Cotton yield stagnation

Addressing a common effect of various causes

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Abstract

Yield is stagnating at world level, in developed countries or in developing countries, either under irrigation or not. Yield results from economic optimisation by farmers under existing technical and/or economic factors, analysis of yield stagnation is a tool to help clarify the issues cotton reseach has to address in order to modify the current yield trends. In a limited number of countries, yields actually reached are close to potential yields, cotton research has then to cope with the increase of potential yields, in particular through better exploitation of favorable interactions between genotypes and technical practices. However, in many countries, actual yield are still far from potential ones, cotton research has then to contribute to reduce this gap This paper emphasizes the role social scientists should play to clarify the reasons of the existing gap. Reluctance of many cotton producers to using too many costly inputs is also underlined, promoting more efficient use of these inputs is therefore a challenge to address, giving rationale to undertaking more studies to assess, for instance, the mechanism of cotton response to input use.

It is common to consider yield as an indicator of a production competitiveness for a country or an indicator of its profitability for the producers. Unconsciously, we, scientists, use to take yield as an indicator of our research performance. So, if yield is stagnating, such phenomenon could be interpretated as a demand addressed to scientists to carry out new outputs destined to improve production performance. Implicitly, we think that this demand is only a call for new techniques or new varieties. This contibution is devoted to somewhat clarify the issues cotton scientists have to tackle in order to have yield follow again an upward trend.

It is essential to emphasize that, from a producer's point of view, yield is not the final goal. Yield is only a means by which cotton producer could achieve better income, higher profitability. Under certain circonstances, yield increase leads to better revenue, however, beyond some level, yield increase will cause income reduction if this increase has requested higher production costs that additional income from the marginal gain of yield cannot pay back. This is the distinction we have to make between technical optimum and economic optimum. We can therefore consider that yield stagnation is the result of economic optimisation under the current production environment associated to technical and economic factors. As a consequence, new economic optimum at a higher yield level would require either new techniques or change in production environment, or both. Our position here is to advocate that cotton research must go beyond only carrying out new techniques.

In this contribution, I will firstly emphasize on the extend of the phenomenon of cotton yield stagnation. Then, clarification will be made on the issue of this stagnation for cotton scientists, and finally, research topics and methods will be underlined.

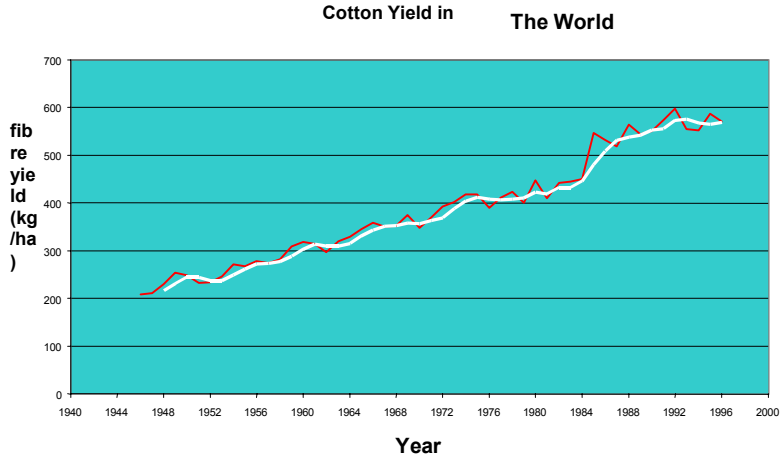
Liability of the information about yield could be a limitation to this contribution. Yield is a ratio combining production and acreage. Commonly speaking, in the case of cotton production which needs to be processed at ginnery, availability and liability of production

figures are of little trouble. For acreage figures, trouble is bigger because system for registration of crop acreage may be lacking. Even when such system exists, it ensures provision of acreage data, but this is not enough to ensure data liability. In many countries of francophone cotton producing countries, it is reported that farmers are willingly under-declaring their cotton acreage (Cousinié, 1993) while farmers in other countries may have rationale to over-declare their acreage. However, as we are focussing on the trends of the yield evolution for the recent period, liability on the exact value of yield is of limited impact on our analysis.

1. Yield stagnation as a worldwide phenomenon

From the world level perspective, it seems clear that yield is stagnating, this phenomenon takes place from the beginning of the 1980s (fig. 1).

Fig. 1 Cotton Yield evolution in the world



As cotton is produced either under irrigation or not, we have separated cotton producing countries into two groups of countries, a group with no irrigation at all and a group with irrigation, at least partly. Fig. 2 and Fig. 3 show that yield stagnation occurs with both types of production, although our distinction is rather rough as the level of irrigation is very diversified between countries within the second group.

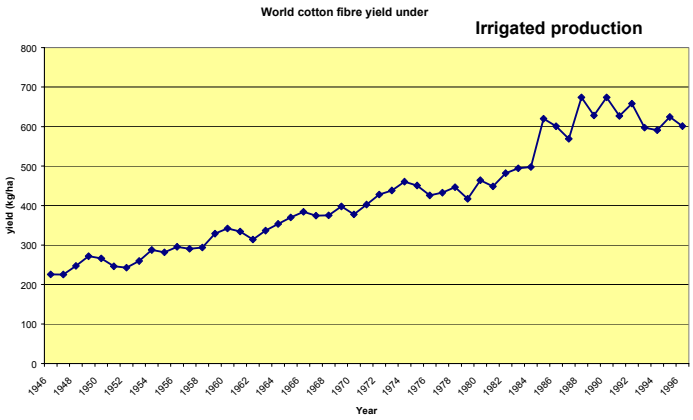


Fig. 2 World Yield evolution, irrigated production (data from ICAC)

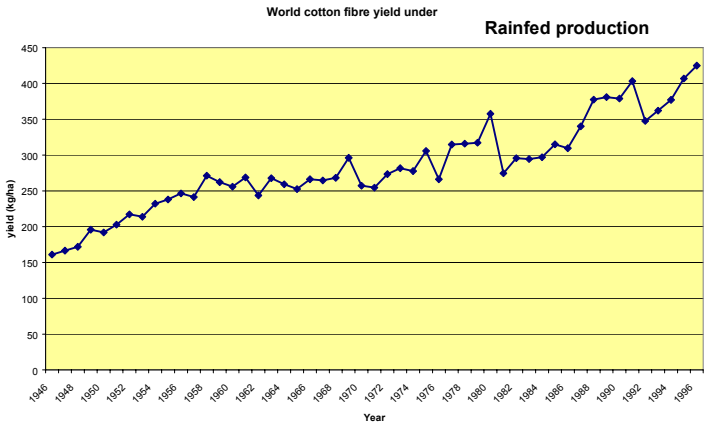


Fig. 3 World yield evolution, rainfed production (data from ICAC).

At the country level, yield stagnation occurs in developed countries (Australia, USA, Israel, Argentina) by the end of 1980, as well as in developing countries (China, Francophone African countries, India, …) by mid-1980s. In these developing countries, during the same period, yield decrease is even observed (Zimbabwe, Uganda, Paraguay, Mexico…). There are few countries experiencing yield increase during the last period, Turkey being a special case. Within a country, yield trends could be homogenous for some countries, like in the USA, or divergent in others, like in several cotton provinces in China (Graphic 1, Annex 1).

We should however remember that yield stagnation is not a new phenomenon. If we refer to the case of the USA which has played so significant role in cotton production in the world, yield stagnation was the normal course for a long time, until the end of the Great Depression, without stagnation of the cotton production (Graphic 2, Annex 1). We should then clarify the issue with the current yield stagnation and its impacts.

2. What's the matter with yield stagnation ?

2.1. Issue of the impacts of yield stagnation

At a first glance, one can wonder whether yield stagnation is an issue. In spite of such stagnation, world cotton production has kept on increasing, although at a low rate compared to the world potential demand[1]. Yield stagnation does not necessarily mean production stagnation, just like the period prior to WW1. However, in some extent, such limited growth may have been a factor of cotton loss of competitiveness towards man-made fiber.

Yield stagnation may imply, in some locations, income stagnation or even decrease, this is for example the case in the Delta or the SouthEast cotton Regions of the USA (Graphic 1, Annex 2). This effect on income is however not a generalized one. In countries where farmers have access to more land, they can compensate yield stagnation by increased cotton acreage to preserve or even increase their income (case in African countries, in particular in Mali, Graphic 2, Annex 2). Nevertheless, this cotton acreage extension may concern fragile soils not very suitable for cropping (Berckmoes, et al., 1990), and cotton production sustainability is threatened.

Yield stagnation is questioning however seriously cotton production attractiveness, at least in locations where farmers have choices for cash crop production. In China, as a consequence of yield stagnation, cotton value-added per labor is less favorable compared to rice growing, while cotton production has become financially more risky because of high input costs (Graphic 1, Annex 3). Hence, withdrawal from cotton production is becoming obvious in several Chinese provinces like Zhejiang, ShanDong, Shanghai…(Graphic 2, Annex 3), just like in many countries of Central America (Gabriele, 1994, Micarelli, 1991, Uribe Calad, 1994)

Reduction of cotton production in some countries has direct impact on their cotton exchange patterns. India has faced recently unsufficient production to cover its national consumption needs and has been pushed to import (Ferguson A.F. & Co, 1994, Sheth, 1997, Singh, et al., 1993). Yield stagnation, if not reduction, has made some countries to miss the

[1] According to an analysis based on a long period, the annual growth rate of cotton production in the world has been 2.30% during the second half of the century, while the rates for population growth and for income growth have been respectively of 1,85% and 2,18% (Fok, 1997).

opportunity of taking full advantage in exporting to the regional market, this is, for instance, the case of Zimbabwe (Macrae, 1995).

It makes sense to resume an upward trend of yield evolution. However, reasons of the observed yield stagnation need to be previously clarified.

2.2. Clarifying reasons of yield stagnation

Yield stagnation may derive from climatic constraints, but such constraints have only concerned few places. As yield stagnation has occurred more or less worldwide, lasting since around ten years, climate could not have been a general limiting factor. However, in some areas, like Sahelian regions of some African countries, diminution of rainfalls has been critical during the last 20 years, making cotton production less secure. As there are limited cash crop opportunities in these places, farmers keep on producing cotton although with less yield expectation (Fok, 1993).

Yield stagnation could signal also limits of the existing technical practices. Nevertheless, even if this hypothesis could not be rejected, such limitation only concerns a small number of countries. Fig. 4 and Fig. 5 provide the distribution of cotton yields obtained by various countries in 1996, with distinction of irrigated and non-irrigated production. Under irrigation, cotton yield varies from 300 to 1800 kg/ha, with only 5 countries showing yield over 1000 kg/ha. Under rainfed production, yield varies from 80 to 1100 kg/ha, with major part of the countries with yield below 600 kg/ha. The current performance does not point out that there is full exploitation of existing research outputs to reach higher yields, although insect resistance to some pesticides has limited yield expectation in major cotton producing countries. In many countries, there is still a great gap between the actual yield and potential yield with existing technical practices. For these countries, extending the yield potential by new techniques will not suffice to actually augment cotton yield.

In many countries, and this is the particular case of developing countries, yield is constrained by unfavorable conditions of technical progress application. This is not only true for food crops, it applies also to cash crops like cotton, in some extent some unfavorable conditions apply also to developed countries.

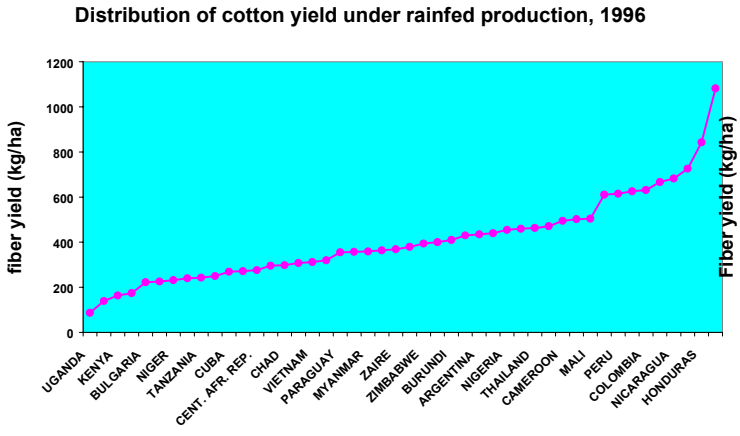


Fig. 4 Yield distribution of rainfed cotton

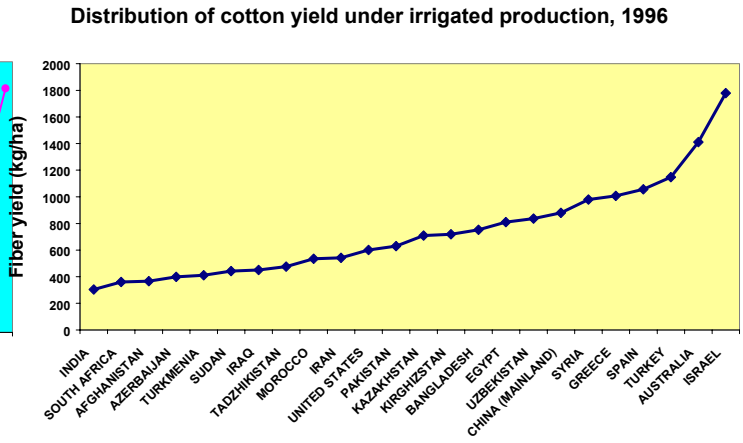


Fig. 5 Yield distribution of irrigated cotton

Among unfavorable conditions, lack of appropriate information dissemination is to be emphasized, it is connected to a wider topic of agricultural extension which we are not elaborating here.

However, one thing is to know how to use and how profitable it could be to use inputs, another is to be actually enabled to use inputs. The Training & Visit is an extension method promoted in many countries, this is a method that only considers provision of technical information, paying no attention to how farmers would get the inputs they need. For this reason, input application and desired yield progress have not been experienced significantly in countries where this method has been followed .

Lack of incentive for using inputs is another big issue. Although cotton is a cash crop ensured of finding an outlet, un-sufficient price is a factor that could not encourage investing in buying inputs. Non-price factors could also discourage farmers to do so (Lele, et al., 1989a, Lele, et al., 1989b). Tanzania is a case, for many years cotton farmers have experienced very delayed payment, up to one to two years (Dercon, 1994). Farmers provided their seedcotton and did not know when they will be paid, it was then risky to invest too much in production charge.

It is pitiful to observe that, even when farmers feel incentives to use inputs in order to increase their yield, inputs are not available. In many countries of Eastern and austral Africa, inputs are often not physically accessible, because no operator takes charge of the service of input provision. When there are such operators, they either do not accept to provide inputs with credit, or if they do, they apply high interest rate under various shapes (Upton, 1992).

However, in many countries, including in developed ones, inputs have become too expensive, leading to use less. Such phenomenon occurs in developed countries, like the USA (Graphic 1, Annex 4) or in developing countries, like in Mali (Graphic 2, Annex 4). This behavior of farmers' adaptation is an implicit demand towards cotton scientists. Such behavior is a way of expressing need for new combination of production factors that can ensured better profitability than the existing ones. In Mali, according to a survey we have participated to implement, we realized that farmers are using less compound fertilizers than recommended but they are using more urea, less expensive, while these fertilizers are not perfect substitutes (Programme coton, 1998).

3. What are research issues to address

From our analysis, we can consider two groups of research issues, one to deal with the reasons why yield is stagnating , another is to have yield improved. To have yield be improved, there is either to extend the existing yield potential or to decrease the gap to existing potential yield.

3.1. Analysing specifically reasons of yield stagnation

Reasons of yield stagnation is location-specific that need location-specific studies and that should involve more social scientists. Studies for identification and clarification of these reasons are a basis for setting up or amending cotton policies. In some countries those studies exist or have been implemented. It is however common to notice that such studies are implemented by external consultants, with little involvement of national scientists.

It is quite curious to realize that decision makers on cotton policies seem not to expect outputs regarding the functioning of cotton sectors from national scientists. It is worthwhile to correct this situation, this is beneficial also to technical scientists to know more about the conditions of application of their technical recommendations.

3.2. Achieving a new increment of potential yields

Yield potential could be improved following 3 possible ways. One is to have new varieties better fitted to an existing set of technical practices or technical patterns, this would mainly call for geneticists' implication. Another is to question the existing technical practices, available cultivars remaining unchanged, this would essentially call for agronomists' implication as well as crop protection spacialists. Finally, a more promising one would be to achieve new interactions between new cultivars and new technical practices, such way demands actual multi-disciplinary approach.

Improving yield potential without change in technical practices

Such improvement is requested for instance after environment change, either biotic or abiotic, is limiting yield potential. The most obvious phenomenon in this case is the occurrence of insect resistance to pesticides. Answers are expected from genetics, and in particular through biotechnology. These answers are already implemented, although still at a limited scale and we are still too close to have a proper view about the sustainability of such answers. Less obvious is the climatic change that demands new varieties more adapted for instance to reduced rainfalls.

For countries where farmers are reluctant to use costly fertilizers, implementing then a kind of soil mining through cotton growing (Van der Pol, 1990), breeding for genotypes with high fertilizer efficiency ratio makes sense. This breeding could concern also mechanisms of nutrient assimilation, or schemes of vegetative growth leading to higher harvest index.

Extending yield potential through new technical practices.

Experiment and implementation of new practices have become an reality in developed countries or at commercial cotton farms in developing countries. This is the case of ultra-narrow row planting (Reed, 1997, Stalcup, 1997). This is the case of no-tillage, of direct sowing as it is reported in Brazil (Seguy, et al., 1998).

In the area of crop protection, some achievements deserve to be mentioned. Scouting as a method to monitor chemical pest control has become common in developed countries, while Mali and Cameroon are experimenting a similar approach with illiterate farmers (Silvie, et al., 1998). In the USA, there are softwares to fine tune crop monitoring in terms of irrigation, of fertilizing, of pest control while a new generation of models is being achieved (Jallas, et al., 1998). Likely, great progress could come out to help achieve better cotton crop management, ensuring better yield, better income and better control of undesirable environmental impacts.

However, in developing countries, little is being done to carry out new technical practices that save input use, limit mineral exportations from the soil, ensuring both better yield and better income. For sure, new technical practices in the USA or Australia are not relevant to developing countries. Computerized crop monitoring neither. Nevertheless, there are implicit demands being addressed. In Francophone African countries, yield of around 1200 kg/ha of seedcotton is achieved with cotton plants up to 2 meter tall. There is room to maintain or even increase this yield level by limiting the vegetative growth which would favor a better mineral balance under the current practice of low fertilizer use. In Mali, according to a survey we have conducted, it is clear that farmers are implementing plant density lower than recommended (Programme coton, 1998), while the situation is quite reverse in Bolivia, where farmers are implementing high densities up to 100 000 plants/ha, and geneticists are keeping on testing genotypes at an unvaried density of 50000 plants/ha. It seems that there is a demand from farmers for new densities, in accordance with their strategies in input use.

Yield increase through new genotypes x technical practices

We think that the most promising way of extending yield potential could derive from exploitation of new genotypes x technical practices interactions. Genotypes react differently to technical practices. It seems therefore sound to expect that new technical practices should be experimented along with genotypes screening to obtain better outputs. This is not however the common practices. It is very usual that geneticists just ask agronomists what are the technical practices to follow. Therefore, genotypes are selected taking technical practices as given for ever.

So, there are serious prospects of progress from breeding on the basis of genotypes x technical practices interactions. Of course, such process will need an actual interaction between different disciplines, genetics, entomology, agronomy. As farmers' actual practices could differ somewhat significantly, interaction with farmers makes sense as well. This is one factor that gives rationale to the principle of Participatory breeding.

3.3. Reduction of the gap to potential yield

Of course, the existing large gap between the potential yield and yields that farmers achieved actually has some relationship, in many countries, with the issue of extension or more generally speaking with the information upon the use of inputs. Lack of information induces that valuable techniques remain unknown. However, non-application of research outputs does not necessarily mean that farmers do not know them, non-application also means that existing techniques are not suitable to farmers under constraints that were not taken into account by scientists.

Moving forward more efficient use of costly inputs

In many developing countries, as a consequence of suppression of subsidy policy for input use, there is an obvious reluctance from farmers to use costly inputs at dosages previously recommended before. As it was indicated in the case of Mali, farmers are trying to recombine fertilizers to decrease fertilizing costs (Annex 5). They are also delaying fertilizer spreading, in the extent that they may spread fertilizer at the most rainy period, with high leakage. In other words, trying to save costs, farmers may actually waste their money in a bad use of fertilizers.

Such situation means that scientists have to carry out new techniques more suitable to reluctance for using costly inputs. This is not an impossible challenge. Using less inputs but more efficiently is not an impossible task. The issue is to achieve better understanding of cotton response to input use, it is also to carry out new ways of diffusing information about input use, in order to allow farmers to monitor input use according, for instance, to the crop development or the rainfalls patterns.

Contribute to make inputs more accessible

Making input costs more acceptable is not an issue of technical research, however it is not an issue beyond the scope for research. Reasons that make input costs not-acceptable by the farmers is of course the costs level, but the costs level is not only an issue of input price. What are the real reasons and how to satisfactorily address them deserves to be tackled through specific studies.

Because of landlocked situation, some countries are facing transaction costs that could double the input price at farm gate position. In addition, some debatable tax policy could make input affordable to only few farmers. In Sub-Saharian Africa, international fertilizer providers use

to claim that preferential tax policy on fertilizer is the best incentive to promote actual fertilizer supply, even in remote areas, and therefore to promote yield. A 5% tax is a maximum, the best being no taxing at the importation of fertilizers.

Affordability, pertaining to the price of inputs, is a factor of input accessibility. There are other factors being involved. In many developing countries, inputs are just not physically available at the locations where they are needed, at the right time, for the types expected (Fontaine and Sindzingre, 1991, Gergeley, 1992, Lele, et al., 1989a). This is a situation that we, in developed countries, can hardly imagine, but this is a very common thing in developing countries.

Beyond the availability, there is also the constraint of liquidity or credit access that prevent many farmers to get the inputs they need (Creupelandt, 1979, Lele, et al., 1989a). Reasons of non-accessibility are nevertheless very diversified, studies about the issue of input accessibility must be also location-specific. By the time being, there is a dominating belief that privatising input provision will improve the situation, there are few research works to contest this belief (Upton, 1992). In which extent this solution is working belongs also to cotton scientists' research scope, involving of course more social scientists.

4. Conclusion

Yield stagnation is often an issue for its impact on farmers' incomes, on the country production and exchange of cotton fiber, and also on undesirable environmental effects.Yield stagnation signals need for new technical progress. Of course, technical progress expected is to extend the limits of potential yield, but this need only concerns a restraint number of cotton countries. Many countries actually need to have the actual yield move closer to the potential yields.

To address the challenge of improving the yield potential, cotton scientists have to carry out new genotypes, new technical practices, and more promising is to propose outputs coming from exploitation of proper interactions between genotypes and technical practices. Exploration of such interactions demands actual multi-disciplinary approach, within which social sciences have also their words. In addition, social sciences are to get involved to help set up cotton policies in order to favor input accessibility.

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