Paper 21

WHEAT CULTIVAR IMPROVEMENT IN THE PACIFIC NORTHWEST USA

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ABSTRACT

Yield data from the Western Regional Soft White Winter Wheat Performance Nurseries (WRPN) from 1956 to 1984 were examined. Kharkof and Elgin were included in the nurseries annually and their average yield was used to determine cultivar and nursery performance. The mean yield of the WRPN has a linear increase of 48 kg. ha^{-1} (P<0.01) per year from 1956 to 1984 and a predicted production increase from 3093 kg. ha^{-1} to 4438 kg. ha^{-1} for an overall increase of 43%. The WRPN mean yields increase linearly (P<0.01) from 107% of the check in 1956 to 157% in 1984 — a 47% improvement. There is no indication of a yield plateau. Mean squares associated with genotype-environment interactions increased linearly indicating that the new varieties are more specific in their adaptation.

KEYWORDS

Yield, genotype, environment.

INTRODUCTION

The Pacific Northwest (USA) produces 5.5 to 7 million tonnes of wheat each year. Environmentally and geographically the region is very diverse. Precipitation in the cropping area varies from 15 to 76 cm, with the driest months being July to September. Part of the area receives partial to total irrigation. Elevation ranges from 183 to 1219 m above sea level, and a difference of 305 m may occur on a single farm. The environmental and geographical diversity presents unusual conditions for the development of wheat cultivars. For a cultivar to be successful it needs to perform well under a wide range of conditions, such as low to excess moisture, and very low to high temperatures. In addition to tolerating stress, cultivars need resistance to most major cereal diseases. The Western Regional Performance Nursery began in response to concern for evaluation and selection of cultivars adapted to the varied growing conditions of the Pacific Northwest.

The Western Regional Performance Nursey has been grown for many years at numerous locations across the wheat growing region of the Pacific Northwest. The availability of data from these nurseries makes it possible to study trends in adaptation of new cultivars. This paper uses nursery data to examine performance of new cultivars in relation to long term check cultivars in the Pacific Northwest.

MATERIALS AND METHODS

Yield data from the Western Regional Soft White Winter Wheat Performance Nurseries (WRPN) from 1956 to 1984 were examined. The nurseries contain experimental and commercial soft white winter wheats developed by scientists with the US Department of Agriculture/Agricultural Research Service and State Agricultural Experiment Stations. The WRPN was grown primarily in Idaho, Oregon, and Washington in locations which represented diverse environmental conditions. The number of cultivars in the nursery each year ranged from 10 to 27. Ten locations in Idaho (1), Oregon (3), and Washington (6) were selected for analysis. Seeding rate, planting date, and fertilisation conformed to local practices.

Experimental lines were usually included in the nursery for three to five years. Kharkof and Elgin were included in the nurseries annually and their average yield was used to determine the cultivar and nursery performance. Yield increases attributed to improved cultivar and management practices were determined using annual nursery means. Yield increases attributed to genetic improvement were calculated by expressing the annual nursery mean yields as a percentage of the yield of the checks. Genotype-environment (G*E) interaction mean squares were calculated for each year using a multi-location analysis of variance to estimate variances among cultivars for yield. Yields of the checks were not included in calculations of annual nursery mean yields and mean squares for the G*E interactions.

An indirect measure of changes in cultivar response to environmental variation was calculated as a regression of an environmental index of nursery means from each location on the check cultivar mean yields (Eberhart and Russell, 1966) for each year. Significance of trends over years for all parameters were determined using regression analysis.

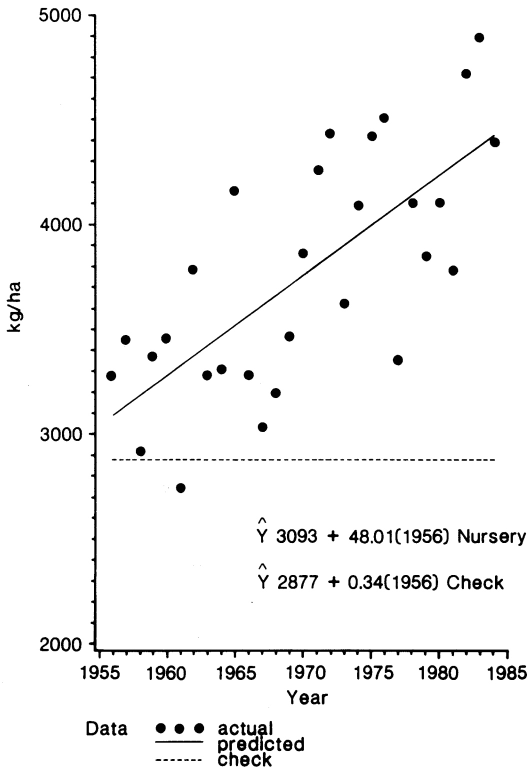

Figure 1. Mean yield of cultivars and check in Western Regional Performance Nursery grown at 10 locations from 1956 to 1984.

RESULTS AND DISCUSSION

The mean yield of the WRPN over locations increased annually in a linear fashion by 48.01 kg. ha^{-1} ($P<0.01$) from 1956 to 1984 (Fig. 1). Predicted yields per hectare increased from 3093 in 1956 to 4438 in 1984 for an overall increase of 43%. This compared to yield increases of 67% for the Southern Regional Performance Nursery and 77% for the Northern Regional Performance Nursery (Peterson *et al.*, 1985). There is no indication that cultivars have reached a yield plateu in the Pacific Northwest.

The difference in the nursery mean yield and the yield of the long term check will indicate the proportion of the yield increase attributed to genetic improvement. The proportion of the increase due to improved management practices such as weed control, crop rotations and fertiliser is reflected in the increased production of the long term check from 1956 to 1984. However, the yield of the long term check (Fig. 1) in the WRPN has remained relatively constant indicating that changes in management practices have had little effect on increasing crop production. Peterson *et al.* (1985) reported that 55% of the increased yield production in the Southern Regional Performance Nursery was attributed to genetic improvement and 40% of the increase in yield of the Northern Regional Performance Nursery was attributed to improved cultivars. Schmidt (1984) reported a yield increase of 34% when he analysed data from several regional nurseries between 1958 and 1980. Fifty per cent of the increase was attributed to genetic improvement.

Cultivar stability is inversely proportional to the sum of squares for genotype-environmental (G*E) interaction ascribed to that cultivar (Baker, 1969). Trends in the magnitude of the G*E interaction mean square will show trends in production stability attributable to cultivar development. The predicted G*E interaction mean squares increased linearly from 212 804 in 1956 to 367 583 in 1984 ($P<0.064$) for a 73% increase (Fig. 2). The results of the G*E interaction mean squares indicates that new cultivars are more specific in their adaptation, indicating the necessity for a wheat grower to be very selective when determining which cultivars to grow. He also needs more

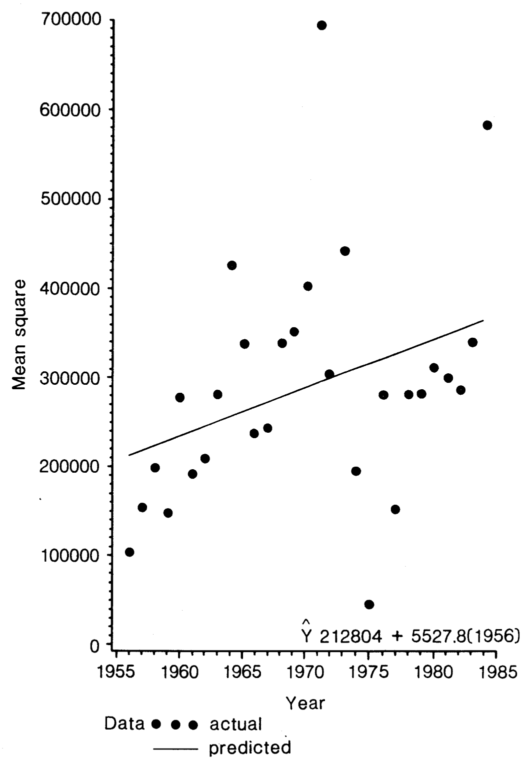

Figure 2. Mean squares associated with the interaction of genotype and environment effects on yield of cultivars in the Western Regional Performance Nursery from 1956 to 1984.

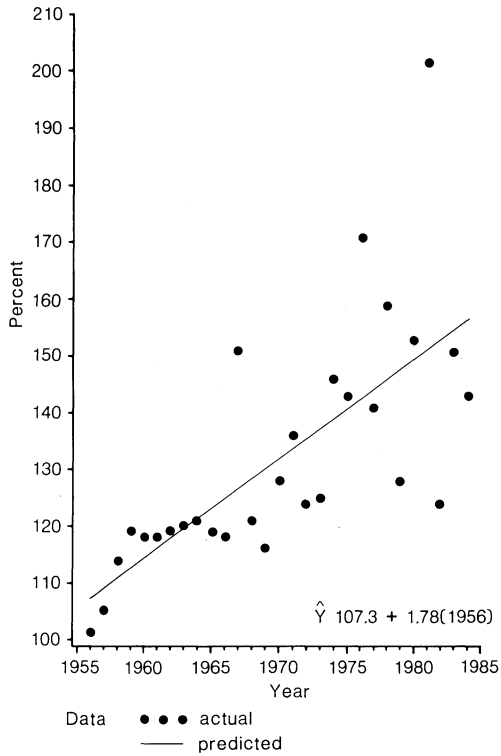

Figure 3. Mean yield of cultivars in the Western Regional Performance Nursery expressed as a percentage of the yield of the long term check cultivars (average of Kharkof and Elgin) from 1956 to 1984.

information on the cultivar's region of adaptation. It is more difficult to determine optimum growing conditions for an improved cultivar with specific adaptation. A more extensive breeding programme is required to develop cultivars for the diverse environments experienced in this region.

The WRPN mean yields over locations increased linearly ($P<0.01$) from 107% of the check in 1956 to 157% in 1984 (Fig. 3) for a 47% improvement in yield. The lack of an increase in yield due to management practices may be partially explained by the fact that seven of the WRPN were grown on State Experiment Stations. In most locations the WRPN nurseries received special care (such as hand weeding, crop rotation, etc.) and because of this, improvements in management practices which may have increased production for the wheat grower would not be evident in this data. The across-location means of the check cultivars were quite erratic and there was no significant change in yields over time. This may also account for the lack of a response to improved management.

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SYMPOSIUM DISCUSSION

Dr D.S.C. Wright, Crop Research Division, DSIR

Would you comment on the changes in the disease spectrum over that period?

Peterson

Our disease picture has changed a little over that period, although not to a great deal. Stripe rust became a major problem in 1960-61 on the variety that was being grown at that time, and it is still a problem, especially on our club wheats. We have been using adult resistance on our common types and consequently we have had pretty fair results in controlling this disease. We are using a lot more Benlate to control root rot that has given us problems over the years. In the last three or four years there has been more stem rust and leaf rust than previously. This is partly due to some environmental changes such as later springs, which resulted in later maturity of our material, allowing leaf rust and stem rust to build up. It was not possible to go into those nurseries and get a true picture of what the diseases were doing, and I am sure that would have had some effect as far as our results are concerned. The data from Nebraska was put together by my son, who is working there, and we used the same programme. I was amazed to see that we could not strike anything as far as increased management was concerned.

Dr A. Klatt, CIMMYT

Over the same period, what did farmers' yields do? Did they go up by a similar amount?

Petersen

I would say that farmer's yields have gone up by at least as much. We were looking at yield in the high rainfall area with average yields of about 60 bushels of Omar before stripe rust, and now those same farmers are getting at least 80 to 85 bushels.

Dr W.B. Griffin, Crop Research Division, DSIR

Your first slide indicated that white wheats are grown in high rainfall areas. Could you comment on possible sprouting problems.

Petersen

We have had some sprouting problems in the Pacific north-west with soft white wheats. We have serious problems about 2 years out of 10. Normally our summers are very hot and dry, only occasionally we run into problems due to high rainfall in August. About 80% of our production is in soft white winter wheat, about 10% in soft spring wheat, and about 10% in hard red winter wheat.

Griffin

Are the entries in the nurseries of the same proportions?

Peterson

No, this nursery is all soft wheats. There is a hard red regional performance nursery but it was not included in this study.

Dr A.J. Rathjen, University of Adelaide, South Australia

There has been an increase in irrigation. Has that had any effect on your programme?

Peterson

Irrigation has increased — there is about half a million acres under irrigation at the present time. It has affected our programme slightly. In the last 5 or 6 years we have begun testing under irrigation. So far we have found that the varieties that have done well under conventional tillage and regular rainfall have also done well under irrigation, especially the variety Stevens developed by Dr Kronstad.

Professor R.H.M. Langer, Lincoln College

I find your statement that management had nothing to do with yield increase very surprising. Does it mean that management was so perfect it could not be improved upon or did it not respond to the potential that the new variety presented?

Peterson

The first varieties that we looked at had already reached their potential at the time that we started taking the data in 1956. I was surprised that we could not pick it up when we started using Gaines and Nugaines, but when they were released we were already using high amounts of fertiliser. The extension service was recommending an increased use of fertiliser of about 25%. I cannot really explain why we are not picking it up in this data, but certainly it is not there.

Langer

Is there anything like sowing time or sowing date which might have been taken advantage of?

Peterson

Two changes in management took place about the time that Gaines and Nugaines came out. We changed the way we sow our semi-dwarves, especially in low production areas — a drill is used which makes a furrow and places the seed at the bottom of the furrow so it does not have to emerge very far in order to come up. The other change in management has been an increase in leaving the straw on the surface in order to control erosion on our steep hillsides. I really cannot explain why there is no apparent yield increase due to management.

Rathjen

I think we have much more abrasive herbicides in the last few years. Could this be a factor that is involved as well?

Peterson

The use of herbicide could certainly be a factor on the farmers' fields. However, on the plots where this data was taken from, we were using good weed control measures; most of it was hand-hoed, so the data here may not relate exactly to what has happened to the farmer.