Vol XXI
No. 4

ISSN 0019-5014

CONFERENCE
NUMBER

OCTOBER-
DECEMBER
1966

INDIAN JOURNAL OF AGRICULTURAL ECONOMICS

INDIAN SOCIETY OF
AGRICULTURAL ECONOMICS,
BOMBAY

INTENSIVE DEVELOPMENT APPROACH TO AGRICULTURAL DEVELOPMENT—INTENSIFYING CEREAL PRODUCTION FOR BETTER ECONOMIC RETURNS

S. L. CHOWDHURY*

Assistant Professor of Farm Management
Division of Agricultural Economics
Indian Agricultural Research Institute, New Delhi

The people-food ratio is the most important issue facing India today. The urgency of its solution calls for a preference of short range ventures over the long range projects which, even when they are launched, take decades to complete and be productive. Of all the short range factors capable of immediately increasing crop production in a traditional agriculture, the largest yields and most substantial returns on the capital invested come from chemical fertilizers. In fact, it has been estimated that an extra application of 1 million tonnes of nitrogen can wipe out India's food deficit and an additional 0.2 million tonne of this nutrient each year will cope with the increase in her population.

At times there is a tendency among policy-makers to indulge in a kind of intellectual anarchy—some advocating a single factor solution for all the ills that a country's agriculture is heir to, others vehemently holding that the complexity of local conditions makes each situation unique and that no knowledge gained in one place is transferable to another. This is unfortunate. There is enough basic farm knowledge for almost universal application.

Fertilizers add to the natural supply of plant nutrients in the soil. Nutrient needs of crops are fairly definite. For instance, a 1,000 pound per acre crop of paddy rice needs about 30 pounds of nitrogen, 10 pounds of phosphorus and 25 pounds of potassium. To double this yield, the supply of nutrients available to the crop plants must be twice as much. It is as simple as 1, 2, 3. It is known that most of the soils of the tropics and sub-tropics supply only about 30 pounds of nitrogen a year. This limits the yield of most cereals to 800-1,200 pounds per acre. Where water is not a limiting factor, even the existing crop varieties would yield much more than the present average yield if nitrogen is added to the soil as a chemical fertilizer. The inter-dependencies among the inputs are strong but it could be safely generalized that even on irrigated lands sown to high yielding crop varieties the limit to output will be set by the availability of plant nutrients in the soil. Unless the level of nutrients is raised by adding mineral fertilizers, yields will be low. It is an established fact of agronomy that irrigation water is most efficiently utilized only in conjunction with commercial fertilizers. The grain yields in pounds per acre of some cereals per inch of soil water used are approximately of the following order :

---

* The author is grateful to Dr. S. S. Bains, Professor of Agronomy, who guided the study reported.

(*grain yields in lbs. per acre*)

Crop	Fertilized	Unfertilized
Wheat	170	30
Barley	160	77
Oat	208	46
Maize	250	50
Paddy	70	20
Bajra	150	40

The need for provision of irrigation facilities of any type over all the potentially feasible area of cultivated land is indisputable in the first instance. The subsequent yield levels of crops on these lands are, however, determined by the rates of fertilizers used in the production of these crops. It is equally obvious, also, that the new fertilizer-responsive, non-lodging (dwarf) and diseases-resistant crop varieties will benefit relatively much more from fertilizer use than the existing varieties.

CEREAL CROPPING PATTERNS WITH AND WITHOUT FERTILIZER USE

In a system of non-fertilizer use only one cereal crop is grown in a year on any piece of land. This is necessary because cereals are exhaustive crops and, unlike the legumes, can make use of only that fraction of soil nitrogen which becomes usable due to biological activities in the soil (about 30 pounds per acre in a year). Consequently, two crop sequences are in common practice. The *kharif* cereals are succeeded in *rabi* by such non-cereals as gram, pea, etc. The *rabi* cereals (wheat, etc.) are preceded by a period of fallowing in the monsoon season. This sequence effectively restricts the extent of area that can be sown either to the *kharif* cereals (maize, paddy, jowar or bajra) or to *rabi* cereals (wheat, barley, etc.). Apart from the low yields of cereals, there is, thus, a clear restriction on the area that can be sown to these crops in the absence of fertilizer use.

On dry lands this restriction on cereal acreage will continue; since on these lands the facility of fertilizer application cannot be availed of due to limited moisture supply in these soils. *Kharif* cereals can, for good reason, follow only some *rabi* legumes which restore soil fertility and wheat, etc., must follow a period of fallowing with frequent cultivation of the soil to conserve moisture through weed control and to help natural biological agencies transform unavailable soil nitrogen into the usable form (nitrate).

On irrigated lands (currently 20 per cent of cultivated area), soil fertility is no longer a limiting factor in crop production as the soil nutrient supply can be adequately augmented through needed amounts of fertilizers. Removal of this restrictive element permits an intensification of cereal cropping patterns. *Rabi* cereals can follow *kharif* cereals on the same land and *vice versa*. Expansion

of acreage under all cereals (irrigated) without fear of yield reduction, thus, becomes a pragmatic proposition. Fertilizers substitute admirably for land in irrigated farming. As will be shown in the subsequent section, fertilizer use, in fact, enhances considerably both the output and economic returns of cereal enterprises and thus places these enterprises at par, if not higher, with such competing cash crops as sugarcane, cotton and vegetables.

One possible objection to continuous cereal growing that may be voiced is the supposedly unfavourable effect of this sequence on the physical conditions of the soil. Wilkinson[1] has furnished twenty years' data establishing that continuous cereal growing does not create any problem of soil condition under normal management practices. The overall status of most soils actually improved over the period.

EXPERIMENTAL EVIDENCE

In a five-year study Chandnani[2] grew wheat in various rotations and reported the following yields and net profit per acre :

TABLE I

	Rotation	Maize yield maunds/ acre	Wheat yield maunds/ acre	Net profit (Rs./acre) for rotation
A	Maize—fallow	14.0	—	9.1
B	Fallow—wheat	—	19.6	226.1
C	Maize—wheat	16.8	12.7	155.0
C_1	Fallow—wheat + 20 lbs. N/acre	—	23.0	222.0
D	Maize (10 tons farm manure/acre)—wheat	15.8	16.1	150.2
E	Maize—peas	14.2	—	134.9
F	Green manure (60 lbs. P_2O_5/acre)—wheat	—	23.1	222.7
G	*Kharif* legume (60 lbs. P_2O_5/acre) — wheat	—	15.0	210.2
H	Maize (green manure in alternate rows with 60 lbs. P_2O_5 acre) — wheat	12.7	15.1	134.4

Note : Maize yields were not significantly different in any rotation.

The use of fertilizers in the above rotations is conspicuous by its absence. Perhaps, the attempt was to improve upon the economics of the traditional fallow-wheat sequence by introducing double cropping with maize or introducing green manuring with needed amounts of phosphatic fertilizers. As is obvious from the above table no pattern was found superior to the fallow-wheat rotation which, in fact, yielded the highest return of Rs. 226/acre (=Rs. 558/hectare). Apparently, neither the output nor the economic returns of wheat crop could be increased without tackling the problem of soil fertility through fertilizer use.

1. B. Wilkinson, "Continuous Cereal Growing," *Agriculture*, Vol. 73, No. 4, 1964, pp. 162-166.
2. J. J. Chandnani, "Studies on the Value and Economics of Green Manuring," *Indian Journal of Agronomy*, Vol. II, No. 4, 1958, pp. 209-213.

It was to enquire into the output potential and economic returns of wheat production with fertilizer use that a study was conducted for two years (1962-64) at the farm of the Division of Agronomy, Indian Agricultural Research Institute, New Delhi. Several years' work at the Institute had shown that excellent wheat yields can be secured after such *kharif* cereals as maize, paddy or bajra. The most dreaded crop to precede wheat is jowar (sorghum). In this study wheat (N.P. 823) was grown after a fodder crop of jowar. Four levels of nitrogen (0, 30, 60 and 90 kgs. N/ha.) were used for the wheat crop over a basal dressing of 50 kgs./ha. of P_2O_5 and 25 kgs./ha. of K_2O. The jowar crop received a dressing of 25 kgs. N/ha. each year.

A combined study of the nitrogen response curves gave the following yield equation :

$$Y = 17.2113 + 0.3598x - 0.0016x^2.$$

An optimum economic dose was calculated from the above response equation by the following formula :

$$X = \frac{\frac{p}{q}}{2c} - b$$

where X = optimum economic dose of nitrogen, p = cost per unit (kg.) of nitrogen, q = price per unit (quintal) of wheat grain and b and c are the linear and quadratic coefficients, respectively, in the response equation. A dose of 101 kgs. of nitrogen per hectare was found to be the optimal rate at which profit will be maximized. Yields and returns from nitrogen application to wheat following another cereal crop (jowar) are shown in Table II.

TABLE II—YIELDS AND RETURNS FROM APPLICATIONS OF NITROGEN TO WHEAT FOLLOWING SORGHUM FODDER

Level of nitrogen (Kg.N/ha.)	Grain yield (quintal per ha.)	Added yield (quintal per ha.)	Value of added yield at Rs. 50 per quintal (Rs./ha.)	Cost of added N at Rs. 1.80/ kg. (Rs./ha.)	Net profit over preceding levels (Rs./ha.)	Net returns per Re. 1 invested in N at specified level
0 ..	17.2	—	—	—	—	—
30 ..	26.6	9.4	470.00	54.00	416.00	7.70
60 ..	33.0	6.4	320.00	54.00	266.00	4.92
90 ..	36.6	3.6	180.00	54.00	126.00	2.33
101* ..	37.2	0.6	30.00	19.80	10.20	0.51
110* ..	37.4	0.2	10.00	16.20	—6.20	—0.38

* Yields at these levels were calculated from the response equation. Other yields are those actually obtained.

These yields and returns from an adequately fertilized wheat crop are in striking contrast with those of the unfertilized wheat crop in different rotations reported in the preceding text. In this study, the unfertilized crop gave a net profit of Rs. 490 per hectare. The first level of 30 kgs. N/ha. yielded an additional profit of Rs. 416. The second and third units of nitrogen gave added profits of Rs. 266 and Rs. 126, respectively. The calculated gain from an application of another 11 kgs. N/ha. also brought in a net gain of Rs. 10.20. Nitrogen application beyond this point did not pay. Application of 101 kgs. N/ha. thus yielded a net profit of Rs. 818 over and above the net profit of Rs. 490 per hectare from the unfertilized crop. This made a net profit of Rs. 1,308 per hectare from the wheat crop alone. When the net profit of Rs. 576 per hectare from the preceding sorghum crop is added to the profit from wheat, the yearly net returns total upto a goodly sum of Rs. 1,884. It is also important to point out that in these calculations of income the value of wheat *bhusa* has not been included. This by-product is a valuable cattle feed and sells about one-fifth the price of grain.

In terms of net returns per Re. 1 invested in nitrogen, it may be noted that the net return of Rs. 7.70 for each Re. 1 invested upto 30 kgs. N/ha. was indeed very attractive. For the next level of nitrogen, the return continued to be handsome at Rs. 4.90 for each Re. 1 invested. The return of Rs. 2.33 for each Re. 1 invested in the highest level of nitrogen tried could not be taken as a poor dividend.

The study has conclusively indicated that fertilizer inputs in a cereal rotation enhance very considerably both their yields and economic returns. In fact, without fertilizer use the annual income from cereal growing is so low that they cannot compete with many non-cereal cash crops.

The evolution of new fertilizer-responsive varieties of cereals (wheat, maize, paddy, jowar and bajra) encourages the scientists' belief of an early closure of the food gap. Yields of 6.5 tons of wheat (Sonora 64) and 4.1 tons of jowar (CHS No. 2) per hectare have already been obtained at the Institute.[3] In about a decade wheat yields have been quadrupled and maize yields doubled in Mexico.[4]

3. M. S. Swaminathan, "Genetic Manipulation of Fertilizer Effectiveness," *Fertilizer News*, Vol. 10, No. 12, 1965, pp. 13-18.
4. John Strohm, "Mexico Closes the Food Gap," *The Reader's Digest*, Vol. 89, No. 532, 1966, pp. 35-39.