A Brief Report on Progress Being Made by the Indian Coordinated Wheat Improvement Program

Norman E. Borlaug

INTRODUCTION

It has been a great pleasure to again visit India to review the progress being made by the Coordinated Wheat Improvement Program. The progress that has been made by Indian scientists since the introduction of the first dwarf wheat breeding materials from Mexico for the 1963-64 crop cycle is phenomenal. During this short period much data have been developed which bear on India's wheat production potential. Briefly these may be summarized as follows:-

The Breeding Program:

(1) Dwarf high yielding wheat varieties are a new "catalyst", which when combined with proper agronomic practice, including the application of high levels of the proper kinds of chemical fertilizers and proper irrigation practices are capable of greatly increasing per acre yields. The maximum yield potential for certain of these varieties has already been established at more than 90 mounds per acre, and when this harvest season is completed it would not be surprising to learn that some cultivator has passed the 100 mound per acre level. This is more than double the yields obtained with tall strawed varieties when they are given their corresponding optimum levels of fertilization and irrigation.

The high yield potential of the dwarf varieties is due to two unique characteristics. The fact that they are of short stature make them more resistant to lodging than taller strawed varieties. Tall-strawed varieties generally lodge when more than 40 to 50 pounds of nitrogn are applied per

acre, whereas the dwarf varieties will stand even when fertilized with from 100 to 120 pounds of nitrogen, and in the process produce much higher grain yields. The second factor which contributes to the higher yield of the dwarf varieties is the larger numbers of grains produced per spikelet. Under optimum conditions for growth the tall strawed varieties will set three grains per spikelet whereas the dwarfs will produce five and sometimes six grains per spikelet.

The establishment of the high yielding potential of the dwarf varieties when properly cultivated opens new vistas to Indian irrigated wheat production.

Last year the Indian government took rapid action to attempt to utilize this breakthrough in research and thereby increase its wheat production as rapidly as possible. This is being accomplished through three different approaches, in order to save time:

(A) The importation of 250 tons of seed of the varieties Lerma Rojo 64 and Sonora 64, which are grown extensively in Mexico and therefore were immediately available in commercial quantities. These two varieties had previously shown superiority in yield over tall strawed varieties under Indian conditions. They were not as good, however, as the material described in point B below.

Sonora 64 and Lerma Rojo 64 are to be considered only as "stop gap" dwarf commercial varieties which will soon be replaced by superior dwarf varieties. Meanwhile, they will serve a twofold purpose, namely (1) to permit the cultivator to learn how to effectively handle these varieties commercially, and (2) to increase yields and wheat production until the seed of the better varieties described below can be multiplied and distributed.

In general this year's results with the two introductions have been successful. Lerma Rojo 64 has proved itself to be better adapted to a wider range of conditions in India than has Sonora 64. Nevertheless, there are areas and places in the rotation where Sonora 64 has outperformed Lerma Rojo 64. There will be from 175,000 to 200,000 mounds of seed of these varieties harvested in the next few weeks.

(B) The rapid multiplication of the best experimental dwarf wheat varieties selected by Indian scientists, from partially developed breeding stocks sent to India from Mexico for sowing during the fall of 1963. Among this group are a number of very promising lines which substantially outyield Sonora 64 and Lerma Rojo 64, and also are improvements over these varieties in a number of other respects, such as grain type, and disease resistance. Among the most promising of these varities are V18, S-227, S-307, S-309, S-326, S-331 and S-521. Several of these lines are being multiplied at the same time that they are being re-evaluated for yield in the coordinated Regional Yield Nurseries. The best of these lines should be multiplied aggressively during the 1966-67 wheat season.

(C) The Aggressive Development of Lines Derived from Crosses made in India between the best Indian varieties and the best dwarf introductions. It will be from this phase of the breeding progrm that the ideal Indian dwarf varieties will eventually be developed. Lines showing a great deal of promise are now being grown in the third and fourth (F_3 and F_4) generation after the cross. If the program continues to advance aggressively within the next two years high yielding disease resistant dwarf lines with good grain and chapatti making quality will be identified. The best of these will then be increased rapidly to replace the varieties referred to above in (A) and (B).

Summer Nursery:-

There is urgency to expand and improve the summer nursery facilities in order to move the breeding program ahead as rapidly as possible. The summer nursery grow at Wellington for the past two years has been helpful but is too small in size and also has other limitations. The proposed new location at Lahaul, Punjab would be adequate to serve the entire Coordinated Program. It would permit the production of two generations of all breeding materials each calendar year and would permit discarding all rust susceptible lines twice each year. It would also strengthen the bonds between wheat programs of the various states and the central government. This site should be developed as rapidly as possible, and it is urgent that financial support be granted to make this possible.

A Glance at the Organization and Philosophy of the Coordinated Breeding Program as it now Exists

The enthusiasm of the scientists now working on the breeding phases of the improvement program is excellent. The genetic base of the breeding program is broad and must be kept that way to minimize the dangers that are sure to appear with the development of new races of the rust fungi which will make varieties that are currently rust resistant rust-susceptible. The best protection against losses from rusts provoked by such race changes is an aggressive, diversified broadly based breeding program, combined with an aggressive seed multiplication program. I caution against the complacency of placing too much faith in the longevity of the rust resistance of any single variety for the next decade. With the increased use of fertilizer and imporved irrigation practices conditions within the wheat fields will be more favorable ecologically than ever before for the development of rust epidemics. The protection against losses must depend upon the genetically built-in resistance of the variety.

The Agronomic Research:

In order to capitalize on the high yield potential of the dwarf varieties it is necessary to employ adequate amounts of the right kinds of fertilizer, to irrigate correctly and to use the correct cultural practices.

Within the past year the research done in this field at a number of different locations has provided valuable information on a number of different factors affecting the performance of the dwarf varieties.

This research, beautifully conducted, has shown clearly that these varieties perform best when sown at depths that do not exceed two inches. In the past in India they had generally been sown at greater depths, thereby resulting in inadequate plant populations for obtaining maximum yield. Now that this point has been clarified it will permit the cultivators to modify their planting methods accordingly.

Other agronomic studies have established that proper timing of the applications of irrigations are very important to assure maximum yields. Other experiments have also established the best dates of sowing for the new varieties.

Complex experiments involving the interaction of different levels of fertilizer and different timing of watering have shown the best practices for dwarf varieties as compared to tall strawed varieties under different soil and climatic conditions. In these studies it has become evident that the dwarf varieties are capable of producing economic increases in grain yields with applications of up to 120 pounds of nitrogen per acre, whereas the tall strawed varieties begin to lodge at between 40 to 50 pounds of nitrogen, whenever irrigation practices are favorable for good plant development.

There still exists a great need for establishing, through additional agronomic research, the levels of fertilizer that give best economic results when wheat follows different crops on the different soil types on cultivators' fields in different parts of the wheat producing region.

The previous data developed by the so-called "Rapid Soil Fertility Survey" was confined to low levels (mostly at 20 and 40 pounds, and in a few cases up to 60 pounds of nitrogen per acre) of fertilizer applications. The break-through obtained in yield increases when dwarf wheats are heavily fertilized and properly watered now necessitates that the response patterns of yields be obtained at 60, 80, 100 and 120 pound levels of nitrogen per acre, when combined with 40 pounds of P_2O_5 and with good watering. Much of this type of research will need to be done on cultivators' fields, since the soil fertility levels on government experiment stations is nearly always higher than it is on farms. During the current season considerable information will be developed on the response to fertilizers at higher levels of application by farmers who are increasing the dwarf varieties. Ways must be found to superimpose simple strip or plot fertilizer tests upon a large number of farmers increase fields of dwarf varieties, and upon demonstration plots next season. This information is badly needed.

Pathologic Research:-

Dr. Prasada, in the course of the recent wheat seminar, mentioned that there are more than 30 different diseases attacking wheat in India. This obviously indicates that there must be some system of priority given in order to concentrate the research effort on those diseases which are likely to become more important with the greater intensification - heavy fertilization and good irrigation - of wheat culture.

Under these conditions the thicker, more lush growth of wheat plants will produce ecological conditions in the wheat fields much more favorable for the development of epidemics of the rust fungi, whenever the varieties are susceptible to the prevalent races of these organisms.

The diseases that should be given top priority in the research and breeding program within the next five years should probably be, in order of importance:

1) stem rust or black rust

2) brown rust

3) yellow rust (in the hills and northern plains only)

4) Alternaria leaf spot

The rust fungi must obviously continue to be controlled by the distributi of rust resistant varieties. The breeding program must be dynamic and employ a wide breadth of different types of resistance in its crossing programs, and assure a constant flow of the production of new high yielding rust resistant dwarf varieties.

The rust survey must be expanded for both black and brown rusts, so that all new races will be spotted early, and the resistance of the current commerci varieties, and all advanced generation promising varieties in the breeding program can be checked for resistance to such new races soon after they appear.

If and when potentially destructive new races are found, then new high yielding dwarf lines with resistance to these new races, as well as the races formerly prevalent, must be multiplied vigorously and aggressively distributed.

Changing the culture of wheat from a traditional culture to one of intensi cultivation will create many new problems, but all can be handled adequately by an aggressive research and seed multiplication program.

Entomological Research

When wheat is heavily fertilized and properly watered the microclimate inside of the grain field will also become more favorable for insect pests. The insect likely to give trouble will be the English grain aphid. Vigilance will be needed to keep it under control, especially in those years when the normal predators do not adequately control it. One properly timed application of an effective insecticide will provide good protection in such years.

Weed Research:-

When wheat is cultivated more intensively it will be necessary to pay more attention to weed control. The fertilization of weeds is poor economy. One weed species that particularly appears to merit research attention is the field bindweed (Convolvulus arvense). A new chemical designated "Velsicol Dicamba" has recently been reported to be effective on this weed. Limited research should be conducted during 1966-67 to check up on the efficiency of this product.

Rats:-

During the 1966 wheat crop large losses are being caused by field rats in the maturing crop in the Pant Nagar area of U.P. In many fields more than half of the crop has been destroyed by this pest, as the rats move into the wheat fields from the sugar cane fields. Tremendous damage is also being done by rats to the sugar cane. This type of problem can only be solved by an anti-rat campaign on a community rather than individual farm basis.

Such problems require action programs for there is little point in investir money to increase per acre yield and have the crop lost from such pests.

Quality Considerations:-

The first dwarf wheats to be introduced into India - Lerma Rojo 64 and Sonora 64 differ in grain color from the current commercial Indian varieties. Indian varieties are currently mostly white in grain color, but 30 to 35 years ago most were red in color.

Indian scientists feel that as soon as possible high yielding dwarf wheat varieties should be developed to replace Sonora 64 and Lerma Rojo 64. Much progress has been made already in this direction since the newer, still unnamed experimental varieties S-227, S-317, S-318, etc. which are now being placed in multiplication do possess white grain of good quality for chapatti making.

It should be emphasized that for the immediate future, grain color and grain quality should be considered of secondary importance to yield. Currently many millions of tons of red grained wheat are being imported, accepted and eaten by the consumer. This whole aspect of quality preference is more academic than scientific, and is a vogue just as the preference for certain brands of cigarettes which does not stand up under blindfold, coded, unbiased tests.

There are however, two fields of quality evaluation that merit more research. These are:-

(1) Chapatti making properties, and chapatti keeping quality. Dr. Austin has made a good start this past year to develop a standardized chapatti test. This research must be continued and expanded during 1966-67. The alveogram patte and Pelshenke values appear to be promising as a basis for developing screening tests which can be used in the early segregating generations of the breeding program as a guide for selecting lines which are likely to demonstrate good

chapatti quality in the subsequent generations in the standardized chapatti quality test.

(2) Research must be done during 1966-67 to determine how to produce wheat grain with from 13 to 15 percent of protein at a yield level, i. e. 80 mounds per acre and above. In general there is a tendency in all cereals, including wheat, to manifest a drop in percentage of grain protein as per acre grain yields increase. This could be very unfavorable from a nutritional standpoint and ways must be found to reverse this trend. Late applications of nitrogen made, either pre-heading or early post-heading, in some cases through the foliage and in others in the soil, are a possibility. We have done considerable research on this approach in Mexico and results are promising, but more research is needed in order to work out a satisfactory practical recommendation.

The International Program is also initiating a basic approach to increasing grain protein content and protein quality through breeding.

Contributions of R.F. Scientists to the Coordinated Wheat Improvement Program

I have been very favorably impressed with the excellent understanding and mutual respect that has developed between R.F. scientists and their Indian counter-parts on the Coordinated Wheat Improvement Program.

Drs. D. Krantz and W. Wright have done yeoman's jobs in getting the agronomic research off to a flying start. They are to be commended for this fine work during the past year. Dr. Glen Anderson has contributed greatly to the overall development of the breeding aspects of the program. His vigor, enthusiasm, vision and experience have served as a catalyst in the overall program. He has done an excellent job.

Looking Ahead Toward Wheat Production Targets

India now has the know-how and will soon have the plant materials to move aggressively forward toward increasing per acre wheat yields.

The dwarf wheat varieties with high per acre yield potentials when properly grown will be the catalyst. To capitalize on this breakthrough, however, several of the other production factors must be modified, especially the widespread introduction of heavy applications of chemical fertilizer, and better irrigation practices.

Fertilizer Bottle-neck

Plans must be made now to greatly increase fertilizer imports and production (both nitrogen and phosphate) as soon as possible. Where dwarf wheats are to be grown under full irrigation they should be fertilized with from 100 to 120 pounds of nitrogen and 40 pounds of P_2O_5 per acre. The tall strawed varieties should be fertilized with 40 pounds of nitrogen (the maximum they will stand without lodging) and 40 pounds of P_2O_5 per acre when grown under irrigation. There are those who would reduce the amount of fertilizer on the dwarf varieties to 40 or 60 pounds of nitrogen per acre, and spread the difference (other 60 pounds of nitrogen) on all of the other cultivated wheat area. I am against this dispersion and dilution of fertilizer application, and instead feel that the program should try to produce tremendous yield increases on the area where the dwarf varieties can be heavily fertilized and properly watered. By so doing a complete change in the psychology of wheat production - from one of survival to one of high yields - will shock both the farmer and the scientist. Such large increases in yield will convince all who see them, whereas a small grain yield increase achieved by the application of 20 to 30 pounds of nitrogen

per acre will be overlooked among the other year-to-year variables affecting yield.

It is certain that all of the fertilizer plant production capacity that can be planned for and financed in the current five year plan will be completely inadequate by the time these factories are completed and in production. The demand for fertilizers will expand greatly within the next five years and unless every effort is made now to build vast production facilities, - employing both public and private sector financing - these demands will far outstrip production, and black market fertilizer prices will persist and grow worse.

Bottle-necks in Irrigation

It is hard to realize that vast areas of the Rabbi wheat crop produce yields of four 5 to 8 mounds per acre in a year such as 1965-66 largely because of a shortage of irrigation water. In many cases vast areas of wheat badly hit by the current drought have large quantities of "sweet" water only 15 to 25 feet below the surface. It seems incredible that some effective way cannot be found to vastly expand the number of private shallow wells - both those powered by centrifugal pumps and those by Persian wheels. Moreover, the longer range programs for the development of deep tube wells, especially in areas where there is little or no "sweet" water near the surface, must be pushed vigorously.

The canal water that is now available could produce much more food if it were properly used. In a country short in food grains, it appears to be a sin, if not a crime, to use irrigation water on crops that have not been fertilized. Moreover, there is a great need to improve the handling of canal waters to the cultivator. The current system wherein the user has little or no say in water distribution policy contributes to making yields lower. Better coordination

must begin by establishing better cooperation between the Ministry of Water and Power, the Ministry of Agriculture and the cultivaters.

Agricultural Extension:-

The current breakthrough whereby wheat yields of from 60 to 80 mounds per acre are achievable when the dwarf varieties are grown with heavy fertilization, proper irrigation and other improved cultural practices presents a unique challenge to the extension program. Never before has the extension program had a concrete specific program based on sound research data of the magnitude of importance of the current irrigated wheat production program. If they move vigorously to extend this know-how to millions of cultivators in the next five years, wheat yields will skyrocket. Moreover, the production know-how learned from this experience with wheat, can with slight modifications be applied to other crops. This is a field job and the extension worker will need to spend virtually all of his time in the field - not in the office - if he is to achieve this goal. If he fails in the extension effort on wheat now, he will likely fail in other challenges in the future. In all of his extension efforts on wheat he should attempt to make his demonstrations and wheat yields as spectacular as possible, but at the same time these demonstrations should be based on a sound economic input.

Continuity of Research Personnel in Their Own Field of Specialization :

It does little good to develop a top-notch wheat breeder and wheat production scientist, and then have him suddenly transferred to sugarcane research, in order that he can obtain his rightful increase in grade and salary. A truly outstanding and permanent wheat research team cannot be established on such a system of advancement.

Moreover, it appears that the number of positions in wheat research at the higher grades and salaries is unrealistically small from the standpoint of the importance of the crop to the Indian economy.

It is suggested that as soon as significant concrete contributions by scientists to wheat production are apparent - and this should happen within the next three years - that an all out effort be made to improve the salary status of the agricultural scientists. This would do much to stem the tide of loss of many talented Indian scientists to other countries. India can no longer afford the loss of much of its best scientific talent to other countries when it is badly needed at home.

Still in effect. Goal achieved

Cooperation Between State Governmental Agencies and the Central Government in the Coordinated Wheat Research and Production Program:

Tremendous progress has been made during the past two years to develop a truly Coordinated Wheat Research and Production Program. This effort and spirit must be perpetuated and strengthened. When new varieties are named and when recommendations on cultural practices are formulated all organizations and individuals who have participated in such developments must be given due credit. Unless this is done misunderstandings will arise and further progress will not be made.

Outlook for Wheat Production in the Future:

If the Coordinated Wheat Improvement Program continues to move forward aggressively as it has during the past year results will be forthcoming within the next five years that will much improve India's wheat production. The frontal attack must be maintained on all of the production factors mentioned above, and in proper proportion.

The breeding and agronomic research programs should be "forwarders" or catalysts and their research efforts must be aggressive, vigorous and visionary. Traditionalism and conservatism should be downgraded, for they are poor foundations upon which to build a revolution in agricultural production.

Norman E. Borlaug

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