The Benefits of Public Investments in Northwest

Potato Breeding Research

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A. A. Araji and S. L. Love

Introduction

Agricultural research in the United States has evolved into a decentralized federal/state system. The state agricultural experimental stations have responded with considerable flexibility to changing circumstances and have developed local, appropriate technologies. The contribution of research to productivity growth in agriculture is well documented. The economic benefits of investment in agricultural research have been evaluated for all major agricultural commodities in the United States (Araji 1980, 1989, 1990, 1998). The spillover effect and return to investment in potato research was analyzed for six potato-producing sub-regions in the United States (Araji et al. 1995). However, the benefits of specific research programs—breeding, for example—have not been evaluated. This study evaluates the benefits of potato breeding research to potato producers and processors in Idaho, Oregon, and Washington.

Potatoes are an important U.S. agricultural commodity with an annual farm value of more than $2.62 billion and a processed value of about $3.4 billion. The Pacific Northwest states of Idaho, Oregon, and Washington are the largest sub-region in the United States in the production and processing of potatoes. In 1998, the Pacific Northwest produced 60 percent of the fall potatoes in the United States and accounted for 54.4 percent of all potato production. Idaho accounted for 32.4 percent of the fall potato production and 29.4 percent of all potato production in the United States for a total farm value of $636,521,000. Oregon potato production accounted for 6.5 percent of the fall potato production and 5.9 percent of total potato production in the United States for a total farm value of $142,595,250. Washington potato production represented 21.1 percent of the fall potato production and 19.1 percent of total U.S. potato production for a total farm value of $427,091,000. The Pacific Northwest total potato farm value is $1.206 billion or 46 percent of the total U.S. potato farm value (National Potato Council 2000).

In 1998, an estimated 271,348,080 hundredweight (cwt) of potatoes were processed in the United States, representing 59 percent of the total production at an estimated processed potato value of $3.4 billion. The Pacific Northwest sub-region processed an estimated 186,435,410 cwt of potatoes, 68.7 percent of the total U.S. processed potatoes at an estimated value of $2.33 billion. Idaho processed 58.7 percent of its potato production for a total of 79,497,410 cwt. This represented 29.2 percent of the U.S. processed potatoes at a market value of $994 million. Idaho processed an estimated 13 million cwt of potatoes produced in other neighboring states. Total potatoes processed in Idaho is estimated at 92,497,410 cwt, accounting for 34 percent of the total U.S. processed potatoes at a market value of $1.156 billion (National Potato Council 2000).

An estimated 80 percent of potato production in Oregon is produced for processing. The total amount of potatoes produced for processing is estimated at about 21,728,000 cwt. This represents 8 percent of the total U.S. processed potatoes at an estimated market value of $271.6 million. An estimated 82 percent of Washington potatoes are produced for processing. Total annual potatoes processed in Washington state is estimated at 72,209,200 cwt at an estimated processed value of $902.6 million. This represents 26.7 percent of the total potatoes processed annually in the United States (National Potato Council 2000).

In 1998, the United States produced an estimated 128,775,360 cwt of potatoes for the fresh market. The Pacific Northwest sub-region accounted for 44.2 percent of the fresh potato market. Idaho potato production for the fresh market represented 31.6 percent of the total U.S. production of potatoes for the fresh market. Oregon and Washington accounted for 3.1 percent and 9.5 percent, respectively (National Potato Council 2000).

In 1998, the United States produced an estimated 59,788,560 cwt of seed potatoes. This represented 13 percent of the total U.S. potato production. The Pacific Northwest subregion accounted for 36.1 percent of the total U.S. seed potato production. Idaho produced 29.5 percent of the total U.S. seed potato production. Oregon and Washington accounted for 2.2 percent and 4.4 percent, respectively. Less than 1 percent of the potato acreage in this subregion is in chip potatoes (National Potato Council 2000).

In general, the Pacific Northwest sub-region is the most important area in the United States for the production of potatoes for processing, the fresh market, and seed potatoes. This sub-region also processes the major segment of potatoes and accounts for

about 69 percent of all processed potatoes in the nation. The future competitive position of this area in the domestic and international markets for fresh, processed, and seed potatoes will depend significantly upon new technologies to enhance the productivity and the quality of potatoes.

Major potato varieties planted in the Pacific Northwest

The major potato varieties planted in Idaho, Oregon, and Washington during the 1985-98 period is summarized in this section.

In Idaho, Russet Burbank is the major variety produced for the fresh market and for processing (Table 1). During the 1985-91 period, this variety accounted for more than 90 percent of the Idaho potato acreage. It gradually declined to 77.9 percent of the acreage in 1998. Shepody, a Canadian variety, was introduced in 1985 and reached a maximum of 10 percent of the Idaho acreage in 1995. Shepody represented 5.6 percent of the Idaho potato acreage in 1998. Russet Burbank and Shepody were the two dominant potato varieties in Idaho, representing about 83.5 percent of the potato acreage in 1998. Russet Norkotah, a fresh market variety, accounted for 4.8 percent of 1998 potato acreage. Ranger Russet, a variety developed by the Northwest Potato Breeding Program and released in 1991, represented 6.6 percent of 1998 acreage.

Russet Burbank was the dominant potato variety in Oregon through the mid-1980s. It accounted for about 75 percent of the potato acreage through 1990. With the introduction of Shepody and Russet Norkotah in the late 1980s, the percentage of potato acreage planted to Russet Burbank declined significantly. For example, in 1998, only 39.5 percent of Oregon potato acreage was Russet Burbank, 24.8 percent was Russet Norkotah, 17.2 percent was Shepody, and 10.3 percent was Ranger Russet.

Russet Burbank also dominated Washington potato acreage. In 1987, about 87 percent of the potato acreage was planted with Russet Burbank. The percentage of potato acreage planted with Russet Burbank is rapidly declining. In 1998, about 58.1 percent of the acreage was planted with Russet Burbank, 8.9 percent with Shepody, 13.2 percent with Russet Norkotah, and 11.4 percent with Ranger Russet. The rapid adoption of Ranger Russet has been at the expense of declining Russet Burbank acreage (Table 1).

Russet Burbank is still the dominant potato variety in the Pacific Northwest for both processing and the fresh market. This variety is susceptible to diseases, has a relatively low percentage of U.S. No. 1 tubers, has a short shelf life, lacks the smooth appearance desired by consumers, and has low processing yield.

Shepody, a variety used primarily for processing, is inferior to Russet Burbank in both yield and quality. To maintain and/or improve this subregion's competitive position in the production and processing of potatoes, new varieties that are higher yielding, better quality, and a higher processing yield need to be developed.

Potato breeding research program for the Pacific Northwest

Because of the national importance of the Pacific Northwest in the production and processing of potatoes, the U.S. Department of Agriculture (USDA) supported the establishment of a potato breeding research program in 1984 located in Idaho to serve the potato industry in the three Pacific Northwest states of Idaho, Oregon, and Washington. The objective of the program is to develop new potato varieties to replace or upgrade the present two dominant processing varieties, Russet Burbank and Shepody; the two dominant fresh market varieties, Russet Burbank and Russet Norkotah; and the two major chip varieties, Gemchip and Norchip.

Table 2 shows the distribution of potato acreage by market channel for

Table 1. Percent of major potato varieties planted in the Pacific Northwest, 1998.

State	Acres planted	Percent of major varieties: Russet Burbank	Shepody	Russet Norkotah	Ranger Russet	Other
Idaho	402,000	77.9	5.6	4.8	6.6	5.1
Oregon	57,000	39.5	17.2	24.8	10.3	9.2
Washington	153,000	58.1	8.9	13.2	11.4	8.4
Pacific Northwest	612,000					

Source: National Potato Council, Potato Statistical Yearbook, Englewood, CO., 2000.

Table 2. Potato acreage, production, prices, and planting by market channel for Idaho, Oregon, and Washington, average, 1995-98.

State	Acres harvested	Production	Price	Percent processed	Percent fresh	Percent seed	Percent chip
	(1,000)	(1,000 cwt)	($/cwt)				
Idaho	402	136,963	5.03	58	30	12.2	0.8
Oregon	57	27,355	5.38	80	15	4.2	0.8
Washington	153	87,967	5.46	82	14	2.2	0.8
Pacific Northwest	612	251,285					

Source: National Potato Council, Potato Statistical Yearbook, Englewood, CO., 2000.

Idaho, Oregon, and Washington. About 12.2 percent of the potato acreage in Idaho is in seed potato production; 30 percent is in fresh potato market production; 57 percent is processing potato production; and 0.8 percent is in chip potato production. About 2.2 percent of the potato acreage in Washington is in seed potato production; 14 percent is in fresh potato market production; 82 percent is in processing potato production; and 0.8 percent is in chip potato production. About 4 percent of the acreage in Oregon is in seed potato production, 15 percent is in fresh potato market production, 80 percent is processing potato production, and 0.8 percent is in chip potato production.

Since its establishment, the potato breeding research for the Northwest released the following potato varieties:

Gemchip

Released by the Tri-State Potato Breeding Program in 1989, Gemchip quickly became the dominant chip variety in Idaho and the Northwest (Fig. 1). Gemchip combines high yield with good chip quality and long-term storability. It is a round, white potato with thin skin. In comparison with Norchip, the variety it replaced in the Northwest, Gemchip produces 16 percent higher total yield and 31 percent higher U.S. No. 1 yield. On average the tubers have 0.6 percent higher solids than Norchip and return a higher chip yield. Gemchip tubers maintain physical integrity and chip color for a longer period of storage than do Norchip tubers, allowing growers to market for one to two additional months into the spring. Gemchip is resistant to early die, does not require soil fumigation to control this problem, and requires about 20 percent less nitrogen than Norchip.

Frontier Russet

Released by the Tri-State Potato Breeding Program in 1990, Frontier Russet (Fig. 1) was never widely adopted but has been grown on small acreage in both the Northwest and Northeast. It produces tubers that have excellent appearance and are generally free from both external and internal defects. Frontier Russet typically produces a total yield that is about 10 percent less than that of Russet Burbank, but has the advantage of producing U.S. No. 1 yields that are 20 percent higher. It has similar storage and processing characteristics to Russet Burbank. Frontier Russet has established itself in a niche market for the production of skin-on fried products.

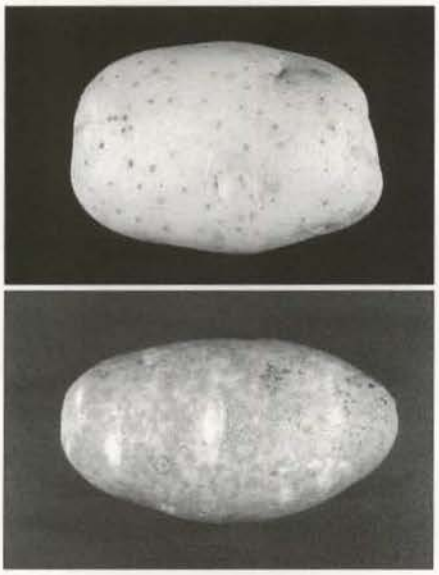

Fig. 1. Gemchip and Frontier Russet

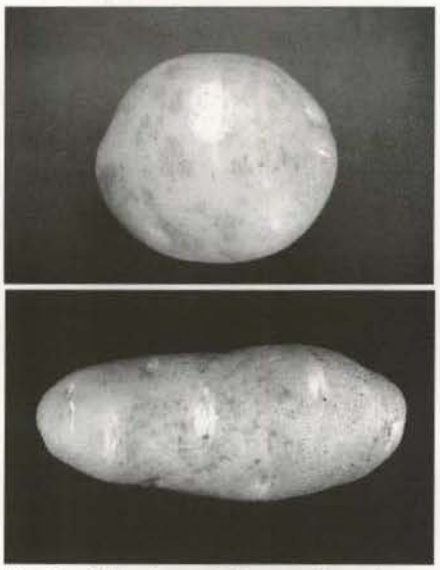

Fig. 2. Chipeta and Ranger Russet

Chipeta

Chipeta is a 1993 Colorado release of a selection that originated with the UI's Aberdeen breeding program (Fig. 2). Chipeta is currently the most widely grown chipping variety in the Northwest. Compared with Norchip, it produces 18 percent higher total yield and 32 percent higher U.S. No. 1 yield. Like Gemchip, Chipeta has excellent storage characteristics and has the ability to extend the marketing of potatoes for an additional one to two months. Chipeta has tuber solids that are 3 percent higher than those of Norchip and, consequently, can produce a greater yield of higher quality chips. Chipeta is resistant to most field diseases, does not require soil fumigation (except for control of nematodes), nor treatment for early blight, and uses about 20 percent less nitrogen than Norchip.

Ranger Russet

Released in 1991 by the Tri-State Potato Breeding Program, Ranger Russet has been widely adopted as a processing variety, both from field delivery and storage situations (Fig. 2). Ranger Russet produces 5 percent higher total yield and 29 percent higher U.S. No. 1 yield than does Russet Burbank. It has about a 10 percent advantage in total and U.S. No. 1 yield over Shepody. Ranger Russet does not store well for more than six months and has a fairly serious problem with susceptibility to blackspot bruise, but is almost completely free of other external and internal defects. A combination of suitable tuber shape, freedom from de-

fects, and high solids gives Ranger Russet a high level of processing efficiency, with about 70 percent finished product derived from raw tubers. Russet Burbank typically returns around 45 percent. Ranger Russet also gives better processing efficiency than Shepody due to its 3 percent higher solids content. Ranger Russet is resistant to early blight, net necrosis caused by leafroll virus, (PVY), and early die. It does not require soil fumigation (except to control nematodes) nor control measures for any of these diseases. It is estimated that replacing Russet Burbank and Shepody with Ranger Russet will eliminate up to two chemical applications at $15-$20 each to control green peach aphid and two chemical applications at $20 each to control early blight.

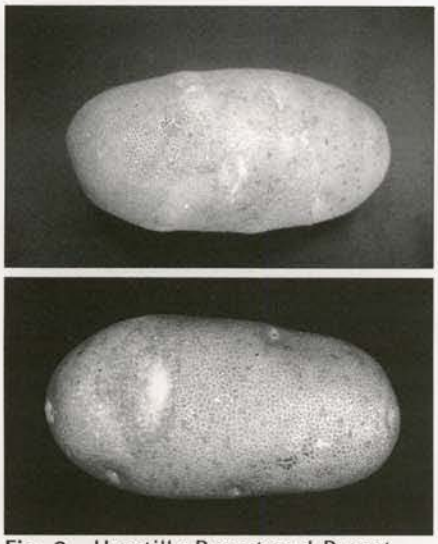

Fig. 3. Umatilla Russet and Russet Legend

Umatilla Russet

Released in 1998 by the Tri-State Potato Breeding Program, Umatilla Russet is similar in many respects to Ranger Russet including appearance and resistance to internal defects (Fig. 3). It is almost identical in yield potential and processing quantity. It does not have the severe blackspot bruise problem expressed by Ranger Russet. Umatilla Russet is expected to have the same yield and processing advantages over Russet Burbank as does Ranger Russet, with the added advantage that it will store for a longer period of time—up to eight months. Ranger Russet and Umatilla Russet are expected to replace Russet Burbank and Shepody as processed potatoes.

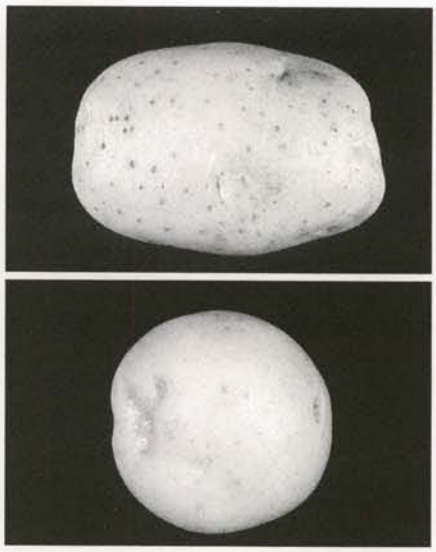

Fig. 4. Gem Russet and NDO1496-1

Russet Legend

Released in 1998 by the Tri-State Potato Breeding Program, Russet Legend is only moderate in yield potential but has an extremely high percentage of U.S. No. 1's (Fig. 3). It produces oblong shaped tubers with heavy russet skin and is superior to Russet Burbank in its appearance and grade. Russet Legend produces about 7 percent lower total yields, but 23 percent higher U.S. No. 1 yields in comparison with Russet Burbank. It is estimated that each 1 percent increase in U.S. No. 1 yield above 60 percent will increase price to growers by 1¢ per cwt. Russet Legend has one flaw that will limit its utility: the development of stem-end discoloration after two to three months of storage. However, Russet Legend will likely replace some of the Russet Burbanks in the fresh market during the first two months of the storage season. It is resistant to early die, will not require soil fumigation for this problem, and will use 10 to 20 percent less nitrogen than Russet Burbank.

In addition to the six varieties that were released, the Northwest potato breeding program recently released these varieties:

Gem Russet

This new variety was released in 1999. It has Russet Norkotah's appearance and superior processing quality to Russet Burbank (Fig. 4). Gem Russet's total yield potential is similar to that of Russet Burbank, but it produces about 21 percent higher yield of U.S. No. 1's. Gem Russet has about 3 percent higher solids and a larger tuber size, which should give it better processing efficiency (almost as good as Ranger Russet). Gem Russet has excellent storage characteristics and should be marketable for 10-12 months of the year. It is resistant to net necrosis caused by leafroll virus and will usually not require treatment for green peach aphid. It is estimated that at least two chemical applications at $15-$20 will be eliminated to control green peach aphid with the adoption of Gem Russet. Russet Legend and Gem Russet are expected to replace Russet Norkotah and Russet Burbank as fresh market potatoes (Fig. 4).

NDO1496-1 (unnamed)

This unnamed selection is a round, white chipper (Fig. 4). It produces good yield, but its appeal comes from its outstanding chip quality after storage at colder-than-normal temperatures. It produces 9 percent higher yields than Norchip and about 9 percent less than Chipeta. Its U.S. No. 1 yield is higher than Norchip by 18 percent. Because NDO1496-1 is a cold chipper, it can be stored at cooler

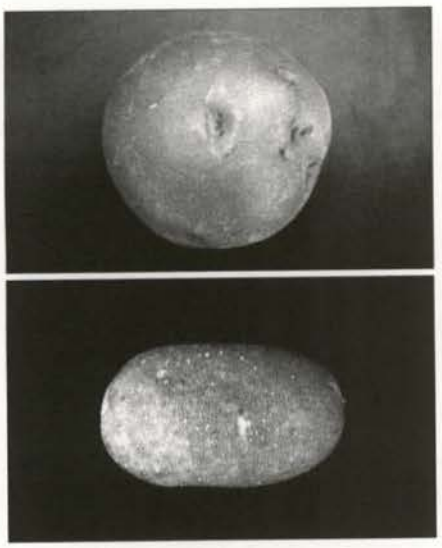

Fig. 5. IdaRose and Bannock Russet

temperatures and still maintain quality. This should reduce the amount of shrinkage in storage by as much as half, and extend the market season by one to four months.

IdaRose

This selection was released in 1999. IdaRose has round tubers with bright red skin (Fig. 5) and combines high yields with an excellent appearance and an outstanding eating quality. It exceeds the yield of Dark Red Norland by as much as 20 percent. IdaRose has long storage potential, which is an unusual trait for a red-skinned variety. This should allow it to be used in the rapidly expanding red storage market. This is a market into which the Northwest has not yet capitalized.

Bannock Russet

This selection was released in 1999. Bannock Russet has oblong tubers with heavy, dark russet skin and combines excellent disease resistance with high yield and good appearance (Fig. 5). It has shown the ability to produce 2 percent higher total yield and 29 percent higher U.S. No. 1 yield than does Russet Burbank. It produces very few undersized potatoes, combined with 1 percent more solids, which should give it processing efficiency approaching that of Ranger Russet. Bannock Russet has good storage characteristics and will be capable of supplying high quality potatoes for 10-12 months of the year. Additionally, Bannock Russet is resistant to all diseases associated with early die and will not require soil fumigation. It is also immune to PVY and resistant to net necrosis caused by leafroll virus. Bannock Russet also uses about 40 percent less nitrogen than Russet Burbank. It is expected that this variety will replace Russet Burbank, Shepody, and Russet Norkotah.

The benefits of public investment in potato breeding research

This study, using an *ex-ante* approach, will analyze the benefit of the Northwest Potato Breeding Program to potato producers and processors in Idaho, Oregon, and Washington (Araji et al. 1978).

The model

The flow of benefits from each variety developed by the breeding program is estimated by the following equation:

$$\beta_{jt}=A_{jt}\{(\Delta P_{jt}V_t-V_o)-C_{jt}\} \quad (1)$$

Where:

β_{jt} = the benefits accruing to the j^{th} variety in year t

A_{jt} = the expected total production or acreage affected by the j^{th} variety in year t

ΔP_{jt} = the expected change in net productivity and/or quality of potato due to the j^{th} variety in year t

V_t = the expected price received per cwt of raw potato or pound of processed potatoes in year t

$$V_t=\{V_o+V_o(f\Delta P_t)\}$$

where f is flexibility ration and V_o is the price per unit in the base year

C_{jt} = is the cost associated with the development, technology transfer, implementation, and maintenance of the j^{th} variety in year t.

β_{jt} is the benefit that accrues to potato producers and processors as a result of adopting and implementing the new variety. The outcome β_{jt} is probabilistic because it depends on the probability of successful development of the j^{th} variety (P(S)), and the probability of adopting j^{th} variety (P(A)). The expected value of β_{jt} is defined as:

$$E(\beta_j)=\sum_{t=1}^{N}\beta_{jt}\{P(A)\cap P(S)\} \quad (2)$$

The present value of the expected flow of benefits from variety j^{th} is calculated by "discounting" the right-hand side of equation (2) as shown in equation (3) below.

$$E(\beta_{jt})=\frac{\sum_{t=1}^{N}\beta_{jt}\{P(A)\cap(S)\}}{(1+r)^t} \quad (3)$$

Where:

r = the social discount rate (6 percent)

N = number of years for which the j^{th} variety affects productivity, quality, and/or cost (20 years)

The 6 percent social discount rate is the risk free rate on government bonds used by federal agencies.

The present value of the flow benefit was calculated over 20 years from the first year of adoption. Maximum adoption was projected not to exceed 70 percent and will effect 50 percent of the potato acreage.

The present value of costs is expressed as:

$$C_{jt}=\sum_{t=1}^{N}\{(R_{jt}+T_{jt}+I_{jt}+M_{jt})\}/\{(1+r)^t\} \quad (4)$$

Where:

C_{jt} = the present value of total costs associated with the development of the j^{th} variety

R_{jt} = research investment in the development of the j^{th} variety

T_{jt} = technology transfer cost of the j^{th} variety

I_{jt} = implementation cost to adopt the j^{th} variety

M_{jt} = the cost of maintenance research required to sustain the productivity of the j^{th} variety at its potential level

Expenditures in the development, transfer, implementation, and maintenance of the j^{th} variety before 1998 were compounded at 6 percent to bring it to the 1998 level. The flow of expenditure after 1998 was discounted by 6 percent to bring it to the 1998 level. The 1995-98 average acreage, production, and prices shown in Table 2 were used to calculate the expected value of the flow of benefit.

Results

The flow of benefits, costs, and returns associated with the development, transfer, and implementation of the new potato varieties developed by the Northwest Potato Breeding Program are analyzed in this section.

Benefits

Five major areas of expected benefits from the development of new potato varieties are analyzed. These areas are: (1) development of high yielding potato varieties for processing, (2) development of high quality potato varieties for the fresh market, (3) development of disease resistant potato varieties for all market channels, (4) development of new potato varieties with a high percentage of processing yields, and (5) development of high quality and high yielding varieties of chip potatoes. The benefit from each area is analyzed in the following sections.

1. Development of high yielding processed potato varieties

The estimated benefit of improved yield of Ranger Russet and Umatilla to growers producing potatoes for processing is shown in Table 3. Idaho growers of processed potatoes will benefit by an estimated $63.4 million over a 20-year period at the 1998 purchasing power of the dollar by adopting Ranger Russet and Umatilla to replace Russet Burbank and Shepody. The annual benefit to Idaho growers of processed potatoes will exceed $3 million. Oregon growers stand to gain an estimated $9.1 million over a 20-year period at an annual benefit of $457,108 at the 1998 purchasing power of the dollar. Washington growers will benefit a total of $35.9 million over a 20-year period at the 1998 purchasing power of the dollar. The annual benefit to Washington growers producing potatoes for processing will exceed about $1.8 million.

In general, the adoption of the higher yielding Ranger Russet and Umatilla as the two processing varieties will benefit the Pacific Northwest by an estimated $108.5 million over 20 years at the 1998 purchasing value of the dollar. The annual present value of the flow of benefit exceeds $5.4 million. The flow of benefit was calculated based on projected probability of adoption of 3 percent in 1997, 5 percent in 1998, 10 percent in 1999, 15 percent in 2000, and 10 percent increments in subsequent years. In 1998, Idaho had 6.6 percent of its potato acreage in Ranger Russet, Washington had 11.4 percent of its potato acreage in Ranger Russet, and Oregon had 10.3 percent of its acreage in Ranger Russet.

2. Development of high quality potato varieties for the fresh market

The two fresh market varieties developed by the Northwest Potato Breeding Program are Russet Legend and Gem Russet. Russet Legend was released in 1998 and Gem Russet was released in 2000.

The projected probability of adoption of these two fresh market varieties is 10 percent of the acreage the first year, 10 percent the second year, and 10 percent increments in each subsequent year not to exceed 70 percent. The estimated benefits to growers producing potatoes for the fresh market due to the improved quality of these two varieties of table potatoes are shown in Table 4.

Table 3. Benefit to potato producers growing potatoes for processing.

State	Gross annual benefit	Present value	Annual present value
Idaho	$10,511,255	$ 63,397,969	$3,169,898
Oregon	1,515,753	9,142,168	457,108
Washington	5,959,461	35,944,117	1,797,208
Pacific Northwest	$17,986,469	$108,484,254	$5,424,214

Table 4. Benefit to potato producers growing potatoes for the fresh market.

State	Gross annual benefit	Present value	Annual present value
Idaho	$4,503,342	$20,710,460	$1,035,523
Oregon	316,606	1,456,043	72,802
Washington	1,052,703	4,841,287	242,064
Pacific Northwest	$5,872,651	$27,007,790	$1,350,389

Growers in the Pacific Northwest producing table potatoes will benefit by over $27.6 million over a 20-year period at an annual rate of more than $1.4 million per year at the 1998 purchasing value of the dollar. Growers in Idaho producing table potatoes will gain the most as Idaho has a larger proportion of its potato acreage planted in table potatoes than do Oregon and Washington. It is estimated that Idaho growers of table potatoes will benefit by about $20.7 million over a 20-year period at an annual rate of over $1 million at the 1998 purchasing power of the dollar. Oregon growers will benefit by about $1.5 million over a 20-year period at an annual rate of $72,802. Washington growers will benefit by more than $4.8 million over a 20-year period at an annual rate of $242,064.

3. Development of disease resistant potato varieties

Russet Burbank, Shepody, and Russet Norkotah are highly susceptible to net necrosis, early blight, and late blight. Ranger Russet, Umatilla, Legend, and Gem Russet are more resistant to PLRV and early blight. The results of this study indicate that the adoption of the new varieties will eliminate one to two spray applications per year to control green peach aphid at $15-$20 per application and will eliminate two applications to control early blight at $20 per application.

Idaho has 402,000 acres planted with potatoes annually. Before the introduction of Ranger Russet, about 83 percent of Idaho potato acreage was planted with Russet Burbank, 7.1 percent with Shepody, and 5 percent with Russet Norkotah. An estimated 95.1 percent of Idaho potato acreage was planted with these three varieties that are highly susceptible to disease. Before the introduction of Ranger Russet an estimated 65.7 percent of Washington potatoes was with Russet Burbank, 7.6 percent was in Shepody, and 17.5 percent was in Russet Norkotah. An estimated 90.8 percent of Washington potato acreage was planted with these three varieties. An estimated 30.9 percent of Oregon potato acreage was planted with Russet Burbank, 18.2 percent with Shepody, and 38.8 percent with Russet Norkotah for a total of 87.9 percent in these three varieties.

The benefits from reduced pesticide cost of adopting Ranger Russet, Umatilla, Russet Legend, and Gem Russet are shown in Table 5. The present value of the future flow of benefits to potato growers in the Pacific Northwest is estimated at $77.1 million. The adoption of the new varieties will significantly reduce active toxic materials with beneficial environmental impacts.

Idaho potato growers will gain an estimated $48.4 million at the 1998 purchasing power of the dollar by adopting the new disease resistant varieties. Annual benefit at the 1998 purchasing power of the dollar is estimated at $2.4 million for a 20-year period. Washington potato growers expected benefit is $21.1 million over 20 years, or over $1 million per year. Oregon potato growers are expected to gain $7.6 million over a 20-year period, or $380,803 per year. In addition to the economic benefits of the development and adoption of disease resistant potato varieties, a minimum of 1,224 pesticide applications will be eliminated from the environment on 612,000 acres of potatoes annually. In Idaho an estimated 804 chemical applications will be eliminated. In Oregon an estimated 114 applications will be eliminated, and in Washington an estimated 306 applications will be eliminated.

Table 5. Benefit to potato growers by adopting new disease resistant varieties.

State	Acres harvested[1]	Percent affected[1]	Annual gross benefit	Present value	Annual present value
	(1,000)				
Idaho	402	95.1	11,469,060	48,400,035	2,420,001
Oregon	57	87.9	1,503,090	7,616,067	380,803
Washington	153	90.8	4,167,720	21,117,590	1,055,879
Pacific Northwest	612		17,139,870	77,133,692	3,856,683

[1]Source: National Potato Council, Potato Statistical Yearbook, Englewood, CO., 2000.

4. Development of new potato varieties with high processing yields

The Pacific Northwest states of Idaho, Oregon, and Washington produce about 69 percent of the processed potatoes in the United States. Idaho potato processing plants account for 34 percent, Oregon accounts for 8 percent, and Washington accounts for 26.7 percent. Russet Burbank and Shepody are the two main varieties produced for processed potatoes. Before the release of Ranger Russet, an estimated 83 percent of Idaho potato acreage was planted with Russet Burbank and 7.1 percent was with Shepody for a total of 90.1 percent. Washington had 65.7 percent of potato acreage planted with Russet Burbank and 7.6 percent with Shepody, for a total of 73.3 percent. Oregon had 30.9 percent of its potato acreage planted with Russet Burbank and 18.2 percent with Shepody, for a total of 49.1 percent.

Russet Burbank has a low finished processed product from raw potatoes: about 45 percent. Shepody may have higher processing yields than Russet Burbank. The competitive position of the potato processing industry in Idaho and the Pacific Northwest in the domestic and international market will be significantly enhanced by the development and adoption of potato varieties with high processing yields. Ranger Russet and

Table 6. Benefit to the potato processing industry in the Pacific Northwest from the development and adoption of varieties with high processing yields.

State	Total production[1]	Percent processed[1]	Annual gross value	Present value	Annual present value	Percent in Russet Burbank and Shepody
	(1,000 cwt)					
Idaho	136,963	58	$ 83,972,015	$517,621,267	$25,881,063	90.1
Oregon	27,355	80	15,017,895	92,573,482	4,628,674	49.1
Washington	87,967	82	59,482,625	366,663,685	18,333,184	73.3
Pacific Northwest	252,285		$158,472,535	$976,858,434	$48,842,921	

[1]Source: National Potato Council, Potato Statistical Yearbook, Englewood, CO., 2000.

Table 7. Benefit to Pacific Northwest growers of chip potatoes from the development and adoption of Chipeta.

State	Total production[1]	Percent in chip[1]	Annual gross benefit	Present value	Annual present value
	(1,000 cwt)				
Idaho	136,963	0.8	$1,102,272	$ 8,103,217	$405,160
Oregon	27,355	0.8	220,153	1,416,018	70,800
Washington	87,967	0.8	707,955	4,553,547	227,677
Pacific Northwest	252,285		$2,030,380	$14,072,782	$703,637

[1]Source: National Potato Council, Potato Statistical Yearbook, Englewood, CO., 2000.

Umatilla Russet produce 70 percent finished processed potatoes from raw potatoes. This is 25 percent more finished processed potatoes than that produced from Russet Burbank and Shepody. Average price for finished processed potatoes is 25¢ per pound.

The benefits to the potato processing industry from the development and adoption of the new varieties are shown in Table 6. Results show that the development and adoption of Ranger Russet and Umatilla for processed potatoes will benefit the Pacific Northwest potato processing industry a total of $976.9 million at an annual rate of $48.8 million. Idaho potato processors will capture about 53 percent of this benefit at an annual benefit of more than $25.9 million. Washington and Oregon potato processors will capture 38 and 9 percent of this benefit, respectively.

5. Development of high quality and high yielding chip potato varieties

The two main varieties of chip potatoes planted in the sub-region are Norchip and Gemchip. These varieties, however, are low yielding. A new variety, Chipeta, developed by the Northwest Potato Breeding Program, is 20 percent higher yielding than Norchip and Gemchip. The Chipeta variety is projected to replace Norchip and Gemchip.

The benefits to Pacific Northwest growers of chip potatoes from the development and adoption of Chipeta is shown in Table 7. The present value of the flow of benefit to growers in the Pacific Northwest producing chip potatoes exceed $14 million over a 20-year period at an annual value of $703,637. Idaho growers will capture more than 57 percent of this benefit at an annual value of about $405,160.

Total benefits

Total benefits to potato producers and processors from the development, transfer, and implementation of the varieties developed by the Northwest Potato Breeding Program is summarized in Table 8 for Idaho, Oregon, and Washington. The results show that the potato industry will benefit by about $1.2 billion over 20 years at an annual benefit of $60.2 million at the 1998 purchasing power of the dollar. The present value of benefits to Idaho potato growers and processors is about $658.2 million at an annual benefit of about $32.9 million at the 1998 purchasing value of the dollar. The Idaho potato industry will benefit the most from adopting the new varieties of potatoes compared to Oregon and Washington. The Idaho potato industry captures about 55 percent of the expected flow of benefit from the development, transfer, and adoption of the new potato varieties.

The present value of benefits to the potato industry in Washington is estimated at $433.1 million at an annual benefit of $21.7 million at the 1998 purchasing power of the dollar. The present value of benefits to Oregon potato growers and processors are estimated at $112.2 million at an annual benefit of $5.6 million at the 1998 purchasing power of the dollar.

Table 8. Total benefit to the Pacific Northwest potato producers and processors from the development, transfer, and adoption of the new potato varieties.

State	Gross annual benefit	Present value	Annual present value
Idaho	$111,557,944	$ 658,232,948	$32,911,647
Oregon	19,061,299	112,203,778	5,610,188
Washington	70,882,662	433,120,226	21,656,011
Pacific Northwest	$201,501,905	$1,203,556,952	$60,177,846

Table 9. Total funding for Northwest potato breeding research, 1984-98.

State	Source of funds			
	Federal[1]	State[1]	Private	Total
Idaho	$ 4,721,696	$ 867,977	$ 306,280	$ 5,895,953
Oregon	4,721,696	2,227,500	707,000	7,656,196
Washington	4,721,696	1,559,282	1,189,000	7,469,978
Pacific Northwest	$14,165,088	$4,654,759	$2,202,280	$21,022,127

[1]Direct research expenditures including 10 percent overhead costs.

Costs

The Northwest Potato Breeding Program is supported with funding from three different sources. Since its inception in 1984, the breeding program received funding from the federal government, the state government, and the potato industry. The USDA has been the primary source of funding, followed by state funding and funding from the potato industry (Table 9).

The USDA contributes to the Northwest Potato Breeding Program in two ways. First, the USDA/ARS Potato Breeding Program, located at Aberdeen, Idaho, plays an integral role in Northwest potato variety development. This federally funded project supplies all germplasm to the university program in the Northwest. This program also assists with early generation selection and supplies materials for initial seed increases for new varieties. The state projects are dependent on the federal breeder for their success. Direct research budget in this portion of the federal contribution ranged from $188,816 in 1984 to $401,805 in 1998. The total direct investment during the 1984-98 period totaled $4,856,229. Direct research budget for the 1999 fiscal year was increased to $493,953.

Second, the USDA contribution to the Northwest Potato Breeding Program through cooperative agreements with the three land-grant universities in the Pacific Northwest (PNW) ranged from $192,300 in 1984 to $633,600 in 1998. Total USDA contribution to cooperative agreements was $8,021,125 during the 1984-98 period. In general, total annual USDA funding for the Northwest Potato Breeding Program ranged from $381,116 in 1984 to $1,035,405 in 1998. The USDA total funding during the 1984-98 period was $14,165,088.

The three land-grant universities in the PNW directly contributed a total of $4,654,759 in state funds to the Northwest Potato Breeding Program during the 1984-98 period.

Oregon State University's contribution is estimated at $2,227,500. Washington State University contributed $1,559,282, and the University of Idaho contribution during this period is estimated at $867,977. The potato industry in the PNW contributed a total of $2,202,280 to the Northwest Potato Breeding Program during the 1984-98 period. The potato industry in Washington accounted for 54 percent of this total. The Oregon potato industry accounted for 32 percent, and the Idaho potato industry accounted for 14 percent.

In general, a total of $21 million was invested in potato breeding research for the Northwest during the 1984-98 period. About 67 percent of this investment was from federal sources, 22 percent from the states, and only 11 percent from the private sector. Research expenditures in 1999 until the expected release of the last varieties in 2005 are projected at the 1998 level of $1,642,483 per year. Research expenditures for the 1999-2005 period are projected to be $9,854,898. Total research investments from 1984 until the release of the final varieties under development will be $30,877,025.

Return to investment

Total gross annual benefit, using the probability of research success and the probability of adoption, is estimated to be $201.5 million. The gross annual benefit discounted by 6 percent annually over 20 years will yield present value of $1.2 billion. Direct research expenditure plus overhead since the inception of the program in 1984 to 2005 will total $30,877,025. The benefit-cost ratio is 38.97. The benefit-cost ratio indicates that for every dollar of investment in the Northwest Potato Breeding Program, the potato industry in Idaho, Oregon, and Washington will benefit by $38.97. This is a healthy return to investment in addition to the program environmental benefit and long-run contribution to enhancing the economic viability and the industry competitive advantage both nationally and in the international market.

Summary

■ Potatoes have a U.S. annual farm value of over $2.6 billion and a processed value of about $3.4 billion.

■ The Pacific Northwest (PNW) produces about 60 percent of the fall potatoes in the United States and accounts for 54.4 percent of all U.S. potato production.

■ The PNW total potato farm value is $1.2 billion or 46 percent of total U.S. potato farm value.

■ Idaho grows 32.4 percent of the fall potatoes and accounts for 29.4 percent of all U.S. potato production.

■ Washington potato production is 21.1 percent of the fall potato production and 19.1 percent of the total U.S. potato production.

■ Oregon potato production accounts for 6.5 percent of the fall potato production and 5.9 percent of the total U.S. potato production.

■ An estimated 271,348,080 cwt of potatoes are processed in the United States annually, which is 59 percent of the total production at an estimated value of $3.4 billion.

■ The PNW sub-region processed an estimated 186,435,410 cwt of potatoes, which is 68.7 percent of the total U.S. processed potatoes at an estimated value of $2.3 billion.

■ Idaho processed an estimated 92,497,410 cwt, which is 34 percent of the total U.S. processed potatoes at a market value of $1.2 billion.

■ Washington's total annual potatoes processed are estimated at 72,209,200 cwt, which is an estimated processed value of $902.6 million and 26.7 percent of the U.S. total.

■ Oregon's amount of potatoes produced for processing is estimated at about 21,728,000 cwt, which is 8 percent of the total U.S. production and an estimated value of $271.6 million.

■ The U.S. produces an estimated 128,775,360 cwt of potatoes for the fresh market.

■ The PNW sub-region portion of the fresh potato market is 44.2 percent (Idaho 31.6, Washington 9.5, and Oregon 3.1 percent).

■ The U.S. produces an estimated 59,788,560 cwt of seed potatoes.

■ The PNW sub-region accounts for 36.1 percent of the U.S. total seed potatoes (Idaho 29.5, Washington 4.4, and Oregon 2.2 percent).

■ Russet Burbank and Shepody are the two dominant varieties of potatoes produced for processing in the Pacific Northwest.

■ Russet Burbank and Russet Norkotah are the two main varieties of table potatoes produced in the Pacific Northwest.

■ Norchip is the main chip variety used in the Pacific Northwest.

- The Northwest Potato Breeding Program has released 10 new varieties of potatoes since 1984 (Bannock Russet, Chipeta, Frontier Russet, Gemchip, Gem Russet, IdaRose, NDO1496-1, Ranger Russet, Russet Legend, and Umatilla Russet).

■ The 10 newly released varieties are expected to become varieties that replace Pacific Northwest use of Norchip, Russet Burbank, Russet Norkotah, and Shepody because the new varieties are more disease resistant, higher yielding, and have better qualities.

■ An *ex-ante* technology assessment model, with probability distribution, is used to estimate the economic benefits of adopting the new varieties. The results show:

- The benefit to potato growers who grow potatoes for processing in the PNW is estimated at over $108 million (Idaho $63 million, Washington $36 million, and Oregon $9 million).
- The estimated benefits for producing fresh market potatoes with the new varieties in the PNW is $27 million (Idaho $21 million, Washington $5 million, and Oregon $1 million).
- The adoption of disease-resistant potato varieties will benefit the PNW an estimated $77 million by eliminating one spray application.
- An estimated 1,224 chemical sprays will be eliminated from the PNW environment when the new PNW disease-resistant varieties are adopted.

■ In general, the PNW potato industry is estimated to receive a $1.2 billion benefit by adopting the 10 new varieties from the Northwest Potato Breeding Program.

- Idaho will capture 55 percent of this benefit, Washington will receive 36 percent of the benefit, and the Oregon potato industry will receive a boost of 9 percent.

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