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PLANT PROTECTION - A KEY TO MAINTAINING PRESENT GAINS IN FOOD PRODUCTION

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PLANT PROTECTION - A KEY TO MAINTAINING PRESENT GAINS IN FOOD PRODUCTION

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Although the main theme of the present workshop is to discuss the problems arising out of the increase in food production in the developing countries, it is appropriate that we understand the problems which are likely to reverse this trend and then discuss what we could do to avoid such reversals. Every one knows that the recent breakthroughs in food production in the developing countries have been possible mainly because of the introduction of high yielding cultivars and the technology which goes with them. More and more farmers in these countries are enthusiastically adopting these varieties and new cultural practices. More fertilizers and water are used to exploit the high yield potential of such varieties. It is well-known that when more fertilizer and more water are given to a higher plant population, there always is a danger of more intense attacks by pathogens and pests. Also, when germplasms are introduced for the first time into a new geographical region, certain pathogens and pests, hitherto unimportant, are apt to become more destructive because of the likelihood of susceptibility of these germplasms. As pointed out earlier, the successful cultivation of high yielding cultivars requires correspondingly advanced cultural practices. In attempting to increase food production, there is naturally a tendency to cultivate only those few varieties, even sometimes a single one, over large contiguous areas. This poses the danger of sudden outbreaks of epiphytotics (epidemics) of diseases and pests. It is a novel experience for the farmers in these developing countries to use agrochemicals. Mistakes committed, through ignorance or carelessness, in the application of chemicals result in crop losses. The purpose of this paper is to highlight the crop disease and pest problems which have assumed importance since the introduction of high yielding varieties. Since I am an Indian and a Plant Pathologist, I will base my observations on my experiences in India as a Plant Pathologist. For the sake of convenience, I will first

discuss the problems of individual crops, then make some general observations on the occurrence of problems arising out of the increased use of agrochemicals, and finally discuss what steps need to be undertaken to protect crops.

WHEAT

In July 1968, the Government of India issued a special stamp commemorating the wheat revolution in the country. The production of wheat had made a big leap in 1967-68 from 11.4 million tons in the previous year and 12.3 million tons in 1964-65 -- the earlier year of record production -- to 16.6 million tons. This meant almost a 50 percent increase over the previous year and 33 percent over the previous record production (12). This achievement and breakthrough in the wheat production undoubtedly justified the issue of a special stamp. Much of this achievement has been attributed to the cultivation of new high yielding varieties.

Before I discuss how these varieties have performed this far, I would like to narrate what happened to the wheat variety Gaines in the United States (4). The American delegates assembled here, I am sure, know the story. This is, therefore, primarily for the delegates from other countries. The story of Gaines has an important lesson to teach those of us who represent developing countries. Under the recommended management schedule for the high yielding wheats grown in the Pacific North-West, the variety Gaines has a yield potential up towards 6000 lb.(100 bu.) per acre. Because of this high yield potential, the release of Gaines for production in that region was hearlded with great optimism, but with little appreciation or apprehension for its potential susceptibility to diseases. Consequently, few people were prepared for the destructive onslaughts of disease that followed, to nullify much of the yield potential inherent in this variety.

In the development of Gaines wheat, consideration of disease resistance was limited to smut (bunt), because that was the only serious disease in the Pacific North-West for the previous half

century or more. However, other diseases were very much present in the area. These included rusts, leaf spots, seedling blights, root rots, snow molds, powdery mildew, etc. All these diseases started becoming more evident as soon as a favorable target was available. Gaines became an easy prey, since it was susceptible to all of them except smut. Besides, the management practices recommended as essential for expression of the high yield potential in Gaines are the same practices that create ideal conditions for epiphytotic development of such diseases as yellow rust, foot rots, and powdery mildew. In the Pacific North-West, Gaines wheat yields best when it is planted early and given high levels of nitrogenous fertilizer. The seedlings that develop from early seeding are fully exposed to infection from late summer spores of both the yellow rust and powdery mildew fungi. This not only sets the stage for epiphytotic development of both of these diseases in the autumn but it also provides for widespread overwintering of inoculum to continue them in epiphytotic proportions in the following spring and summer. Moreover the long pre-winter growing season brings the plants to the stage of development most vulnerable to invasion by Cercosporella foot rot disease.

Every year of its production in the Pacific North-West, Gaines has sustained significant losses from one or the other of these diseases, one of which was an epiphytotic of powdery mildew in 1965-66, the first epiphytotic of this disease ever recorded in that region. The conditions which led to this situation were (i) ample soil moisture which permitted early seeding, (ii) warm and vigorous development of plant growth, (iii) heavy rates of nitrogen fertilizers for exploiting yield potential, and (iv) favorable winter weather for the overwintering of the powdery mildew inoculum. All these factors contributed to the summer epiphytotic which followed and swept across 753,000 acres of Gaines wheat, reducing potential yields significantly, by an estimated 15 percent.

I have gone into these details mainly to set the stage for discussion of similar situations on the Indian scene.

The dwarf varieties like Sonora 64 and Lerma Rojo were introduced into India from Mexico in 1964. Lerma Rojo did not attract growers or housewives because of the red grain color and the poor quality of the chapati (Indian flat bread) made from it. Sonora 64, though red-grained, was cultivated over a large acreage primarily because of high yielding capacity and dwarfness which gave it a better chance to withstand strong winds late in the season. By 1966, however, it was realized that Sonora 64 was susceptible to loose smut, and at some locations as much as 13 percent loose smut was recorded. The years of cultivation of Sonora 64 coincided with the drought periods and hence its susceptibility to yellow rust was not fully realized until 1967 when northern India had slightly above-normal rains. Sonora 64 was plastered with yellow rust. An amber-colored germ plasm developed from Sonora 64 and called Sharbati Sonora, which was released soon after to the farmers was equally susceptible to yellow rust. Sonora 64 has now more or less been discarded.

Fortunately, two more varieties were made available in 1966. These were Kalyan Sona and Sonalika. Sonalika was developed from the original Mexican S308 and Kalyan Sona from the unselected S227 seed also obtained from Mexico. Both these varieties were accepted by farmers because the grain is amber-colored, and, of course, they are dwarf and high yielding. Both these varieties are still popular but each is having its share of problems. Originally both were claimed to be resistant to all three rusts. The year (1966-67) when Sonalika was cultivated on large scale, the country on the whole had good winter rains and there were some late showers around harvest time. The plump grains of Sonalika are exposed before harvesting (this leads to shattering also). The rain at this time provided favorable conditions for infection by that ubiquitous fungus, Alternaria tenuis, and many farmers in north India had rather a high incidence (as much as 50 percent in some fields) of "black point" of wheat grains. The fungus causes a superficial brown discoloration on the tip of the grain just above the embryo. Immediately there

was a big scare amongst the farmers as well as the general public because of an apprehension that such grains could be carrying some toxic substance. This particular fear arose because in the preceding Kharif (July-October) season, the pearl millet (Pennisetum typhoideum) crop suffered from ergot and there were cases of cattle and human poisoning. The scare became more intense because of excess publicity in newspapers. The prices of infected wheat stocks fell. Fortunately, however, this situation did not continue very long because, within three months, the results of research carried out in at least four agricultural institutions in North India clearly established that (i) the infected seed did not carry any poisonous substance, (ii) the infected seed germinated normally, and (iii) the infection remained localized even under poor storage conditions.

As pointed out earlier, both Kalyan-Sona and Sonalika were hearlded in 1966 as rust-resistant. However, by 1968, it became clear that in certain regions these were susceptible to brown rust as well as to black stem rust. In fact, in one of the south Indian stages, the cultivation of Kalyan-Sona has almost been discontinued. It is still not clear whether new races of these two rust fungi have appeared on the scene. What appears to be a dangerous situation at the moment is that these two varieties are being planted more and more each year and this situation is likely to contribute to an epiphytotic of rusts or some other disease. In fact the very first year, 1966, when Kalyan-Sona was released for general cultivation, fears were expressed of a rust epidemic since weather till December, 1966 continued to be very favorable for a rust epiphytotic. A meeting of wheat pathologists was immediately convened to discuss steps to be undertaken to handle this potentially dangerous situation. The outcome of the meeting was the initiation of a rust survey and a long-term project putting up spore traps at several locations with a view to developing a rust forecasting service, besides, of course, strengthening the breeding program and having nationwide coordinated fungicidal trials for rust control. I have pointed out all these details just to emphasize that the danger of disease

epiphytotics really exists. As pointed out earlier, Kalyan-Sona is no longer recommended for cultivation at least in one state in the south. The same variety had brown rust in isolated areas in the north during the last season (1968-69). Also loose smut is raising its head since we observed relatively more of this disease in the last season.

Another factor which is likely to contribute to a future rust epiphytotic in north India is the delayed planting date of the high yielding varieties. Tall wheats are planted in the latter half of October, whereas the optimum sowing time for most of the dwarf wheats is the middle of November. The black stem rust, which in an epiphytotic can be disastrous, starts spreading when the weather gets warm (early March). The varieties planted in October, particularly the early maturing ones, often escape infection, but dwarf wheat varieties planted in the middle of November and onwards till the end of December have no such chance.

Another disease, Karnal (and not kernel) bunt, caused by the fungus, Neovossia indica, hitherto an unimportant disease, is being observed more frequently in Kalyan-Sona and Sonalika, as well as other dwarf varieties. Intensive work has already been initiated at different institutions to discover more about the disease and its control. Similarly, flag smut, which used to be a minor problem in parts of Punjab state, is being reported on some of the dwarf wheats from other areas too and its incidence has significantly increased.

Fortunately, no bacterial, viral, or nematode disease has so far been observed in any serious proportions in the high yielding varieties. However, a watch will have to be kept on these too.

The lush growth of high yielding varieties attracts more insect pests in general. The wheat thrip (Anaphothrips flavicinctus) has become one of the most serious pests of high yielding wheats. Infestation by thrips in early stages causes a setback to the growth, and if no control measures are adopted, the yield losses could be serious.

Other pests which are found to attack new varieties are the cutworm (Agrotis ypsilon), climbing cutworm (Heliothes sp.), and the shoot fly (Atherigona sp.).

RICE

Rice is the most important food crop of India and is a staple food of more than half of its population. The crop is extensively grown and covers about 84 million acres. According to an estimate, in 1968-1969 eight and a half million acres were brought under high-yielding varieties, and by 1973-1974 the area should increase to about twenty-five million acres (3).

The era of high yielding, dwarf rice varieties began in 1964 with the introduction of Taichung (native 1). Though short-grained (long-grained rice is preferred in India) the variety caught attention of the farmers because of the strikingly high yields (over 6 tons/hec.), which were two to three times over the tall local types. This was soon followed by another high yielding variety, IR-8. As everybody knows, IR-8 was developed at the International Rice Research Institute (IRRI). In July 1966, a half-ton of IR-8 was air-freighted from the IRRI for seed increase, and one year later, India had 250,000 acres planted with this variety (14).

The major disease problem the Taichung (native) 1 faced was the bacterial blight caused by Xanthomonas oryzae. This disease is important in many countries of Asia. These include, in addition to India, Japan, Korea, Taiwan, the Philippines, Indonesia, Thailand, China, Ceylon, Cambodia, and Malaysia (6). It is known to cause yield reductions of 20 to 30 percent after moderate infections and over 30 percent after severe ones (6). Bacterial blight was first recorded in India in 1959 (11), but was not considered important until 1963 when an epiphytotic was reported on tall, local varieties from one of the north Indian states, Bihar. However, it was never widespread until Taichung (native) 1 was introduced in most of the rice-growing states. This is probably because (i) no single germplasm, like Taichung (native) 1, was grown on such an extensive

scale in different parts of the country, and (ii) Taichung (native) 1 is extremely susceptible to the disease. The latest position is that bacterial blight has become endemic all over the rice-growing areas of the country (12). A correlation has already been established; i.e., the higher the nitrogen application, which is necessary to get more yields, the greater is the susceptibility to the bacterial blight.

Another disease, false smut caused by the fungus, Ustilaginoidea virens, has been known to occur in India for a long time, but considered of no importance. However, during the last two years, several reports from different areas have been made on the serious incidence of false smut in Taichung (native) 1 as well as IR-8. We do not know much about the epidemiology of the disease at present.

IR-8 has withstood bacterial blight better than Taichung (native) 1. Though the incidence is fairly common, it is much less severe than on Taichung (native)1. As pointed out earlier, false smut has also been reported on IR-8. But the disease which is affecting IR-8 most, particularly in north India, is brown spot, which is caused by the fungus Cochliobolus miyabeanus (Helminthosporium oryzae). The disease is not new to India. The "Bengal famine" of 1942 - 1943 was caused by the failure of the rice crop primarily due to brown spot. While IR-8 gives high yields, withstands other diseases like blast and to some extent bacterial blight, it is quite susceptible to brown spot.

Viral diseases of rice have to be watched carefully. Yellow dwarf was observed in south India (8). Out of the three leaf hopper species which are vectors of yellow dwarf, two; viz, Nephotettix apicalis and N. impicticeps, are commonly found. Another viral disease, Tungro, has been observed at some locations. The leaf hopper, N. impicticeps, which transmits tungro virus is common in most parts of India. With susceptible varieties like Taichung (native) 1 and IR-8 available, it would not be surprising if a tungro epiphytotic is observed in the future.

Taichung (native) 1 and IR-8, while moderately tolerant to stem borer(s) particularly Tryporyza incertulas, are susceptible to the

rice gall midge, Pachydiplosis oryzae and leaf hoppers, Nephotettix spp. A disease and insect survey was conducted in 1967 by a team of scientists from the IRRI and Japan (8). According to their findings, IR-8 and Taichung (native) 1 were more heavily infested than local varieties. They found infestations severe enough in several fields to cause up to 80 percent yield reductions. The pest was found in almost all the south and south-eastern Indian states.

At present, little information is available on the basic bionomics, factors affecting abundance and chemical control of this pest. It seems that the dwarf and heavy tillering varieties provide a more suitable habitat for the gall midge than the sparsely tillering tall varieties (8). Since we will have to live with these plant characters at least for sometime, it will be necessary to investigate this pest more thoroughly.

The survey team found white-black planthoppers, Sogatella furcifora, and the brown planthoppers, Nilaparvata lugens, to be more numerous than others. Taichung (native) 1 is more severely damaged than IR-8. Again lush vegetative growth of these varieties as a result of heavy application of fertilizers has been considered conducive to the buildup of leaf hoppers.

CORN

The first corn improvement program in India was initiated in 1945. By 1956, there were three improvement programs, all independent of each other. In 1954, the Government of India invited Drs. Wellhausen and Grant of the Rockefeller Foundation (RF) to survey India to determine the potential for corn and to suggest a research program in corn-improvement (10). They recommended the introduction of a wider range of germplasm and the setting up of a coordinated national program. In 1957, a coordinated corn-breeding program on a national scale was initiated by the Indian Council of Agricultural Research in cooperation with various state governments and the Rockefeller Foundation. Later, two agricultural universities, one of which I represent, were included in the program. As a result of the

work done, four hybrids were released in 1961. Subsequently other high yielding hybrids were also released. By 1964, the hybrids started catching the attention of most of the progressive farmers. According to estimates, more than 2.5 million acres have been planted by this year to hybrid corn and the area is expected to increase to about 5 million acres by 1974 (3).

However, all is not well with hybrid corn. In addition to problems related to agronomic practices, plant diseases have posed a serious threat to the rapid spread of maize, particularly in north India. To limit citing examples, I will deal primarily with our experiences on the cultivation of Ganga Hybrid Makka No. 2 and 3 (Ganga 2 and 3) and the composites, Jawahar and Kisan. Ganga 3 became quite popular because of its yellow grain and good chapati-making quality. Since 1962, a disease characterized by severe leaf striping has been observed in several corn growing areas of India. Severe outbreaks of the disease occurred in 1962-1964 in the west Bengal hills, in 1963 in western Madhya Pradesh and south-eastern Gujarat, in 1964 in north Bihar, in 1965 in the Tarai region (Pant Nagar) of Uttar Pradesh, and so on. The disease was described as a "new downy mildew;" and later called "brown stripe" (9). Soon after its release it was realized that Ganga 3 was quite susceptible and the crop at many places was badly damaged. Brown stripe, since then, has been recognized as a major disease problem. Though the attempts to breed resistant hybrids are continuing, none of the released ones are highly resistant, though some are tolerant.

Ganga 2 was found to be fairly tolerant to the brown stripe, but during the last two years, it was highly susceptible to stalk rots caused by Cephalosporium sp. and Fusarium moniliforme. Both these were unimportant earlier. The same has happened to the two composites, Jawahar and Kisan, which are susceptible to these stalk rots. Corn at many places in the north failed last season and, in addition to other causes, brown stripe and stalk rots played a definite role in this failure. The poor performance of high yielding corn varieties in the north has to some extent shaken the confidence of the farmers

in these varieties. The present situation has to be taken seriously.

Corn hybrids and composites have their pest problems too. The sorghum shoot fly (Atherigona sp.) has been found to be a new pest of all varieties of corn. The two other pests which have assumed importance are the stalk borer (Chilo zonellus) and the pink borer (Sesamia inferens). Chilo zonellus has been found more on Ganga 2 and 3 (5).

SORGHUM

Sorghum is an important cereal crop in India covering an area of about 46.5 million acres. The first hybrid, CHS-1, was developed and released in 1964 by the Coordinated Hybrid Sorghum Scheme in collaboration with the Rockefeller Foundation (16). This hybrid has not only a high yielding potential, but also produces grain of acceptable quality. Average yields of 2,000 lb. per acre without irrigation and 4,000 lb. per acre with irrigation are common. Under best agronomic practices, a yield of 6,000 lb. can be obtained. Another hybrid, CHS-2, a long duration hybrid, was later released for late rainfall areas.

Sorghum hybrids have been highly susceptible to Sphacelia sorghi which causes sugary disease. Male sterile lines, in general, have been more susceptible. The disease assumed importance only after the release of these hybrids. Another disease, not reported earlier, became important in 1968. This is a leaf spot caused by the fungus, Ramulispora sorghicola, which has been a serious problem in Nigeria (13).

Both these hybrids are susceptible to pests which were considered minor earlier. The pests which have assumed importance in relation to these hybrids are: shoot(stem) fly (Atherigona indica and A. stripalpus), earhead webbing caterpillar (Stenachroia elongella) and gall midge (Contarina sorghicola and C. andropogonis).

NON-INFECTIOUS PROBLEMS

The current agricultural strategy to increase crop yields in India necessitates increasing use of agrochemicals, such as herbicides,

fungicides, insecticides, and fertilizers. Though on one hand the use of agrochemicals by the farmers for raising high yielding crop varieties has resulted in crop yield increases, it has also created a few problems. Through ignorance or careless handling, many non-infectious disease situations arose in the past and are becoming more frequent. Plant pathologists are invariably invited to investigate these problems and many times it becomes difficult to establish the cause (7). I would like to mention some of our experiences to illustrate the point. Accidental sprays of the herbicide, 2, 4-D, has resulted in widespread injuries on lentil, chick pea, urd (Phaseolus mungo), and soybean with symptons varying from misshapen leaves to the appearance of watery blisters on shoots and roots. Simazine at high rates, applied carelessly in maize, resulted in the withering of seedlings of the following wheat crop. The use of copper fungicide by a few farmers on IR-8 paddy in 1968 Kharif resulted in copper injury. Excessive concentrations of urea used for foliar sprays resulted in injuries in sorghum and many other crops. Zinc sulfate, when used without lime, contrary to the recommendations, for the control of Khaira (zinc deficiency disease of paddy) resulted in the appearance of reddish brown spots on the leaves. Heavier application of fertilizers to high yielding varieties have possibly resulted in aggravating zinc deficiency in crops like wheat and corn. The purpose of presenting this information is to emphasize that as we attempt to increase crop yields through better technology, we also face more and more crop injury problems.

WHAT SHOULD WE DO?

It should be evident from the foregoing account that in some crops the disease and pest situation vis-a-vis high yielding varieties has already become serious, whereas in others there exists a real potential danger of heavy losses. In some cases, varieties have been found to be highly susceptible to hitherto unimportant diseases and pests. Since there is a tendency to grow those few varieties of a crop, which find general acceptability, in large contiguous areas,

the danger of disease and pest epiphytotics is a real one. It is therefore absolutely essential to think, discuss, and plan the steps which should be undertaken to meet the present situation, so that we will be able to ensure the maintenance of gains in food production. I am suggesting a few measures in the following paragraphs.

1. Allocate More Funds to Plant Protection Teaching, Research, and Extension.

In most developing countries, plant protection is very much "underdeveloped". Until recently plant protection in India was not considered as important as agronomy (including breeding). This was perhaps because of the notion that resistant varieties for all the major diseases and pests can be bred and improvements and alterations in cultivation practices can reduce their incidence. The notion continued further. That is, if after doing all this, a disease does appear after all, there is nothing which a plant pathologist can do to save the crop. Fortunately, however, these notions are disappearing fast and there is a much better realization of the importance of plant protection and better appreciation of the crop protection measures other than resistant varieties. For imparting good teaching at agricultural universities and institutes, for conducting intensive research on disease and pest control, and for doing extension work in plant protection, more funds are surely needed. In India several steps have already been taken in this connection. The establishment of eight agricultural universities, oriented to practical agriculture, has already started yielding results. The Union Ministry of Agriculture some time ago established a Central Plant Protection Training Institute, where plant protection officers from different states are sent for better training. As far as allocating funds to plant protection research is concerned, more preference should be given to those projects which directly aim to control important diseases and pests. And project approval should be more liberal. One reason why extension work in plant protection has not made much progress is the lack of proper and convincing demonstrations. Plant pathology demonstrations should be encouraged

and these should be separate from agronomy demonstrations.

2. Emphasis on the Training of Plant Disease Diagnosticians.

I am mentioning this point separately because of the emphasis it needs. It has been a common experience that plant pathologists and entomologists do not always make good diagnosticians. I would like to site one recent example. In the last rice season (1969), a good deal of publicity was given to a so-called "epidemic" of an obscure disease in several eastern districts of the state of Uttar Pradesh. The disease was considered to be caused by a virus (Tungro?). The symptoms were described as tip and marginal burning of leaves followed by the death of the plants. High yielding varieties were said to be more severely affected. Experts from different institutions were invited to look into the problem. Some said it was "hopper burn" and others said it could be tungro virus. A pesticide mixture was recommended and made available at subsidized prices. The mixture, however, did not help because there was really no one cause of the leaf burning. At some places it was clearly nitrogen dificiency (as little as 10 lb/acre was applied), at other places chemical injuries were evident (even the weeds were scorched), and at still other places, the soil was calcareous. Tip and marginal burning of paddy leaves can occur due to any of hundreds of factors. Several plant specimens brought from these areas fully recovered when transplanted in good soil and grown in a pot house. Thus you can see why properly trained persons are needed to make correct diagnosis.

Proper diagnosis is very important in the present context of new agricultural technology. More and more chemicals will be used and therefore plant pathologists must keep themselves ready to distinguish injuries or deficiencies from infectious diseases.

3. Support for Research on Crop Losses due to Pests and Diseases.

Information on crop losses is very basic for the planning of any kind of plant protection program. Surprisingly, however, the information on the losses caused by most diseases and pests in developing countries is very inadequate and unreliable. I would like to reproduce below three paragraphs from a paper (15) presented by Drs.

Vallega and Chiarappa of the Food and Agriculture Organization (FAO) of the United Nations in a symposium on plant disease losses.

> "The problem of appraisal of plant disease losses and their effect on agricultural production is of primary importance throughout the world, for it is only through such an appraisal that rational control measures can be developed and applied. Such an appraisal is also essential for its educational value, through which public support to plant protection organizations and institutions is made available.
>
> The problem of disease losses, therefore, has been receiving much attention in many of the most developed countries. Yet despite all efforts and contributions, progress has been rather limited. Probably one of the reasons for the limited progress is that the whole economic impact of plant disease losses can not be measured simply by the actual quantitative or qualitative reduction of agricultural commodities. In some areas of the world it is not possible to grow certain crops because of disease. This type of loss seldom can be evaluated properly. In other areas, disease losses have often had far reaching social effects which are also extremely difficult to assess. Furthermore, to obtain a true picture of the real cost of a plant disease, all expenses must be considered including studying, controlling, and delimiting the disease. This involves highly developed organizations for the collection and processing of statistical information.
>
> If we consider that it is not easy in highly developed countries to obtain realistic information on plant disease losses, we can certainly imagine how difficult this task would be in less developed countries. In those receiving FAO assistance, technical services are often limited and statistics are nil or fragmentary. Topography, climate, prevalence of peasant farmers and of small holdings, intercropping, and often lack of a uniform language and measuring system make the collection of information extremely difficult."

It is clear from these paragraphs how important it is to have information on crop losses but how difficult it is to collect. If research is conducted on losses which would yield information at least on the extent of quantitative loss at a particular severity of the disease or pest, it should be of great utility in planning for plant protection program.

4. <u>Preference to Disease and Pest Control Research</u>.

At the present time, it would be better if the plant pathologists

and entomologists divert their energies to solving field problems. Administrators of various organizations and institutions can ensure this through preferential budget allocations to support problem-solving research. It is true that work in some developing countries is satisfactory, but in many countries, not enough is being done.

Disease and pest problems should be attacked by more than one method. It is true that developing disease and pest resistant varieties is theoretically the best method, but it is high time we realize that we will perhaps never come up with a "perfect" variety which, besides expressing high yield potential, will also be resistant to all the major diseases and pests in a certain area. Breeding for disease and pest resistance should be attempted where no easier method is known. The example of loose smut of wheat would perhaps illustrate the point. We now know that seed treatment with a systemic fungicide is very effective against smut. Therefore, there is no need for an intensive breeding program for loose smut resistance. In developing countries, possibilities of controlling diseases and pests through the use of chemicals should be thoroughly explored. Again finding an effective chemical is not enough. Researches should be continued till proper schedules are developed for the purpose of making recommendations to the farmers.

In most developing countries, availability and costs of pesticides are real problems. In certain countries like India, in spite of local manufacture, the prices are too high. This discourages not only a farmer but also a research worker. It is interesting to note that India spends only about Rs 0.29 (approx. $0.04) on pesticides per acre as against Rs 7.14 (approx. $1.00) by the USA and Rs 57.14 (approx. $8.00) by Japan. Surely the scarcity and high cost contribute greatly to this situation. Action by the governments of developing countries is therefore needed to ensure a supply of pesticides at cheaper rates.

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