MAXIMUM YIELD SYSTEMS WITH SPECIAL REFERENCE TO MEY

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Summary

Everywhere in the world yields obtained by farmers are far below the potential. Yields must be increased on a global scale to meet the food needs of the world nationally to increase food self-sufficiency for the farmer to reduce unit production costs and to increase income. It is important to analyse the contribution of various factors to yield increase and to demonstrate their use in practical farming.

Maximum yield systems are discussed with examples from Europe, the USA and the Far East where up to 14 t/ha wheat, 14 t/ha rice and 22 t/ha maize have been grown. Methods vary in detail but all are based on skilful soil and crop management and on increased use of inputs. The interactions of the input factors in yield building are discussed.

It is important for research to establish maximum possible yield but the aim of the farmer is maximum economic yield. This point of maximum economic yield is a little below, but close to maximum yield. Yields rise with increasing expenditure on inputs and at the same time unit production costs fall up to the point of maximum economic yield. This is particularly important where agricultural prices are low and increasing yield may decide not just profit but actual survival of the farmer. The outstanding role of fertilizer among the input factors is stressed; it is a most profitable investment and absolutely essential for maximum economic yields.

Introduction

In a world where population is increasing rapidly there is an increasing threat of food shortage and therefore there is every reason why priority must be given to making the best possible use of scarce land resources through increasing crop yields. While in some parts of the developed world yields are at a level which ensures self-sufficiency with some surplus for export, there are countries which were formerly food exporters but now depend on imports. In many developing countries appreciable parts of the population subsist on an inadequate food supply while the farmers have insufficient income; the need to import food imposes strain on scarce resources in foreign exchange. There is an equal need to increase production of industrial crops, an important source of national income.

The same applies to the individual farmer, even in highly developed agricultures. Here rising production itself imposes a strain, there is a tendency for produce prices to decline while fixed costs remain at a high level. The farmer reacts by aiming for yet higher yield, thereby lowering production costs.

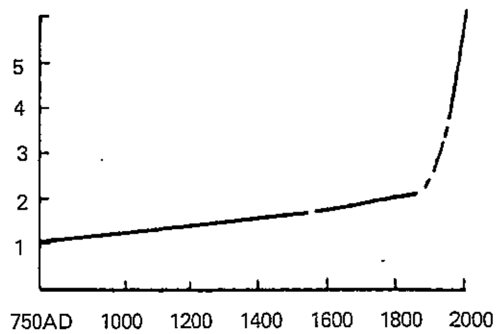
Even in the most highly developed countries, average yields are far below the best yields obtained by individual farmers and on experimental stations but even the latter are known to be considerably below the known potential yield. While maximum possible yield is not always achievable at an economic cost, "research on maximum yield will identify the factors which limit yield, show how they interact and how they may be overcome" (Cooke 1982). With this knowledge it is then possible to advise farmers as to how they should go about producing — under their own financial and environmental conditions — the maximum economic yield, i.e. maximum profit.

The problem is discussed here in the context of the major cereal crops, taking examples from the work which has been done in a number of countries.

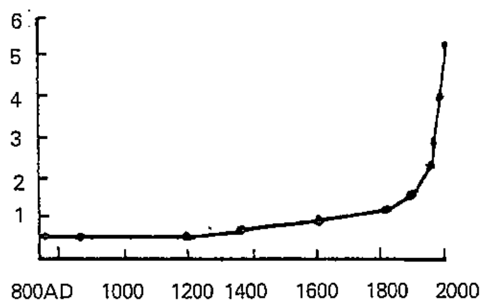
Maximising yields

Historical

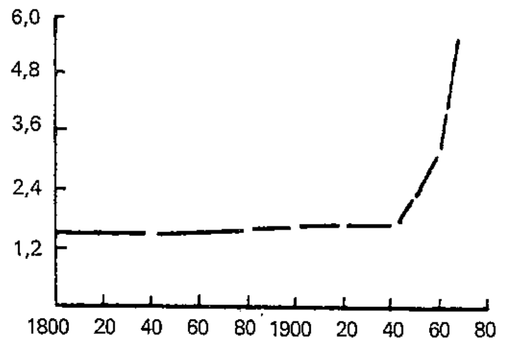
Figure 1 shows how average yields of rice, wheat and maize have developed in Japan, United Kingdom and the USA respectively with comparative national average yields 1981 for countries with the highest national average (countries where the respective crop is of major importance) and with the lowest national average. There has been spectacular increase since the second World War.



Rice yields in Japan. Adapted from L.T. Evans (1975) and Jack R. Harlan (1977).
Tons per hectare



Wheat yields in England. Adapted from L.T. Evans (1975).



Maize yields in the U.S. Adapted from Jack R. Harlan (1977).

Fig 1. Cereal yields per ha in selected countries (Cooking, 1979).

Korea has the highest rice yield, the Netherlands the highest wheat and the USA the highest maize yield. The lowest yielding countries are all in Africa. Yields grew very slowly for centuries and started to rise appreciably only towards the end of the last century.

Potential & yields

FAO statistics for 1981 for the three main cereals are shown in Table 1 and indicate great differences between developed and developing countires; they also show how low yields are in Africa. They show how unbalanced world cereal production is — there may be surplus in some developed countries and deficits in the developing.

TABLE 1 Average yields of major cereals 1981 according to regions compared to best country and world record (in t/ha) (FAO 1981. Cooke 1982)

	Wheat	Rice	Maize
World	1,9	2,9	3,4
Developed countries	2,1	5,3	5,5
Developing countries	1,7	2,8	2,0
Africa	1,2	1,8	1,5
Asia	1,7	2,9	2,3
Latin America	1,5	1,9	2,0
North America	2,2	5,5	6,9
Best country	6,7	6,1	6,9
World record	14,5	14,4	22,2

One line has been added to the FAO table to show reported world record yields. A striking feature is that the best country averages are well below the world records while regional averages are in turn well below best country averages. This shows how much progress towards high yield is yet to be made but also suggests that progress can be made — what one has achieved others can also. Such progress will however, only be made when research has identified the factors which in the various areas, are the main constraints on yield. This research involves the coordinated efforts of various disciplines: plant breeders, irrigation experts, mycologists, entomologists, agronomists and, not least, soil chemists and the fertilizer industry itself.

Foundation for maximum yield

Basic considerations

The attainment of high yield within the limits imposed by the environment depends upon:

- the identification and elimination of factors limiting plant growth,
- optimising factors which promote growth and exploitation of the interactions between these positive factors.

Though climate and other environmental conditions may place limits on possible yields and largely dictate the crops which can be grown, it is possible to overcome some of the limits, notably through irrigation.

The limits imposed by climate are illustrated by the map of France in Figure 2.

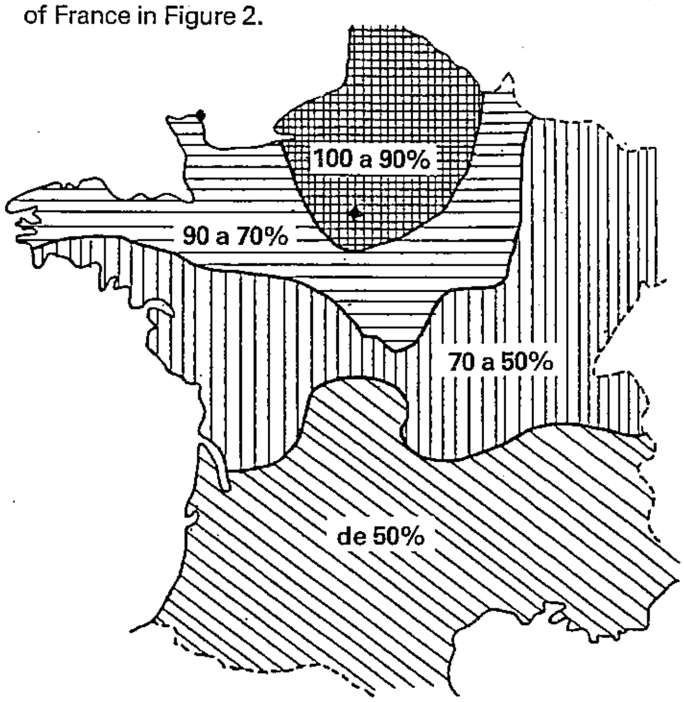


FIG 2 Yield potential of winter wheat in France (+ La Beauce = 100%) (Bouchet 1982)

The highest wheat yields are obtained in the Beauce (= 100) where climatic conditions (temperature, rainfall etc.) are most favourable. As we move southwards, conditions — in particular soil and climate — deteriorate until attainable yield is only a half of that of the North. Climate is a major factor. The U.K., the Netherlands and northern Germany have climates similar to that of northern France and maximum yield work in these countries has shown that very high yields are attainable.

Much useful information has come from large scale work by ICI in cooperation with farmers in the U.K. It has emerged (Hollies 1982) that though soil type is often blamed for poor yields, correct crop management in practice has much greater influence on yield. This is shown in Figure 3 where yields are grouped for three classes of soil.

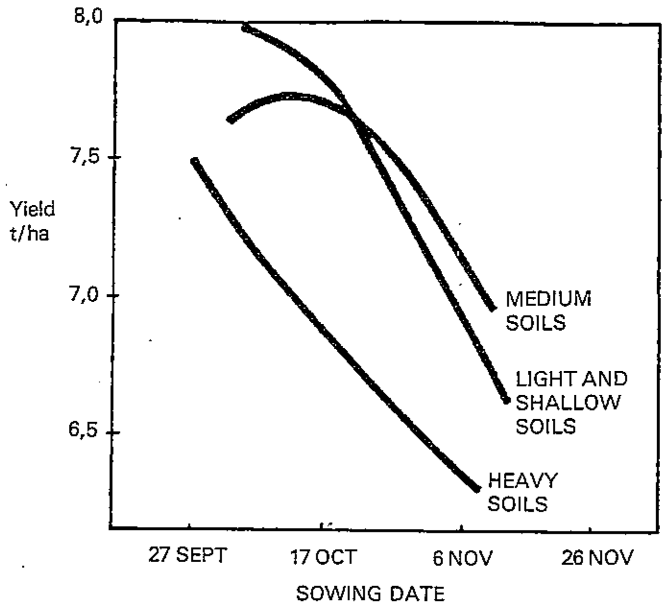
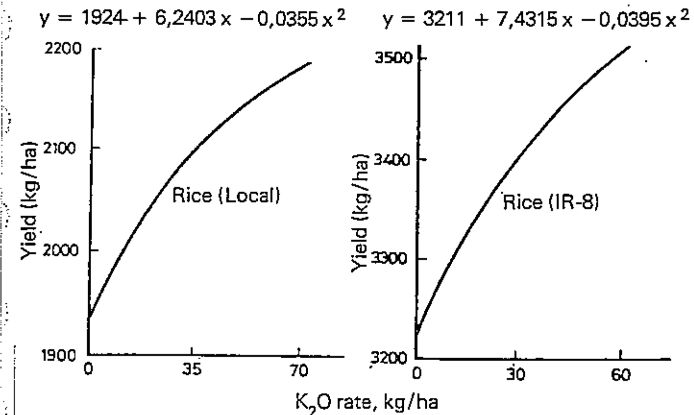
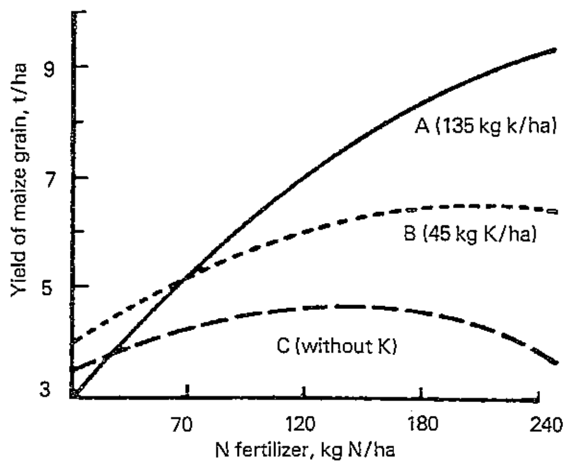
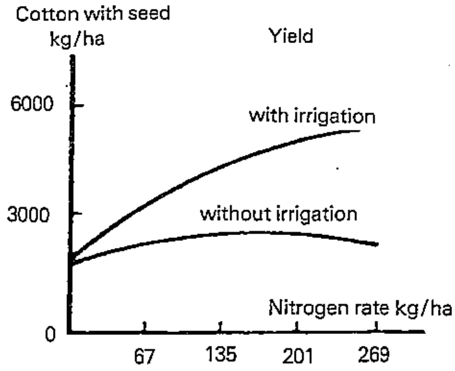


FIG 3 Effect of sowing date on different soil types (ICI 82)

The soils do have different potentials but these differences are smaller than the effects of sowing date.







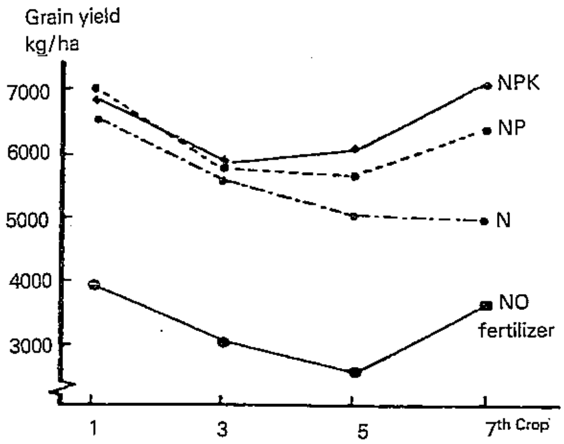


FIG 4 Fertilizer effects and their interaction with other factors

Figure 4 shows how factors interact in their effects on yield and how skilful manipulation of these factors and their interactions may be expected to have profound effects. It is clear that three of the prime factors are: variety, water supply (irrigation and drainage) and nutrient supply (fertilizers). Such interactions are illustrated by the examples in figure 4 showing interactions between variety and K, between different nutrients (N and K), between N fertilizer and irrigation and between N fertilizer, CCC and fungicide for a range of crops.

Important factors

It appears from maximum yield work by ICI and in other European wheat schemes that the most important components of yield are plant population (ears/m2) and grain weight per ear. Patently, selection of the right variety and sowing date is of the highest importance here (Fig. 5). Striking evidence on the same point is given in results in N. Germany.

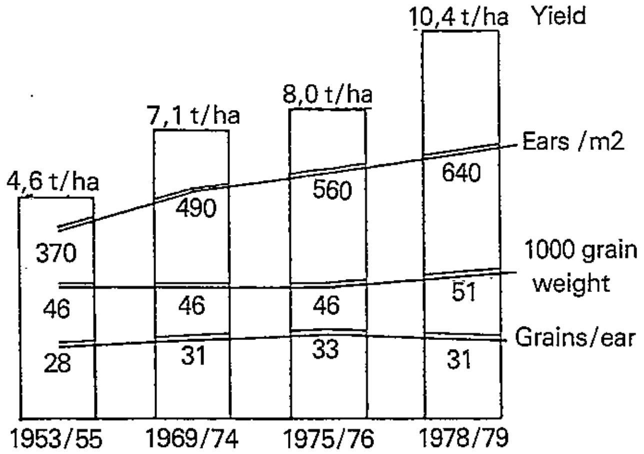


FIG 5 Average yield of winter wheat in field experiments Schleswig-Holstein (Wichman 1982)

It should be noted that above a certain level grain number and weight may be in competition, suggesting that effects of individual nutrients on these components is worthy of study. For instance increasing N increases grain number while K increases grain weight (Sturm 1982, Loué 1982).

Inherent soil fertility is obviously important and this is illustrated in Table 2.

TABLE 2 Yields in relation to soil values and NPK rates in 30 farms over 4 years in West Germany (Köpke 1982)

	Maximum	Average	Minimum
Wheat Yields (t/ha)	9,1	6,6	2,0
Soil value (1/100)	80	54	18
rates kg/ha N	335	179	28
P	175	63	0
K	266	134	0

However, it is obvious that inherent fertility can be modified by fertilizers and equally that inherent fertility will not support high yields for any length of time unless nutrient removal is compensated by using fertilizer.

Fertilizers

Fertilizer is certainly the most important input for increasing yields. World fertilizer consumption has risen form 16 to 115 million t. over the past 30 years and the trend will continue. There is a general correlation in international comparisons between yield and fertilizer usage, and it is held by expert opinion that 50% of the increase in yield over the past few decades is due to fertilizer. There is much evidence to show that as a general rule 1 kg NPK produces 10 kg grain. (See Table 3).

TABLE 3 Response ratios as seen by various authors (FAO 1981)

Author	kg cereal grain produced by 1 kg $N2P_2O_52K_2O$	Remarks
Bajwa and Randhawa	12,0	India/Punjab
Borlaug	20,0 to 25,0	High yielding varieties
Couston and Aspiras	10,0 to 15,0	High yielding varieties in Asia
Deichmann	11,0	
Herdt and Barker	10,0	
Huppert	12,0	Average 1800 to 1975/76 Germany
McCune	12,0	
Pinstrup-Andersen	10,0	
Shields	10,0	
Tandon	8,5	

It should be noted that this rule of thumb is based on experience in many countries, at different times and at various yield levels. It is not restricted to a certain yield level or time span; so 50 years experiments in Germany with wheat and 40 years in Japan with rice come to the same conclusion: 10 kg increase in grain yield per 1 kg N have been achieved during the whole period of experimentation. (Buchner 1976, Murayama 1977). There is evidence here that the law of diminishing returns does not necessarily apply as soil and crop management is progressively improved.

Deciding on the optimum rate of nitrogen is a crucial point in fertilizer management, provided that soil of adequate phosphate and potash is assured.

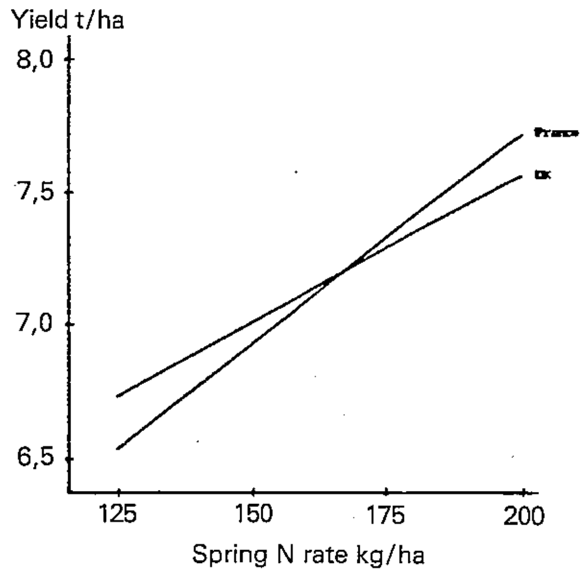


FIG 6 Relation between N-rates and wheat yields 1982 (Number of fields: France 899, UK 1764) (ICI-SOPRA 82)

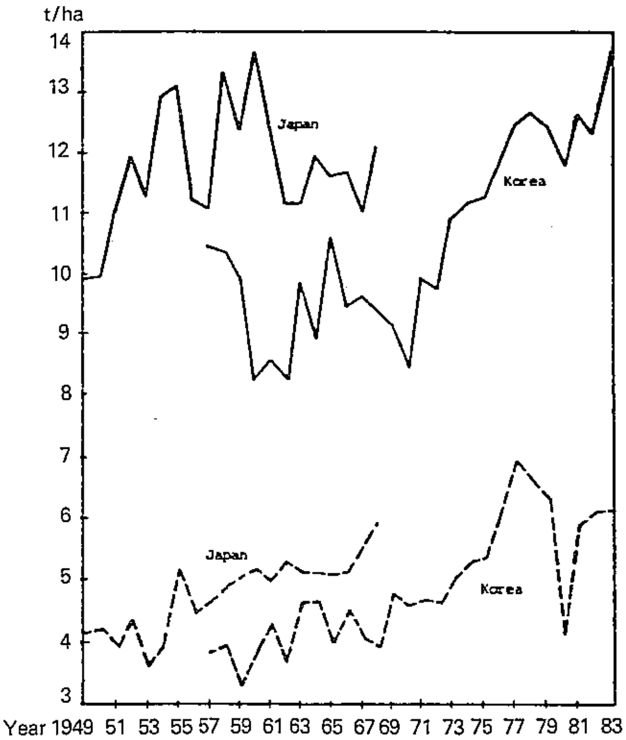
Figure 6 shows that under these conditions response to increasing nitrogen is linear up to 200 kg/ha N; this figure is based on data collected from 1764 fields surveyed in the UK and 899 in France. In France, 50% of the fields received two N dressings and 42% 3 top dressings. Depending on conditions the timing of nitrogen top dressing is most important and it may be advisable to apply in several split dressings. At high rates of N the use of growth regulators (CCC) is important in minimising the risk of lodging, similarly there is positive interaction between N rate and fungicide (as shown in Figure 4).

Maximum Yield Systems

Various approaches in working towards maximum yield on practical farms have been adopted in different countries, some of which are discussed below. Note that we are not here concerned with work on research stations but on real farms.

Yield competitions

These were held in Japan from 1949 to 1968 and were started in Korea in 1957 and still continue. The prizewinners' yields are compared with the country averages in Figure 7.



By contest winners applied:
Japan: kg/ha 219 N 81 P 202 K
N:P:K = 100:37:92

Korea: kg/ha 196 N 77 P 120 K
N:P:K = 100:39:61

FIG 7 Maximum and average paddy yields achieved in Japan and Korea (Ishizuka 1979, APR 1983)

Both these competitions showed that attainable yields were at least twice and often over three times the national average yield and reached up close to 14 t/ha.

The yield contests were given wide publicity and, in showing what could be accomplished had a spin-off effect in showing other farmers what could be done with the result that all round standards were improved.

Particularly in Japan, the methods used by leading farmers were subjected detailed analysis to find out what were the most important factors contributing to the winners' success. In order of importance these ranked as follows:

- water management
- fertilizer usage
- soil improvement
- plant protection

Rates of fertilizers used by contest winners were:

	N	P	K	N	:	P	:	K
		kg/ha						
Japan	219	81	202	100	:	37	:	92
Korea	196	77	120	100	:	39	:	61

Farmers' Clubs

'Ten Ton Club': wheat & barley; U.K.

From 1976 to 1980 in the UK, ICI operated the 'Ten Ton Club' for wheat and barley. In this scheme, up to 1 100 farmers took part each year, entering selected fields for the field competition. At the outset many sceptics were critical of the name 'Ten Ton Club' because they thought such a target unrealisable, but the organisers were well justified as the number of fields reaching this level increased from year to year. Other activities including exchange of field experience, and research information, visits to experimental centres, discussion meetings, demonstrations and farm walks, were grafted onto the central theme. Quartile analysis was carried out each year and the main features of the results of this are summarised in Table 4.

TABLE 4 Wheat yields (t/ha) and N-applications (kg/ha) in ICI 10 tons clubs (Hollies 1982)

		1977	1978	1979	1980
Yield:	No of > 10 tons	5	27	16	41
	top 25%	8,1	8,8	8,6	9,1
	national average	4,9	5,3	5,3	5,7
N-rates:	to 10 t/ha crops	153	148	166	175
	average clubs	139	154	169	169
	national average	115	125	134	145

ICI report on the 1982 crop highlights the importance of the following: Early drilling, particularly on heavier soils with care not to damage soil structure by untimely operations.

Maintenance of a good level of P and K in the soil (the best managers applied at least sufficient to balance removals in the crop.)

Ensuring a steady supply of N through the spring growing period with 35-50 kg/ha applied early (end February to early March) and the main application as a single dose or double split in April.

Improving response to N by complementary use of growth regulator and fungicide.

Good weed control.

As might be expected, participating farmers were above the average and the overall average yield was 7 t/ha (14% over the national average) while the top ten per cent of fields averaged 9,5 t/ha.

'Ten Ton Club': wheat & maize; France

Ten ton wheat clubs were started in France in 1979 and by 1982 data were available from 3 000 fields with an average yield of 7,1 t/ha (national average 5,3 t/ha). Nine farmers exceeded 10 t/ha and the highest recorded yield was 10,5 t/ha in 1982, average fertilizer treatment was (kg/ha) N 182, P 56, K 114. The highest yielding fields received up to 200 kg/ha N in four splits.

A 'Ten Ton Club' for maize was also started in 1980 by ICI and SOPRA but it was soon found that the target was set too low; it is now the '15 Ton Club'. Results of analysis of the effect of inputs on yield are summarised in Table 5 where fields are divided into a high yielding and low yielding groups.

TABLE 5 Factors linked to high resp. low yields of maize in France (ICI-SOPRA 1982)

Input	Low yields <8 t/ha	High yields >10 t/ha
Sowing date	April 16 - April 25	April 26 - May 5
No. of tillage operations	2	5
Weed control	Before sowing	After sowing
No. of irrigations	2-3	4-9
Total amount of water applied (mm)	50-100	200-300
Fertilization kg/ha		
— N	170-190	210-260
— K	<130	>130

Analysis of fertilizer use by yield groups is given in Table 6.

TABLE 6 Fertilizer use according to yield groups of maize in France (ICI-SOPRA 1982)

Yield t/ha	7-8	8-9	9-10	10-11	11-12
N	193	197	216	225	241
P	76	65	65	86	80
K	127	117	117	143	142

Ohio Growers Maize Club, USA

This club has been running for 17 years over which period Ohio State average yield has moved from 4,9 to 7,1 t/ha while the club average has risen from 7,3 to 10 t/ha, Table 7 groups results into three yield groups and shows fertilizer usage by these groups.

TABLE 7 Average yields and fertilizer use according to yield groups (Sullivan 1982)

Growers Groups	Yield t/ha	Average kg/ha		
		N	P	K
Highest 1/3	10,4	259	53	186
Middle 1/3	8,7	239	33	152
Lowest 1/3	7,0	234	38	168

Growing systems

Blue prints

Attempts have been made to evolve complete growing systems which would specify more or less exactly the cultural methods and inputs which should be used to assure maximum yield. Precise 'blue prints' were first established for glasshouse crops where with the current degree or sophistication the grower has almost complete control over the crop's environment. When the concept is extended to field crops such close control is lacking and the problem therefore more difficult.

Success has attended the potato blue print of Evans (1977) in the U.K., defining blue prints as "systems of growing crops to produce what is predicted as their maximum potential". The hypothetical basis is that available energy may be the only constraint to crop growth while moisture and nutrient should always be available as required by the crop.

Specifications have been drawn up for the potato crop which includes the fertilizer treatment apart from recommendations on seed, irrigation, plant protection etc.

Fertilizer treatments are shown in Table 8 together with those of blue prints from Hungary on maize and from Pakistan on sugarcane:

TABLE 8 Fertilizer treatments in some blue prints

	Target Yield t/ha	Fertilizer treatment (kg/ha) N	P	K
Potato. UK (Evans 77)	90	250	218	311
Maize. Hungary (Kranitz 1981)	11	200	52	149
Sugarcane, Pakistan (Hussain 1982)	138	328	50	205

In evaluating the IPI Colloquium 1981 Cooke stressed that "production specifications (blue prints) have an essential place in 1. testing the adequacy of current information 2. forming the basis for the multifactorial experimentation" (Cooke 1981).

Blue prints are an excellent basis for advice on intensive production systems because they assemble the results of a diverse range of research in several disciplines.

Schleswig Holstein and Laloux systems

A number of what growing systems have been developed in Europe which differ in detail but have similar aims. Two systems which have received much publicity are the Schleswig Holstein and Laloux systems, and it is interesting to compare these as there is considerable difference between them.

The favourable climate (780 mm rain well distributed) and fertile soils of Schleswig Holstein allow very high yields to be grown — 10 t yields are frequent and up to 16 t/ha is said to have been recorded. The system advocated is characterised by "generosity". This is a high cost system but does produce very high yields of 10-12 t/ha. In contrast the Laloux system evolved in Belgium sets a lower target yield and advocates a somewhat more conservative approach to expenditure on inputs. Features of the "rival" systems are summarised in Table 9.

The chief contrast is between the high plant population (more ears/m^2) advocated in Schleswig Holstein and the lower population (relying on increasing grain number per ear) advocated by Laloux.

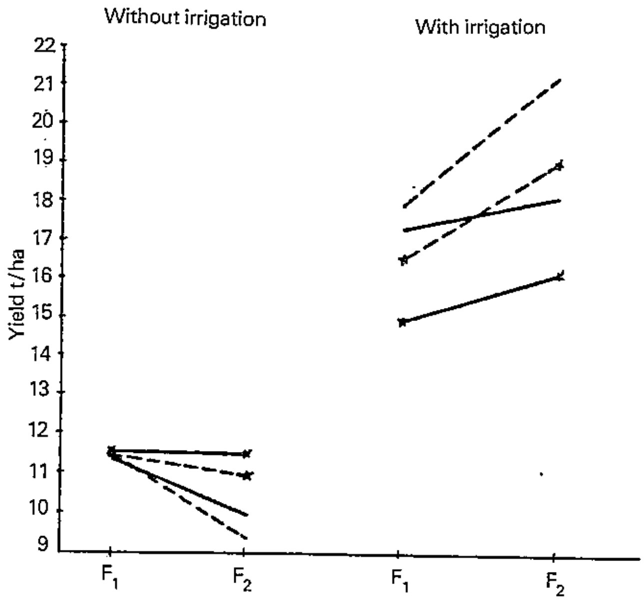
Systems evolved for other parts of Europe with other climates differ in detail and may appear to lie between the two systems mentioned above but their bases, paying attention to the factors listed in the table, is essentially the same.

TABLE 9 (Becker 1982)

Production systems	Schleswig-Holstein	Laloux (Belgium)
Yield expectation	Very high (8-10 t/ha)	High (6-8 t/ha
Planting		
— time	Very early (beginning Oct)	Normal (end October)
— density	Very high (400-500 seeds/m2)	Low (200-500 seeds/m2
N-fertilization		
— beginning of growth in spring	High rate (80-110 kg N/ha)	Small rate (30-50 kg N/ha)
— beginning of stem elongation	Small rate (20-30 kg N/ha)	High rate (80 kg N/ha)
— further stem elongation	1-2 small rates (each 20-30 kg N/ha)	—
— ear emergence	High rate (60-80 kg N/ha)	Medium rate (50-70 kg N/ha)
ccc-application		
— during tillering	Higher quantity (0,5-1,5ℓ ccc/ha)	Total quantity (−1,0ℓ ccc/ha)
— during stem elongation	Smaller quantity (0,5ℓ ccc/ha)	—
Plant protection	Full support of yield formation by herbicides, fungicides, insecticides	Biocides according to requirements
Yield formation		
— number of ears/m2	Very strongly promoted	Restricted
— number of grains/ear	Promoted	Very strongly promoted
— 1000-grain weight	Very strongly promoted	Strongly promoted

Record yields

The record yields achieved by Dr R Flannery, extension soil specialist in New Jersey are worth a special mention; in 1982 he grew the record yield of 21,2 t/ha maize. Figure 8 illustrates the striking finding from his work, a finding which is now particularly relevant to South African farmers: the very large interaction between irrigation and fertilizer. With insufficient water crop growth is limited and the crop cannot make use of generous fertilizer application. When the constraint of inadequate soil moisture is removed, the crop is able to realise its potential and to profit also from a higher plant population.



F_1 = 336 kg N + 86 kg P + 163 kg K/ha
F_2 = 560 kg N + 171 kg P + 325 kg K/ha

Variety 1: x——x 80700 plants/ha
x– – – –x 92300 plants/ha
Variety 2: ——— 80700 plants/ha
– – – – 92300 plants/ha

FIG 8 Record maise yield. Effect of fertilizers with and without irrigation (PPI 1982)

Dr Flannery has also worked with soyabean and achieved another record — 7,3 t/ha. The fertilizer rates used for these record crops were generous by any standards:

kg/ha	Maize	Soyabean
N	560	140
P	171	98
K	325	232

Maximum Economic Yield (MEY)

So far we have been concerned mainly, though not entirely, with maximum yield. It is important to find out what the full potential yield may be under a particular set of circumstances; it is an essential step since it is important to know how far we fall short of the maximum possible. Having found this out, the farmer may need to lower his sights a little because maximum yield may be attainable only at an unrealistic cost. He is much more concerned with profit and loss and therefore he will aim for the *maximum economic yield,* balancing the cost of inputs against the marginal return.

Maximum economic yield obviously varies with conditions: environmental conditions which may place limits on maximum yield and economic conditions (produce and input prices and the availability of funds). However, experience show that MEY is generally very close to maximum yield. Wagner (1983) indicates that MEY can be at least 95% of maximum yield.

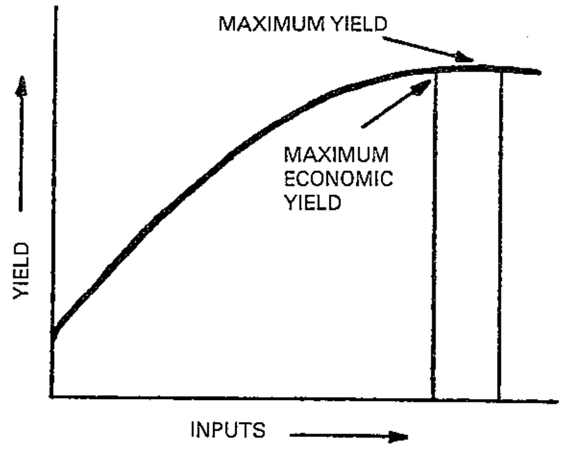


FIG 9 MY and MEY (Wagner 1983)

In this connection, consideration of the usual response pattern (a relatively steep rise towards the maximum followed by a flattening of the curve and then a gentle decline) shows that in the quest for maximum profit the potential loss through failing to reach the MEY by economy in input cost by far outweighs the marginal fall in profitability which might be caused by slightly over-generous use of inputs.

In many parts of the world yields harvested are only a fraction of the potential; consequently farmers have to live on an income which is far below what they could obtain if their yields were higher. The need to progress towards maximum economic yield is urgent. We do not need here to go into all the reasons for this situation which may be simply lack of farmer education, high risk, high input or low produce prices and so on but will concentrate on demonstrating, from selected examples, the interdependence of increasing yield and increasing profit.

Increasing yields and profits

The three following examples show the influence of yield level on the financial benefit.

(a) 5 years data from France show that in wheat growing the highest yield, obtained in the most intensive of three growing systems resulted in the highest profit.

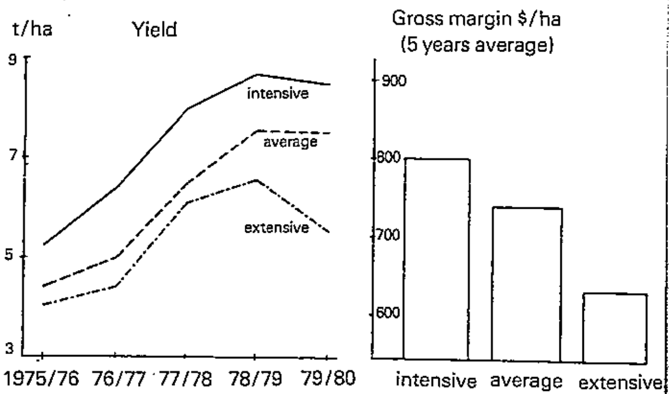


FIG 10 Yields and gross margins of 3 intensity systems over 5 years in France (Bouchet 1982)

(b) Grouping of results obtained by members of the Ohio Grower Maize Club (Table 10) shows progression from a loss by the lowest third to a handsome profit by the top third.

TABLE 10 Results from Grower Maize Club in Ohio (15 year averages) (Sullivan 1982)

Group of Growers	Maize yield t/ha	Average profit $/ha
Highest 1/3	10,4	238
Middle 1/3	8,7	94
Lowest 1/3	7,0	−27

(c) The example in Figure 11 refers to financial results on 1764 surveyed fields. Over the range 5 to 9 t/ha yield the increase in gross margin is linear.

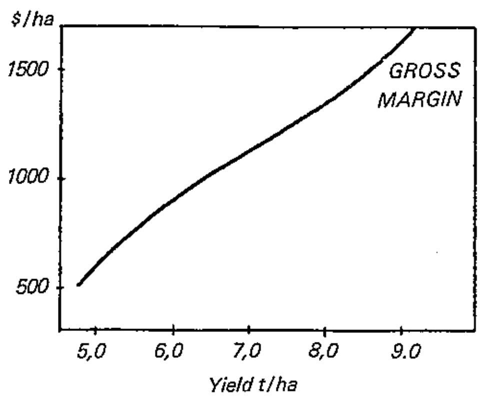


FIG 11 Relationship between yield and gross margin (ICI 1982)

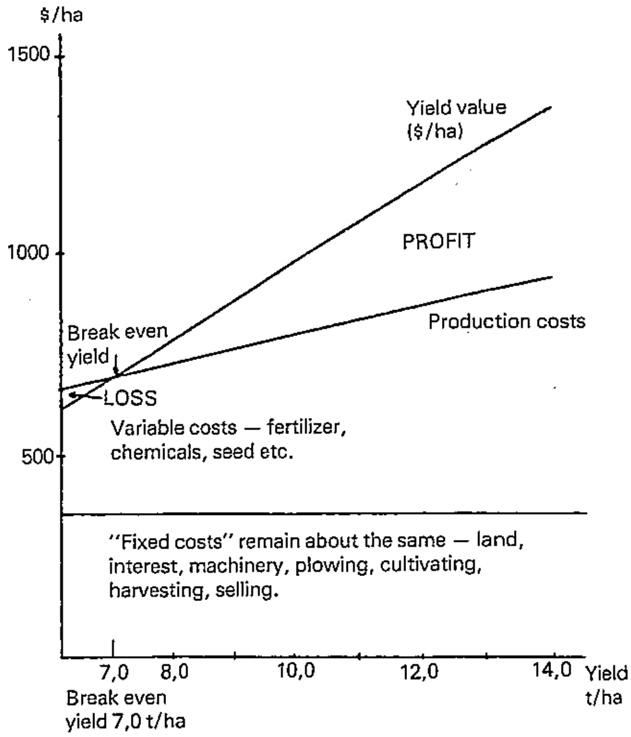


FIG 12 The Development of production costs and profit according to the yield of maize (Sullivan 1982)

MEY and production costs

Pricing policies for agricultural products form an important part of a national food policy but the pricing of necessary inputs is equally important; both affect the farmer's chances of making a profit. It is preferable to speak of the price ratio produce price: input cost. For instance in one country only 1 ton of wheat may be needed to pay for a ton of NPK fertilizer while in another more than 4 tons are needed (von Peter 1980).

Fixed costs form an important part of the total cost of growing a crop but these costs — rent, interest, buildings, machinery etc. — remain the same whether the yield is high or low. While variable costs grow with the yield so also does profit as demonstrated in Figure 12 showing a loss with minimum inputs and low yield on account of unavoidable fixed costs, but up to a limit (MEY) increasing profit as inputs are increased and yield rises.
In numerous countries great problems are caused for agriculture by production costs which are rising constantly while crop prices do not follow or at least not to the same extent.

The index of input prices in 1982 was in all 3 European countries higher while the index of agricultural product prices was lower than 1970; the difference amounts to 15-20%. The curves make also obvious that this trend can be expected to continue in the future. (Figure 13).

In USA it is assumed that production costs will double in less than ten years while crop prices are not likely to keep pace (Murphy 1983). The only way — it is concluded — to balance this cost-price squeeze is by producing higher yields that cut production costs per ton. Based on costs for maize production 1983 in Nebraska index values have been calculated and are shown in Figure 14.

It is obvious that production costs her ha (index based on 7,5 t/ha) increase considerably as yields increase in particular those for fertilizers. These higher costs are however worthwhile since the costs per ton maize produced are 20% lower on the higher yield level!

These major points made for maximum economic yields are summarized in Table 11; the data are based on maize production in 3 different conditions of USA.

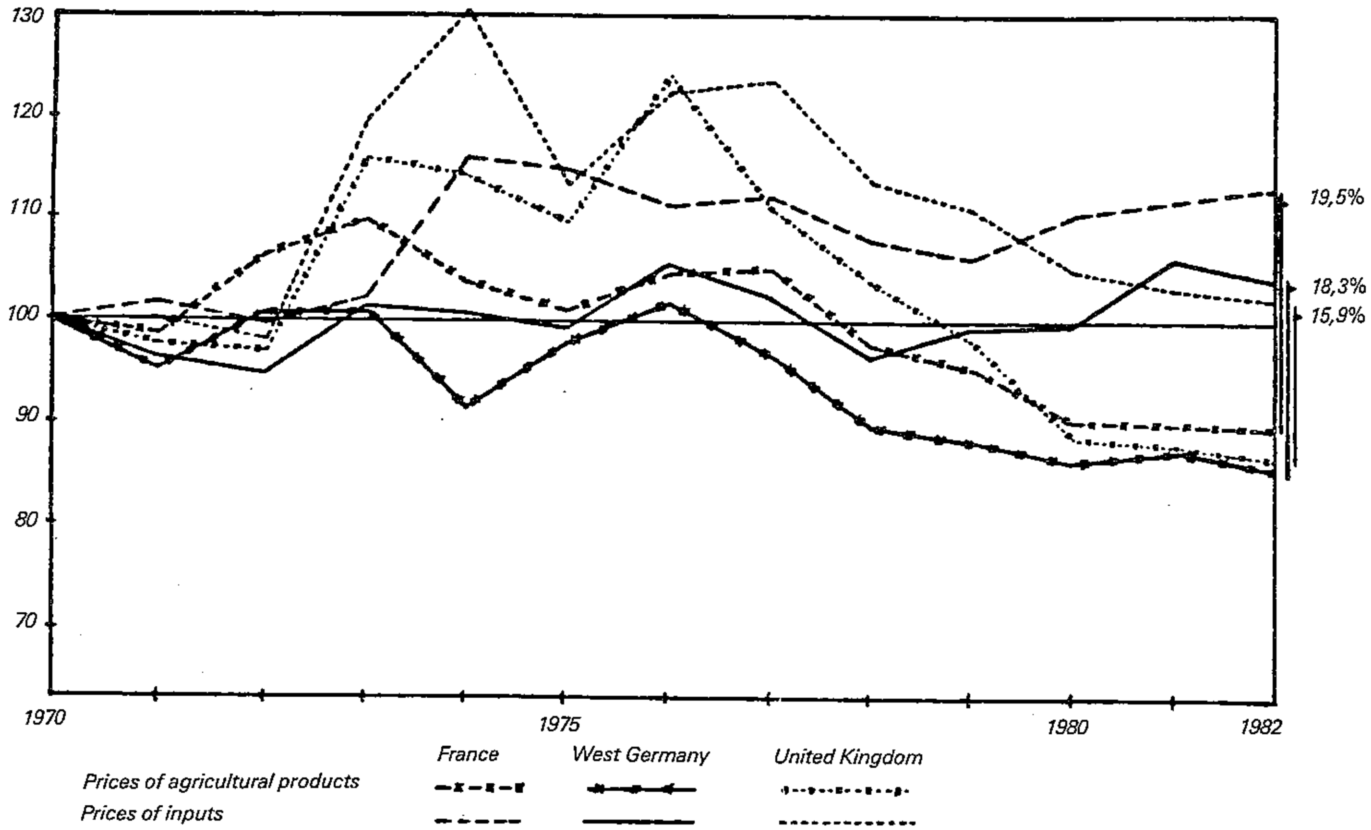


FIG 13 Development of prices of agricultural products and inputs in 3 European countries (1970 = 100) (AGPM 1983)

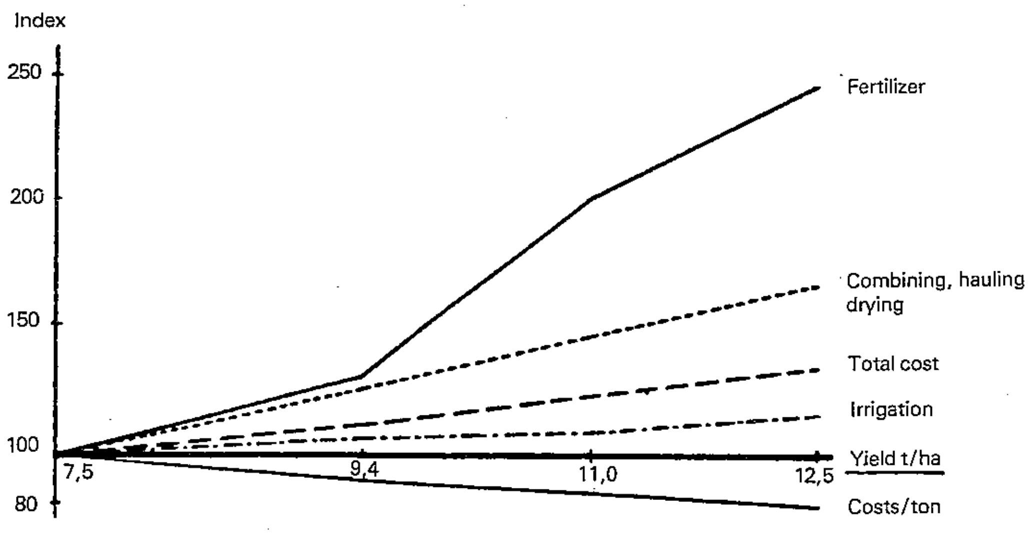


FIG 14 Index of estimated production costs 1983 according to yield levels (Murphy 1983)

TABLE 11 Economic impact of changes of production costs, maize price and yield

(a) Production costs increase — profit turns into deficit (Johnson 83)

	1975	1981
Production costs $/ha	630	959
Yield t/ha	7,5	7,5
Maize price $/t	98	98
Profit/loss $/ha	+111	−218

(b) Maize prices decrease — higher break even yield needed (Waters 83)

	1980	1981	
Maize price $/t	143	103	−28%
Net return $/ha	504	277	−45%
Break even yield t/ha	4,4	6,1	+39%

(c) Yield increase — profit increases (Warsaw 80)

	Farm average (469 farms)	Record yield (Mr. Warsaw)
Yield t/ha	9,3	21,2
Break even yield t/ha	5,7	8,3
Break even price $/t	68	47
Profit $/ha	393	1337

Saving costs

To escape the cost-price squeeze by reducing production costs per ha may be ocassionally a short term but never a long term solution.

There is only limited scope for decreasing fixed costs so the farmer must examine critically possibilities for decreasing variable costs. There are limited possibilities here but, as we have demonstrated this is a critical matter. Inputs, particularly fertilizers, build yields and a saving here can easily be outweighed by loss of yield. Wherever, as is usually the case, higher yields are possible the most effective means of optimising the return is by *increasing* expenditure on inputs, thereby increasing yield and reducing overall unit production costs.

This is shown in Figure 15.

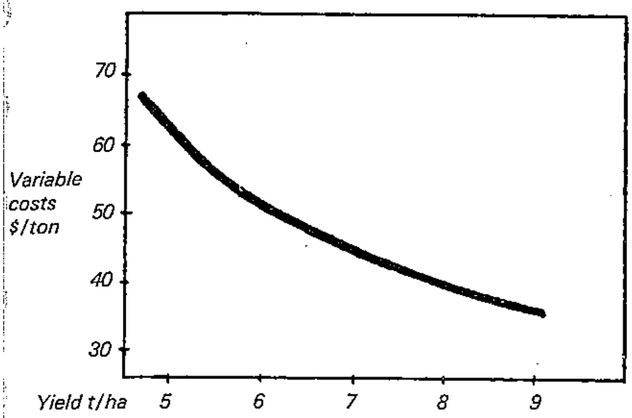


FIG 15 Relationship between variable costs and yield (ICI 1982)

Fertilizers in MEY systems

We have shown in our discussion of maximum and maximum economic yield how all the input factors interact in achieving very high yields. Fertilizer is a major if not the major factor in all MEY production systems. In this connection we would emphasise the following points:

— Fertilizer is a most profitable investment: it contributes ca. 50% to yield increases and in general 1 kg NPK produces at leat 10 kg cereals. Thus maximum economic yields are virtually impossible without high NPK.

— High yields remove large quantities of nutrients thus it is very important to monitor soil fertility by soil and plant testing.

— Provided phosphate and potash are adequately applied — ranges in the above examples: P 50-218 kg/ha, K 120-325 — nitrogen is of prime importance. Although rates vary widely in general rates of 200 kg/ha and over have been found highly profitable in MEY systems in particular when given in 2-4 applications.

— The optimum N application is often substantially increased by the combined use of CCC and plant protection measures.

— All available information indicates that MEY is very close to MY and therefore farmers must aim for the maximum yield under their specific conditions by high fertilizer application.

— As shown in Figure 16 the optimum N-dressing is very close to maximum yield. It is interesting to note that under these conditions the optimum rate would be lowered by only 11% (from 144 to 128 kg N/ha) if the price of N doubled.

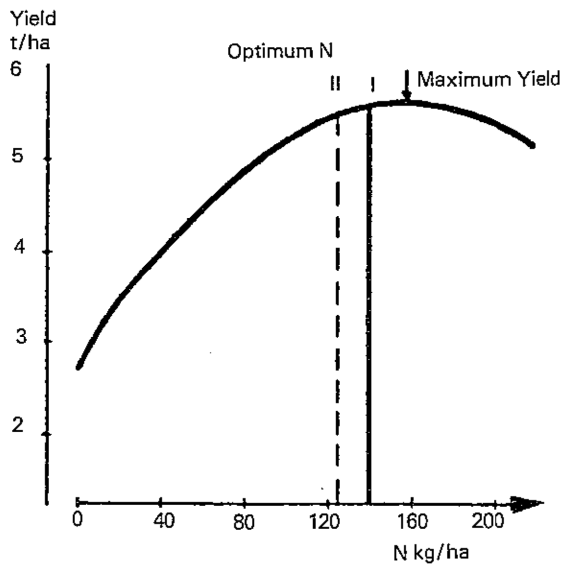


FIG 16 Optimum N rate on different N-price levels (Steinhauser 1983)

— In other words reduction of such a highly effective input is usually not profitable since it decreases yields and income more than production costs.

— It can be said with confidence that fertilizer is a most essential part of MEY systems.

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