limited intramolecular motion in the crystal. If the molecule is assumed to vibrate in a direction perpendicular to the plane made by the central four carbon atoms, the average distance between the central carbon atoms will appear to be shorter than the actual value.

The above interpretation is not restricted to 1,2-diarylethanes alone. A similar explanation was invoked to account for the apparently short C=C bond lengths found through X-ray crystallography for stilbenes[19]. In general, molecules with fragments of uneven sizes may not pack uniformly tightly. Some parts may have greater room for large-amplitude motion. This in turn may affect geometrical parameters determined as averages. The same phenomenon may occur in **1**. The molecule has a rigid ring connected to a rod-like ethynyl unit. Movement of the latter much in the manner of a stick-shift in a car could tilt the cyclopropene unit back and forth. The average distance between the carbon atoms would appear shorter as a result. Large amplitude motion of the ethynyl fragment has been demonstrated earlier in a different structure[20]. However, it must be pointed out that the structure analysis of **1** was performed at a fairly low temperature (120 K). Also, Baldridge *et al.* specifically ruled out elongated anisotropic displacement parameters in the direction of the double bond. Nevertheless, a careful examination of the thermal ellipsoids may still be useful.

Before indulging in further speculations on the origins of the failure of theory or experiment, it is perhaps preferable to first identify which one of them is wrong and by how much in the present case. This is best done using alternative experiments, rather than through additional higher level calculations. Neutron diffraction is one possibility. Another approach could be to persuade a synthetic chemist to make derivatives of **1**, preferably with a group which causes the least electronic and steric perturbation and to follow it up with low temperature X-ray structure determination.

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J. Chandrasekhar is in the Department of Organic Chemistry, Indian Institute of Science, Bangalore 560 012, India.

COMMENTARY

Thomas Malthus and sustainable agriculture

Suresh K. Sinha

Thomas Malthus, two centuries ago, wrote *'An essay on the principle of population'*. One of his many conclusions states: 'The existence of a tendency in mankind to increase, if unchecked, beyond the possibility of an adequate supply of food in a limited territory, must at once determine the question as to the natural right of the poor to full support in a state of society where the law of property is recognized'.

Malthus has been described as a multifacet personality, as a demographer, an economist, a politician, a sociologist, and as a moralist. However, he also had a keen perception of agriculture, and in today's terminology the concept of unsustainability is quite important. Both his essays of 1798 and 1830 clearly bring out his concern for agricultural production, labour, and the laws on taxation in the country of produce against free import of the same product from abroad. We recollect here a few of his statements which concern agriculture in the developing societies.

'In the growth of wheat, a vast quantity of seed is unavoidably lost. When it is dibbled instead of being sown in the common way, two peeks of seeds, wheat will yield as large a crop as two bushel, and thus quadruple the proportion of the return to the quantity of seed put into the ground. In *Philosophical Transactions* (1768) an account is given of an experiment in which, by separating the roots obtained from a single grain of wheat and transplanting them in a favourable soil, a return was obtained of above 500,000 grains. But without referring to peculiar instances and peculiar modes of cultivation, it is known that calculations have often been made, founded on positive experience of the produce of wheat in different soils and countries, cultivated in an ordinary way, and making allowance for all ordinary destruction of seed'.

'Homboldt has collected some estimates of this kind, from which it appears that, the north of Germany, Poland and Sweden, taken generally, produce from five to six grains from one, some fertile lands in France produce fifteen to one; and the good lands in Picardy and the Isle of France, from eight to ten grains for one. Hungary, Croatia, and Slavenia yield from eight to ten grains for one. In the Regno de la Plata, twelve grains from one are produced; near the city of Buenos Aires, sixteen to one; in the northern part of Mexico, seventeen; and in the equinoctial regions of Mexico, twenty four to one'.

There has been considerable progress in the last two centuries in improvement of wheat varieties which today cover large parts of the globe. The seed rate in several parts of the world ranges from 100 to 150 kg ha^{-1}. The highest average yield of wheat in Punjab is 4500 kg ha^{-1} but in many other regions it varies from 1200 kg ha^{-1} to 3000 kg ha^{-1}. If we consider the highest ratio of 1 grain to 24 in production in Mexico, at the time when Malthus wrote his essay, without fertilizer, modern tillage and modern agriculture, it would amount to saying that improvement has not more than doubled.

'Elevated as man is above all other animals by intellectual faculties, it is not to be supposed that the physical laws to which he is subjected should be essentially different from those which are observed to prevail in other parts of animated nature. He may increase slower than most other animals, but food is equally necessary to his support; and if this natural capacity of increase be greater than can be permanently supplied with food from a limited territory, his increase must be constantly retarded by the difficulty of procuring the means of subsistence'.

Malthus did realize that man had the capacity to increase the means of production, thereby in a sense predicting emergence and evolution of new techniques and technology in agriculture. This indeed has happened. But he considered land and its productivity as the potential limiting factors for agricultural production. This is brought out from the following statement.

'The main peculiarity which distinguishes man from other animals in the means of his support is the power which he possesses of very greatly increasing these means. But this power is obviously limited by the scarcity of land – by the great natural barrenness of a very large part of the surface of the earth – and by the decreasing proportion of produce which must necessarily be obtained from the continual addition of capital applied to land already in cultivation.

'It is, however, specifically with this diminishing and limited power of increasing the produce of the soil that we must compare the natural power of mankind to increase ....

'In an endeavour to determine the natural power of mankind to increase as well as their power of increasing the produce of the soil, we can have no other guide than past experience.

'The great check to the increase of plants and animals we know from experience, is the want of room and nourishment were the most abundant'.

He emphasized his point by giving the example of well-peopled countries such as England, France, Italy or Germany which would not be able to meet the food requirement from their land. By using the term well-peopled countries he was only calling them as developed countries in the present context.

'If, setting out from a tolerably well-peopled country such as England, France, Italy or Germany, we were to suppose that by great attention to agriculture, its produce could be permanently increased every twenty-five years by a quantity equal to that which it at present produces, it would be allowing a rate of increase decidedly beyond any probability of realization. The most sanguine cultivators could hardly expect that in the course of the next two hundred years each farm in the country on an average would produce eight times as much food as it produces at present, and still less than this rate of increase could continue so that each farm would produce twenty times as much as present in five hundred years, and forty times as much in one thousand years'.

'If the soil of any extensive well-peopled country were equally divided amongst its inhabitants the check would assume its most obvious and simple form. Perhaps each farm in the well-peopled countries of Europe might allow of one, or even doublings, without much distress, but the absolute impossibility of going on at the same rate is too glaring to escape the most careless thinker. When by extraordinary efforts, provision had been made for four times the number of persons which the land can support at present, what possible hope could there be of doubling the provision in the next twenty five years.

It may be expected, indeed, that in civilized and improved countries, the accumulation of capital, the division of labour, and the invention of machinery will extend the bounds of production; but we know from experience that the effects of these causes, which are quite astonishing in reference to some of the conveniences and luxuries of life, are very much less efficient in producing an increase of food; and although the saving of labour and an improved system of husbandry may be the means of pushing cultivation upon much poorer lands than could otherwise be worked, yet the increased quantity of the necessaries of life so obtained can never be such as to supersede for any length of time, the operation of the preventive and positive checks to population.

If in any country the yearly earnings of the commonest labourers determined, as they always will be, by the state of the demand and the supply of necessaries compared with labour, be not sufficient to bring up in health the largest families, one of the three things stated before must happen; either the prospect of this difficulty will prevent some or delay other marriages; or the diseases arising from bad nourishment will be introduced and the mortality be increased; or the progress of population will be retarded, partly by one cause, and partly by the other.

It is unquestionably true that in no country of the globe have the government, the distribution of property, and the habits of the people been such as to call forth in the most effective manner the resources of the soil.

It is the laws of nature, therefore, and not to the conduct and institutions of man, that we are to attribute the necessity of a strong check on the natural increase of population'.

The following important points emerge from the above statements, although these statements represent only a few of them:

The availability of land and productivity of soil limit food production; there would be improvement in technology for food production but it cannot match the increase in population; the best example of the productivity potential of wheat at the time Malthus wrote his essay was 1 to 24 seed production. Now the best we have is 100 kg to 5000 kg at field level. In many areas of the world the ratio remains 100 kg to 1500 to 2500 kg ha^{-1}. Therefore, we need to judge our progress more realistically; it was considered important not to favour liberal import of food from other territories to promote own production. This concept is valid even today in view of WTO regime; while Malthus calculated doubling of population in every 25 years, it has actually not happened in many countries. At the time the essay was written the world population was 1 billion. Accordingly, the present world population should have been at least 32 billion (even assuming a doubling time of 40 years) as against 6 billion now. By the same reasoning the population of India since independence should have been 1560 million by now. Fortunately all this has not happened.

One of the many reasons that the population has not reached the level according to the estimates and predictions of Malthus is the conscious control of population despite reduction in death rate. However, it would have been difficult to support the present population if some significant advances in agriculture and food production had not occurred. Let us consider the productivity levels of important crops such as wheat and rice during the times of Malthus and after. The yield of brown rice (husked rice) in Japan in 900 AD was 1 ton per hectare and rose to about 1.8 tons brown rice by the year 1800. The yield of wheat in England was 1.2 tons ha in 1800 AD. Therefore, it is not surprising that Malthus did not expect food production to meet the demand of growing population. Three major scientific steps changed the whole process of food production almost all over the world:

(a) Mendel's laws of inheritance postulated in 1866 were rediscovered in 1900. While earlier than this experiments on plant hybridization were done and segregates (in today's terminology) were obtained, it did not constitute the basis of inheritance. The concept of gene emerged which now is the foundation of genetic engineering and biotechnology. However, the most dramatic effect of the use of genetics in crop yield improvement occurred through the mechanism of heterosis and hybrid vigour. The high yields of maize obtained through this mechanism made crop improvement attractive to entrepreneurs and led to commercialization. This also brought into prominence and focus the importance of germplasm and biodiversity.

(b) Recognition of nutrient requirement and fertilizer use: It was shown by chemists that plants contained many elements in varying qualities. These nutrients must be obtained from soil. This led to the concept of fertilizers and its usage. The chemical process of ammonia production was a major step in this respect which created the whole fertilizer industry.

Realization that plants could mobilize nutrients from the soil only when it was adequately wet and the concept of irrigation which already existed in some form helped in the development of irrigation projects.

There were several famines in India in the nineteenth century. India experienced unprecedented droughts and the consequent famine in 1899–1900 which led the then government to establish the Irrigation Commission in 1901. One of the major recommendations of this commission was to develop irrigation to reduce the impact of drought and the chances of famine through increased production. More area was brought under cultivation, but there really was no significant impact on the productivity of major crops. The productivity of three major crops, wheat, mustard and gram (chickpeas) is given in Figure 1 for the period between 1895 and 1995. Wheat yield did not change until 1965 and that of rape-seed and mustard until 1985. However, a dramatic change in productivity of wheat started from 1970 but there is a slowing down in this crop also of late.

Three factors, genetic, nutrient and water, were independently realized as important for crop improvement and yet until they came together from 1965 a significant change in productivity and production did not occur. Indeed, Malthus had not visualized such an integration of methods or technology for crop production.

(c) The productivity and production of crops has often been reduced by diseases and insect pests. In mid-1930s, pesticides, particularly for insect pest control, were discovered and quickly became a component of agricultural practice. Some of the worst famines such as the one in Ireland and Bengal, India were triggered by plant diseases. Therefore, overcoming plant diseases became a major objective around the world. The genetic control of wheat rust in India was achieved earlier than the arrival of Mexican dwarf (*Rht*-1 and *Rht*-2 genes-based dwarfism along with other traits) wheats to India. A detailed study of the genetics of rust resistance shows that most Indian wheats have an important trait.

However, the insect pest problems continue to cause losses in crop productivity. Recent advances in technology such as genetic engineering have led to significant increases in yield in many crops. Genetic engineering resulting in insect-resistant transgenic plants and crops is a major effort these days. Consequently 38% of the transgenic crops are for making plants resistant against diseases and insect pests. Almost all these resistant crops belong to private sector in most countries with the possible exception of China. Since there is a transfer of genes across organisms, the technology has in some regions raised the question of safety and ethics. For example, the corn produced in USA from transgenic corn was not acceptable in Europe. In developing countries including India such crops can play an important role but the problems of ownership by multinational organizations may become a matter of concern, though it is unlikely that public sector transgenic crops would be seen in the

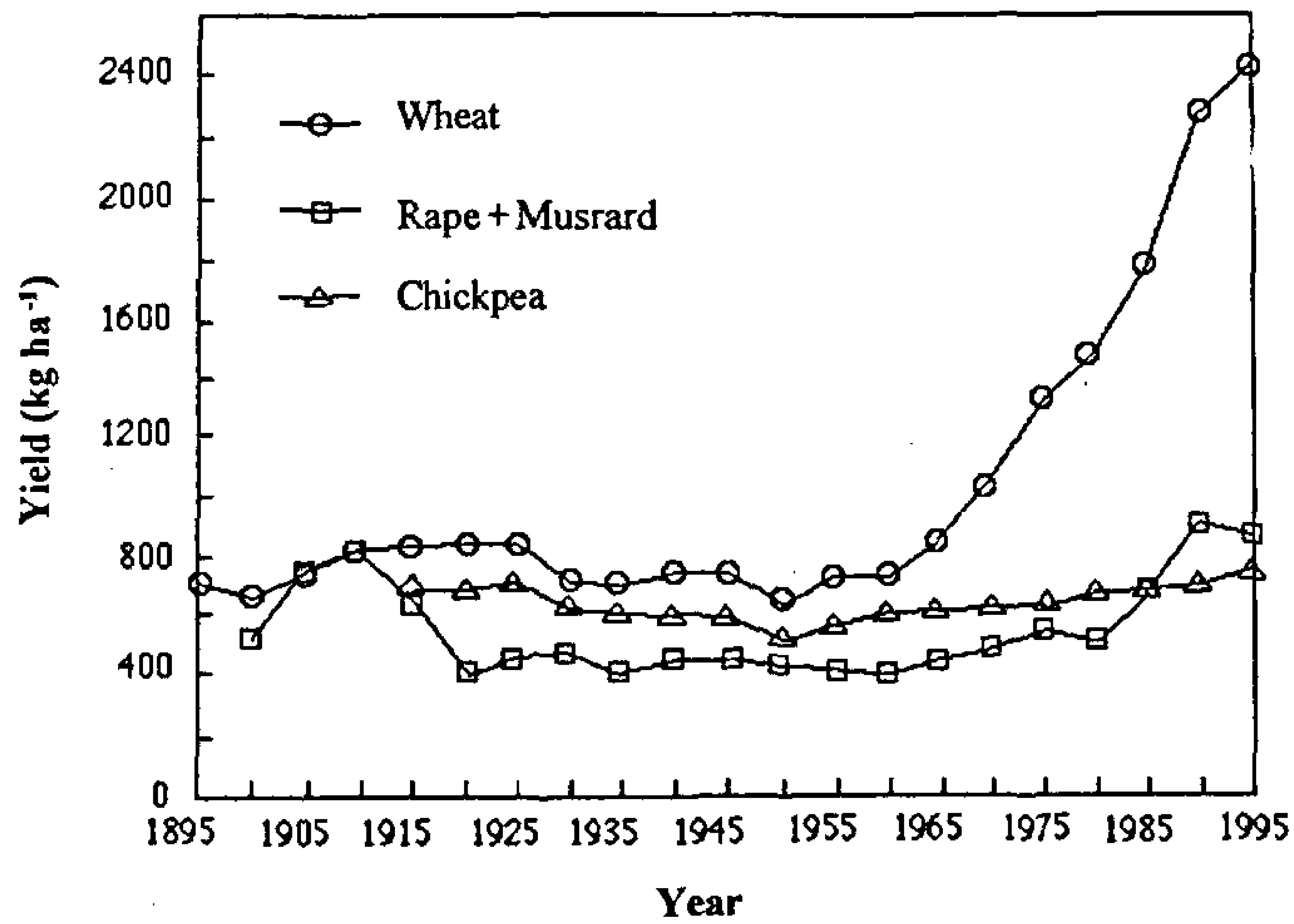

Figure 1. Change in productivity of wheat, rape + mustard and ckickpea in India since 1895 (each point is mean of proceeding 5 years)

farmer's field in the next 5–10 years. Efforts are now on for genetic management of nutrient efficiency. Such technologies help maintain the sustainability of cropping systems. These technologies were not described even in scientific fictions during the times of Malthus.

Future scenario

The future of mankind is still linked with the production and supply of food. The world population is expected to rise from the present 6 billion to 9 billion in the next 50 years. There is already a decline in cultivated area per person and the production of foodgrains per person after stabilization is showing signs of decline. This is because in many parts of the world the actual productivity is far below its potential. Many of these countries do not have access to capital resources and technology to use natural resources for achieving the desired levels of productivity. There are some countries which provide subsidy to farmers to keep land vacant and thus maintain a certain level of production. At the global level there is a possibility to sustain food supply for a regulated population. However, it seems that mankind is moving fast to an era of economic competition and survival of the fittest. Therefore, the question of sustainability has acquired a different perception and meaning to different countries and communities. Malthus talked of ethics and compassion which have been the basic tenets of Indian society, and these would have to be blended with technology to maintain sustainability without imposing segregation.

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Suresh K. Sinha is at the Water Technology Centre, Indian Agricultural Research Institute, New Delhi 110 012, India.

OPINION

The rise of the techno-baboo: IT is a brain-sink

Rajesh Kochhar

Computer software is the new pagoda tree which India is shaking vigorously. Earnings from software (SW) exports this year (1998–99) are expected to touch Rs 11,000 cr, up 60% from last year. The rise this year is higher partly due to depreciation of the rupee and the fact that the US has magnanimously agreed to issue entry visas to a larger number of SW professionals than before. One-third of this Rs 11,000 cr comes from a single city, Bangalore, which is home to some 270 firms, big and small, employing more than 80,000 people. The pace of SW growth can be gauged from the fact that barely seven years ago (1991–92), India's SW earnings stood at a paltry Rs 430 cr including Bangalore's Rs 6 cr.

The global SW market is worth $800 bn ($1 bn = Rs 4200 cr), so that India's share of the pie is a minuscule one part in 300. SW exports comprise about 8% of total Indian exports. It is a measure of India's tottering economy that though small as percentage, the SW earnings come as *manna from heaven* for the beleagured budget-makers.

On the domestic front, the SW effect is discernible in two sectors: motorbike and soft-porn. There has been a spurt in the sale of motorbikes, the entry-level *savari* of the young, ambitious software professionals (that is, the yaspies). This spurt is in sharp contrast to the decline in the sale of scooters, the life-long vehicle of the lower middle class. While the craze for motorbikes is merely a rearrangement within the two-wheeler segment, soft-porn is a new vista. Moneyed but overworked, and away from the loving but intrusive eyes of the fam-