AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523
BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY ARDA
Batch 84

1. SUBJECT CLASSIFICATION	A. PRIMARY: Food production and nutrition	AF30-0000-0000
	B. SECONDARY: Plant breeding	

2. TITLE AND SUBTITLE
Genotype selection for agricultural technology transfer and utilization

3. AUTHOR(S)
Leininger, L.N.; Peterson, H.B.

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1977	~~22p.~~ 23p.	ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS
Utah State

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*

9. ABSTRACT Many variety cultivar testing trials are conducted throughout the world every year. Most of these tests generate large amounts of information but the data are time and site specific and not readily transferrable. Insufficient information is collected systematically which does not permit the data to be utilized very far from the test site. This paper presents the more immediate aspects in regard to genotype selection for international testing and the benefits which can be expected to result from a thoughtful and systematice selection process. The selection rationale is appropriate to all agricultural research involving plants and will have its greatest synergistic effects when all agricultural research embraces the concept. The greatest plantgrowth research-data void which exists at the present time is the extensive area of plant environment interactions. This paper identifies part of a rationale for eliminating the void with a minimum of expenditure and in a relatively short time. Limitations of current yield tests are discussed as well as the genotype X environment interaction. The strategy for genotype selection includes characterization of the plant and its environment, use of open pedigree lines, use of indicator lines, and use of specific genotypes. The adaptation of the basic principles outlined can make significant contributions in agricultural research and production to all agricultural research, to genotype by environment interaction understanding, to selecting lines for specific environments, to plant breeding and genetics, to reduce necessary testing, to produce specific genotypes for specific environments, to ensure a broader genetic base and to agricultural production.

10. CONTROL NUMBER: PN-AAF-605	11. PRICE OF DOCUMENT
12. DESCRIPTORS: Adaptation; Environmental factors; Field tests; Indicators; Plant genetics; Research; Technology transfer; Utilization	13. PROJECT NUMBER: 931011600
	14. CONTRACT NUMBER: CSD-2459 211(d)
	15. TYPE OF DOCUMENT

AID 590-1 (4-74)

CSD-2459 211(d)
Utah State
PN-AAF-605

GENOTYPE SELECTION FOR AGRICULTURAL TECHNOLOGY TRANSFER AND UTILIZATION

by

L.N. Leininger and H.B. Peterson

Financial support was largely provided by the United States Agency for International Development under contract AID/csd-2459 with USU. All reported opinions, conclusions or recommendations are those of the authors and not those of the funding agency or the United States Government.

Utah State University

Logan, Utah

August, 1977

GENOTYPE SELECTION FOR AGRICULTURAL TECHNOLOGY TRANSFER AND UTILIZATION[1/]

by

L. N. Leininger and H. B. Peterson[2/]

INTRODUCTION

A means for rapidly improving world food production is through the innovative transfer of crop production technology found in temperate regions to developing nontemperate regions where major food deficits exist. This requires that current and newly developed production technologies be transferred as rapidly as possible to deficient areas, and there integrated into farming systems which are acceptable to the indigenous farmers.

The primary objective of the Utah State University Agricultural Technology Transfer and Utilization (ATTU) program (6)[3/] is an increase in food availability to inhabitants of food deficient geographic areas of the world through local production. Most of these deficient areas are located in subtropic and tropic climatic areas where economic food production appears to be possible, at least to some degree. However, despite repeated attempts to transfer the more advanced agricultural technology[4/] from one climatic area to another, only limited success has been achieved. The ATTU program offers a vehicle by which such transfer can become a reality, and proper genotype selection is an integral and important part of the program strategy.

[1/] Paper developed under partial support from U.S. Agency for International Development under contract AID/csd-2459, and from the Agricultural and Irrigation Engineering Department, Utah State University, Logan, Utah.

[2/] Research Collaborator and Professor, Agricultural and Irrigation Engineering Department, Utah State University, Logan, Utah 84322.

[3/] Numbers in parentheses refer to citations listed in the reference section of this report.

[4/] Words underlined, when they appear for the first time in the text, are defined in the glossary appended.

Annually, many variety (cultivar) testing trials are conducted throughout the world. Most of these tests generate large amounts of information, but these data are time and site-specific, i.e., not readily transferrable. Insufficient information is collected systematically which does not permit the data to be utilized very far from the test site. Previous and current research rationale dictates that the only solution to selecting genotypes for any area is through a blanket screening of all genetic material available. This is done in hopes that some genotype will exhibit an appreciable degree of adaptability to the test area.

Some degree of progress has been achieved by this method, but the cost efficiency is low and there is no assurance of success. Whenever sufficient details are collected on water, weather, soils, and crop data, and if proper biological and physical models are developed, transfer of most of the biological components of agricultural technology can be made. Since large expenditures of time and money are required to conduct the numerous yield trials throughout the world, data transferability is essential. Effective transfer requires the consideration of the component parts (climate, soils, variety, pests, fertility, and husbandry) of crop production technology.

This paper presents the more immediate aspects in regard to genotype selection for international testing and the benefits which can be expected to result from a thoughtful and systematic selection process. The selection rationale is appropriate to all agricultural research involving plants and will have its greatest synergistic effects when all agricultural research embraces the concept.

The greatest plant-growth research-data void which exists at the present time is in the extensive area of plant environment interactions. This paper identifies part of a rationale for eliminating the void with a minimum of expenditure and in a relatively short time.

The primary deterrent to a more successful transference of agricultural technology is a failure to understand the Genotype by Environment (G x E) interaction. Consequently, research which will at least partially elucidate these interactions is needed to enhance agricultural technology transfer.

Research utilizing the rationale of a systematic and comprehensive program can significantly assist all other disciplines of agricultural research involving plants and in so doing, significantly contribute to a resolution of the G x E interaction. This will be accomplished through adaptation of the basic principles and strategy of the technology transfer program to each investigator's individual research area, regardless of the discipline involved. The more significant of these principles are:

A. Characterize the test site used for research and the climatic history at that site.

B. Characterize the plant and its environment fully, including phenology, temperature, radiation, water, soil and pests.

C. Use indicator lines for research continuity between tests, locations, and years.

D. List the pedigree of every genotype used in experimentation.

E. Collect complete and uniform data in standard units.

F. Compute, analyze, and store the collected data in a universally suitable location in a readily available form.

G. Fit accessed data to existing plant growth and yield models or generate new mathematical abstractions which will fit the acquired data. The newly generated models should be useful for completing data deficiencies in past research data as well as being useful for prediction purposes.

H. Make all information easily accessible to all agricultural research from individual plot data to inferences and conclusions drawn from the computed and analyzed data.

When most agricultural research accepts these basic attributes as a necessity, practically every research endeavor can draw from and contribute to most other past, present, and future agricultural research.

LIMITATIONS OF CURRENT YIELD TESTS

Early plant breeders and geneticists recognized that each new genotype must be tested under a varying set of climatic conditions to elucidate the best estimate of the ultimate merit of that particular gene combination. Attempts to test plants under artificially created environments such as greenhouses or growth chambers resulted in plant growth quite different from that experienced under field conditions. Therefore, to get a sampling of environmental effects upon a selected genotype, testing was necessary under as many different environments as time, money, and political boundaries would permit. Consequently, a particular genotype is tested under relatively few environmental conditions of concern to the investigator. Even rather extensive testing within a given state of the U.S.A., for example, samples only a few of the possible environments available within that state.

In addition, the usual recommendation of plant breeders and agronomists is for any genotype to be field tested three years before its performance has a reasonable chance of being statistically significant. This results in nearly three times as many environments as one year of testing, but is still a small sample of the environments possible. Experimental substations are strategically located to more efficiently sample as many different environments as economically possible, but even this strategy samples only a relatively few environments.

Another limitation is the paucity of knowledge available from entries made in many current yield tests. Entries in most corn yield tests, for example, generally consist largely of commercial hybrids which pedigree is unrevealed. Without knowledge of the pedigree, investigators cannot make inferences from the performance of any one hybrid at any one location and planting date to any other hybrid or environment. Furthermore, when a check is made of the number of these entries that appear in the same location for three consecutive years, which is the minimum number recommended by most testing institutions, it is found that only one or two hybrids are continuously tested for that long, and these are more likely to be genotypes which have been discarded for commercial production because new lines of supposedly higher yielding ability are available.

Using an actual state yield test to exemplify, three test locations are found which are geographically close to each other. Out of a total of 146 entries by 27 companies, only 16 hybrids appear in all three test sites for one year, only 4 hybrids appear in all three tests in two consecutive years, and only 2 hybrids appear in all three tests for three consecutive years or more. Of those which do appear for two or more years, the reader does not know how similar or dissimilar in genetic constitution any of the entries might be since no pedigree is ever revealed by the companies providing the entry. Of the 4 hybrids which appeared in all three test locations for two years, any or all of them could be from the same genetic background. This would be possible especially if all 4 hybrids were from different companies.

This illustration points out that under the present corn testing system for commercially available hybrids in the U.S.A., very few hybrids are available to farmers which have been tested three years or more at a given site and only two or three might really be significantly different in genotype and without the grower knowing which are genetically different.

Some state testing is done with open pedigree hybrids, but these hybrids are not usually entered in competitive yield tests with the commercial hybrids. Consequently, even though many commercial hybrids entered in state yield tests are hybrids made primarily or entirely through use of inbreds released by state and federal experiment station plant breeders, failure to disclose these pedigrees negates the possible use of this information for predictive purposes.

The limited yield tests conducted by the plant breeders on open pedigree hybrids are too few with not enough data collected to be of value for predicting the possible range of adaptation of these lines in hybrid combination. The hybrid breeder has a fairly good idea of his plant's adaptive probabilities, but this further points out the need for a complete record of genotypic and environmental data so this intuitive knowledge possessed only by the "expert" can be readily available to all who could make use of such information.

THE GENOTYPE X ENVIRONMENT INTERACTION

Recognition of the G x E interaction has forced temperate climate investigators to plant hundreds of cultivar tests each year. Since so little is understood about specific gene action response to various and varying environmental events, every new genotype of interest must be tested under a wide range of environmental sites. This is necessary to obtain some evidence on each genotype's adaptability to specific environments or, in some cases, the genotype's ability to produce high yields even though under the influence of relatively widely different environmental factors. With a better understanding of the G x E interactions, the number of tests necessary to ascertain a genotype's environmental "niche" will be significantly reduced.

All biologists are familiar with the use of the hereditary equation:

$$H = G + E \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [I]$$

where H is the hereditary expression of an individual, G is that part of H due to the recombinations of genes, and E is that part of H due to the environment in which the individual developed.

Most biologists are also familiar with hereditary expressed on the basis of variation of a population as follows:

$$\sigma_P^2 = \sigma_G^2 + \sigma_E^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [II]$$

where σ_P^2 is the variation expressed by the phenotypes, σ_G^2 is that portion of σ_P^2 due to the recombination of genes; and σ_E^2 is that portion of σ_P^2 due to the environmental influence upon the expression of the genotype.

Therefore, as E in equation [I] approaches zero, G approaches H. Also, in equation [II], as σ_E^2 approaches zero, σ_P^2 approaches σ_G^2 in value. This means that as the environmental influence on the genotype is more correctly understood so that its influence can be controlled or directed, the more closely will the observed phenotype approximate the actual genotype of an individual. (When E or σ_E^2 equal zero, the phenotype observed is the true genotype.) The technology transfer program of Utah State University should supply material aid in getting E and σ_E^2 nearer to zero.

The G x E phenomenon was recognized early by agricultural investigators and many scholarly attempts have been made to resolve this issue. When arithmetic analysis of test data failed to throw much light on the problem, the use of second moment mathematics was attempted as developed by Fisher (2). One of the first reported attempts in America to use a statistical approach on the genetics of crop plants was by Sprague and Tatum (8). Several other investigators followed with attempts to separate the environmental aspects from the genotypic effects with varying amounts of success. A paper by Allard and Bradshaw (1) gives a good review of the results of these studies.

Many other attempts to reduce the masking effect of the plant's environment and to collect data for predictive purposes have been made for many years by a wide range of research knowledge and talent. Probably the most successful studies to date have been those known generally as "growing degree days" or heat units. There are several variations on the general theme, but most establish a base temperature below which a plant's net growth is zero. Then, anything above this base is assumed to be a positive factor in causing the plant to accumulate additions to its growth structure. The method has been particularly valuable in predicting usable planting dates to induce the flowering stages of different maturing lines to occur at nearly the same date. This has made possible the efficient production of commercial hybrid lines using early and late maturing hybrids in a single crossing block.

Using the growing degree day system to predict adaptive properties of a genotype has met with far less success. This is probably due to the system's major deficiency of not taking into account many of the environmental vagaries that are present and operating on the plant's environmental response, e.g., the separation of temperature effects from radiation, or the varying effects on plant growth of different temperatures.

A STRATEGY FO R GENOTYPE SELECTION

Much of our past research in attempts to improve the economic yield of many crop species, has led to progress, but no "breakthrough" has been achieved; the fundamentals of the G x E interaction are still a

mystery. It is this mystery which largely prevents an effective transfer of temperate climate biotechnology into the subtropical and tropical food deficient areas. An intimate knowledge of the plant and its environment is critical in the transference of temperate technology to other climatic zones. A logical and efficient way to achieve this necessary intimacy is through a test system which monitors the entire growing season. Such a testing scheme should be carefully coordinated into a linked, international regimen, as proposed (4).

Characterization of the Plant and its Environment

The benefits of the ATTU program strategy are accomplished through a systematic stratification and characterization of climate (6, 8), soils (7), water, and any other environmental characteristic which can be stratified to any extent such as varying amounts of nutrient application, soil pH, and pest control, to name a few. A record of the test plant phenology and the use of indicator lines (5) is necessary for the effectiveness and efficiency of the project.

There are a few environmental events which are not controllable such as, storms, extreme heat, or cold , daily weather, timing of attack by disease or insects, and others. But, if every environmental event is monitored and recorded by properly trained and equipped technicians all data should be effectively uniform. This would result in information, which carried out over a period of years could be used to elucidate the G x E interaction.

Use of Open Pedigree Lines

With universally available information as the objective, the parentage of all genotypes used in research should be known. This may cause some concern for seed companies whose economic health relies somewhat upon keeping such information confidential, but there are several good reasons for complete pedigree revelation:

1. It is an efficient way to keep the number of test entries at a minimum and eliminate unknowingly duplicate testing.

2. Any hybrid tested can be reinstituted at any future time when complete pedigrees are known, and, therefore, eliminate the need to maintain a large number of cross combinations to hedge against possible future need.

3. There is a predictive value for relatives of pedigrees tested. Since it is nearly impossible to make all possible cross combinations between all inbred lines available at any one time, selection for or against certain inbreds is enhanced by comparing performance of a near relative.

4. Use of diverse genetic backgrounds in production fields can be maintained and, thereby, reduce the chances of having most of the world's supply of that crop susceptible to attack by a new pest which could threaten severe reduction of the crop. For example, if two hybrids are desirable for a selected production unit and a choice of three nearly equal producing hybrids are available whose pedigrees are known such as (A x B), (A x C), and (C x D), the two selected should be (A x B) and (C x D) since this likely results in the use of the most widely diverse source of germ plasm. If the pedigrees are not known, the two selected could be more closely related. The nearly universal use of the Texas source of cytoplasmic male sterility to produce hybrid seed corn resulted in the sudden appearance of Southern Corn Leaf Blight (*Helminthosporium Maydis*, Race T).

5. Commercial seed companies, through their respective research departments could compare the exposed pedigrees of the test lines to the genetic composition of their hybrids and cultivars and produce for sale those pedigree combinations most nearly akin to the pedigree of the test lines. Thus, it would not be necessary to test every genotype for sale by each commercial seed company since, as long as a competitive structure is maintained between commercial seed companies, there would be little danger of their offering inferior lines for sale since their competition would not likely do so. They would produce seed that is at least equal to the productive capacity of the best pedigree(s) in the test lines.

By testing only material whose lineage is known and collecting all the pertinent climatic and soil information in a thorough and methodical manner, it is possible to ascertain those aspects of the environment which are either beneficial, indifferent, or harmful to any one genotype. The use of *pure lines* would appear to offer the best hope for results that are both productive and repeatable in *self-pollinated* crops; but *cross-pollinated* crops, such as corn, will need to seek the

same objective through the use of single cross hybrids since pure lines (inbreds) in cross-pollinated crops lack growing vigor. Open pollinated and synthetic lines of cross-pollinated crops can be used in areas where they are used for production, largely outside the U.S.A. However, the "intra-line" variation complicates the separation of genetic and environmental effects, so their use will probably add little to the knowledge of the interaction of the environment on other genotypes.

The acquisition of open pedigree hybrids in crops such as corn for research purposes will cause some apprehension for agricultural investigators where training is other than plant genetics, since commercially available hybrids are not identified by pedigree. By working through a station plant breeder or geneticist, however, ample supplies of any desirable pedigree can usually be obtained.

Use of Indicator Lines

The selection rationale for indicator line selection is more fully developed in another paper (5). Briefly, an indicator line is one of a set of lines selected from the array of genotypes available from any one crop. These lines are selected for their response to defined environments and may be adapted to a specific environment or to a range of different environments. In all cases, these lines are of known parentage and can be reproduced as needed for future use. All variety testing programs should include a set of indicator lines appropriate for that crop and climatic area. All other agricultural research, using plants as the test vehicle, should select an indicator line from within the array of lines available for the crop selected. By using indicator lines in all tests, the largest possible amount of information will be available to all agricultural investigators and each research project can have objectives both for the immediate as well as for the distant future.

Indicator lines are a key part of the research linkage rationale to make past research an active and integral part of present and future examinations of the vagaries of nature. Proper genotype selection should be as integral a part of agricultural research as all other criteria set down for any inquiry. The test environment will vary

despite the best efforts of man, but use of a constant genotype will remove one more variable for which an accounting will not be needed.

Use of Specific Genotypes

Quite often, selected varieties are identified as being narrowly adapted. This usually implies an adaptation to the naturally occurring environment of a specific site. The extensive use of agricultural production technology, however, has resulted in varieties being synthesized which have been released for use in an environment which has been drastically altered, from that which occurs naturally. A knowledge of the specific environment in which a genotype is to be grown can be essential.

For example, dwarf barley varieties have been released because they have the potential for high yield in environments where ample water and soil nutrients are available, since their reduced height reduces the likelihood of lodging. "Normal" height varieties under the same conditions fail to produce high yields primarily because the increase height and head weight resulting from abundant water and soil fertility makes lodging a near certainty and reduces yield. Consequently, use of the dwarf varieties in the altered environment always yield higher than normal height varieties.

If, however, the site environment is not altered by the additions of water and/or nutrients, a very different yield results from use of the same varieties. The normal variety is not as likely to lodge in the natural environment and its yield will be near normal for these environmental conditions. The dwarf variety, being selected for an enriched environment, cannot maintain its competitive advantage and may well produce less yield in the natural environment than a normal variety. Therefore, a complete characterization of the environment including the possible alteration in which a variety is to be grown is essential, especially for narrowly adapted (site specific) varieties.

CONTRIBUTION FROM GENOTYPE SELECTION

The adaptation of the basic principles outlined above can make significant contributions in agricultural research and production.

To All Agricultural Research

When widely and narrowly adapted lines are growing together in a fully monitored environment, it should be possible to isolate the most outstanding factors operative in genotypic adaptive differences. As these are identified and catalogued, the lesser and currently unidentifiable environmental factors will be revealed to investigators for the first time. Plant physiology, especially, should benefit by the identification of these elements, since the reduction of the unknown environmental influences on plant metabolism will make observation of the internal plant activity less subject to error. Specialists in the disciplines of plant pathology and entomology will also be able to more accurately determine yield losses on plants due to diseases and insects. Water and soil research will be able to associate specific events in water and nutrient uptake to precise genetic information since the pedigree will be known. This should make soil research more repeatable since the same genotypes can be used in successive cycles.

To G x E Interaction Understanding

It should also be possible to relate specific environmental characteristics to specific genotypes, and, when highly successful, to specific genes or gene groups. It has long been recognized that certain genotypes are more sensitive to changes of environment even though they may be closely related genetically to other genotypes. By having all possible environmental information recorded on each test in which these lines appear, it should ultimately be possible to isolate the gene or gene group which is responsible either for a reaction to a specific environmental trait or for the lack of such reaction.

To Selecting Lines for Specific Environments

After such gene isolation has been made, it will be possible to select against lines which have certain adaptive characteristics when they might be deleterious or, conversely, when they might be beneficial to those lines in a selected or known environmental niche. It will also be possible to select genotypes that are nearly insensitive to all environmental variables so that new lines could eventually be produced

which can be evaluated on their total energy requirements and conversion efficiency. When this has been achieved, a new line bred in Iowa, for example, can be transferred to any area of the world where the energy availability is known and the temperature is suitable for plant growth.

To Plant Breeding and Genetics

At present, much selective effort is expended in searching for genetic combinations that are relatively insensitive to environment, i.e., they will produce well over relatively wide climatic areas. As a result, many lines are discarded that may well be the highest yielding line under a different environment, since only a few lines can be tested over several test sites. For example, from any one cross made in the attempt to generate an improved inbred line, segregation in the F_2 and later generations of self pollination give rise to thousands of possible genetic recombinations.

Since it is possible to physically handle only a few hundred of these possible recombinations, many newly created lines are discarded without ever being tested. Many others are discarded after only one year in one environment since they did not favorably "impress" the plant geneticist who is making observations and selections. This selection process goes on generation after generation between and within lines so that seldom is more than one genetic recombination selected to become an inbred line or variety from any one cross and, many times, no segregate from a cross becomes a "named" line.

To Reduce Necessary Testing

Following selection of "improved" inbred lines in cross-pollinated crops like corn, test matings are made to tester lines to ascertain that line's value in hybrid combination. These test crosses are usually grown in one environment and those hybrid combinations that show some degree of possible merit are retained for further testing in intra and interstate yield trials. The number so selected is usually determined more by the amount of time and funds the plant breeder has available rather than upon the specific merits of any one selected hybrid combination.

Regardless of type of pollinations, once a line has been selected for testing, it is necessary to enter it into state and regional yield trials. At this point in the life history of any line, very little is known about its ability to produce an economical yield under variations of climate, soil, and/or water, and under our current state of knowledge on plant adaptation, predicting a line's possible adaptive properties is haphazard at best. Therefore, all new varieties or hybrids are entered in interstate states to obtain information on their broad range of adaptation and in intrastate states to test their specific areas of adaptation. Iowa, for example, divides the state into six corn testing zones and one of these zones is subdivided into two areas because of diverse soil types. There should be faster and less expensive methods of finding a new line's adaptive range.

To Produce Specific Genotypes For Specific Environments

In this selection process, there must be many genetic recombinations that are highly site specific if they were only tested under the environment specific for their genetic constitution. Since it is not possible to test all these segregates in all possible environments, knowledge of enviromental specific genes or gene combinations would allow the plant breeder to make use of these in his program of synthesizing the ideal genetic combination.

To Ensure a Broader Genetic Base

Using only test genotypes whose full genetic background is revealed makes possible the selection of genotypes for production that are dissimilar in genetic constitution even though they may have similar yielding ability in the same environments. The principal advantages of this selection is to maintain as broad a genetic base as possible in the production fields to help guard against the attack by unknown organisms or new genetic recombinants of existing pathogens. A broad genetic base gives the highest probability that all current production will not be susceptable to attack by a new pest.

To Agricultural Production

When plant and environmental characterization is fully implemented, the time span from the selection of a new, superior genetic combination to its use on the farm will be greatly reduced. Since the variety

was selected in a characterized environment, the specific environmental sites to which it is most likely to be adapted will be known concurrently with its release. The several years of testing currently needed to establish the adaptability of the new genotype will essentially be eliminated and the new variety will be ready for production as soon as seed supplies can be increased to a quantity sufficient for the adapted areas. The cost efficiencies resulting from this rapid utilization of new technology will be substantial.

Glossary

Adaptability - the ability of a biological organism to produce its maximum yield under a given set of environmental conditions.

Agricultural technology - a collection of rules and established operating procedures for producing food and fiber, along with the physical, chemical, and mechanical aids to implement those rules.

ATTU - A research project with a rationale applicable to all agri cultural research involving plants which characterizes the plant and its environment to the fullest extent possible.

Biosphere - that part of the atmosphere dealing with living entities.

Bio-technology - that part of agricultural technology dealing with living entities.

Characterization - the quantification in standard units of those measurable components of an entity that have been chosen to capture the important essence of the entity with regards to the problem at hand.

Climate - the long term trends of atmospheric events.

Crop - designation of a specific genus and species of the plant kingdom, e.g., *Zea mays* is corn, *Glycine max* is soybeans.

Cross pollinated - the pollination of a plant by pollen from a different plant of the same variety.

Diploid - a biological organism whose cell nucleus contains two basic sets of chromosomes.

Double cross hybrid - a cross between two single cross hybrids.

Environment - the collection of factors experienced by the plant that interact with the genetic potential of that plant to result in the actual observed plant response. Environment includes consid ation of the local site and climatic conditions, the specific weather and pest conditions existant, and the modifications of these by the plant husbandry utilized during the chosen time period.

F_2 - the second filial generation following a cross.

Genotype - the identifiable fundamental heredity constitution of a biological organism, i.e., it can be a variety, line, or hybrid.

Genotype x Environment (G x E) Interaction - the action of the various environmental components upon a genotype and the reaction of that genotype to these various environmental stimuli.

Homeostasis - the tendency of an organism to maintain within itself relatively stable conditions in reaction to varying environmental elements by means of its own regulatory mechanisms.

Hybrid - the first generation cross between two or more varieties, e.g., Iowa 939, Nebraska 801, Pioneer 3369, and DeKalb X145 are hybrids of corn.

Inbred line - a relatively homozygous line produced by inbreeding and selection.

Indicator line - a crop genotype of known pedigree capable of producing sufficient growth under widely varying and different environmental conditions to be commensurate with specific experimental requirements.

Narrowly adapted - when a biological organism produces its maximum yield under environmental conditions which can change very little little without a detrimental effect upon yield.

Open pedigree - any variety of hybrid of publically known parentage, e.g., Amsoy soybeans, Iowa 939 corn.

Open pollinated - the pollination of a plant by random pollen from any neighboring plant or plants.

Pests - any biological entity (such as disease, insects, or rodents) which can have a negative effect on plant growth and/or yield.

Phenology - the science of relations between environmental conditions and periodic biological phenomenon.

Phenotype - the physical properties expressed by a plant due to the influence of its genetic constitution.

Pure line - a selection of biological organisms that is comparatively pure genetically (homozygous) because of continued inbreeding.

Self pollinated - the pollination of a plant by pollen from the same plant.

Single cross hybrid - a cross between two inbred lines.

Synthetic line - a line produced by a combination of selected lines or plants and allowed to intercross randomly.

Tester lines - lines of known pedigree and performance which are crossed with newly constituted genotypes to evaluate the genetic merit of the new genotype, usually in yielding ability.

Variety - a genetic selection within a crop, which is capable of being reproduced in kind by its own seed, e.g., Amsoy, Clark, and Williams are named varieties of soybeans.

Weather - the day to day events commonly associated with the atmosphere. At a minimum temperature, solar radiation, precipitation, dew point, and wind.

Widely adapted - when a biological organism produces its maximum (or near maximum) yield and a relatively wide range of environmental conditions.

References

1. Allard, R. W. and A. D. Bradshaw. 1964. Implications of genotype x environment interaction in applied plant breeding. Crop Sci. 4:503-508.

2. Fischer, R. W. 1946. Statistical methods for research workers, 10th ed. Oliver & Boyd, Ltd. Edinburgh and London.

3. Hill, R. W. and Jack Keller. 1977. Water manipulation to simulate environmental regimens. Utah State University and AID 211(d).

4. Keller, Jack and L. N. Leininger. 1975. An agricultural technology transfer system. Proceedings of a specialty conference conducted by the I & D Director, ASCE. Logan, Utah. August 13-15, pp. 57-65.

5. Leininger, L. N. and H. B. Peterson. 1977. Crop indicator lines for agricultural research and production. Utah State University and AID 211(d)-12.

6. Shaw, R. H. and R. W. Hill. 1975. Reference climate sites for agricultural technology transfer. Utah State University and AID 211(d)-11.

7. Southard, A. L. and H. B. Peterson. 1977. Soil taxonomy in relation to agricultural technology transformation and utilization. Utah State University and AID 211(d)-13.

8. Sprague, G. F. and Lloyd Tatum. 1947. General vs. specific combining ability in single crosses of corn. Jour. Amer. Soc. of Agron. 34:923-932.