

Winter Wheat Improvement in Washington to 1982 1/

O. A. Vogel 2/

Wheat improvement by breeding in the Pacific Northwest was pioneered by W. J. Spillman at Pullman, Washington. From crosses made in 1899 he formulated the principle of segregation and showed how new combinations of plant characters could result in the development of new cultivars more suitably adapted to soil and climatic conditions in Washington (Spillman, 1901). He left Pullman in 1902, but the breeding and selection activities were continued by Elliott and Lawrence.

The first cultivars resulting from the breeding program were released in 1907 (Spillman 1909). All were club type selections, namely Hybrids 63, 108, 123, 128, 143 and 150, all of which represented one or more desired agronomic improvements, especially in resistance to shattering and lodging (Schafer and Gaines, 1915). Hybrid 128 became the most widely grown, principally because of its over-all superiority over the other five cultivars.

The first lax or common type head hybrid selection from Washington State was Triplet, an awnless soft red winter type released in 1918. It was widely adopted but the hairs from its pubescent chaff caused severe soreness of the skin of members of harvesting crews. Therefore, the increased production potential of it and other pubescent wheats was limited to those who could endure the discomforts during harvest. Thereafter, high yielding segregates having pubescent chaff were never released for commercial use in Washington.

Breeding for resistance to bunt or stinking smut was first under-

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taken by E. F. Gaines in 1915 (Gaines, 1920). In 1924 he released Ridit, a hard red winter hybrid selection resistant to all collections of bunt available to him at that time. In 1928 he released Albit, a soft white club selection to replace the heavily smutting club varieties grown at that time. These two cultivars never became widely grown because Ridit was not a high yielder and Albit was too susceptible to shattering during the dry weather harvesting seasons.

In spite of efforts to control stinking smut through breeding, plant introductions, and seed treatments, the wheat grading smutty during 1923-28 ranged between 27 and 62 percent. This problem plus the Pacific Northwest being plagued by far too many varieties, over 50 in 1929, caused a very serious handicap in marketing the various market classes in domestic and export markets (Clark and Ouisenberry, 1937). These and other problems were evaluated by concerned leaders during the Pacific Northwest Wheat Improvement Conference at Pullman in 1928, at which time it was decided to request Congress for funds to establish a cooperative western regional wheat improvement program. Such a program was established in 1930 with operating funds and personnel provided by the U. S. Department of Agriculture.

The Cooperative Western Regional Wheat Improvement Program was organized to cover all wheat growing areas west of the Continental Divide, thereby involving 11 states. The original breeding objectives at Pullman were to develop high yielding, good quality white wheats resistant to lodging, shattering, bunt and stripe rust. The program was organized as a team participation in evaluating the agronomic adaptabilities of new genetic combinations and in the free exchange of information useful to all participants within the region. O. A. Vogel was employed by the USDA in February of 1931 and stationed at Pullman to

work under the direction of E. F. Gaines and to cooperate with Earl Barbee in field testing experiments. C. S. Holton, subsequently was employed by the USDA to work cooperatively with the Department of Plant Pathology in research to control bunt in the Pacific Northwest. Results from bunt and varietal trials annually were to be reported to the respective state cooperators, and to the regional coordinator, who in turn compiled summaries of data provided by all workers in the region.

The methods of planting and threshing experimental materials were too slow and cumbersome to permit reasonably adequate field testing of the greatly increased numbers of materials resulting from the expanded breeding and testing activities at Pullman and other experiment stations. Consequently in 1932, Vogel built a 3-row planter, the first to use a cone-shaped seed distributor, to replace the single-row Planet Junior, also a self-cleaning nursery thresher to replace an old "Kansas" machine. In 1933, he built a small head thresher to speed up the threshing of individual heads and plants. The original machines were crude in design and therefore subsequently were greatly improved for increased efficiency and sturdiness.

A new problem in milling and baking resulted from the production of a popular bunt and lodging resistant soft white lax-headed winter wheat named Rex which was released by Oregon in 1933. When milled by procedures practiced by Northwest millers, its flour was unusually slow in passing through the bolting screens, thereby requiring from 10 to 15 percent additional time to produce a given amount of flour. Consequently commercial millers strenuously objected to its production and the release of any new cultivar of comparable slow-milling quality.

A lack of suitable techniques for eliminating slow milling segre-

gates in early generations prompted the milling industry to help organize the Pacific Northwest Crop Improvement Association in 1943 and subsequently made arrangements for commercial organizations to test a limited number of new agronomically promising cultivars. These services, although valuable, represented mere tokens when compared with the hundreds of early generation selections needed to be evaluated for milling qualities. These needs led to the establishment of the Western Wheat Quality Laboratory at Pullman in 1946 with M. A. Barmore in charge. Subsequently a micro-mill was developed to classify the milling characteristics of 5-gram samples at the rate of several hundred per day, thereby enabling the laboratory to classify early generation selections from all the breeding projects in the region. Also the laboratory was equipped to annually determine the milling and baking properties of hundreds of advanced generations selections, thereby greatly increasing the progress of breeding for good quality wheats.

The dominant influence affecting decisions for releasing new cultivars from Pullman for commercial production in the thirties, forties and early fifties was increased resistance to bunt. Desirable improvements in resistance to lodging and shattering, however, became increasingly influential following the increased use of commercial fertilizers and the adoption of management practices permitting early planting on summerfallowed fields.

Progress in the development of needed new cultivars during the early years of the cooperative regional program was not as rapid as anticipated. A major obstacle for the slow progress was the continued appearance of new races of bunt and the discouraging grain yields of the most bunt resistant new hybrid selections.

In 1934 Hymar, a bunt resistant winter hardy club type was released from Pullman to replace the shatter susceptible Albit. Although the most winter hardy club type, Hymar never became widely grown, principally because it yielded considerably less than Elgin, a highly bunt-susceptible club type released from Oregon in 1934. The superior yield of Elgin represented a new plateau in production capability.

The greatly increased yielding potential of winter wheats resulted in a growing disparity of yields between winter and spring wheats. Consequently the production of spring wheat in Washington dropped to levels insufficient to provide adequate seed for spring planting following severe over-winter damage to fall-sown wheats.

In 1943, Orfed was released because of its winter-spring growth habit, high resistance to lodging, shattering and bunt and its desirable dual-purpose flour qualities. It never became a widely grown fall planted cultivar because most of the growers could produce more profitably the higher yielding bunt susceptible cultivars. When spring planted it matured too late to compete with other spring wheats. However, when fall-planted stands were partially reduced by winter injury it was useful for replanting in early spring, thereby avoiding the mixing of cultivars.

While enroute to inspect one of the first commercial fields of Orfed, Mr. Earl Barbee was killed in a collision with a train engine. He was very highly respected by wheat growers for his common sense information on the problems of grain and pea production in eastern Washington. In the mid-thirties, he observed that often times volunteer wheat seedlings emerging in wheat stubble, and in some late-planted winter wheat following wheat in annual cropping, were much weaker at the

2-leaf stage than would be expected from the food contained in the seed. Plant pathologists examining the seedlings at that time did not find any pathogen apparently responsible for the sickly appearing seedlings. Consequently this type of seedling growth was relatively ignored by research personnel until in the late 70's when some annual cropping and systems of conservation tillage were adversely affected by various kinds of seedling abnormalities.

The only hybrid selection of spring wheat developed from the cooperative federal wheat breeding efforts at Pullman was Marfed a soft white awnless cultivar released in 1946. It was released to replace Federation for late fall planting on pea ground in the Walla Walla area and for spring planting in other areas. Although never widely grown, it became an important spring wheat in the intermediate rainfall areas for approximately 20 years. Why an awnless cultivar should remain popular in such a harsh area was explained by R. J. Cook after he learned that it was noticeably tolerant to the *Fusarium* root rot in that area. In the higher rainfall areas it was too susceptible to winter injury when fall planted, and when spring planted, it never was as widely grown as Idaed, an earlier maturing cultivar released by Idaho.

State participation in winter wheat breeding was increased after S. P. Swenson succeeded the ailing E. F. Gaines in 1939. Swenson's wheat breeding efforts were concentrated primarily on simplified backcrossing procedures to more rapidly develop new high yielding bunt resistant winter wheats. Vogel concentrated on the more complicated and time consuming multiple combinations of agronomic characters and disease reactions needed to improve winter wheats in the Pacific Northwest.

In 1947 Swenson became chairman of Farm Crops; his wheat breeding activities were assigned to F. C. Elliott. Subsequently, the wheat breeding responsibilities were divided as follows: Elliott the spring wheats and Vogel the soft winter wheats at Pullman, and Walter Nelson, primarily the hard red winter wheats at Lind.

In 1949 two new bunt resistant winter wheats, Elmar and Brevor, were released in the hope of reducing the losses caused by bunt. Elmar, a backcross derived club type similar to Elgin in appearance and performance rapidly became widely grown. However, new races of bunt increased on Hymar and some other cultivars were not controlled by Elmar. Brevor, a short, stiff straw lax head soft white winter wheat continued to maintain high resistance to the new races of bunt. It never became popular because too often it was severely damaged by *Cercospora* foot rot and *Cephalosporium* stripe. However, the performance of Brevor under high applications of commercial fertilizers revealed the need for the development of new winter wheats having much shorter and stiffer straw, and a high level of resistance to foot rot. Without such a type, a highly desired method of early fall planting for high yield and good control of soil erosion would not be widely practiced.

*Cephalosporium* stripe was first noticed on Brevor. This pathogen could have been responsible for many of the previously unexplained erratic yields from Brevor.

The high resistance to bunt in Brevor resulted from the combining of so-called minor genes for resistance with selected major ones to obtain a cumulative effect less susceptible to constantly appearing new races of bunt. However, the procedures for identifying new minor genes and assuring the transfer of all genes in subsequent breeding projects

became increasingly complicated and time-consuming, and therefore, were discontinued. Subsequently the breeding for bunt resistance was continued by the more simplified procedures of the more easily identified dominant reactions to the various races of common bunt.

Brevor continued to maintain relatively high levels of resistance to new races of dwarf bunt, when compared with subsequently released so-called highly resistant dominant-gene cultivars. Unfortunately with the appearance of new races of dwarf bunt which could not be controlled with HCB, the increasing prevalence of dwarf bunt spores in exportable wheats resulted in the embargo by China of wheats grown in the Pacific Northwest.

In 1946 Vogel assumed additional responsibilities as coordinator for wheat improvement in the western region. The cooperative regional program subsequently was expanded to include hard red winter wheats. The resurgence of losses from common bunt during 1946-52 prompted an intensified effort to gain public and private support for a greatly expanded federal participation in the development of new, high-yielding, bunt-resistant cultivars and new chemical seed treatments for more effective control of bunt. Consequently in 1953, Congress appropriated additional funds which were sufficient to employ two additional staff members in the smut laboratory and Joe Craddock and Everett Everson were employed to assist Vogel in breeding and field testing at, and from, Pullman. Additional personnel were employed in Oregon, Idaho and Utah.

The added regional responsibilities eventually became excessively time-consuming and the kinds of progress made therefrom were so meagerly rewarded by certain federal personnel officials in Washington, D.C. that Vogel requested to be relieved of the coordinator's activities. The request was granted in 1955.



A dramatic reduction in losses from bunt resulted from the release of the highly bunt resistant cultivar Omar and the widespread use of the highly effective fungicide HCB for treating the seed. Omar rapidly became the most widely grown soft white club type winter wheat in the Pacific Northwest. It had unusually good milling qualities. Especially outstanding was the rapid flow of its flour through bolting screens. Consequently the milling industry arduously objected to the release of any new soft white cultivar having flour which screened less freely in the milling process. The bolting quality of Omar ranked above that of previously acceptable levels by a margin roughly equal to the below-acceptable level of the notoriously slow milling Rex wheat.

The persistence of the milling industry to vigorously object to any new soft white cultivar having milling qualities notably below that of Omar required breeders to expand the breeding and testing programs in the hope of finding acceptable selections in early generations. Progress in finding acceptable soft white club types was very slow, while that of finding the desired soft and semihard white common types was practically nil.

The result of greatly expanded breeding and relevant research efforts at Pullman was the need for a much larger seedhouse and much more land suitable for plot trials. Consequently Vogel undertook the task of developing a preliminary plan for a new seed house to accommodate the variously requested storage and work areas. This plan was turned over to the Agronomy Department to finalize and to authorize its construction. Construction of this structure was begun in 1955. He also spent a very considerable amount of time examining farms within a 15-mile radius of Pullman which contained enough portions of land

suitable for experimental trials. The Mennet farm two miles south of Pullman was found to contain the largest portions of various sizes and topographical locations most suitable for a large number and variety of experimental trials. The acquisition of 222 acres containing the most suitable portion of the Mennet farm in 1955 resulted from an outstanding combination of prudent public relations by B. R. Bertramson, the new chairman of the Agronomy Department, and persuasive activities of many individuals among the farm organizations. The site was subsequently named the Spillman Agronomy Farm.

Several years later Vogel became aware that 160 acres adjoining the Spillman farm would be for sale at a reasonable price, and that a down payment of \$9000 would bind its purchase for the College. He persuaded Roscoe Cox, a farmer friend of the College, to write a check to cover the down payment, and then apprized Bertramson and members of the Wheat Commission of the availability of the adjoining land, much of which was suitable for experimental plots. Subsequent quick action by the College officials resulted in the acquisition of the additional land.

In addition to major changes in the availability of plot land, there were major changes in the USDA winter wheat research personnel at Pullman. R. E. Allan filled the position vacated by Everson, and C. J. Peterson filled the position vacated by Craddock. Allan concentrated on the genetic studies relevant to plant height, slow emergence, and the development of new combinations of genes needed for resistance to the rapidly increasing number of races of stripe rust. Peterson concentrated on the breeding of soft white winter wheat and on the adaptation of new cultivars to various areas of Washington. A major change also occurred on the state staff, with C. F. Konzak filling the

position vacated by Elliott, concentrating on the breeding of spring and facultative wheats.

To facilitate the breeding and research efforts, Vogel concentrated on designing and building new and more efficient planting and harvesting equipment and on new seed storing facilities. An 8-row planter was developed from a grant from the Rockefeller Foundation. A 24-compartment self-emptying plastic seed container was developed to automate the planting operation of the planter. A special extrusion die to produce thousands of the containers was purchased from funds provided by the Wheat Commission. Subsequently the purchase of the thousands of containers permitted a crew of 3 to plant up to 5,000 rows per hour..

A new self-cleaning plot combine was developed and a new truck to transport it resulted from funds made available by the Washington Wheat Commission. This commission also provided continued funding for operations and additional facilities. An 8-foot rototiller attachment for a field tractor was developed from funds which the Ford Foundation, provided in honoring Carl Boyd for farming efficiency. Seed and sheaf storage facilities to supplement the new seedhouse were designed and built on the Spillman Farm from funds provided by the Wheat Commission.

In 1959 it became apparent that Omar was highly susceptible to a new race of stripe rust. By 1960 the rust had become a very serious problem, resulting in multimillion-dollar losses in the Pacific Northwest. Consequently, the production of Omar rapidly declined, and the breeding for resistance to the rust was greatly expanded at Pullman.

Another problem receiving increased attention was the need for developing lodging resistant cultivars more suitable for production under the rapidly increasing use of commercial fertilizers which were

resulting in increasingly heavy losses from lodging, especially in fields planted early in the fall. The most encouraging prospects for the development of the needed plant type appeared to be the performance of several unusually short straw selections from crosses involving Norin 10.

Norin 10, an unusually short straw plant introduction was grown from a March planting at Pullman for the first time in 1948. A cross of Norin 10 X Brevor marked the beginning of breeding for very short straw in winter wheat. Selection Number 14, although not suitable for commercial production, became the parent widely used in winter wheat breeding at Pullman and shared with many other breeders in breeding for short straw in winter and spring wheats.

Additional crosses with other cultivars netted a very short straw type more suitable than current cultivars for early fall planting on summerfallow to control soil erosion and obtain more nearly the yield capability from summerfallow systems of management.

To classify the newly developed short straw type, it was agreed to class it as semidwarf, especially since Brevor already was classed as very short and the new type generally was shorter by 6 to 12 inches. Any semidwarf plant type suitable for early fall planting on summerfallow had to have resistance to the prevalent races of stripe rust before it could be considered for release. However, since the breeding for resistance to stripe rust previously had not been a formal function, the incidental use of moderately resistant parents produced segregates ranging from none to useful levels of resistance. A selection susceptible in the seedling stage of growth but increasing in resistance at later stages of growth was released in 1961. It was named

Gaines in honor of the late E. F. Gaines.

Gaines represented a breakthrough to a new plateau for yield with above-100-bushel yields soon becoming commonplace. Its high resistance to lodging and shattering and resistance to stripe rust at late stages of growth were features aiding in the widespread production of Gaines wheat in the Pacific Northwest.

The milling quality of Gaines was below that of Omar, and therefore certain members of the milling industry strenuously objected to it. To pacify this industry, a sib-selection having a notably better milling quality, named Nugaines, was released in 1965. It soon replaced Gaines, primarily because it was notably more resistant to stripe rust. As for pacifying the milling industry, the major milling companies had by then increased the bolting capacity of their mills and subsequently no objections have been received for cultivars having milling qualities comparable with Gaines. The widespread adoption of semidwarf soft white winter wheats was accompanied by a very notable reduction of acreages of hard red and hard white winter wheats in the low rainfall areas of Washington.

A very significant decline in damage from stripe rust resulted from a combination of the widespread production of Nugaines, a short-lived increase in the moderately resistant Brevor, and the release of Moro from Oregon in 1965. Moro, a tall weak straw soft club cultivar was highly resistant to the rust and because of its unusually good emerging characteristics, became a popular cultivar in the low rainfall areas where lodging was not a serious problem. It emerged from deep plantings notably faster and more reliably than any other cultivar, especially when planted in warm summerfallowed fields in early fall.

The highly desired fast emerging characteristics of Moro were attributed to the lack of post-harvest dormancy of the seed and an unusually long coleoptile which enabled the seedling to emerge from deep plantings. The transfer of these characters to the notoriously slow emerging semidwarf winter wheats became one of the major objectives of the breeding and genetic projects conducted by Allen. Progress to date has been much slower than anticipated.

The breeding of strong gluten hard white winter wheat was not encouraged by most segments of the wheat industry concerned with marketing and processing the so-called bread wheats. The major objections were the problems of separate storage, insufficient quantities of high protein lots and the difficulty of keeping separated the hard and soft white wheats.

In 1956 the hard white winter cultivar Burt was released, primarily for production in the drier areas. It became the dominant hard winter wheat during 1959-1964, representing approximately one-tenth the total acreage, much of which was grown in summerfallow in the medium rainfall areas and following peas in the higher rainfall areas. It yielded considerably below Gaines, and therefore the production of Burt dropped sharply after 1964. An attempt to revise the production of hard white winterwheat was the release in 1971 of Coulee, a semidwarf backcross to Burt. It, however, never became widely grown.

The acreage production of hard red winter wheat reached a low of roughly two percent in 1964. However, the release of Wanser and McCall at Lind in 1965 revived interest in hard red winter wheats. By 1969 the two cultivars were grown on over 17 percent of the acreage, with Wanser being the more widely grown. Although lower yielding than the semidwarf

soft white wheats, the new hard reds were superior in emerging characteristics and in winterhardiness. In addition, Wanser was moderately resistant to stripe rust and highly resistant to flag smut, a disease commonly found in Omar in the traditionally hard red winter areas of Washington. The moderate levels of resistance to stripe rust plus the high resistance of Moro, appeared to be major deterrents to the early spread of stripe rust from the irrigated areas into eastern Washington.

Winter hardiness of the highly productive soft white semidwarf wheats consistently ranked notably below that of the hard red standard height wheats. It appeared that the high yielding semidwarf soft wheats were less dormant during the winter months, and therefore resumed growth more rapidly during the mild temperature periods which oftentimes occurred during the winter months. The resulting additional over-winter growth apparently enabled the lesser hardy wheats to resume growth earlier in the spring and thereby produce higher yields of grain. However, the over-wintering seedlings of the earlier growth resuming wheats were more seriously damaged by sub-freezing temperatures than the hard red wheats.

It appeared, therefore, that if the freeze tolerance of the early growth resuming seedlings could be increased, these seedlings should survive the winter in a more vigorous condition of growth. Consequently, a special winter-hardiness screening program was initiated at Pullman in 1963. Since no suitable freezing facility was available, it was necessary to design our own. With Wheat Commission funds, Vogel developed specifications for a freezing chamber large enough to simultaneously freeze several hundred lots of wheat seedlings by a modification of a crown-freezing technique developed elsewhere. Special features of

the freezer were a constantly running compressor with variable refrigerant flow controls and a system of uniform flow of cold air emanating from orifices located over the full length of one side of the freezing chamber and uniformly withdrawn from the opposite side.

In 1965, Don George was transferred to Pullman from Pendleton to conduct crown freezing trials and also to continue his studies on post-harvest dormancy. A notable early result of the crown freezing studies was the discovery of several early generation hybrid selections more hardy than the currently growing semidwarf wheats, and which culminated in the release of Daws in 1977. Although presently the most winter hardy soft white semidwarf, Daws is not as hardy as presently grown hard red winter wheats. It was named in honor of the late Dawson Moodie who was killed in an auto accident.

A general feeling that bunt practically had been eliminated by the use of HCB and resistant cultivars was shattered by the appearance of dwarf bunt on Gaines wheat in several areas of eastern Washington. The most dwarf bunt resistant hybrid selection suitable for commercial production at that time was a late maturing weak straw winter wheat released in 1970. It was named Luke, as suggested by Peterson, in honor of a Nez Perce Indian who saved the life of H.H. Spalding an early missionary of the Pacific Northwest.

With dwarf bunt becoming an increasingly serious problem in annual cropping and late planting on summerfallow, and Luke maturing too late and lodged too heavily to satisfy most growers, it became apparent that a greatly expanded effort was needed to breed for new, dwarf, bunt-resistant cultivars which are resistant to lodging and are early maturing for more suitable use in annual cropping systems of management.



Luke was found to be moderately tolerant to some soil borne diseases on summerfallow in the intermediate rainfall areas. Its weak straw is tolerated by some growers in that area because it often out-yields other cultivars. A new selection slightly less susceptible to lodging, more resistant to dwarf bunt and equally late maturing, named Lewjain, was released in 1982 to replace Luke. It was named in honor of the late Lewis G. Jain, an ardent supporter of wheat breeding and pure seed programs.

The increased production of common soft white and hard red winter wheats resulted in a greatly reduced supply of club wheat for the export and domestic markets. To aid in assuring adequate supplies of club wheat for the grain trade, the cultivar Paha was released in 1970. Shortly after its release, it was found highly susceptible to flag smut. To control this smut, it was necessary to adopt a new seed treatment using Vitavax.

Snow mold on winter wheat often has caused severe losses in Douglas County and other areas having persistent snow cover during the winter months. The task of developing control measures and breeding for resistant cultivars primarily has been assumed by the Department of Plant Pathology. Assistance in planting and field testing was by Peterson of the Cooperative USDA program who also conducted independent breeding for resistance to snow mold. Vogel retired in 1973. Thereafter, the cooperative white winter wheat breeding and research activities were continued by Allan and Peterson.

Thereafter, Vogel continued as a volunteer in developing new planters and plot combines for use in the cooperative wheat improvement programs at Pullman and Lind, and in the establishment of the Vogel

Wheat Research endowment for fundamental research to increase production capabilities of wheat.

Expanded wheat research efforts at Pullman and in other states resulted from combined efforts by wheat-grower organization and political personnel to obtain federal appropriations for STEEP (Systems to Solve Environmental and Economic Problems) in the western states. Allan Chia was added to the federal staff to conduct research on various systems of crop management. The retirement of George in 1982 resulted primarily from a severe cut in federal funding.

#### IN RETROSPECT

The successive breeding of new winter wheats for increased productive capabilities resulted from the cooperative efforts of a succession of administrators and of other personnel funded by the USDA, WSU, and various segments of the wheat industry. It was my good fortune to have benefited from personal contacts with the most influential of the various personalities involved in the cooperative western wheat improvement program.

The outstanding success of the program resulted primarily from team approaches to problem-solving by Federal and State personnel, with continuous exchanges of materials and information. Contributing to the success was the continuous efforts by administrators to secure fundings for updating facilities and research to counter the progression of new diseases and other hazards of production. Of all the administrators who aggressively and successfully promoted needed fundings, the most effective one was Dr. B. R. Bertramson.

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