

ECONOMIC IMPLICATION OF VARIETAL YIELD IMPROVEMENT RESEARCH IN WHEAT IN PUNJAB, PAKISTAN (FROM 1990-91 TO 2013-14)

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ABSTRACT-The present paper investigates the social and economic implication of breeding research in wheat in Punjab, Pakistan. The study used data on varietal distribution of wheat crop in Punjab from 1990-91 to 2013-14. Simple Economic Surplus Model was used to assess the economic benefits from breeding research. The results of the study indicate that breeding research in wheat is still generating enormous benefits. On an average, wheat breeding research in Punjab had been adding Rs.30.5 billion annually as an additional gain since 1990-91 to 2013-14. This study further explores that 435 kg per hectare additional wheat of worth Rs. 4749 per hectare had been reaped annually by the farmers of Punjab.

Key words: Social, economic implications, varietal distribution, breeding research, wheat.

Introduction

Wheat is an important food crop of the world and is the top source of vegetable protein in human food. It is the second most favorite human food except rice and it is being cultivated on maximum area than any other crop worldwide. It is the single largest crop in terms of trade; its trade is more than the collective trade of all the other crops. Wheat has different classes which are grown in different regions and countries. For example Hard wheat (Red and White) class has higher gluten and other protein contents and is widely used for bread making and noodles. Hard wheat is mainly grown in countries having hot and dry summer like USA, Canada and Pakistan. Soft White class of wheat has relatively low protein content, yields, weak flour and insufficient baking strength. This type of wheat is widely used for making cakes and biscuits products. Most of the wheat grown in Europe is of this type. Durum Wheat is very hard wheat and is widely used for making pasta products. This type of wheat is mainly grown in regions with hot dry summers e.g. North Africa, Turkey and other countries of Eastern Mediterranean. [6].

Wheat crop was originated from Mesopotamia. During 3000 B.C it was planted in many parts of Eurasia, North Africa and China. Its presence was observed in 2000 B.C. [14]. [21] found current flows of wheat crop; which began in 1500 A.D. Cereal hybridization development work was first started in England in 1790s and continued till mid -19th century. Plant breeding is the science and art of changing the traits of plants in order to produce desired characteristics. According to [13] breeding is about manipulating plant attributes, structure and composition to make them more useful to humans. The new plants produced by hybridization, inbreeding, or other methods of reproduction must be better than parent plants in qualities, like higher yield potential, higher nutritional value, less environmental pollution, fiber characteristics, better drought tolerance and more heat resistance.

Europe, North America and Australia showed more interest in both cross-breeding and better method of selection during the last decades of the 19th century. Wheat improvement for better production characteristics was started by crossing of

local adapted material with wheat from other areas of the world [20].

Combined Punjab was considered as the bread basket for the whole India. During 1880s, surplus wheat in Punjab was used to supply other provinces of India. In 1886, on the strength of Punjab granary, India took second place among the wheat exporting nations of the world. During 1889, Karachi became the biggest exporthub of wheat in the East, and before World War I, it broke all records by exporting no less than 1.3 million tons of wheat in 1912-13 [1].

History of varietal yield improvement research in Punjab goes back to 1905 when British Government established Punjab Development of Agriculture. Punjab Agricultural College and Research Institute at Faisalabad (the then Lyallpur) was established in 1906 [17].

A botanical survey was conducted by the Punjab Board of Agriculture in 1907 to collect and classify the available wheat landraces. During this survey twenty five (25) landraces belonging to three wheat species (Durum, Bread and Sphareococcum) were identified.

Durum wheat (*T. durum* Desf.) was cultivated in the districts of Sialkot and Gujranwala. *Triticum sphareococcum* (adwarf drought tolerant wheat) was grown in Southern districts of Punjab (Multan, Muzaffargarh and DG Khan. Bread wheat (*Triticum aestivum* L.em. Thell) was grown, more or less, all over the province. An isolation T9 was approved for general cultivation in 1911 which was followed by T11 in 1913 [18]. In 1914, another survey of landraces was conducted by the Economic Botanist R.D. Milne. As a result of this survey, improved cultivar 8A was released in 1919 for commercial cultivation. The early efforts were devoted to replace the mixed wheat culture with uniform local types [17].

In 1926, a Cerealist (Cereal Botanist) was appointed at Lyallpur which provided a stimulus to wheat breeding efforts and three wheat varieties were released over the next eight years. 9D, a selection from local landraces, was released for cultivation in 1932. Later on, cross breeding techniques were used to develop wheat varieties through hybridization. The first variety, C 518, a cross between T9 x 8A, was released in 1933 and C 591, a cross between T9x8B, was released in 1934. Two additional varieties (sister lines) C228 and C250

were released before partition; C228 in 1941 and C250 in 1944 [11].

In 1957, two tall bread wheat varieties were released for general cultivation i.e. C 271 and C 273. These varieties had hard vitreous grain with good gluten strength with low yield potential.

During the first two Eras quality was a dominant consideration therefore only a yield increase remained 2.5 kilograms per hectare over a period of 46 years.

A Revolutionary era in wheat production was started in 1961 when Manzoor Ahmad Bajwa, a trainee studying at CIMMYT later on became the Director General of Ayub Agricultural Research Institute, Faisalabad, identified a medium-to-hard white-grain line from the segregating generations of the cross 8156 or CB.90 [17]. This was a cross between Penjamo 62'S' and Gabo 55. CB 90 was segregated for red and white color. Though the cross was made in Mexico but selection of that cross was performed by Pakistani Scientists [17]. To commemorate the collaboration, the variety was named Mexipak-65. The red grain sister line of Maxipak-65 was named Indus-66. They not only responded well to high fertilizer doses but were also resistant to diseases especially loose smut and rusts. Maxipak-65 became more popular than Indus-66. It revolutionized wheat production in Punjab. Pakistan became pioneer of Green Revolution in wheat production. Hybridization program to cross the Mexican semi-dwarf wheat genotypes with tall local varieties was started by the scientists of AARI in 1961. First high yielding semi-dwarf variety released from this work was Chenab-70. Since the process continuous, different high yield wheat varieties have been developed and opted by the farmers in Punjab till today.

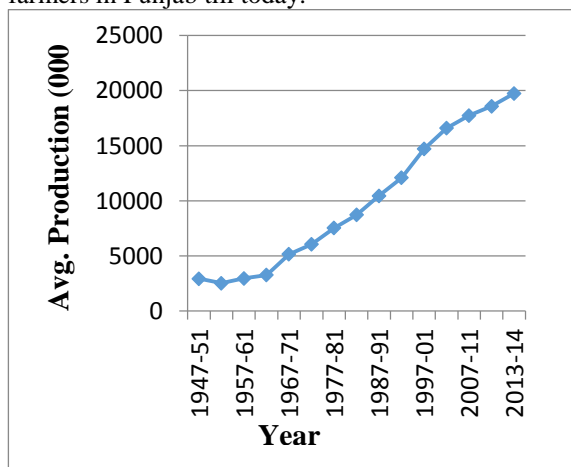


Fig 1: Five year average wheat production in Punjab

Objectives of this study

This study has been designed to analyze the importance and need of varietal yield improvement in Punjab. The main objective of this study is to assess the economic implication of varietal yield improvement of wheat varieties in Punjab from 1990-91 to 2013-14. To provide feedback to researchers on the acceptance/rejection of wheat varieties. Findings of the study would be helpful for wheat researchers about the performance of their varieties in the field and also

raise awareness of the importance of breeding research in wheat in Punjab particularly and in Pakistan generally.

MATERIAL AND METHODS

Plant breeding is the science and art of changing the traits of plants in order to produce desired characteristics. According to [13] breeding is about manipulating plant attributes, structure and composition to make them more useful to humans. Benefits associated with wheat breeding research may be categorized as yield benefits and non-yield benefits. Yield benefits measure the value of additional wheat produced attributable to wheat breeding research. Non- Yield benefits do not show up in the form of increased grain yields and include: improvement in grain quality, improvement in quantity and quality of by-products, reduction in the usage of chemicals to control insects/pests and diseases and reduction in crop growth cycle- allows farmers to increase cropping intensity. Non-yield benefits could be very important and sometimes they actually exceed the value of yield benefits [19].

The methodology used to estimate the economic and social implications of wheat varieties follows a rich literature in the welfare economics of agricultural research developed by [22] and further strengthened by [4, 2, 16, 8, 3, 15,19].The gross annual benefits generated by varietal yield improvement of wheat were estimated using Simple Economic Surplus Model. [7] used this approach to evaluate the combined impact of spring bread wheat breeding activities carried out by CIMMYT and NARS. [19] used the same approach to assess the impacts of international wheat breeding research in the developing world from 1988 to 2002.

Following [19], annual benefits generated by a wheat variety “ *i* “ were estimated by using Economic Surplus Model of the following form:

$$\beta_{it} = A_{it}Y_{it}P_{it}$$

where

β_{it} is the value of additional wheat produced attributable to the wheat variety “ *i* “ in year *t*

A_{it} is the area planted to the wheat variety *i* in year *t*

P_{it} is the price of wheat grains in year *t*

Y_{it} is the net yield gain attributable to the wheat variety *i*

Net yield gain attributable to an individual wheat variety is the difference between the yields of variety “*i*” over check variety in the breeder's trials. Using relative yield performance data from wheat variety trials is implicitly assumed that actual producer yields are equivalent to wheat variety trials yields in the breeder's experiments. [9] suggested that although the absolute level of producer yield may be over stated by experimental yield data, the relative yields between varieties are likely to be similar in both experimental and producer fields. [10] Concluded that the only reliable sources of relative yields are variety trials.

Basic data used in this report included; variety wise area of wheat crop in Punjab, yield gain of wheat varieties included in the analysis and average annual prices of wheat prevailed in Punjab.

Data on varietal distribution of wheat crop in Punjab since 1990-91 were taken from the [12]. Prices of wheat crop were

obtained from Agricultural Marketing Information Services [5], Government of Punjab, Lahore from 1990-91 to 2013-14. AMIS compiles average prices of wheat on monthly basis. Average annual prices of wheat were calculated and used in the analysis.

Net yield gain attributable to an individual wheat variety is the difference between the yield of that variety over check variety in the breeder's trials. Data for varietal yield trials were collected from Ayub Agricultural Research Institute (AARI), Faisalabad. Wheat varieties developed by AARI have been widely accepted and opted by the farmers. These varieties covered almost 99% wheat cultivation area in 2013-14.

RESULT AND DISCUSSION

In this study Simple Economic Surplus approach has been used to estimate the economic benefits attributable to the adoption of wheat varieties in Punjab from 1990-91 to 2013-14. Results of the Economic Surplus Model are presented in Table 1.

It is apparent from Table 1 that economic benefits of wheat breeding research in Punjab were estimated at Rs. 6.3 billion during 1990-91. Pak-81 was the main contributor which added wheat of worth Rs. 3.1 billion. The value of additional wheat produced attributed to Bahawalpur-79 and WL-711 was Rs. 528 million and Rs. 511 million, respectively.

In 1991-92, farmers of Punjab were able to harvest additional wheat of worth Rs.7.3 billion by planting wheat varieties. Pak-81 contributed Rs. 4.1 billion. The economic benefits of WL-711 and Bahawalpur-79 were Rs. 365 million and Rs. 584 million, respectively in this year.

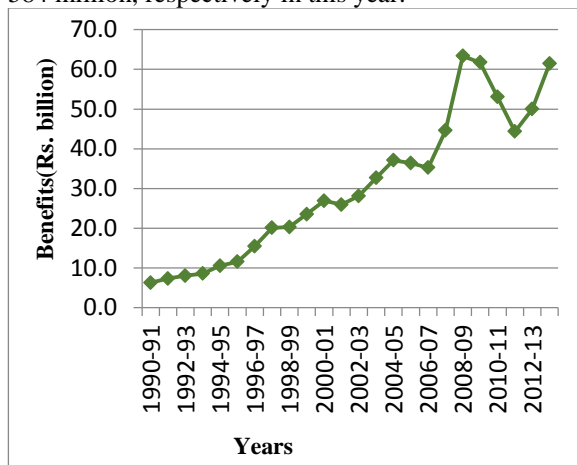


Fig 2: Economic benefits due to varietal yield improvement in wheat in Punjab

Value of additional wheat produced due to wheat varieties in 1992-93 was Rs. 8 billion, out of which Rs. 4.9 billion were added by Pak-81. The contribution of WL-711 further reduced to 238 million whereas Bahawalpur-79 increased its contribution from 584 million to 880 million in this year.

In 1993-94, total economic benefits attributed to wheat breeding research were Rs. 8.5 billion. Pak-81 was the main contributor; its share in economic benefits was Rs.5.6 billion. Share of WL-711 further reduced to Rs. 172 million while the share of Bahawalpur-79 also decreased from 880 million to 741 million in this year.

Economic benefits attributable to wheat varieties in Punjab in 1994-95 and 1995-96 were Rs. 10.5 billion and Rs. 11.5 billion, respectively. Pak-81 remained the highest contributor in both years, its contribution in the first year was Rs. 6.2 billion and in the second year Rs. 4.6 billion. The share of WL-711 was estimated at Rs. 127 million in 1994-95 and Rs. 46 million in 1995-96. The value of economic benefits of Bahawalpur-79 reduced from Rs. 513 million to Rs. 447 million during these years. The share of Desi in additional benefits were Rs. 359 million in the first year and Rs.369 million in the second year. Inqlab-91 a new wheat variety added Rs. 1.6 billion in 1994-95 and Rs. 4.6 billion in 1995-96.

During 1996-97, farmers of Punjab reaped additional wheat of worth Rs. 15.4 billion. Pak-81 decreased its share to Rs. 4.3 billion while Inqlab-91 became the leading contributor in additional economic gain with Rs. 8.4 billion. WL-711 and Bahawalpur-79 contributed Rs.43 million and Rs 634 million, respectively in economic benefits. Value of additional wheat produced due to Desi was Rs. 430 million.

In 1997-98, total economic benefits due to wheat varieties were estimated at Rs. 20 billion. Inqlb-91 was once again the main contributor with Rs. 13 billion as additional benefits. Pak-81 added Rs. 3.4 billion while Desi added Rs. 582 million. Share of WL-711 and Bahawalpur-79 was Rs. 35 million and Rs. 586 million, respectively in the total economic benefits.

Value of additional wheat produced wheat varieties in 1998-99 was same as in the previous year Rs. 20 billion. Inqlab-91 remained the highest contributor among all the wheat varieties. Its economic impact on Punjab's economy was estimated at Rs. 14 billion. Contribution of Pak-81 was Rs. 2.1 billion while of Bahawalpur-79 Rs. 376 million. Value of additional wheat produced due to the planation of Punjab-96 was Rs. 1.3 billion.

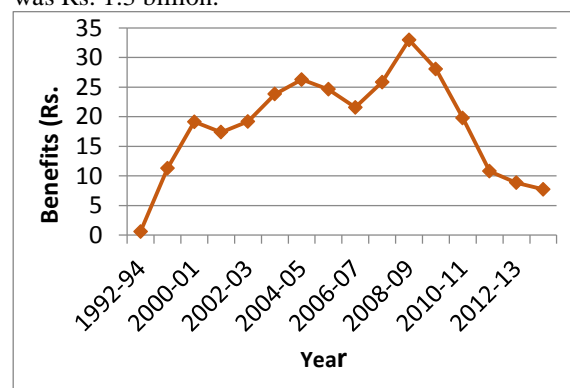


Fig 3: Economic Benefits due to Inqlab-91

During 1999-2000, wheat growers of Punjab reaped additional wheat of worth Rs.23.5 billion. Economic benefits of Inqlab-91 and Wattan was Rs. 16 billion and Rs.1.6 billion, respectively. Pak-81 and Punjab-96 added additional wheat of worth Rs. 1.5 billion and Rs. 1.6 billion, respectively.

Economic benefits of wheat varieties in Punjab were estimated at Rs. 27 billion during 2000-01. Inqlab-91 was the main contributor which added wheat of worth Rs. 19 billion. The value of additional wheat produced attributed to Wattan, Punjab-96 and Pak-81 was Rs. 2.181 billion, 2.6 billion and

Rs. 859 million, respectively. The share of Desi in economic benefits was Rs. 456 million in this year.

In 2001-02, farmers of Punjab were able to harvest additional wheat of worth Rs.25.9 billion by planting wheat varieties. Inqlab-91 contributed Rs. 17 billion while Pak-81 contributed Rs. 667 million. The economic benefits of Wattan and Punjab- 96 were Rs. 2.9 billion and Rs. 2.1 billion, respectively. Share of Bahawalpur-79 and Uqab-2000 in economic benefits was estimated at Rs. 1.2 billion and Rs. 107 million respectively.

Value of additional wheat produced due to wheat varieties in 2002-03 was Rs. 28 billion, out of which Rs. 19 billion were added by Inqlab-91. Wattan added Rs. 3.9 billion and Punjab-96 added Rs. 2 billion. Contribution of Pak-81 in economic benefits was of worth Rs. 540 million. Rs. 256 million were added due to the plantation of Uqab-2000.

In 2003-04, total economic benefits attributed to wheat varieties were Rs. 33 billion. Inqlab-91 was the main contributor; its share in economic benefits was Rs.24 billion. Share of Pak-81 further reduced to Rs. 345 million. Uqab-2000 added wheat of worth Rs. 376 million. Value of additional wheat produced in Punjab due to Wattan was Rs. 4.8 billion, due to Punjab-96 Rs. 1.7 billion and due to Bhakkar-2002 Rs. 305 million.

Economic benefits due to wheat varieties in Punjab in 2004-05 and 2005-06 were Rs. 37 billion and Rs. 36 billion, respectively. Inqlab-91 remained the highest contributor in both years. Its contribution in the first year was Rs. 26 billion and in the second year Rs. 25 billion. The share of Pak-81 was estimated at Rs. 376 million in 2004-05 and Rs. 298 million in 2005-06. The value of economic benefits of Wattan remained Rs. 6.5 billion during these years. The share of Punjab-96 in additional benefits reduced to Rs. 977 million in the second year from Rs. 1.2 billion in the first year while the share of Uqab-2000 increased from Rs. 384 million to Rs. 498 million in these two years. Bhakkar-2002 added wheat of worth Rs. 1.3 billion in the first year and of worth Rs. 2.6 billion in the second year.

During 2006-07, farmers of Punjab reaped additional wheat of worth Rs. 35 billion. Inqlab-91 added Rs. 22 billion while Wattan added Rs 6.7 billion in economic benefits. Pak-81 and Punjab-96 contributed Rs.306 million and Rs 789 million, respectively in economic benefits. Value of additional wheat produced due to Uqab-2000 was Rs. 683 million, due to Bhakkar-2002 Rs. 4 billion and due to Abdul Sattar-2002 Rs. 385 million.

In 2007-08, total economic benefits attributable to wheat varieties were estimated at Rs. 44.6 billion. Inqlb-91 was once again the main contributor with Rs. 26 billion as additional benefits. Wattan added Rs. 8.2 billion, Pak-81 added Rs. 307 million while Punjab-96 added Rs. 712 million. Share of Uqab-2000 and Bhakkar-2002 was Rs. 699 million and Rs. 6.6 billion, respectively in the total economic benefits. Economic benefit attributable to Abdul Sattar-2002 was Rs.986 million and Sehr-2006 Rs. 36 million in this year. Value of additional wheat produced due to wheat varieties in 2008-09 was Rs. 63 billion. Inqlab-91 remained the highest contributor among all the wheat varieties. Its economic impact on Punjab's economy was estimated at Rs. 33 billion, which was highest during the whole study period. Economic

impact of Wattan was Rs. 12 billion and of Bhakkar-2002 Rs. 11 billion. Contribution of Pak-81 was Rs. 356 million while of Punjab-96 Rs. 711 million. Share of Uqab-2000 in additional benefits was Rs. 713.5 million and of Abdul Sattar-2002 was Rs. 1.8 billion. Value of additional wheat produced due to the planation of Sehr-2006 was Rs. 1 billion.

During 2009-10, wheat growers of Punjab reaped additional wheat of worth Rs. 61.8 billion. Economic benefits of Inqlab-91 and Wattan was Rs. 28 billion and Rs.11 billion, respectively. Pak-81 and Punjab-96 added additional wheat of worth Rs. 30 million and Rs. 425 million, respectively. Uqab-2000 contributed Rs. 815 million in additional benefits. Economic impact of Bhakkar-2002, Abdul Sattar-2002 and Sehr-2006 was found to be Rs. 9 billion, Rs. 2 billion and Rs. 7 billion, respectively.

In 2010-11 total economic benefits attributed to wheat varieties were Rs. 53 billion. Share of Inqlab-91 decreased considerably from Rs. 28 billion in 2009-10 to Rs.20 billion in 2010-11 while share of Sehr-2006 increased significantly from Rs. 7 billion in 2009-10 to Rs. 11 billion in 2010-11. Value of additional wheat produced attributed to Wattan, Abdul Sattar-2002 and Bhakkar-2002 was Rs. 8 billion, Rs. 1 billion and Rs. 6 billion, respectively. Economic benefits generated by Pak-81 and Punjab-96 were Rs. 106 million and Rs. 313 million respectively. Amount of additional benefits from Shafaq-2006 was Rs. 936 million.

Economic benefits generated by wheat varieties during 2011-12 were Rs. 44 billion. Contribution of Inqlab-91 in economic benefits further decreased and was estimated at Rs. 11 billion. Sehr-2006 was the highest contributor. It contributed Rs. 14 billion in additional benefits. Wattan, Abdul Sattar-2002 and Bhakkar-2002 added Rs. 7 billion, Rs. 1 billion and Rs. 3 billion, respectively. Share of Pak-81 and Punjab-96 in economic benefits was Rs. 39 million and Rs. 330 million, respectively. Value of additional wheat produced attributed to Shafaq-2006 was Rs.1 billion. Economic impact of Faisalabad-2008, Lasani-2008 and AAS-2011 was estimated at Rs. 495 million, Rs. 415 million and Rs. 854 million, respectively.

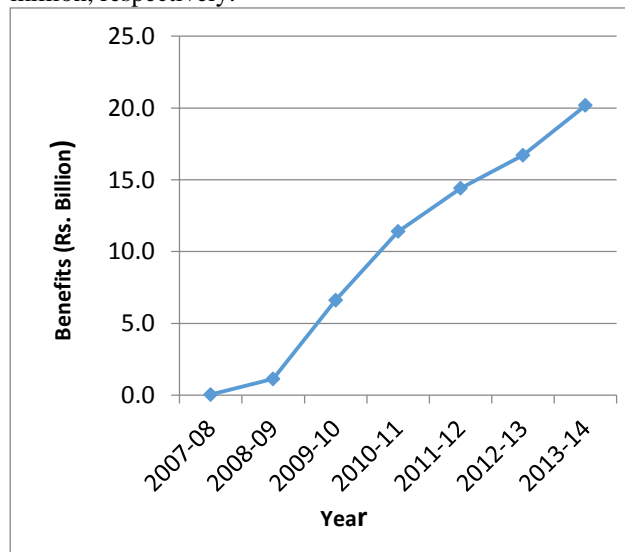


Fig 1.4: Economic Benefits due to Sher 2006

Table: 1 Economic Impacts of Wheat Breeding Research in Punjab (1990-91 to 2013-14) (Rs. Million)

S.No	Variety	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02
1	PAK-81	3105.8	4092.3	4910.9	5628.0	6243.8	4584.4	4339.5	3377.0	2093.6	1491.8	859.1	667.5
2	INQLAB-91	0.0	0.0	11.3	196.6	1637.9	4589.5	8446.0	13295.3	13949.6	16082.4	19137.5	17397.0
3	PB-81	293.9	290.1	300.4	271.7	296.7	202.1	170.8	166.9	148.7	103.3	87.0	53.7
4	DESI	197.5	332.3	317.7	258.1	359.2	368.6	429.5	581.6	542.7	404.8	455.5	343.9
5	WL-711	510.8	364.8	238.3	172.1	127.4	46.1	43.0	35.2	33.9	0.0	0.0	0.0
6	B-SIVER	299.7	299.9	255.9	162.5	104.3	46.1	28.6	17.6	50.9	0.0	0.0	0.0
7	CHAKWAL-97	0.0	0.0	0.0	0.0	0.0	67.2	41.8	154.2	49.5	107.3	242.3	276.6
8	B-79	527.9	583.5	879.6	741.1	513.2	446.5	634.2	585.5	375.6	611.4	341.3	1162.2
9	WATAN	0.0	0.0	0.0	0.0	0.0	17.8	155.2	545.9	1313.4	1624.7	2181.1	2894.8
10	PB-96	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	805.2	1922.1	2557.2	2128.3
11	PB-85	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	137.0	59.5	71.0
12	FD-96	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	UQAB 2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	107.2
14	IQBAL 2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	53.9
15	B-97	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	43.8	0.0
16	PB-86	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	BHAKAR-2002	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	MH-97	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	69.8	116.4
19	ABDULSATTAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	SEHR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	SHAFaq	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	FAISALABAD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	LASANI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	AAS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	FAREED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	OTHER*	1337.1	1326.5	1116.9	1113.9	1231.4	1180.5	1141.1	1331.4	906.9	1007.5	841.6	641.2
27	Total	6272.7	7289.4	8031.1	8544.0	10513.9	11548.7	15429.7	20090.6	20270.1	23492.4	26875.5	25913.7
28	Total billion	6.3	7.3	8.0	8.5	10.5	11.5	15.4	20.1	20.3	23.5	26.9	25.9

S.No	Variety	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14
1	PAK-81	540.2	345.5	376.1	298.0	306.1	305.0	355.7	30.0	106.3	38.8	36.2	98.0
2	INQLAB-91	19185.4	23826.8	26269.2	24640.6	21566.0	25841.8	32971.9	28067.2	19784.4	10783.6	8849.9	7737.5
3	PB-81	43.9	52.7	30.5	0.0	32.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	DESI	272.4	200.4	145.9	176.5	210.8	151.6	534.1	337.5	296.7	248.5	323.9	254.1
5	WL-711	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	B-SIVER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

7	CHAKWAL-97	121.6	0.0	86.2	85.8	88.6	169.5	305.2	675.9	1418.0	2039.2	2247.3	2843.1
8	B-79	807.9	411.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	WATAN	3859.1	4759.3	6583.1	6476.9	6684.6	8173.7	12090.7	11027.8	8182.1	7444.2	8613.3	8693.8
10	PB-96	2038.6	1661.4	1245.3	977.4	788.8	707.9	711.1	424.7	313.0	330.0	1549.6	3871.0
11	PB-85	0.0	64.3	50.3	33.7	26.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	FD-96	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	UQAB 2000	256.4	375.9	384.3	498.4	682.9	694.8	713.5	815.4	488.8	289.5	295.7	339.3
14	IQBAL 2000	149.0	142.3	144.3	83.5	64.7	70.0	56.4	28.9	43.9	17.9	48.8	0.0
15	B-97	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	PB-86	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	BHAKAR-2002	0.0	304.7	1322.9	2596.6	3990.5	6573.3	11371.2	9381.5	5689.7	3456.6	3218.8	2764.8
18	MH-97	113.8	135.6	78.7	39.8	60.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	ABDULSATTAR	0.0	0.0	0.0	0.0	385.4	980.4	1808.4	2191.5	1484.2	1361.4	1361.5	1022.4
20	SEHR	0.0	0.0	0.0	0.0	0.0	36.3	1126.2	6616.9	11397.4	14407.7	16713.7	20183.1
21	SHAFaq	0.0	0.0	0.0	0.0	0.0	30.3	216.0	739.0	935.7	1080.3	1306.9	1560.3
22	FAISALABAD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	495.0	1346.8	3821.2
23	LASANI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	414.9	697.7	1348.5
24	AAS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	854.2	1586.4	1267.7
25	FAREED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	191.9	245.8	295.9
26	OTHER*	699.3	386.7	380.7	500.3	340.3	864.3	1111.0	1431.8	2949.7	894.6	1523.1	5329.2
27	Total	28087.3	32667.4	37097.3	36407.4	35227.1	44598.9	63371.4	61768.1	53089.8	44348.5	49965.6	61429.8
28	Total billion	28.1	32.7	37.1	36.4	35.2	44.6	63.4	61.8	53.1	44.3	50.0	61.4

Table 2: Per hectare additional benefits from wheat varieties in Punjab (1990-91 to 2013-14)

Years	Additional Benefits (Rs/hectare)	Additional Wheat Produced (kg/hectare)
1990-91	1098	386
1991-92	1286	377
1992-93	1347	381
1993-94	1481	374
1994-95	1781	380
1995-96	1933	420
1996-97	2642	452
1997-98	3385	478
1998-99	3416	501
1999-00	3801	535
2000-01	4296	544
2001-02	4247	569
2002-03	4607	562
2003-04	5222	548
2004-05	5816	534
2005-06	5616	518
2006-07	5476	489
2007-08	6966	467
2008-09	9270	436
200910	8934	373
2010-11	7935	327
2011-12	6841	275
2012-13	7674	265
2013-14	8901	255
Average	4749	435

In 2012-13 additional benefits attributed to wheat varieties were of worth Rs. 50 billion. Sehr-2006 was the highest contributor towards economic benefits with Rs. 17 billion. Inqlab-91 added Rs. 9 billion and Punjab-96 added 1.5 billion in economic benefits. Watan, Abdul Sattar-2002 and Bhakkar-2002 added additional wheat of worth of Rs. 9 billion, Rs. 1 billion and Rs. 3 billion, respectively. Farmers of Punjab reaped additional wheat of worth Rs. 2 billion, Rs. 36 million and Rs. 296 million by planting wheat variety Chakwal-97, Pak-81 and Uqab-2000, respectively. The value of economic impact of Faisalabad-2008, Lasani-2008 and AAS-2011 was Rs. 1 billion, Rs. 698 million and Rs. 1.6 billion, respectively during this year.

In the last year of analysis, economic benefits generated due to the wheat varieties in Punjab were Rs. 61.4 billion. Sehr-2006 contributed Rs. 20 billion while Inqlab-91 contributed Rs. 8 billion in economic benefits in 2013-14. Contribution of Chakwal-97 and Bhakkar-2002 was Rs. 3 billion each. Pak-81 and Uqab-2000 added additional wheat of worth Rs. 98 million and Rs. 339 million, respectively in the province. Farmers of Punjab reaped additional wheat of worth Rs. 4 billion by planting Punjab-96 and of worth Rs. 3 billion by planting Bhakkar-2002. Additional gain of Abdul Sattar-2002 and Shafaq-2006 was of worth of Rs. 1 billion and 1.6 billion, respectively. Faisalabad-2008 added Rs. 4 billion while Lasani-2008 and AAS-2011 added Rs. 1 billion each in the additional economic benefits.

Table 2 shows additional wheat and additional benefits per acre wheat to the farmers of Punjab. It is depicted from the table that during 1990-91, wheat farmers of Punjab had gain additional wheat of worth Rs. 1089 per hectare by using wheat varieties. During 1991-92, additional wheat produced in Punjab was 377 kilograms per hectare. Value of additional wheat gained by Punjab's wheat farmers was averaged Rs. 1414 per hectare in 1992-93 and 1993-94. In 1994-95 and 1995-96 farmers of Punjab produced 380 kilograms per hectare and 420 kilograms per hectare additional wheat. Value of additional wheat gained by farmers was estimated at Rs. 2642 and Rs. 3385 during 1996-97 and 1997-98, respectively. It is again depicted from Table 2 that wheat farmers of Punjab were able to produce 501 kilograms per hectare and 535 kilograms per hectare additional wheat during 1998-99 and 1999-2000. Punjab's farmers harvested averaged additional wheat of worth Rs. 4272 per hectare during year from 2000-01 and 2001-02. Additional wheat produced in Punjab due to wheat varieties was estimated at 562 kilograms per hectare during the crop year 2002-03. From 2003-04 to 2004-05, wheat growing families of Punjab were able to get additional wheat 548 kilograms per hectare and 534 kilograms per hectare during these year. The additional income generated by wheat varieties was estimated at Rs. 5616 and Rs. 5476 per hectare during 2005-06 and 2006-07. Value of additional wheat produced was of worth Rs. 6966 and Rs. 4270 during 2007-08 and 2008-09. From 2009-10 to 2010-11, wheat growing families of Punjab were able to get additional wheat 373 kilograms per hectare and 327 kilograms per hectare. Additional wheat produced in Punjab due to wheat varieties was estimated at 275 kilograms per hectare during the crop year 2011-12. Value of additional wheat gained by farmers was estimated at Rs. 7674 and Rs. 8901 during 2012-13 and 2013-14, respectively. It can be concluded from the above discussion that wheat farmers of Punjab had gained additional wheat 435 kilograms per hectare annually from cultivation of wheat since 1990-91. On an average, additional income earned by wheat farmers of the province was Rs. 4749 per hectare during the whole study period.

CONCLUSION

This study has been designed to analyze the importance of varietal yield improvement in Punjab and the results of the study indicate that breeding research in wheat is still generating enormous benefits. Simple Economic Surplus Model was used to assess the economic benefits from breeding research. On an average, wheat breeding research in Punjab had been adding Rs. 30.5 billion annually as an additional gain since 1990-91 to 2013-14. This study further revealed that 435 kg per hectare additional wheat of worth Rs. 4749 per hectare had been reaped annually by the farmers of Punjab since 1990-91. This economic gain has helped the farming community to meet with

their essential farm and non-farm requirements.

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