Cotton Production and Supply in the Future in Relation to Increases in World Population and Demand for Food

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Introduction

During recent years a number of publications have appeared which contain statements to the effect that most of the future growth in consumption of textile fibres must *necessarily* be taken up by synthetic materials. This is said to be because the rapidly increasing world population will cause such a great demand for food that there will be insufficient agricultural land available to increase cotton production.

Such statements are seldom, if ever, accompanied by objective evidence, so it is difficult for the ordinary textile technologist or mill executive to come to a rational conclusion on this important matter.

Therefore, an effort has been made to digest some of the enormous amount of data which is available from such sources as the U.N. agencies, the U.S. Department of Agriculture, OECD, and the general literature on population and food production, to see whether evidence can be found in support of a hypothesis that future cotton production must *necessarily* be constrained due to lack of land for food production.

Population

We are living in a period of enormous expansion in the size of the human population, an expansion which seems to have begun, in Western Europe, in the latter half of the last century and will not be completed until the latter half of the next. In those two centuries the numbers will have increased by approximately ten-fold [1].

According to *Deevey* [2] such a rapid expansion is not unprecedented and there must have been at least two previously, probably of even greater relative magnitude, coinciding with the two other great technological revolutions (toolmaking and agriculture) of man's past.

The main driving force of the present expansion is the so-called Demographic Transition, which is the change from a population equilibrium of high birth rates balanced by high death rates to another equilibrium of low death rates and low birth rates. During the transition, the death rate falls relatively quickly whilst the change in birth rate lags behind, thus allowing a rapid growth in population for a while before the numbers finally level off at a new stable size.

Figure 1 shows the latest life-expectancy and birth-rate figures for various regions in the world [3] and confirms the close connection between fertility and life expectancy. In other words, family size is limited after the people realise that more of their children will survive. This diagram also confirms that the transition is virtually completed in Europe and is close to completion in the rest of the developed world. In the developing areas, parts of Asia (especially China) and Latin America are further along than Africa where high birth rates and relatively low life expectancy still prevail.

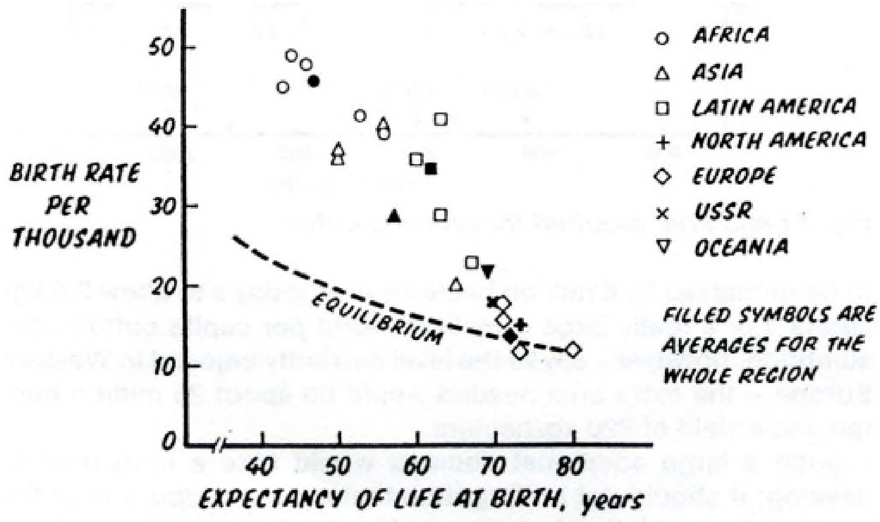


Fig. 1: Birth Rates & Expectancy of Life

The present world population is about 4200 million. Only ten years ago, it was thought by many that the new population equilibrium was likely to be around 10,000 million and could reach 15,000 million [1, 2, 4] (Figure 2).

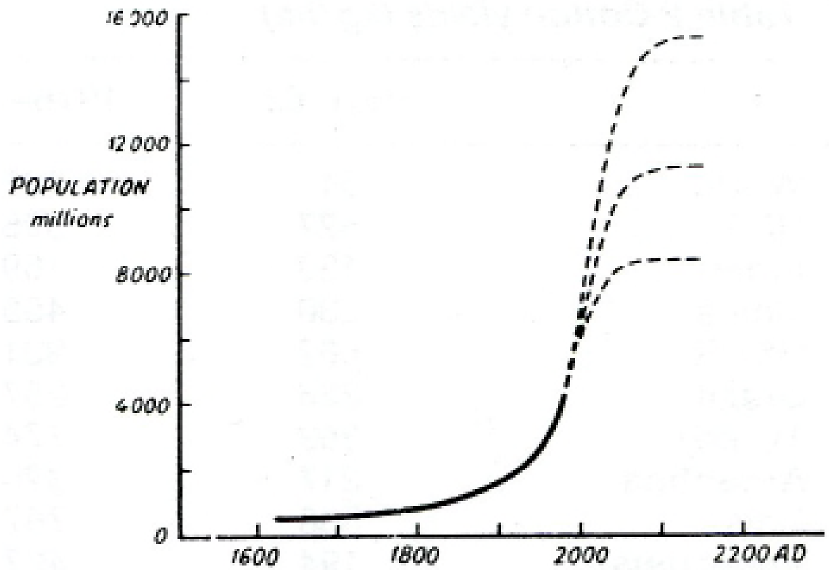


Fig. 2: Population Growth

However, it has now become clear that fertility rates are falling much more rapidly than was expected [5] so that the peak in the growth rate for the world as a whole has already been passed [6] (Figure 3).

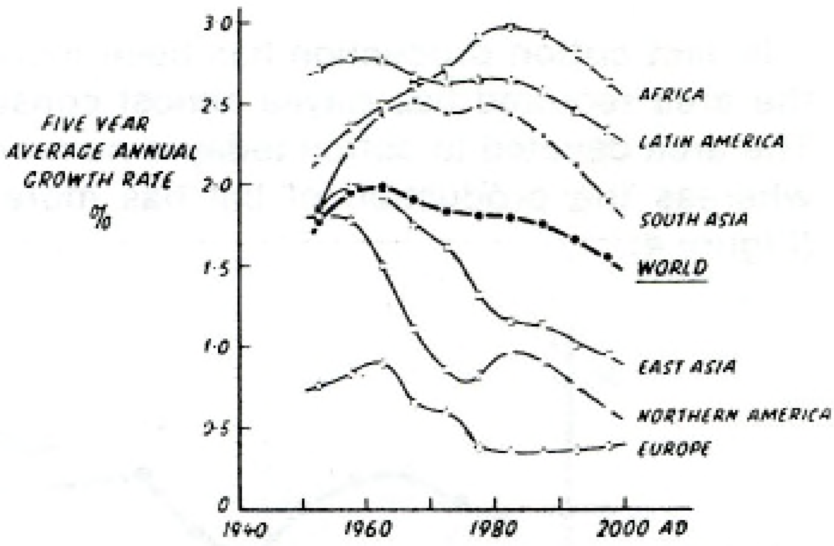


Fig. 3: UN Population Growth Rate Projections

Recent projections for 2000 AD [3, 6] suggest that there will be just over 6,000 million, and the present rapid decline in birth rates would lead to a projection of 8,000 to 8,500 million for the middle of the next century. In other words, the world's population can reasonably be expected to double in size over the next century.

This increase may be less than was once feared, but it is nevertheless substantial so the question naturally arises as to whether the world is going to be able to find the extra land and/or the agricultural productivity to allow for such growth.

Cotton production

As a matter of fact, the human population has already more than doubled within the last 50 years so we could already have seen the cotton-growing countries reacting by cutting their cotton area in order to grow more food.

In fact, there has been a marginal reduction in cotton area over the past couple of decades, the period of most rapid population growth. However, this cut in area was not made by the developing countries of South America, Asia and Africa, who were under the greatest population pressure; it came primarily from North America where food production was consistently in excess of requirements (Table 1).

Table 1: Cotton Growing Area

	1962–66	1975–79	Ratio
N. America	7 056	5 450	0.77
S. America	3 316	3 369	1.02
Asia + Oceania	15 616	15 901	1.02
Africa	3 905	4 048	1.04
USSR	2 421	2 956	1.22
Europe	556	280	0.50
World	32 903	32 007	0.97

Nevertheless, there must have been intense pressure in the developing countries to put maximum resources behind food production and so vital inputs, such as fertiliser and irrigation projects, may have been diverted away from cotton land. This would have been reflected in lower, or stagnant yields of cotton per unit area of land. But that does not seem to have been the case (Table 2) [7].

Table 2: Cotton Yields (kg/ha)

	1961–63	1976–78	Ratio
World	317	407	1.28
USA	527	525	1.00
India	130	159	1.23
China	230	455	1.98
USSR	662	901	1.36
Brazil	226	257	1.14
Turkey	369	774	2.10
Argentina	217	320	1.47
Egypt	568	767	1.35
Venezuela	194	407	2.10
Iran	290	542	1.87
Syria	506	837	1.65
Greece	436	845	1.67
Mexico	579	947	1.64
Israel	1021	1291	1.26
Guatemala	724	1215	1.68

In fact, cotton production has been increasing steadily whilst the area required has stayed almost constant since the 1950's. The area devoted to cotton today is no more than it was in 1930, whereas the production of lint has more than doubled [7, 8] (Figure 4).

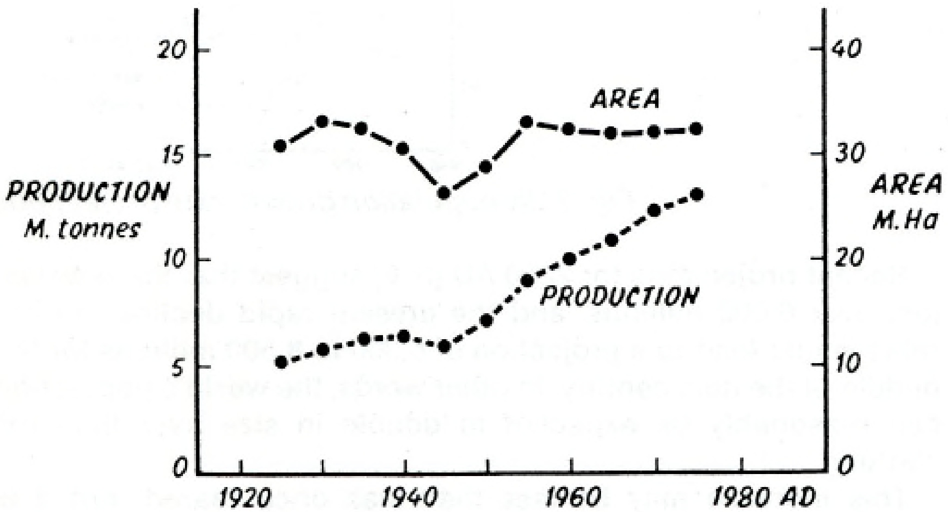


Fig. 4: Cotton Production Trends (10 year averages)

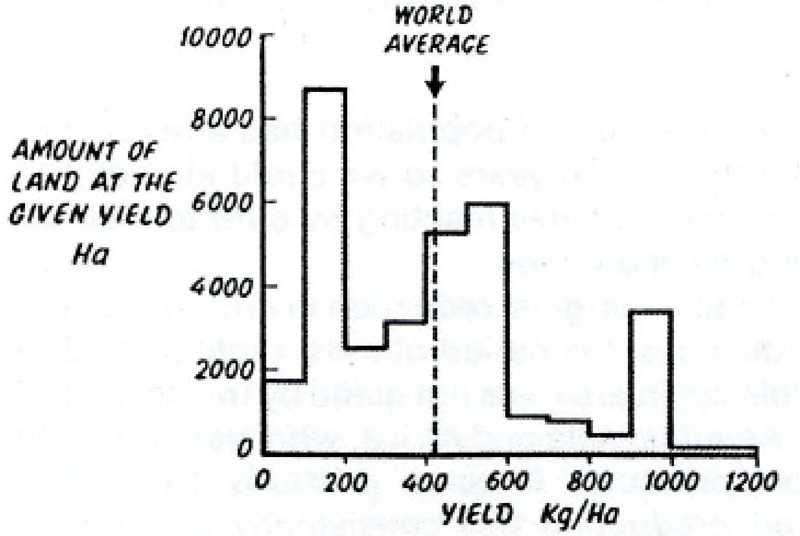


Fig. 5 Distribution of Cotton Land by Yield

Figure 5 shows that there are large areas of the world where the productivity of the cotton land is far below what it could be. The world maximum is about 1,200 kg of lint per hectare; the world average is about 420 kg. About 60% of cotton area is currently producing at below the world average and about one-third is below half the world average.

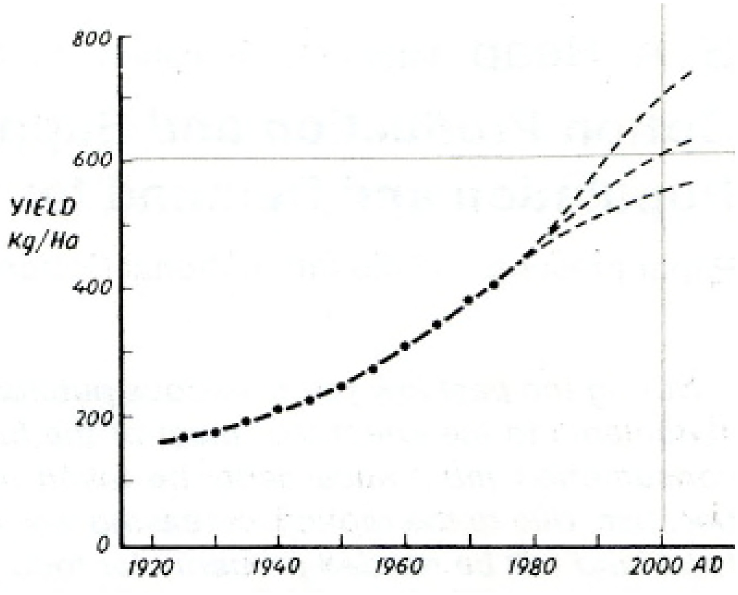


Fig. 6: Cotton Yield Trends (10 year averages)

Figure 6 shows the overall progress in raising world average yields since the 1920's [8]. Assuming the normal S-shaped curve of development [9], we should not be surprised to see cotton yields in the range 550 to 700 kg/hectare by 2000 AD, and perhaps as high as 900 kg/hectare after 2050 AD. This latter figure is presently being achieved on about 20% of the cotton-growing area.

The present world average per capita consumption of cotton is a little less than 3.0 kg/year, but in Western Europe the figure is more than 5.0 kg, and for the developed nations as a whole it is about 6.0 kg [10].

By assuming a range of values for population and per capita consumption, it is easy to calculate the amount of land that would be needed as a function of the average yield, and Figure 7 shows a few typical curves which result (a 10% processing weight loss is built into the calculation).

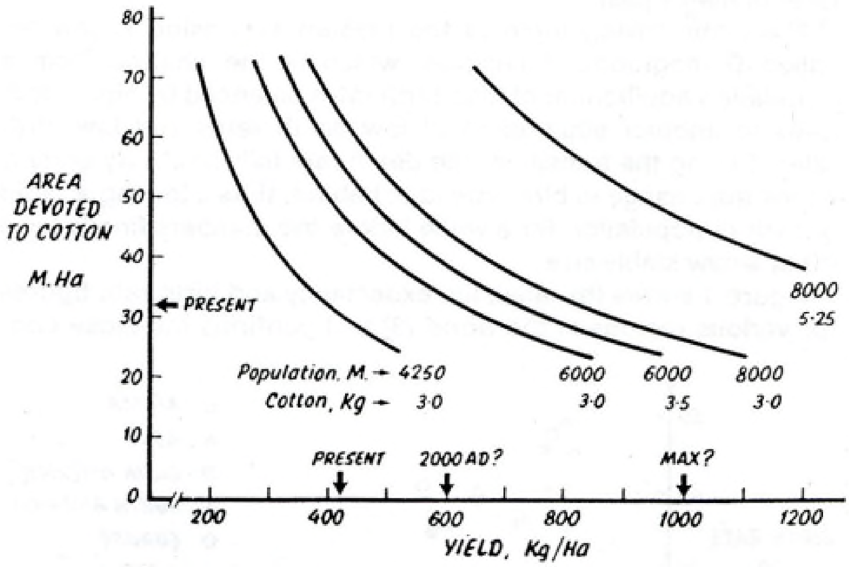


Fig. 7: Land Area Required for Growing Cotton

According to those curves, if per capita consumption remains at about 3.0 kg/year, then in order to supply 6,000 million people on the present land area, an average yield of about 620 kg will be necessary; this is well within the bounds of probability. At the same yield level, an extra 5 million hectares would allow per capita consumption to increase to 3.5 kg.

For a population of 8,000 million, the average yield needs to be about 820 kg/hectare in order to supply a per capita demand of 3.0 kg from the present area; a highly probable achievement over the available time. At this level of yield, the area would need to be increased by 6 million hectares over today's to allow 3.5 kg/ capita. For a really large growth in world per capita cotton consumption, however - say to the level currently enjoyed in Western Europe - the extra area needed would be about 25 million hectares at a yield of 820 kg/hectare.

Such a large additional demand would take a long time to develop; it should not be forgotten that a large proportion of the increase in population is accounted for by poor people who have a below-average per capita consumption of both food and clothing. An interesting analysis of this aspect of population growth has been made recently by *Kayfitz* [11].

Although there seems little doubt that average cotton yields in excess of 820 kg/hectare could eventually be achieved, in circumstances of exceptionally heavy demand and disappointing yields, it may be necessary for the area devoted to cotton to be increased by as much as 30 million hectares in the long run. Can the world really afford to let cotton appropriate an extra 2% of the currently cropped arable land, even in the long term?

Food production

Despite a population increase of 40% over the past two decades [6], food production has been in advance of population growth. This remarkable achievement has been due more to increasing the productivity of the existing land than to the introduction of additional area [12, 13]. Table 3 shows how production of the major food and feed grains was increased by about 38% in the single decade 1962-72 with an area increase of only 8%. During the same period, the population increased by about 20%.

Table 3 Cereals Production 1962-72

		Wheat	Rice	Corn	Total
Production					
m. tons	1962	242.3	247.6	213.1	703.0
	1972	359.6	306.6	306.9	970.1
	Ratio	*1.48*	*1.24*	*1.44*	*1.38*
Area, m. ha					
	1962	206.1	121.9	99.5	427.5
	1972	217.9	132.6	110.4	460.9
	Ratio	*1.06*	*1.09*	*1.11*	*1.08*
Yield, t/ha					
	1962	1.18	2.03	2.14	1.64
	1972	1.65	2.31	2.78	2.10
	Ratio	*1.40*	*1.14*	*1.30*	*1.28*

Likewise, in Table 4 we see that the world's food production increased at an average rate of 2.5% per year for the period 1970/ 78, a time when population growth was averaging only about 1.8%.

Table 4 Regional Growth in Food Production (1970-1978)

	Percent growth	
	Total	Per capita
World	2.5	0.6
Market economies		
Developed	2.2	1.3
Developing	2.7	0.4
Socialist Economies		
Europe	2.6	1.8
Asia	2.8	1.1
Developing regions		
America	3.0	0.2
W. Asia	3.1	0.2
S. Asia	2.7	0.1
Africa	1.4	–1.3

In most parts of the world, therefore, per capita food availability has been consistently increasing. The exception is in Africa where an apparent deficit exists, but where only 10% of the world's population lives.

So far as the cotton growing areas are concerned, Table 5 shows that among the top ten producers, only two have a current rate of population growth which is higher than the growth in food production achieved over the period 1970-78. Of these two, one is an important petroleum producer, and the other operates a deliberate policy of selling cotton to buy food [13]. Indeed, when all cotton growing nations are checked in this way, it is difficult to find as much as 10% of the total cotton area which presently lies in countries which are experiencing negative per capita food growth.

Table 5: 10 Largest Cotton Producers

	% Growth in population[1]	% Growth in food production[2]
India	1.9	2.4
USA	0.6	2.9
China	1.2	2.9
USSR	0.8	2.3
Brazil	2.8	4.3
Pakistan	3.0	3.0
Turkey	2.5	2.9
Nigeria	3.2	1.3
Argentina	1.3	3.1
Egypt	2.6	2.0

[1] 1979 [2] 1970–78

However, the fact that food production has kept in advance of population in the past does not necessarily mean that it will continue to do so. The great gains in productivity over the past few decades have been obtained mainly by increasing the level of inputs. Are we perhaps coming towards the limits of exploitation of the physical resources - Land, Water, Fertilizer, Chemicals, Energy - which will be essential to maintain the pace of agricultural development?

Land

Several surveys have been carried out in recent years to ascertain the amount of land which might be available for expanding food crop production [13, 14, 15, 16, 17] and these have been summarised in [18]. Account was taken of soil type, climate, accessibility, and availability of water. All the surveys found that the area planted to food crops (currently about 1,400 million hectares) could be increased by at least 100% over a period of time, if demand were sufficient. Table 6 shows some data taken from [13].

In addition, there are even greater areas (more than 3,000 million hectares) suitable for pasture for raising livestock. Furthermore, one should consider the fact that large areas of the currently utilised land are not harvested each year for various reasons, and that there are more than 1,000 million hectares of land upon which it would be possible to grow two or more crops per year if the inputs of fertilizer and skilled management were available [13, 19].

Table 6: World Arable Land Resources

	Present	Potential
	million ha	
Latin America	119	570
Africa	214	733
Asia	467	628
Oceania	47	107
N. America	230	495
USSR	225	270
Europe	141	141
Total*	1470*	2944*

Totals only approximate due to overlap between regions and differences in assessment methods.

It is particularly interesting for the present discussion to note that the areas where double cropping is possible are contained within regions where large areas are devoted to cotton. In this context, an extra 30 million hectares (maximum) for cotton seems rather insignificant.

Thus, there can be no question of a shortage of land for agriculture in general or for cotton in particular. However, the land must be made more productive with water and fertilizer, and the crops must be protected with chemical products.

Water

According to *Revelle in* [19] the water resources of the earth are very much under-utilised. Apparently, only about 180 million hectares are irrigated and only about 4% of the total river run-off is consumed. The amount of land which might benefit from irrigation is more than that which can actually be supplied (using present technology) due to the uneven distribution of the world's river water. However, the amount could be increased considerably over the current total human consumption (for all purposes) of just over 3,000 km^3 (Table 7).

Table 7: Global Water Resources

	km^3	Turnover time
Rivers	1 700	weeks
Swamps	3 600	years
Soil moisture	65 000	months
Reservoirs & lakes	125 000	years
Extractable groundwater	7 000 000	centuries
Inaccessible groundwater	53 000 000	millennia
Frozen water	30 000 000	centuries
Oceans	1 370 000 000	centuries
Annual net supply to land	40 000	
Annual consumption (all purposes)	3 000	

In addition, there are truly enormous quantities of water in underground reservoirs which *Ambroggi* [20] argues should be more systematically managed and intensively exploited. He calculates that the top 30 metres of ground water reservoirs contain about 45,000 km^3

of renewable water reserves which will ensure that there is, in principle, no shortage of water for agriculture in the foreseeable future.

In the short to medium term, it is expected that improved management and upgrading of existing water supplies will provide a large proportion of additional demand [13, 19].

Fertilizer

The three main fertilizers are Nitrogen, Phosphorous, and Potassium, and all three, (but especially nitrogen) are essential if agricultural yields are to be maintained and improved to the required levels.

Current average application levels of these products are shown in Table 8 for various regions of the world [21].

Table 8: Regional Fertilizer Consumption (1978)

	Cultivated area m. ha	Average application rate* kg/ha N	P	K
N. America	230	42.2	22.6	23.0
Latin America	119	21.6	19.0	11.7
W. Europe	99	84.4	54.4	50.2
E. Europe + USSR	267	45.3	31.2	32.9
Africa	214	6.2	1.7	0.74
Asia + Oceania	514	26.8	12.1	4.9
World	1470	32.5	19.7	16.2

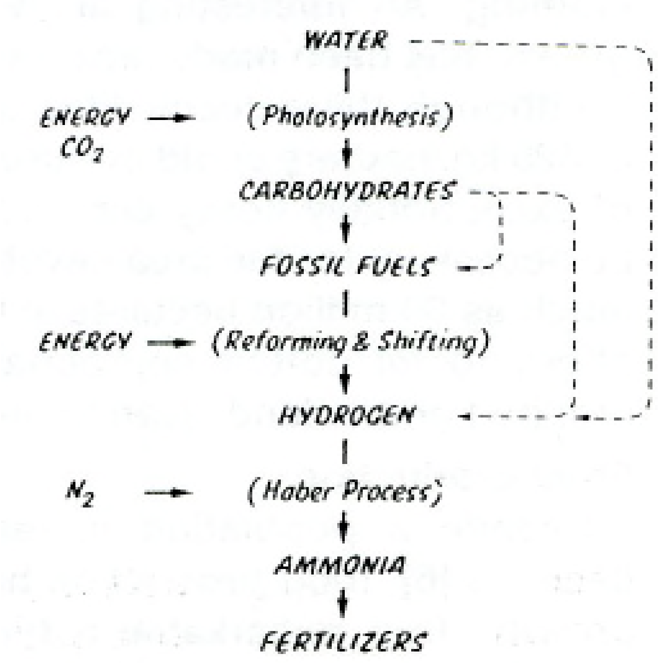
* Total consumption/total cultivated area

If we suppose that, eventually, application levels will generally rise towards those used in Western Europe, and if we suppose that the area of land under cultivation (gross cropped area) will increase to about 2,000 million hectares, then the annual consumption of phosphorous and potassium would be about 100 million tonnes each per year. At that rate, the present known reserves of these two materials will last for about 1,500 years. At higher prices, even greater resources are available.

Nitrogen, however, is another matter. Its main source for the future (in the absence of radical new technology) is bound to be chemical fixation of atmospheric nitrogen by the Haber-Bosch process which requires hydrogen as the main raw material (Fig. 8).

At present, the hydrogen is obtained from natural gas or petroleum derivatives and it takes about 1200-1400 m^3 of gas or 0.8 t of naphtha to make one tonne of ammonia. Assuming again that, in the far, far future, world average application levels were to be as high as those presently used in Western Europe, then an annual demand for rather less than 200 million tonnes can be projected. If natural gas were used to supply this entire demand, less than one fifth of present-day gas production would be required. However, natural gas and petroleum derivatives are thought to be a dwindling resource; present estimated reserves are sufficient for only 25 to 50 years production at present rates of consumption [28].

Fig. 8: Nitrogen Fixation



Any nitrogen fixation process, including the biological one [22] is bound to go through one of two routes. Either the sequence of Fig. 8 which depends upon a source of hydrogen, and therefore of energy, or an oxidation route which is relatively inefficient and needs an even larger supply of cheap energy [23]. Therefore, we see that the future of agricultural production is, like everything else in our modern society, tied to the availability of energy.

There is not space here to go into details of the energy situation, but fortunately that will not be necessary if we can assume that, in principle, there is no shortage of energy, only a shortage of cheap fossil fuel. We have enough expensive energy to last for thousands of years using present technology.

Agricultural production typically consumes roughly 3% of the energy used in an industrialised country (although processing, packaging, distribution and cooking of food account for considerably more) and we can be sure that the farmers, like all other sectors, can and will effect economies in energy consumption as and when the need arises. Furthermore, there will be possibilities for farmers to generate their own energy (in the form of methane or alcohol) from the enormous quantities of organic waste which can be produced when agricultural productivity is raised.

> To digress for just a moment; if we were to make the opposite and pessimistic assumption about energy supply, that there is in fact a real and lasting energy shortage, then our whole discussion would take on a different form altogether. Even in a petroleum-based economy it already needs a good deal more energy to produce synthetic fibres than to grow cotton [24, 25]. In an energy-scarce situation, our starting point for discussion might have to be more to the effect that:

> *"Most of the future growth in textile markets must* necessarily *be taken up by natural fibres because the rapidly increasing world population will cause such a great demand for energy to grow, process, distribute, and cook food that the chemical companies will find it unprofitable to use energy for the production of synthetic fibres."*
>
> When postulated in this form the inherent contradiction becomes obvious. Plainly, if there is no energy, then the population will not grow. The current expansion of population is based upon the simultaneous availability of technologies to extract energy from the environment and to use it for increasing the efficiency of all human enterprises, including agricultural production as well as the manufacture of synthetic substitutes.

Therefore, to return to our main theme, let us assume that there is no real shortage of energy and that the fixed nitrogen will be available in the amounts required for agriculture. The same remarks apply to crop-protection chemicals such as fungicides, herbicides, and pesticides, as well as to power for irrigation works and capital for bringing new land into production.

Social/technological inputs

Adequate physical resources may be a necessary precondition for raising agricultural productivity, but they are not sufficient. The enormous advances of the past decades have been due primarily to changing socio-political forces in which an essential ingredient was the availability of scientists and technologists working both in the research laboratories and in the fields to produce the improved plant varieties and to effect the transmission of advice and know-how to the farmers. Furthermore, it was necessary for the farmers to gain access to adequate finance and realistically priced markets for their produce, as well as supplies of seed and fertilizer at the right time of year.

It is essential that these social and structural developments should continue if the world is to be properly fed, but as a matter of fact it seems clear that there is a general determination in the international aid agencies and among national governments that the good start shall be maintained.

Future Demand for Food

Table 9 shows the per capita food consumption of a few years ago [13]. The world average was about 2500 kcal per day of which 430 kcal was supplied by animal products and about 1900 kcal by cereals and root crops. In the developed countries, out of a total of over 3000 kcal, more than one-third was from animal products. In developing countries only about 2200 kcal were thought to be available of which less than one-tenth came from animals.

The fraction of total nutrition which is provided by animals is important when attempting to assess the demand upon agriculture because it takes up to 5 kg of grain to produce 1 kg of beef or pork, and 3 kg for each 1 kg of poultry-meat or eggs. Milk production is much more efficient; the ratio of grain fed to product being approximately 1:1. These conversion rates have been improving over the years and are expected to improve further. They can also be considerably improved by the use of high-protein supplements such as soya-bean or cotton seed oil-cakes [13, 18].

Table 9: Per Capita Food Consumption (1970)

	Developed countries	Developing countries	World
Total kcal/day	3091	2211	2480
of which, animal products,	1064	189	425
cereals + roots	1360	1830	1880
Effective consumption			
kcal/day	6000	2750	3800
kg grain/year	550	260	350

When these conversion rates are applied in the appropriate proportions [13, 18, 28, 29] to the per capita consumption, then we find that the effective consumption of the developed countries was more like 6000 kcal per person per day, compared to only 2750 for the developing countries, or about 3800 kcal for the world as a whole.

Alternatively, these figures can be expressed in terms of the equivalent weight of food and feed grains. Allowing for 50% of cattle food to be supplied from pasture land, then the resulting effective grain consumption works out at about 550 kg per person per year for the developed countries, compared with 260 kg in the developing regions, and a world average of 350 kg.

Food and feed grains plus animal products together represent about 70% of world food production [29]. Root crops and oil seeds account for at least a further 20% and are generally higher yielding in terms of nutritional energy per hectare. Therefore, a model of world agriculture based entirely upon grain production would not be very misleading.

Consequently, a series of calculations has been made of the area of land required, as a function of the average annual yield. Various assumptions have been made about the size of the population and its average effective per capita consumption of grain. Included in these calculations are:

- 10% of the land area is set aside for growing non-food crops. This is the present proportion.
- 25% of the land is allowed to lie fallow or is not harvested.
- 20% of the crop is assumed to be lost in storage or transportation, or is consumed for seed.
- Forage grown on cropland is assumed to yield approximately the same useful energy per hectare as grain [13, 26].

The results of the calculations are shown in Figure 9. According to these results a population of 6,000 million can be fed at the same level as today from the same land area provided that the average (single crop) yield increases from about 2.2 tonnes/ hectare to about 2.75 tonnes/hectare, an increase of about 25% over about two decades. Similar increases have been achieved in a single decade recently, so the margin of safety is wide, and we may expect some improvement in the average level of nutrition between now and the end of the millennium.

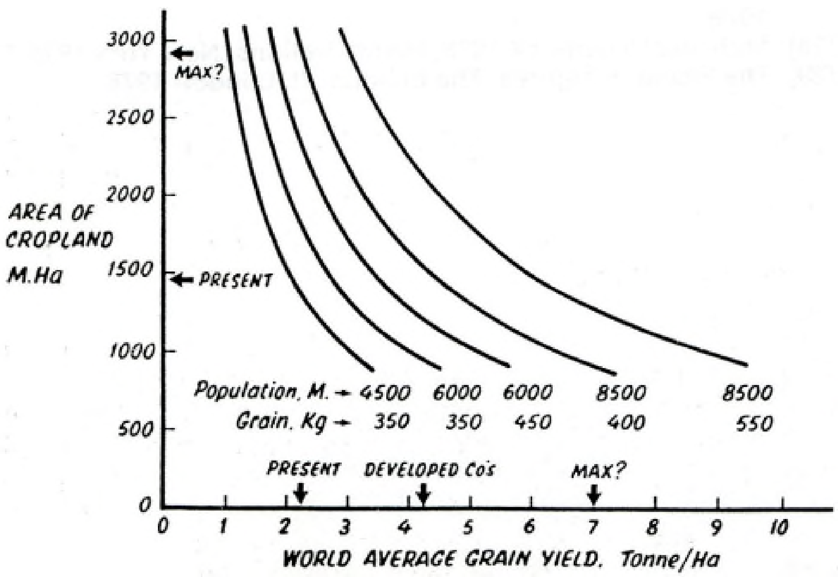


Fig. 9: Land Area Required for Food Production

It is clear from the shape of these curves that there will be a great incentive to increase yields so that the practice of double (and triple) cropping is bound to become more attractive as farm management skills improve in developing countries.

By the time that the population has reached 8,500 million, it will be necessary for the world average (single crop) yield to have climbed to at least 3.8 tonnes/hectare, an increase of 73% over today's, for present levels of consumption to be maintained. If the area of land under crops should concurrently increase by about 3% per decade, then a per capita (effective) consumption of 400 kg per year could be supported. Such a performance over seven decades implies a much slower rate of progress than that which has been achieved over the last two decades and so, again, we see a comfortable margin of safety.

With a single crop maximum in the region of 7 tonnes/hectare, and at least another 1000 million hectares of land available, there does not seem to be any room for being pessimistic in the long term. Clearly, even with the present level of agricultural technology, the world is quite capable of eventually supporting a population well in excess of 8500 million at levels of food consumption such as those presently being enjoyed in the developed economies.

Cotton vs Food

Given that the physical resources are available and that the socio-political evolution is likely to be appropriate for allowing the required improvement in agricultural productivity, why should we then expect that cotton will be allowed to expand at the same rate as food? There are several good reasons:

- Agricultural expansion will not be perfectly timed. As with many other industries, there will be periods of temporary overcapacity or shortage. During periods of shortage, additional investment is made in either bringing new land into production or acquiring new practices or know-how. During periods of overcapacity, production is switched, where possible, to crops whose prices are still at a profitable level. Thus, all crops tend to benefit even though a particular investment was made for a specific (e.g. food) crop. Unlike a synthetic fibre plant, a cotton plant can be brought into production one year and shut down the next, according to demand.

- A group of crops whose price is likely to hold up better than most is the oilseeds. This is because of the inevitable increase of emphasis of animal products in the diet as nations grow richer, and the five to ten-fold advantage of oil cake compared to grain when used as cattle feed [18]. Cotton seed is the fourth most important source of vegetable oil and the second largest source of oil cake after soya bean [27].

- An average hectare of cotton land in the USA yields, in addition to 500 kg of lint, nearly half the weight of oil and oil-cake as an average hectare of soya bean. The average value of cotton seed to the farmers has increased from about 9% of the total crop value to 16% in the last few decades. The price indexes of oil seed products have been consistently ahead of food and feed grains for most of the past two decades [12]. Soya bean will remain the primary supplier of this market but cotton farmers will feel the benefit of the steady demand for concentrated animal feed stocks.

- The expansion of double cropping in the tropics and sub-tropics will provide the perfect opportunity for cotton to increase production without consuming extra land. In many parts of the world cotton is a reasonable choice for crop rotation due to its deep rooting system. For the best results, it may be necessary for plant breeders to develop special short-season varieties to suit local conditions.

- Cotton is a non-perishable cash crop, an important fact for developing countries. The lint may be exported directly for valuable hard currency or it may be used as a domestic source of raw material for an emergent textile industry.

Sometimes, world market conditions are such that, other things being equal, it may be cheaper for a particular nation to grow cotton and import food. For example, the average world free-market prices for cotton and wheat over the period 1974-78 were respectively $1,535 and $140 per tonne. World average yields were 0.42 and 2.0 tonnes/hectare. Thus, an average hectare of cotton land would generate about $650 from lint alone which could have purchased about $4^1/_2$ tonnes of wheat. To produce that $4^1/_2$ tonnes of wheat domestically would have needed more than 2 hectares of land, i.e. about double.

The calculation is, of course, far too simplified but it serves to make the point that all agriculture is interlinked and food should not necessarily be separated from non-food production.

Conclusions

1. In order to supply an increasing world population with the present level of per capita cotton consumption; it may be necessary to increase the area devoted to cotton by up to 10 million hectares over the next seven decades, but only if yield increases are very low. Given reasonable progress in yields, the present land area should suffice.

2. In order to eventually supply a doubled world population with the same level of per capita cotton consumption as is presently enjoyed in the developed countries, it may be necessary to increase the area devoted to cotton by up to 30 million hectares if the world average cotton yield cannot be raised above about 900 kg/hectare. Such an enormous increase in demand would take a very long time to develop.

3. The world has at least another, 1,000 million hectares of potential arable crop land and the physical resources are available to ensure that food production will continue to keep in advance of population growth.

4. Therefore, there seems no reason to suppose that the expected doubling of the world's population will prevent cotton farmers from supplying whatever demand is actually generated within the limits mentioned in 1 and 2.

Postscript

It is important to point out that at no time in this paper has any attempt been made to forecast *actual* production or consumption of food or fibre.

The sole purpose of the calculations and arguments presented here is to allow one to decide whether, in the light of reasonable assumptions about population growth, the world as a whole would have critical problems in feeding its increasing numbers by reason of lack of resources, especially a shortage of land and the necessary agricultural inputs.

The fact that no serious shortages seem to have been found should not be taken to suggest that the task of feeding a doubled population will be an easy one or that the next seven decades will not witness further periods and areas of severe difficulties and deprivation such as have been seen in recent times.

Likewise, the fact that there seems to be no real shortage of agricultural land does not of itself guarantee that cotton production will automatically keep its present share of the total textile fibres market or that per capita consumption will be maintained. It means simply that if consumers should desire to increase their purchases of cotton goods and if the growth in income is sufficient to generate an increased demand for cotton, then there seems to be no good reason why cotton farmers around the world would not be able to meet the demand.

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