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An Economic Analysis of Wheat Breeding Programs for Some Iranian Irrigated Bread Wheat Varieties

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Abstract

The objectives of this research were to determine the impacts of irrigated wheat breeding in reducing costs, Net Present Value (NPV), Cost-Benefit Analysis (CBA) and Internal Rate of Return (IRR) for Mehregan, Shush, Baharan and Narin bread wheat varieties, released in 2014. Replacement indices for Chamran, Shiroodi, Bahar, Morvarid, Zarrin varieties with international origin, and Pishtaz, Alvand, Pishgam varieties with national origins were also assessed. To estimate the profitability criteria's and replacement index of varieties, Ex-ante & Ex-post methods and Weighted Average Age were used. The results revealed that the mean reduction costs of released four irrigated bread wheat varieties (Mehreghan, Shush, Baharan, Narin) equals 406.9 Iranian Rials. The mean of shift in supply function of these varieties is 4.67%. Total costs of research for three varietis (Mehregan, Shush, Baharan) with international origin, and Narin variety with national origin, were 96500 and 21500 million Iranian Rials, respectively. Moreover, NPV for Mehregan, Shush, Baharan and Narin were 266200, 211000, 469200 and 415200 million Iranian Rials, respectively. Benefit Cost Ratio (BCR) for Mehregan, Shush, Baharan and Narin were 4.6, 1.5, 12.2 and 7.7, respectively. IRR for Mehregan, Shush, Baharan and Narin were 47.5%, 28.5%, 72.9% and 51.1%, respectively. The mean of weighted Average Age of irrigated bread wheat varieties over the period of 2004-2016, was 7.72 years. Based on the need and purchase scenarios, the average of replacement rate for Chamran were calculated as 3.8 and 6 years, respectively.

Keywords: Wheat, Benefit-Cost Ratio, Return, Weighted Average Age, Net Present Value

1. Introduction

Agricultural research is one of the important and determinant factors in enhancing the production of agricultural sector (Maredia et al., 2000; Hurley et al., 2014). Among agricultural research, breeding programs and especially, wheat breeding programs play a significant role in increasing food production and security (Jalal Kamali et al., 2012; Crossa et al., 2014) and the impact assessment of these programs need to be justified (Byerlee and Traxler, 1995; Alston, 2010). One of the topics, interested in wheat breeding programs, is the issue of replacement of a variety. The main reasons of replacement of a variety are yield advantage of new variety, more resistance to biotic and abiotic stresses, and better quality properties.

In measuring the replacement rate of a variety, two factors are important: The area percentage of the variety grown in a certain period, and the weighted average age of the variety grown by farmers (Heisey and Brennan, 1991). The final report of international wheat research programs indicates that the world annual investment of wheat breeding research is about US$ 30 million, the annual benefit of wheat breeding research during this period is between US$ 2.2-3.1 billion, and BCR of the world wheat breeding research is between 73-103, during the period of 1994-2014 (Voegele and Kropff, 2016), which overall indicates the effectiveness of wheat breeding research programs. Significant efforts have been made by researcher overtime.

Nikooei et al., (2006) showed that BCR for irrigated wheat research & extension program for Mahdavi variety in Esfahan province of Iran is 8. Asadi (2007) also shows that the IRR and BCR, for 12 irrigated wheat varieties, are 77.8% and 25.8, respectively. Based on the study of Global Wheat Impacts survey, done by CIMMYT in 2014, weighted average age of wheat varieties in Argentina, Czech Republic, Georgia, Hungary, Kenya, Lebanon, Spain, Ukraine are lower than 6 years. However, in Afghanistan, Brazil, Ethiopia, Paraguay, Rwanda, Tajikistan, Uruguay, Zimbabwe are between 6-8 years, in West Australia, Azerbaijan, Bangladesh, Canada, China, Iran, Italy, Japan, Latvia, Mexico, Nepal, Pakistan, Romania, Tanzania, USA, Uzbekistan, Zambia are between 8-10 years, in Armenia, Bolivia, Egypt, Kazakhstan, Nigeria, Turkmenistan, Uganda, Switzerland, Turkey are between 10-12 years, and in Albania, Belarus, India, Israel, Portugal, Serbia, Slovenia, Russia (Omsk) are between 12-14 years. The weighted average age of a wheat variety, in Algeria, Bhutan, Ecuador, Jordan, Kyrgyzstan, Morocco, Sudan, Syria, Tunisia are more than 14 years.

Additional annual production due to international wheat improvement research is estimated between 24-65 million tons. Based on US$ value in 2010, total annual value of additional wheat grain production, attributable to international wheat improvement research, are between US$ 6-17 billion, and total annual benefits, attributable to the CGIAR wheat improvement research are between US$ 2.1-5.7 billion (Lantican et al., 2015). Byerlee and Traxler (1995) shows that the annual economic benefits and IRR of impacts from International Wheat Improvement (all breeding) are about US$ 3.0 billion and 53%, respectively; and the impact of International Wheat Improvement (attributed to IWIN) was estimated about $1.5 billion per year during the period of 1966-90.

Heisey et al. (2002) reports that the economic benefits of impact of International Wheat Improvement for all breeding, attributed to IWIN are US$ 2.4 and US$1.1 billion per year, during the period of 1996-97. Lantican et al. (2005) reports that the annual economic benefits of impact from International Wheat Improvement for all breeding and attributed to IWIN are between US$3.4-4.8 and $1.0-1.8 billion during the period of 1988-2002. Marasas et al. (2004) shows that the NPV of impact from International Wheat Improvement, attributed to IWIN, due to leaf rust resistance are

US$ 5.4 billion per year, during the period 1973-2007.

Shapiro et al. (2002) used an ex-ante impact assessment and an economic analysis of breeding for nutrient vlue. By analytically comparing the common IRR to a modified IRR, Hurley et al. (2014) conclude that the rates of return are implausibly high. Bellon et al. (2015) conclude that the projects supporting on-farm conservation of native crops are effective to maintain crop diversity, in the High Andes of South America. Barkley et al. (2008) calculate the IRR of the CIMMYT wheat breeding program as 55.5%, and the BCR index as 14.99. They conclude that wheat breeding research have been significantly profitable.

Although considerable studies have been made on the topic of economic analysis of agricultural breeding programs, most of them have concentrated on one of the economic indices or one of the crop varieties (e.g., one of the wheat varieties). In this regards, we calculate Net Present Value (NPV), Cost-Benefit Analysis and Internal Rate of Return (IRR) for all Iranian irrigated bread wheat varieties. We also determined the replacement indices for bread wheat varieties with national and international origins. The impacts of wheat breeding in reducing costs were assessed as well.

To our best knowledge, this paper is one of the few studies that have applied several economic indices to assess the breeding programs of Iran's varietal irrigated wheat.

The rest of the paper is structured as follows. In the following, the methods used in this study are explained. The next section is devoted to results and discussion. Conclusion and recommendations is the last section.

2. Materials and Methods

Following other similar research, the weighted average age first introduced by Bernann & Byerlee (1991), and Ex-ante & Ex-post Techniques (Bernann et al. 2002) are applied. These methods have been widespreadly used in agricultural research programs (e.g., Shapiro, et al., 2002; Barkley, et al., 2008; Balana, et al., 2011; Hurley et al., 2014; Bellon,. 2015; Gibson, et al., 2016). In this regards, the shift of supply function for variety, the impacts of wheat breeding programs in decreasing costs, Net Present Value (NPV), Cost-Benefit Analysis (CBA), Internal Rate of Return (IRR) and also the weighted average age of some irrigated bread wheat varieties with national and international origins are calculated. The last index is calculated as follows (Brennan et al, 2002):

$$C_{vb} = (TC_h / y_{v\,(without)}) - (TC_h / y_{v\,(with)}) \qquad (1\,)$$

$$PSS = C_{vb} / P_w \qquad (2\,)$$

Where:

C_{vb}: Cost reduction due to breeding program

TC_h: Total Cost production per ha

$Y_{v(without)}$: Yield of check variety in breeding plots

$Y_{v(with)}$: Yield of new variety in breeding plots

PSS: % supply shift in breeding program

P_w: price of wheat per kg

Following Bernann et al (2002), the gross benefit of irrigated bread wheat research in different regions (B), annual shift of genetic improvement of variety due to breeding program (kt), and fixed and variable costs of research & extension of irrigated wheat breeding in the experiment years (TC) are estimated as:

$$B_t = P_t * Q_t * K_t \quad (3)$$

$$K_t = \sum v_{it} * g_i \quad (4)$$

$$TC = C^s S + C_{vt} \quad (5)$$

Where:
P_t: Price of wheat in year *t*
Q_t : Quantity of wheat production in year *t*
V_{it} : Proportion of area variety in year t
g_i : Genetic improvement for variety i
S: Number of full time breeders and technicians in breeding program
C^s : The costs of breeder and technician in year t
C_{vt} : Fixed and variable costs of production of research & extension in year t

For economically analyzing the genetic improvement of a variety, profitability indexes including Net Present Value (NPV), Benefit-Cost Ratio and Internal Rate of Rreturn (IRR) are calculated. Following Soltani (2007), Net present value (NPV) can be estimated as:

$$NPV_t = \sum_{t=0}^{n} \frac{B_{(t)}}{(1+r)^n} - \sum_{t=0}^{n} \frac{TC_{(t)}}{(1+r)^n}$$
$$PVB_t = \sum_{t=0}^{n} \frac{B_{(t)}}{(1+r)^n} \quad , PVC_t = \sum_{t=0}^{n} \frac{TC_{(t)}}{(1+r)^n} \quad (6)$$

Where:
PVB: Present value of benefits
PVC: Present value of Costs
r: Discount rate
n: period

Replacement Index of a variety is a measure of replacement rate of the variety based on age and proportion of area grown on that variety (or based on certificated seed). As first introduced by Brennan and Bayerlee (1991), Weighted average age can be estimated as follows:

$$VRI_i = \sum_i (A_{it} \times W_{it}) \quad (7)$$
$$A_{it} = (Year_{it} - Year_{ir})$$
$$W_{it} = (S_{it} / S_{Tit})$$

Where:
VRI_i: Weighted average age of the variety in year t
A_{it}: Age of variety
$Year_{ir:}$ Released year of the variety i

$Year_{it}$: Current year of growing the variety i
W_{it}: Proportion of certified seed of the variety: total certified seed in year *it*
S_{it}: certified seed of the variety *i* in year *t*
S_{Tt}: Total certified seed in year *t*

CBR	IRR	NPV	Replacement Index
Calculated by dividing the total discounted value of the benefits by the total discounted value of the costs.	Calculated in a way that the net present value of all the cash flows (both positive and negative) from the project equal zero.	Calculated by subtracting the present values of cash outflows from the present values of cash inflows, over a period of time.	Calculated based on the age and proportion of area grown on that variety

Fig 1. -*The method used in this study for economic analysis of breeding wheat program*

For estimating the impact of time trend on the replacement rate, the Ordinary Least Square (OLS) regression is used. In this research, for analyzing data, Stata13 software is used. Scedasticity diagram and Inflation Variance Factor (VIF) are applied for determining the heteroscedasticity and multicolinearity problems, respectively. Irrigated bread wheat varieties in this research are Pishtaz, Alvand, Pishgam and Narin varieties with national origin, and Chamran, Shiroodi, Zarrin, Bahar, Morvarid, Mehreghan, Shush, Baharan varieties with international origin released by SPII in Iran during the period of 1995-2014. Data were collected from Cereal Research Department of Seed and Plant Improvement Institute (SPII), Agricultural Research, Education and Extension Organization (AREEO), Deputy of Crop Production in the Ministry of Jihad-e-Agriculture, and Certificated and Registered Seed Institute. The costs of breeding program are estimated based on the type of experiments in different projects, the number of locations, the period for implementation, and the number of researchers and technicians for implementation. For estimating the weighted average age of varieties, certificated seed information are used from two sources; i) based on the needs from the Wheat Seed Multiplication and Supply Programs of the Deputy of Crop Production, Ministry of Jihad-e-Agriculture for the period of 2004-2016, and ii) based on purchase of certificated seed obtained from the Certificated and Registered Seed Institute for the period of 2011-2015.

3. Results and Discussion

Based on information of deputy of crop production in Ministry of Jihad-e-Agriculture in 2015-2016, needed certified, registered and breeder-3 seed of irrigated bread wheat were 300,725 tons (14.3% public sector and 85.7% private sector), 26812 tons (27.4% public sector and 72.6% private sector) and 2,395.5 tons (84.8% public sector and 15.2% private sector), respectively. The share of certified seed of varieties in Agro-climatic Zones including Northern Warm and Humid zone (ZONE I), Southern Warm and Dry zone (ZONE II), Temperate zone (ZONE III) and Cold zone (ZONE IV) were 10%, 29.7% , 16.6% and 20.4%, respectively (Table 1 & 2).

3.1 Impact of irrigated wheat breeding program in yield improvement and costs reduction

Based on the experiments in irrigated wheat breeding program and released varieties in 2014, the yield increase in Mehregan, Shush, Baharan varieties with international origin, and Narin variety with national origin were 4, 2.3, 11.9 and 13.7 percent, respectively (Table 3). The costs reduction of Mehregan, Shush, Baharan varieties and Narin variety were 184.9, 107, 600 and 735.7 Iranian Rials, respectively. Shift in supply curve (%) for Mehregan, Shush, Bharan varieties and Narin variety were 4.7%, 1.9%, 5.7% and 6.4%, respectively (Table 3). These results indicate that the effectiveness of irrigated wheat breeding program in yield improvement and costs reduction has been successful. Bellon et al. (2015) also conclude that the projects have been effective at supporting on-farm conservation of native crops. Lantican et al. (2016) shows that the rate of releases of improved wheat varieties is considerable particularly in recent years. They express that this improvement can be due to the introduction of rust-resistant varieties in these years.

3.2 The profitability of variety

Based on the invested years (2000-2020) for four Mehregan, Shush, Baharan and Narin varieties released in 2014, the number of implementation sites was 201 sites, while share (%) of these sites for bread wheat verities with national and international origins were 24.4% and 75.6%, respectively. In general, total costs of researchers and technicians were estimated 79000 and 32000 million Iranian Rials, respectively (Table4).

NPV, BCR and IRR of four irrigated wheat varieties were estimated 1,193,200 million Iranian Rials, 5.6 and 48.5%, respectively. The NPV of Mehregan, Shush, Baharan with international origin were estimated 226,200, 211,000 and 469,200 million Iranain Rials. Benefit-cost ratio of Mehregan, Shush, Baharan were estimated 4.6, 1.5 and 12.2. The IRR of Mehregan, Shush, Baharan were estimated 47.5%, 28.5% and 72.9%. The NPV, BCR and IRR of Narin variety with national origin were estimated 415,200 million Iranian Rials, 7.7 and 51.1%, respectively (Table 5). These results show that the investments can be justified, impressively.

Lantican, et al. (2016) also indicate that the benefit-cost ratios for CGIAR wheat improvement program are between 73:1 to 103:1, which show the justification of wheat research program. Asadi and Saeedi (2000) also show that the BCR of improved varieties for bread wheat are 25.8 and 22. They calculate that the cost of research and NPV as 39300 and 2401700 million rials, respectively. They also show the IRR in new varieties of irrigated wheat crop is significantly high.

3.3 Replacement indexes and Certified Seed of varieties

Descriptive analysis shows that the average quantity of certified seed of 8 studied irrigated bread wheat with national and international equal 198,596.3 tons. The mean of weighted average age of varieties is 7.72 years (Table 6).

The average quantity of certified seed of Chamran, Morvarid, Shiroodi, Bahar and Zarrin varieties with international origin were 82,508, 18,455, 10269, 11,039 and 8,843.3 tons, respectively, over the period of 2004-2016. The average quantity of certified seed of Pishtaz, Alvand and Pishgam varieties with national origin were 21,070, 14,327 and 22,467 tons. The weighted average age of Chamran, Morvarid, Shiroodi and Bahar varieties with international origin were estimated 3.8, 0.72, 0.48 and 0.32 year, respectively. Weighted average age of Pishtaz, Alvand and Pishgam varieties with national origin were estimated 0.62, 0.7 and 0.54 year, respectively (Tables7, 8 & 9). In one of the first attempts, Brennan and Byerlee (1991) show that the weighted average age for wheat varieties in 1970 and is 6.7 and 8.4 year, respectively 1980 at the global level. The average time from varietal release to 10% adoption, the average time from adoption initiation up to 95% adoption, and the time to reach 95% adoption were estimated 1.1 , 5 and 6.1 years, respectively. The weighted average age of wheat varieties was estimated 7.1 years in developed countries. Byerlee and Traxler (1995) indicate that the ex-post rate of return is 50% for wheat breeding programs in less developed countries. The mean weighted average age of irrigated wheat varieties in Iran was estimated 7.72 years for the period of 2004-2016 (Table 10).

3.4 Impact of time trend on weighted average age

Based on an OLS regression, the impact of time trend and certified seed on weighted average age of varieties including; Morvarid, Chamran and Shiroodi were significantly positive (Table 11). For Morvarid variety, the estimated coefficient for time trend and certified seed were 0.009 and 0.0001, respectively. For Chamran and Shiroodi varieties weighted average age were 0.0005 & 0.0001, and 0.0007 & 0.0001, respectively (Table 11). The impact of time trend on weighted average age of Bahar, Pishtaz, Alvand and Pishgam were negative. The coefficient of these varieties were -0.001,-0.0012, -0.0011 and -0.0012, respectively. The impact of certified seed on weighted average age of varieties Bahar, Pishtaz, Alvand and Pishgam varieties were positive and identical 0.00003 (Table 11).

Smale et al. (2008) show that the time trend is positively correlated with wheat yields. Brennan and Byerlee (1991), and Heisey and Brennan (1994) also show that in developed countries, the coefficient of time trend is negative (–0.01). They show that in the period of 1970-80, the coefficient of time trend in North Argentina, and Australia for the period of 1970-85 are –0.06 and –0.11, respectively. The coefficient for time trend in Kansas, USA, for the time period of 1970-86 was positive and 0.06 (Table 12).

4. Conclusion and Recommendation

The main goal of this study was to evaluate the rationality of Iranian wheat breeding program. This paper adopted an economic analysis for investigating the justification of investments in wheat breeding programs on most important irrigated bread wheat varieties. In this regard, NPV, IRR and BCR, and replacement index as the most popular economic indices, were applied. Given the results of the research, costs reduction of Mehregan, Shush, Baharan varieties and Narin variety were estimated 184.9, 107, 600 and 735.7 Iranian Rials, respectively. Shift in supply curve (%) for Mehregan, Shush, Bharan varieties and Narin variety were estimated 4.7%, 1.9%, 5.7% and 6.4%, respectively. The number of implementation sites for wheat variett breeding was 201 sites, while the proportion (%) of implementation sites for national and international origins were 24.4% and 75.6%, respectively. Total costs of researchers and technicians were estimated 79,000 and 32,000 million Iranian rials. NPV, BCR and IRR of four irrigated wheat varieties were estimated 1193200 million Iranian rials, 5.6 and 48.5%. The NPV of Mehregan, Shush, Baharan with international origin were estimated 226200, 211000 and 469200 million Iranian Rials. The BCR of Mehreghan, Shush, Baharan were estimated 4.6, 1.5 and 12.2. The IRR of Mehreghan, Shush, Baharan were estimated 47.5%, 28.5% and 72.9%. The NPV, BCR and IRR of Narin variety with national origin were estimated 415200 million Iranian rials, 7.7 and 51.1%. The weighted average age of irrigated wheat varieties was estimated 7.72 years in 2004-2016. The weights average age of world wheat varieties and developed countries was estimated 8.4 and 7.1 year.

All economic indices approved the justification of Iranian wheat breeding programs. That means the subordinate institutions, especially Iran Agricultural Research Organization, should support the policies that accelerate the rate of variety change and the ways that can lead to contribute to a better distribution of these varieties in all zones, as Smale et al. (2008) indicated. Using these new varieties, introduced by wheat breeding program, we can avoid the excessive water loss and increase the tolerance to salinity of water and soil and also resistance to various diseases. As Asadi and Saeedi (2004) express, these supports can also lead to the reduction of outflow of currency. The results confirmed the success in Iran wheat research programs, however, a considerable share of these varieties is still not replaced by the old varieties. In order to take the advantages of new improved varieties, it is recommended that Iran Agricultural Promotion Organization institutionalize the positive prospect of wheat breeding program through more specific precise related programs.

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Appendix

Tab. 1. *- Seed multiplication and supply program (need) of irrigated bread wheat for four Agro climatic Zones in Iran in 2015-2016 (unit ton)*

Agro-ecological zones	Number of varieties	Certified Seed	Registered Seed	Breeder-3 Seed	Total
Northern Warm and humid (ZONE I)	5	29755	2565	302	32622
Southern Warm and Dry of (ZONE II)	6	89240	6793	501	96534
Temperate (ZONE III)	10	49912.5	4429	495	54836.5
(ZONE IV) Cold	5	61198	5020	515	66733
Studied Irrigated bread wheat varieties	26	230105.5	18807	1813	250725.5
Total Irrigated bread wheat varieties	47	300725.5	.0 26812	2395.5	329933
Share of seed of Studied bread wheat varieties (%)	55.3	76.5	70.1	75.7	76

Sources: Reference No. 7

Tab. 2. *- Purchased and needed seed of irrigated bread wheat from/by public and private sectors in 2015-2016 (unit: ton)*

Seed Class	Purchased		Needed
	Public	Private	
Certificated Seed	42992	257733.5	300725.5
Registered Seed	9069	19476	26812
Breeder-3 Seed	2031.5	648	2395.5
Total Irrigated bread wheat varieties	54092.5	277857.5	329933.0
Share of Irrigated bread wheat varieties as proportion of total irrigated wheat (%)	77.6	68	69.4

Sources: Reference No. 2, 7.

Tab. 3. *- Impact of irrigated wheat breeding program on yield, cost and shift of supply*

Origin of Variety	Variety	Impact of breeding program on yield		Impact of breeding program on cost			Shift of supply curve (%)
		Increase in yield of new variety relative to check (kg/ha)	increasing yield of new variety relative to check (%)	Production costs for new variety (rial/kg)	Production costs of check variety(rial/kg)	Costs reduction in new variety (rial/kg)	
International	**Mehrgan**	218	4	4639.7	4824.6	184.9	4.7
	Shush	124	2.3	4717.6	4824.6	107	1.95
	Baharan	500	11.9	5608.7	6208.8	600.1	5.7
National	**Narin**	589	13.7	5386.7	6122.4	735.7	6.4

Sources: Study Survey

Tab. 4. *- The costs of projects, researchers and technician based on project type for irrigated bread wheat varieties released in 2014 (unit: million Iranian rial)*

Origin	type Project	No of sites	No of Researchers	No of Technician	Costs of Researchers	Cost of Technicians	Total Costs of Researchers and Technicians	Costs of Project and Germplasm exchange
International	Breeding	21	29	27	2702.5	1564.6	4267.3	248.2
	Pathology	18	29	9	6724.9	1122.9	7847.4	400
	Quality	2	2	4	384.6	339.5	724.1	40.3
	On-Farm	4	12	11	2731.4	1029.2	3760.7	76.8
	Research-	4	9	8	2870.2	1239.2	4109.5	58.8
	Total	49	81	59	15413.6	5295.4	20709	765.3
International	Breeding	53	65	66	10378.7	5245.4	15623.9	3853.4
	Pathology	77	149	111	36411.6	12578.9	48991	1973.6
	Quality	4	4	8	1186.3	1256.8	2443.1	112.6
	On-Farm	12	23	19	6662.5	2751	9413.4	236
	Research-	6	22	15	8818	4899.2		13717.1
	Total	152	263	219	63457.1	26731.3		90188.5
Total		**201**	**344**	**278**	**78870.7**	**32026.7**		**110897.5**

Sources: Study Survey

Tab. 5. *- Profitability of released irrigated bread wheat variety with different origines in 2014*

Year of Release	Origin	Varieties	Net present value (NPV) (billion Iranian rials)	Benefit-cost ratio	Internal rate of return (%))IRR
2014	**International**	**Mehrghan**	266.2	4.6	47.5
		Shush	211	1.5	28.5
		Baharan	469.2	12.2	72.9
	National	**Narin**	415.2	7.7	51.1
	Total		**1193.2**	**5.6**	**48.5**

Sources: Study Survey

Tab. 6. - Descriptive analysis of certified seed and replacement index in 2004-2016

Certified seed (ton)				**Replacement Index (year)**			
Mean	Std.Dev	Min	Max	Mean	Std.Dev	Min	Max
198596.3	32560.4	140277	237288	7.72	2.32	4.5	12

Sources: Study Survey

***Tab. 7.* –** Descriptive analysis of certificated seed and Replacement Index Of irrigated wheat varieties in 2004-2016 (unit: tone/year)

Origin	Growth Habit	Varieties	**Mean**		**Std.Dev**		**Min**		**Max**	
			Certificated seed	Replacement Index	Certificated seed	Replacement Index	Certificated seed	Replacement Index	Certificated seed	Replacement Index
International	Spring	Morvarid	18455.2	0.72	6164.3	0.66	9310	0.08	26190	1.62
		Chamran	82508	3.8	20958	1.64	52160	1.74	120079	6.63
		Shiroodi	10269.1	0.48	3287	0.25	4100	0.13	15405	0.87
		Bahar	11038.5	0.32	6537	0.22	1200	0.04	19565	0.57
	Facultative and Winter	Zarin	8843.3	-	3662.6	-	500	-	13576	-
National	Spring	Pishtaz	21070.4	0.62	9064.1	0.	3755	0.04	35480	1.04
	Facultative and Winter	Alvand	14327	0.69	5860.8	0.18	4837	0.34	25380	0.98
		Pishgam	22467	0.54	17605.3	0.5	3875	0.06	46581	1.2

Sources: Study Survey

Tab. 8. *- Certified seed of some Irrigated bread wheat varieties in different scenarios in 2004-2016*

Year	Senario			International origin				National origin		
		Chamran	Shiroodi	Morvarid	Tajan	Bahar	Zarin	Pishtaz	Alvand	Pishgam
2003-2004	Need	53151	4100	-	18556	-	6050	3755	13325	
2004-2005	Need	52160	6430		18326	-	8110	8250	15900	
2005-2006	Need	70287	7700	-	15850	-	10150	11250	18517	
2006-2007	Need	70170	7900	-	7600	-	12700	17450	21810	
2007-2008	Need	77800	9510	-	1800	-	13050	25970	25380	
2008-2009	Need	81856	10210	-	1000	11346	13576	29779	19563	
2009-	Need	77798	9518	-	800	14578	10131	21939	13085	

2010										
2010-2011	Need	75750	10600	-	500	16460	11100	25140	14065	
	Purchase	111093	10314	13753	147	14297	2412	21060	9332	
2011-2012	Need	111870	11095	9310	200	19565	9770	35480	11985	
	Purchase	69878	5720	16332	-	4552	2729	10763	2320	2184
2012-2013	Need	108432	15405	21205	50	14596	6687	27929	11824	3875
	Purchase	75203	2218	22469	-	2501	5016	12828	4412	13739
2013-2014	Need	120079	14530	26190	-	7363	7939	25943	8870	14037
	Purchase	81108	8378	16194	-	1294	4804	14327	4343	22211
2014-2015	Need	94250	12800	17596	-	3200	5200	23340	7090	27375
	Purchase	83887	15357	17904	-	563	969	12945	3884	39778
2015-2016	Need	79000	13700	17975	-	1200	500	17690	4837	44581

Sources: 1. Study Survey 2.Reference No.

Tab. 9. *- Variety Replacement index (VRI) for some Irrigated bread wheat varieties in different scenarios in 2004-2016*

Year	Scenario	International origin						National origin		
		Chamran	Shiroodi	Morvarid	Tajan	Bahar	Zarin	Pishtaz	Alvand	Pishgam
2003-2004	Need	1.74	0.13	-	0.78	-	0.26	0.04	0.56	
2004-2005	Need	1.86	0.23	-	0.82	-	0.36	0.11	0.71	
2005-2006	Need	2.47	0.27	-	0.68	-	0.44	0.18	0.8	
2006-2007	Need	2.53	0.28	-	0.33	-	0.55	0.31	0.94	
2007-2008	Need	2.55	0.31	-	0.07	-	0.51	0.46	0.98	
2008-2009	Need	2.8	0.35	-	0.04	0.06	0.54	0.59	0.78	
2009-2010	Need	3.5	0.43	-	0.04	0.41	0.53	0.61	0.68	
2010-2011	Need	3.8	0.53	-	0.03	0.53	0.63	0.81	0.8	
	Purchase	5.5	0.51	0.1	0.01	0.45	0.14	0.67	0.53	
2011-2012	Need	4.9	0.5	0.08	0.01	0.57	0.49	1.04	0.6	
	Purchase	6.4	0.53	0.3	-	0.28	0.28	0.66	0.24	0.05
2012-2013	Need	5.77	0.82	0.28	0.003	0.53	0.4	1.02	0.71	0.06
	Purchase	6.5	0.19	0.49	-	0.15	0.49	0.77	0.43	0.37
2013-2014	Need	6.63	0.8	1.62	-	0.29	0.49	1.01	0.55	0.27
	Purchase	6	0.62	0.35	-	0.07	0.4	0.75	0.36	0.58
2014-2015	Need	5.7	0.77	1.2	-	0.14	0.35	1.01	0.47	0.64
	Purchase	5.52	1.01	0.39	-	0.03	0.07	0.62	0.28	1.02
2015-2016	Need	5	0.87	0.42	-	0.04	0.04	0.82	0.34	1.19
Average vRI	Need	3.8	0.48	0.72	0.28	0.32	0.43	0.62	0.69	0.54
	Purchase	6	0.57	0.33	-	0.2	0.28	0.69	0.37	0.51

Sources: Study Survey

Tab. 10. *- Weighted average age and lag time for varietal adoption of irrigated wheat varieties in different countries*

Region/ Country	**Period**	**Weighted average age**		**lag and time for varietal adoption**		
		1970	1980	Average time from varietal release to 10% adoption	Average time from adoption initiation up to 95% adoption	Time to reach 95% adoption
Punjab, Pakistan	1978-86	11.8	10.9	3	7.5	10.5
Punjab, India	1978-86	5.4	5.3	-1.1	5.9	4.8
Yaqui Valley, Mexico	1972-86	2.6	3.7	1	1.8	2.8
Parana, Brazil	1979-85	7.3	10.5	4.5	3.8	8.3
Argentina	1970-80	6.7	7.9	-0.4	5.5	5.1
Kansas, USA	1970-86	6.6	6.9	1.8	2.3	4.1
Australia	1970-85	7.7	7.4	1.3	3.7	5
New Zealand	1970-86	12	7.9	1.1	5.9	7
The Netherlands (winter wheat)	1970-86	5.4	7.6	-1.2	8.2	7
Developing countries	1970-86	6.4	8.9	0.8	6.1	6.9
Developed countries	1970-86	7.1	6.7	1.5	3	4.5
Overall	1970-86	6.7	8.4	1.1	5	6.1

Sources: Brennan and Byerlee, 1991.

Tab. 11. *- The impact of Time Trend and seed on replacement index of Irrigated bead wheat varieties during the time period of 2004-2016*

Origin	Growth Habit	Variety	Estimated coefficient		Beta		**T-Test**		**R^2**
			Time Trend	Certified seed	Time Trend	Certifie d seed	Time Trend	Certified Seed	
International	**Spring**	Morvarid	0.009	0.0001	0.58	0.83	3.4	18	80
	Spring	Chamran	0.0005	0.0001	0.01	0.89	0.1	8.4	79
	Spring	Shiroodi	0.0007	0.0001	0.07	0.97	1.13	8.6	91
	Spring	Bahar	0.001-	0.00003	0.2-	0.8	2.4-	8.1	75
National	Spring	Pishtaz	0.0012-	0.00003	0.1-	0.8	0.8-	6.8	67
	Facultative	Alvand	0.0011-	0.00003	0.15-	0.94	4.6-	14.1	90
	Facultative	Pishgam	0.0012-	0.00003	0.11-	1.1	3.4-	30.6	99

Sources: Study Survey

Tab. 12. *- The impact of Time Trend on replacement index In Developed countries*

Regions/ Countries	**Period**	**The Average of Replacement Indexes**	**Time Trend**
North) (Argentina	1970-80	6.8	0.06-
Kansas, USA	1970-86	6.7	0.06
Australia	1970-85	7.6	0.11-
Developed countries	1970-86	7.1	0.01-

Sources: Brennan and Byerlee, 1991. Heisey and Brennan, 1994.

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