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PROBLEMS AND PROSPECTS OF POTATO IMPROVEMENT IN INDIA*

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INTRODUCTION

THE importance of potato as a food crop of mankind needs no emphasis. Of the more important food crops, potatoes give the greatest weight of produce per acre as will be seen from the following figures of yields given in the International Year Book of Agricultural Statistics, 1935-36 and 1936-37.

Potatoes	...	...	...	...	4.15 tons per acre
Wheat	...	...	...	...	0.37 " " "
Maize	...	...	...	...	0.52 " " "
Rice	...	...	...	...	0.59 " " "
Oats	...	...	...	...	0.45 " " "

As a world source of food energy it ranks higher than the cereals yielding as much as four times the calories per acre of the latter. In most countries it forms a regular and considerable part of human diet taking an equal share with cereals and in some countries even a larger share. The average annual consumption of potatoes per man in some of the Western countries is about 500 lbs.

Apart from its energy value, potato has other merits as food ; it contains appreciable quantities of protein, minerals and vitamins B and C. It is also a desirable source of food for neutralizing excess of acidity in the stomach since it contains 9 c.c. of alkali for every 100 gms. of raw tuber. Assuming that a normal man needs a minimum of 3,000 calories to make good his daily expenditure of energy, the consumption of 7 lbs. of potatoes a day would satisfy his requirements ; this quantity would give him, in addition, all the proteins, iron, vitamins B and C, about half the phosphorous and 1/10th calcium he requires. If he drank a pint of milk in addition, he would get sufficient quantity of vitamins A and D and be in possession of a diet nearly perfect in all respects. In fact, the Irish labourers of the last century remained in good health for 10 months of the year on a diet consisting of little else than unlimited potatoes and a glass or two of milk.

In addition to providing wholesome food for the people, potatoes can be used as a fodder for livestock, as a source of starch for food products such as biscuits, and as a raw product for the manufacture of dextrine, glucose and sizing for textile industry. Speaking of the tremendous potentialities of potatoes in the food resources of mankind, Nixion in his book on ' Principles of potato production ' has remarked " the part that

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the potato plays at the present time in maintaining life, through supplying food to the densely populated continent, serves to direct our attention to the part it is destined to play as a source of food in our own country (U.S.A.) and in our own continent (America) in the years to come. The famines which normally devastated Europe became much less frequent after the potato was cultivated as a food crop..... We need only ask what the universal adoption and the scientific production of potato would mean to the starving millions of China". According to Wallace, a former Secretary for Agriculture in the U.S.A., "without the potato the great war could not have been fought..... Certainly it furnished a great reservoir of power and food for the German people and occupied a very prominent place in the dietary of our own people".

The second world war gave a great fillip to the expansion of potato industry in Europe and America. In 1943, the estimated amount of potatoes moving into civilian consumption in the U.K. had risen to 255.8 lbs. per head representing an increase of nearly 45 per cent in the average consumption of potatoes during the war. In all countries, where population has increased, potatoes are being increasingly used to supplement the food resources.

PRESENT POSITION OF POTATO IN INDIA

It is unfortunate that in India, where we are faced with a chronic deficiency in cereals, we have not made use of this valuable food crop to the extent it deserves. Greater production of this food in the country, which it is possible to achieve by scientific research, will, besides providing palatable food for the people, relieve the pressure on cereals.

Potatoes, although introduced into India as far back as the 17th century, have not made much progress in our country. According to the estimate made in 1939, only about 4,80,000 acres were under cultivation of this crop, the average acre yield being of the order of 100 maunds. During the war years there has been a slight increase in the acreage and at present it is estimated to be about half a million acres which represent only about 0.2 per cent of the net area cropped in the country. About 90 per cent of the potatoes are grown in the North Indian plains in winter and the rest in the hills in summer; in the cooler elevations of the peninsula, particularly in the Nilgiris, the crop is cultivated all the year round owing to the mild climate prevailing there. The total annual production of potatoes is about 50 million maunds and the annual average quantity imported into India is about 1 million maunds. After meeting the demand for seed and deducting the heavy losses in storage, the quantity available for human consumption is very small indeed. It is estimated to be about only 8 lbs. *per capita* per year, as against as much as 500 lbs. in some of the Western countries.

There is considerable scope for increasing both the area and yield of this crop in India through scientific research. According to Burns "given disease-free seed potatoes and suitable manuring, the production of potatoes in the existing acreage can be doubled". By breeding superior varieties it is possible to still further increase the yield to at least 250 maunds per acre and with this yield potatoes will provide a quantity of carbohydrate at least five times that of wheat or rice. The significance of this result to India's precarious food supply is obvious. To achieve this result, however, it would be necessary to successfully solve the many complex and inter-related problems of production by scientific research which cover many fields of science. While some of these are short-range problems such as the immediate production of suitable high-yielding varieties for the existing areas and control of diseases and insect pests which cause damage to the crop, others are essentially of a long-time nature such as the production of varieties for special conditions of soil and climate and those with resistance to diseases and pests, frost, drought, etc. The nutritive value and quality of the tubers

would also require improvement and the production of varieties for fodder and industrial use will also come in after we have become self-sufficient in food.

A BRIEF SURVEY OF THE PROBLEMS OF POTATO PRODUCTION

The main problems relating to increased production may be briefly stated as follows :

- (i) The absence of suitable varieties for the varying conditions of soil and climate in the country,
- (ii) the heavy toll taken by fungal, bacterial and virus diseases and by insect pests which attack the crop both in the field and in storage, and
- (iii) the non-availability of sound and healthy seed in sufficient quantities at the right time and at reasonable prices.

A few remarks on the position in regard to each of the above items may not be out of place here.

Varieties : It is our general experience in the country that varieties which are suitable for growing in the hills of North India are not always suitable for growing in the plains. It is further our experience that while the foreign varieties have been found to do fairly well in the hills, they have nearly always proved a failure in the plains. Thus, while many foreign varieties are still cultivated in the hills even to-day, there are hardly three or four popular varieties in the plains which are presumably derived from the foreign varieties which have lost their identity.

The potato plant is very sensitive to temperature and photoperiodic changes and it is, therefore, essential to provide them with the optimum conditions for successful growth and yield. Varieties differ in their reactions to temperature and photoperiods and this factor has to be taken into account in breeding varieties for the different zones in the country. For this reason it is not profitable to cultivate varieties adapted to long-day conditions, such as the European and American varieties, in the North Indian plains where short-day conditions prevail during the growth of the potato crop. Hence, varieties for the plains have to be bred in the plains under the conditions which occur there. Up to now no breeding work has been done for this region which occupies nearly 9/10ths of our area under potatoes. Similarly, varieties have to be produced for the warmer regions of Bengal and for the peninsular regions of India under the local environment.

Perhaps no crop is as responsive to manurial and cultural conditions and to the soil-type on which they are grown, as the potatoes. To get maximum yields it would be necessary to undertake investigations on the reaction of varieties to these factors and fit in suitable varieties for the different regions.

Diseases : The fungal, bacterial and virus diseases take a heavy toll and generally reduce yields. The proper control of these diseases becomes almost a limiting factor in the successful production of the crop in certain regions. Most of our knowledge of these diseases is empirical as gleaned from the works of investigators in foreign countries. It is absolutely necessary to carry out an extensive and proper survey of the fungal, bacterial and virus diseases of the crop in the country with a view to determining the relative importance of the pathogens in the different tracts, the extent of their spread, the conditions which favour their inciting epiphytotics and the magnitude of damage they cause.

In the hills of North India late blight caused by *Phytophthora infestans* is a serious disease while it is practically unknown in the Nilgiris. *Alternaria solani* which causes early blight is fairly widespread in the plains and in the hills. Bacterial and fungal diseases causing wilts of plants in the field and rotting of tubers in storage are quite common. A thorough investigation of these diseases will have to be undertaken with a view to immediately discovering preventive and curative measures for their control and ultimately to breeding resistant varieties.

Insect pests : The problem of insect pests needs the same amount of attention as that of the diseases. Many of these insects such as the cut worm, *Epilachna* beetle and the tuber moth cause considerable damage to the crop ; the tuber moth is particularly destructive in storage. The epidemiology of these pests has to be carefully studied and suitable control measures found out.

The more dangerous aspect of the insect problem is the role of the insects like the aphids and the white fly which act as vectors for destructive viruses. The problem of securing disease-free seed stock would not be solved unless the habitat and mode of transmission of the disease by the vectors are properly understood.

Supply of disease-free seed : Since the use of sound and disease-free seed is imperative for the successful production of the crop, proper arrangements for the supply of sound and healthy seed in adequate quantities should be made in the country. This work is undertaken in other more progressive countries by well organized Seed Certification Organizations which undertake the multiplication of seed under expert supervision and supply the seed to cultivators under certificates guaranteeing purity and freedom from disease. Such organizations have yet to be developed in our country and at present our cultivators are faced with a paucity of seed at sowing time ; whatever seed that is available is not also of approved standard. The inadequate supply of seed and its poor quality stand in the way of expansion of the area under the crop and the production of high yields.

The difficulties of storage of potatoes in the country also accentuate the problem of seed supply. While the problem of seed supply in the hills is comparatively easy, that in the plains is more difficult. Potatoes stored in the plains deteriorate rapidly and owing to heavy losses which amount to as much as 50 per cent, there is not sufficient seed available at sowing time. Attempts are being made to get seed from the hills where storing conditions are more favourable and disease is also less severe, but the quantity so obtained is not sufficient ; for one thing, there is not sufficient area in the hills to provide enough seed for the entire area in the plains and for another, only the seed grown in the lower hills, which is harvested in July, is suitable for growing in the plains and that from the higher regions, which is harvested in later August and September, is unsuitable for sowing the first crop in the plains because of the dormancy of the harvested tubers. Besides, seed obtained from the hills in late November and December for late planting in the plains is exposed to the risk of carrying the destructive disease 'late blight', which is normally absent in the plains. Actually outbreaks of late blight have been noticed in late sown crops in the plains in certain years.

PROSPECTS OF POTATO IMPROVEMENT BY SCIENTIFIC RESEARCH

By pursuing a carefully planned and co-ordinated programme of research and development, it is possible to extend the area under the crop and also increase acre-yields. The Government of India have recently sanctioned the establishment of a Central Research Institute for the purpose, which in co-operation with provincial Departments of Agriculture should be able to solve the many problems confronting potato production in the country. I shall briefly refer to a few lines of work which will help towards achieving the objective.

Breeding : By far the most important line of work connected with the improvement of the crop is breeding. It is possible by using suitable breeding material and methods to go a great way in producing varieties to order. We are now very fortunate in this respect since the discovery and collection of the large range of breeding material consisting of several varieties and species from the home of the potatoes in Central and South America. This collection consists of a great multiplicity of forms and species which contain many genes for resistance to diseases, pests and which are found in the so-called primitive forms occurring in the centres of origin and nowhere. They also

contain forms for early maturity, late maturity, short-photoperiod, long photoperiod, etc. This collection is now maintained and studied from the point of view of their usefulness for breeding, at Cambridge under a scheme sponsored by the Empire countries which financed the expedition. India, as a participating country in the scheme, is entitled to this material and we have already got many of these forms in our collection maintained at the Potato Breeding Substation, Simla. The collection at Simla consists of over 20 species of tuber-forming *Solanum* which are known to contain one or other of the desirable genes for breeding the ideal commercial potato. Thus *Solanum Antipoviczii* and *S. demissum* are late blight resistant, *S. acaule* and *S. curtilobum* are resistant to frost, *S. Rybinii* resistant to certain types of virus diseases, besides possessing non-dormant tubers, *S. andigenum* is high-yielding and *S. phureja* has a high protein content in its tubers. *S. andigenum* and *S. phureja* are of particular value for breeding varieties for our sub-tropical conditions. The former species is adapted to short-day conditions and the latter by virtue of its adaptation to hot valleys at much lower altitudes, should prove valuable for breeding varieties for regions with comparatively high temperatures.

It must, however, be stated that the process of producing the ideal potato with all the desirable characters, viz., high yield, good quality, resistance to diseases and pests, by means of inter-species crosses, is a long and difficult one. While this work goes on, it would be necessary to breed better varieties than the existing ones by means of inter-varietal crosses and by exploiting the variability in the existing commercial varieties. It must be remembered that all the potato varieties in existence even up to the present time, in Europe, have originated through sexual reproduction from a few early introductions. In our own country no attempts have been made up to now, on a large scale, to raise plants from true seed to exploit the variations latent in the commercial varieties. For instance, the popular variety *Phulwa* flowers profusely in the plains of North India and forms berries with a large number of seeds in each. We have now raised large selfed- and open-pollinated progenies from plants of this variety. The progenies are remarkable for the enormous variation they have shown in respect of some characters. These are being studied and it is quite possible that desirable varieties with superior commercial characters may be available for selection from them. It is clear from the foregoing that the chances of breeding better types of commercial potatoes for the different regions in the country are bright if we would adopt the proper approach to the question.

Seed Certification : The question of potato seed certification has already been referred to earlier. Seed certification aims at making available to the cultivator seeds of improved varieties in a state of purity and reasonable freedom from seed-borne diseases at equitable prices. It must be emphasized that without an efficient organization for multiplying certified seed in the provinces, all the good seed that will be distributed will soon degenerate and pass into oblivion. Furthermore, there is the danger of the blame for poor yields being placed on the variety while really it should be on the poor quality of the seed.

The Indian Council of Agricultural Research have already taken steps to help in the setting up of potato seed-certification organizations in certain important potato-growing provinces and have invited schemes from them in this connection. The basic requisites for seed certification are (i) the availability of disease-free foundation stocks of improved varieties, (ii) the location of areas which are least favourable for the spread of virus diseases, where multiplication of seed could be undertaken with reasonable freedom from diseases, (iii) well-trained technical staff for carrying out the inspection of the growing crops and the harvested tubers and certifying that the seed is of approved standard, and (iv) facilities for proper storage of seed. Unfortunately, these conditions are not fully met in most of the provinces, but it is time we created the conditions for setting up the seed-certification organizations which are so essential for the development of the potato industry in the country.

Propagation by true seeds : The advantages of propagation by true seed for exploiting the hidden variability in commercial varieties have been referred to earlier. Now I wish to refer to another more important aspect of this question and that is, propagation by seed for commercial growing of the crop. Although potato crops are raised from tubers, many of them, under favourable conditions, flower and bear fruit (berries) with well-formed seeds inside them. These seeds are capable of germination and they produce seedlings, each with a definite tap root and two or three ovate cotyledons. A good seedling will and has been found to crop as well as a plant derived from a seed tuber. Therefore there is no reason why it should not be possible to raise a crop of potatoes with true seeds. The advantages of such a method are many and may be stated as follows : (i) a crop raised from true seed is free from virus infection which causes considerable reduction in yield ; this method if it could be successfully adopted, will lessen the pressure on the expensive certification schemes, (ii) one ounce of seed (55,000 to 60,000 seeds are contained in one ounce) will suffice for planting one acre thereby releasing about at least 10 maunds of seed tubers for human consumption, (iii) with propagation by true seeds, the cost on seed tubers will practically vanish bringing down the cost of cultivation, and (iv) transport of seed from one place to another will become easy and inexpensive and the problem of storage will be eliminated.

I now wish to examine the possibilities of raising potato crops from true seeds. In Western countries the potato-crop season usually succeeds the winter. Because of low temperatures prevailing in those countries prior to and at the beginning of the potato-crop season, it is not possible for them to raise seedlings on a large scale and that is probably the reason why this method has not been tried on a large scale. In India, however, in the northern plains, warm weather during August and September is quite conducive to the germination of the seeds and the growth of seedlings. Small nurseries could be raised well before the planting season and the seedlings planted out in the field in October and November. Our farmers who are used to raising nurseries of tobacco and chilli seedlings should find it quite easy to do so. We have raised large number of seedlings from true seeds of the variety, *Phulwa*, which flowers profusely in the plains and sets seed abundantly and our seedlings which are planted out at the Central Potato Research Institute in Patna, are growing very well. There does not appear, therefore, that there will be any practical difficulty in the actual cultivation of the crop by means of true seed. There are, however, certain limitations which have to be studied and overcome before the practice can be recommended on a large scale. Through many years of vegetative propagation, the commercial varieties which flower in the plains have developed a highly heterozygous genetic constitution and in some cases have undesirable features like male-sterility and too-little pollen. It is not beyond the capacity of the geneticist to eliminate these undesirable features and produce varieties which will yield a fairly uniform progeny. When this is done, I am confident that the growing of the crop by means of true seed will become a practical proposition much to the advantage of the industry. Work in this aspect of the problem is proceeding in the Central Potato Research Institute and it will be possible to give more details in due course.

CONCLUSION

I have now finished my rambling survey of the problems of potato production in this country and the prospects of its improvement through scientific research. It is clear that our present production of potatoes is very low and it is capable of considerable improvement. In adopting measures for its improvement, short-term programmes dealing with production of high yielding varieties, cultural and manurial problems, seed certification and seed storage should receive attention side by side with highly technical aspects such as breeding for resistance to diseases and pests and adverse conditions of soil and climate, nutritive quality, etc.