural practices and crop yields relied heavily on research. in fact, the advanced level of present-day agriculture in Israel is mainly a result of research and of the ready implementation of it's results into practice.

Yields

Much has been achieved and Israel now compares favourably with the best in the world.

(i) Wheat yields obtained in Israel are given in Tables 1 and 2.

TABLE 1 Comparison of wheat yields obtained in GAT in the southern plain of Israel.

Year	Rainfall	Grain Yield
	mm	kg/ha
1943/44	298	800
1949/50	545	1 350
1978/79	304	4 100
1978/79	304 + 100 (irrigation)	6 640

TABLE 2 Average wheat yields obtained in dryland farming according to rainfall (winter)

Rainfall	Average Wheat Yield
mm	kg/ha
180 - 280	2 000 - 3 500
280 - 400	3 000 - 4 500
Above 400	5 000 - 7 000

(ii) Some further examples are of cotton yields where the variety Accala SJ-2 under irrigation, gives an average yield of 1 400 kg/ha cotton + 3 200 kg/ha seed and the attainable yield is 2 500 kg/ha cotton + 5 000 kg/ha seed.

(iii) Pest-resistant green peppers yield about 40 - 60t/ha.

(iv) Tomatoes cultivated under greenhouse condition with about 1 000 m^3 of water per 0,2 ha given in drip irrigation yield 150 t/ha.

Constraints

The genetic yield potential of most crops is much greater than the yields obtained in practice. Obviously in the everyday agriculture yields are constrained by various factors. One of the primary tasks of crop and soil scientists is to identify the agronomic constraints on crop yields and to find ways, through research, of removing as much as possible of these constraints. A limited nutrient supply to crops is one of the major constraints on crop yields and effective fertilizer application is a major input for improving yields.

Research

Several research activities in Israel significantly improved the understanding of crop responses to fertilizer application.

(i) Yield equation

Relation between the level of an available nutrient in the soil and crop yield has to be expressed in a quantitative way for any rational approach to predicting fertilizer requirements. Quantization of this relationship was based on the Mitscherlich yield equation, by using a statistical approach for solving the parameters of the yield equation according to crop yield data collected in field experiments (Black, 1955). The somewhat altered Mitscherlich equation is:

$$\text{Log}(A - y) = \log A - (cx + c_1 b)$$

where A = maximal yield attainable under given conditions.
y = yield obtained for given values of x and b
x = nutrient added (fertilizer application)
b = nutrient available (soil analysis)
c and c_1 are constants

Although, at the beginning, calculation of these parameters, requiring a numerical solution of the equation, were very cumbersome, today a computer programme solves them quickly and easily. A measure of plant nutrient availability, independant of the method used, and in fact a direct function of the crop response, was obtained by calculating crop yield parameters from the same equation. In addition the yield equation parameters serve for quantitative comparison of effectiveness of compounds, forms or methods of fertilizer application.

This research resulted in the use of yield equation parameters as exact tools for measuring crop response to fertilizers, estimating availability of nutrients in the soil and comparing nutrient sources. They provided a sound basis for predicting crop response to fertilizer application according to soil testing. The practice of soil testing is very well developed in South Africa and the fertilizer industry renders in this respect a remarkable service to the farming community.

(ii) **Phosphate**

A major breakthrough in understanding phosphate fertilizer reactions in soils was the definition of crystalline structure and chemical composition of the reaction products. (Lindsay, Frazier & Stephenson, 1962; Larsen and Widdowson, 1970). This research gave a sound basis for evaluating P soil testing methods and helped to explain the variability of results obtained in testing the availability and effectiveness of phosphate fertilizers in soils varying in their characteristics.

(iii) **Nitrogen**

Research contributed significantly towards improving the prediction of nitrogen fertilizer requirements. First, it was recognized that the supply of soil available nitrogen to crops depended on the rate of transfer of nitrogen bound in complex organic compounds in the soil into simple compounds. (Stanford & Hanway, 1955; Hagin & Ravikovitch, 1959; Stanford, Carter & Smith, 1974). Accordingly the following equation was proposed for calculating the optimum nitrogen fertilization rates (Stanford, 1973):

$$N_f = \frac{(N_y - N_s)}{E_f}$$

where N_f = amount of fertilizer nitrogen (N) to be applied

N_y = quantity of N contained in the expected crop

N_s = residual and mineralizable N in the soil

E_f = fraction of N_f recovered by the crop

A refinement of nitrogen requirement prediction was obtained by programming a computer simulation model on nitrogen changes and movement in soil, taking into account, in addition to the mineralization potential, environmental factors decisive in N leaching, fixation, denitrification and uptake (de Wit, 1972; Hagin, Amberger, et al, 1976).

(iv) **Potassium**

Research on energies of retention and of exchange of potassium in relation to soil minerals led to an improvement in estimating potassium availability (Woodruff, 1955).

$$\Delta F = RT\ell n \frac{cK}{\sqrt{cCa + cMg}}$$

where ΔF = free energy of exchange
R = a constant
T = absolute temparature
c = concentration in mol/ℓ

Free energy measurements proved to be a better indicator of soil available potassium than the conventional measuring of exchangeable potassium. This is another example of basic research on soil minerals contributing to better fertilization practices.

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