Participatory Bread Wheat Breeding in Fars Province

Contents

The International Treaty on Plant Genetic Resources for Food and Agriculture

IFAD Enabling poor rural people to overcome poverty

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Cenesta Centre for Sustainable Development

Background

Participatory plant breeding (PPB) has been practiced for several reasons, including sociological, humanitarian, and egalitarian. However, PPB should be practiced simply because it increases plant breeding efficiency, which is defined as 1) the ratio between the number of varieties adopted and the number of crosses made, 2) the response to selection, and 3) the benefit/cost ratio, not only as often done by public breeding programs, by the number of varieties released. In fact, without adoption, no benefit from plant breeding will occur. The three measures of breeding efficiency can be increased by combining decentralized selection with farmers' participation in a PPB program. The essential features of a PPB program are: a) the objectives are established in communication with the farmers; b) the breeding material is tested in farmers' fields; c) farmers are involved in all major decisions and particularly in deciding which material to carry further and which material to discard at the end of each cropping season; d) locations, chosen to sample as extensively as possible the target populations of environments and users, are treated as independent units of selection, i.e., selection is done within each location regardless of how the best breeding lines in that location perform in other locations, i.e. selection is fully decentralized and is for specific adaptation; e) the agronomic management of the trials is established with the farmers' consent, and different agronomic options, including organic farming, can be incorporated into the breeding trials; f) the objectives of the program are continuously monitored with the participating farmers.

Since its inception in Syria, PPB has been implemented in Morocco, Tunisia, Yemen, Egypt, Jordan, Eritrea, Ethiopia, Uganda, Algeria, Italy, France and Germany with crops such as barley, bread and durum wheat, lentil, chickpea, faba bean cowpea, tomato and cauliflower) and there have been different types of impacts ranging from a) varieties developed and the consequent economic benefit to farmers, b) farmer (men and women) empowerment, c) changes in policies (e.g. change of the variety release system in Jordan), d) institutionalization of participatory plant breeding as in Yemen, partly in Morocco, Jordan, Algeria and Eritrea), and e) capacity building of the scientists associated with the projects. In Iran PPB began in 2006 with barley in Garmsar (Semnan province), an area with irrigated agriculture, and shortly after in Kermanshah province, under rainfed conditions, with both barley and wheat.

The partners

The Centre for Sustainable Development (CENESTA) is a non-governmental, non-profit organization dedicated to promoting sustainable community- and culture-based development. Its main area of work is Iran and Southwest Asia. CENESTA experts have also engaged in extensive activities in Africa, Latin America, Asia, and in the international arena in general. CENESTA is a member of IUCN—the World Conservation Union and is affiliated with the University of the North (Iran).

CENESTA works with a variety of partners, from local communities in Iran and other countries to local and national governmental agencies, from universities and research organizations to national and international NGOs. The UN bodies with which CENESTA and its experts entertain on-going collaboration include UNDP, FAO, UNICEF, UNSO, IFAD, UNCCD and the UN Secretariat.

The Department of Agriculture of Fars Province is an Iranian government body established in 2001with the goal of:

- Preservation, restoration, development and utilization of water, soil, renewable natural resources (forest, pasture and water resources) and plant genetic resources and aquatic animal;

- Increasing the quantity and quality of agricultural production to ensure food security and improving nutrition in the country, self-reliance in basic agricultural products, export development and increasing per capita income of workers in the agricultural sector in the context of sustainable development;
- Development and organization of tribal villages in order to improve the socio - economic conditions of villagers and nomads;
- Reform and development of the system operation and effective participation of villagers, nomads, producers, farmers and NGOs to improve the productivity of the agricultural sector.

The consultant, Dr. Salvatore Ceccarelli has been a Professor of Genetics and Plant Breeding at the University of Perugia (Italy), the manager of the barley breeding program at ICARDA till 2006, and as a consultant till 2014. He has started implementing PPB programs in 1996 and Evolutionary Plant Breeding (EPB) programs in 2008. Currently lives in India and is a Free Lance Consultant. During his career he supervised nearly 25 MSc and PhD students, trained several scientists and published more than 250 papers of which nearly 150 in referee Journals; has been an invited speaker at nearly 30 international conferences.
His areas of expertise are international plant breeding, genotype x environment interaction, breeding strategies, drought tolerance, participatory and evolutionary plant breeding, adaptation, use of genetic resources, food safety, and food security.

The roots of the Shiraz Chamber of Commerce, Industry, Mine and Agriculture (SCCIMA) are to be found in the history of Iran's economy. From the presence of the Silk Road, the crucial thoroughfare of Iran's economy, Fars province has had a great and productive role in thriving the country economic transactions. Shiraz Chamber of Commerce established in 1928 with the purpose of the aggregation of the merchants and the organization of the Fars export condition. Having joined a few city merchants, the chamber were transformed to the "Shiraz Merchants Union". Gradually, with the economic growth, export development, being acquainted and having transactions with the other countries' merchants, it has been converted to Shiraz Chamber of Commerce, Industry, Mine and Agriculture. SCCIMA has 8 active specialized commission on different fields. Agriculture and food industries commission has provided in-kind support to the project in Fars Province.

PPB wheat breeding in Fars Province

In 2011, a meeting at the Department of Agriculture of Fars province was organized by CENESTA with about 30 Ministry officials and scientists. After the consultant's presentation on PPB and EPB, there was a lively discussion with the request of specific details on both the PPB and EPB methodology (Figure 1).

Fig. 1. First meeting on PPB in the Department of Agriculture of Fars province Headquarters, Shiraz

Later, the Director of the Department, who was not able to attend the meeting, was briefed about the progresses and the achievements of the Garmsar program during its first five years (see separate report "Participatory Plant Breeding in Iran: Report of the first five years (2006-2011)" available on the IFAD Asia resource page of the project) and requested a project proposal which was prepared, translated and submitted shortly after (Figure 2).

Fig. 2. Briefing the Director General of the Department of Agriculture of Fars province

The area and the crop

In Fars province the total cultivated area is about 1.1 million ha. Of these, between 60% and 70% is represented by cereals, namely wheat and barley. Beets, corn, vegetables, oilseeds are the other most cultivated crop. Citrus is cultivated on about 30.000 ha.

Wheat is cultivated on nearly half a million ha of which 300.000 – 350.000 ha irrigated and 80.000-100.000 ha rainfed, while barley is grown on about 230.000 ha of which 100.000 – 110.000 ha irrigated and 100,000 – 130,000 ha rainfed.

The Department of Agriculture decided to give priority to rainfed wheat because of the strategic importance of the crop and because wheat breeding in the province was directed at irrigated areas. For this reason it was decided to use as starting material breeding lines developed by the dryland bread wheat breeding program headed by Dr R. Haghparast of the DARI Sub Station at Sararood.

The Department of Agriculture selected three areas in Fars province and the project started officially with visits by CENESTA and the consultant to the three locations where they met with farmers (Figure 3) to discuss with them the PPB approach, its implications and its expectations, and with the local technical staff to discuss technical issues related to planting and data recording (Figure 4).

Fig. 3. Meeting with farmers at the onset of the project

Fig. 4. Meeting with the technical staff in the target locations

Results

First year (2011 – 2012)

The first cycle of PPB in wheat started in Fars with 83 entries including 78 bread wheat breeding lines, 3 varieties recently released (Azar-2, Rijaw (Pato), and Hammam-4), one landrace (Sardari) widely grown throughout Iran, and one landrace (Kal Heydari) widely used in the project area (see APPENDIX I for the list of materials). The experiment included 100 plots with one check variety repeated six times and the other two check varieties repeated seven times, using a partially replicated design in rows and columns. This design allows a good compromise between number of plots and precision of the experiment.

The trial was planted with different randomizations in two villages in Shiraz region, (Kodyan and Hemat Abad), one village in Nour Abad- Doshman Ziari region (Tolombe Khaneh Hassani), one village in Nour Abad – Mahour region (Baba Monier) and two villages in Abadeh region (Khosro and shirin and Mohamad Abad).

The technical staff of the Department of Agriculture planted the trials and organized the data collection and the farmer selection. Data were collected on plant height, percent frost damage, percent of lodging, resistance to brown rust, resistance to yellow rust, number of plants per square meter, number of seeds in per spikes, 1000 kernel weight and grain yield. One CENESTA staff compiled the data and the consultant run the statistical analysis.

Between 5 (Abadeh - Mohamad Abad) and 15 (Shiraz- Hemat Abad) farmers gave a score to all 100 plots in their own location. Farmers decided to conduct selection only once, and decided to score a number of traits such as tillering, height, spike length, number of spike per m^2, lodging and maturity using, for each character a score from 0 = bad to 5 = highly desirable.

Eventually one location (Abadeh- Khosro and shirin) failed and therefore in 2012 we obtained data only from 5 locations.

Table 1. Mean, minimum and maximum grain yield (kg/ha) of 83 barley lines grown in 5 locations in 2011-2012.

Location	Mean Yield	Best line	Best check	Kal Heydari
Shiraz- Kodyan (L1)	187.7	377.6	177.8	343.2
Shiraz- Hemat Abad (L2)	1502.3	3235.3	1077.8	1273.5
Abadeh- Mohammed Abad (L4)	406.3	468.4	468.4	401
Nour Abad- Doshman Ziari (L5)	2211.2	3067.5	3067.5	2176.8
Nour Abad- Mahour (L6)	350.1	539.2	427.2	361.3

Average grain yield varied considerably both between locations and within locations (Table 1). In all locations the best lines out yielded the widely grow landrace Kal Heydari, and in four locations also the best check, among the recently release varieties. In Abadeh- Mohammed Abad and Nour Abad- Doshman Ziari the best line was the recently released variety Hammam-4. There was a large interaction between locations (Figure 5) with the released variety Hammam-4 being the best in Abadeh- Mohammed Abad and Nour Abad- Doshman Ziari, entry 65 in Nour Abad- Mahour and a group of lines such as 3, 5 and 30 performing better than average in Shiraz- Kodyan and Abadeh- Mohammed Abad.

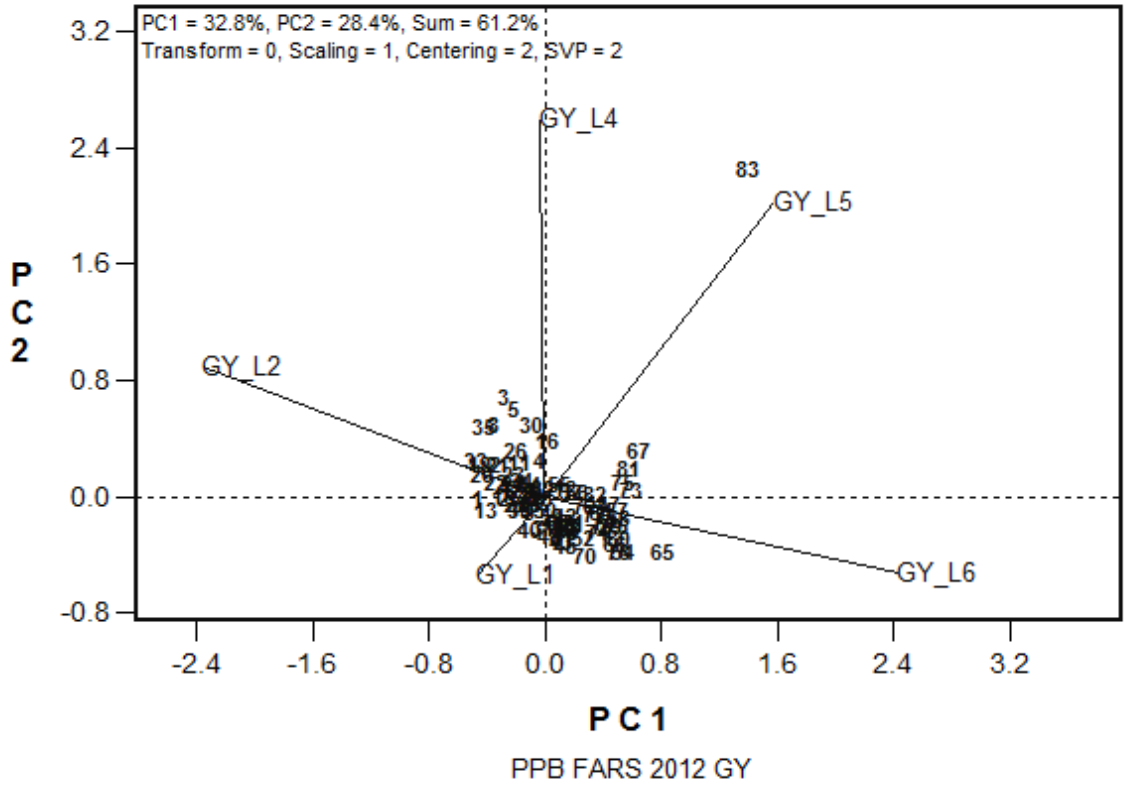


Fig. 5. Biplot of grain yield of 83 breeding lines of wheat measured in 5 locations in Fars province (L1 = Shiraz- Kodyan; L2 = Shiraz- Hemat Abad; L4 = Abadeh- Mohammed Abad; L5 = Nour Abad- Doshman Ziari and L6 = Nour Abad- Mahour) in 2011-2012.

The lumping of lines close to the point of origin indicates a low degree of genetic variation, a common feature of conventional plant breeding program. Contrary to grain yield, farmers' preferences differed considerably between locations (Fig. 6) with the exception of locations 5 and 6 in which farmers have nearly identical preferences. While the recently released variety Hammam-4 was the highest yielding in two locations, it does not appear among those score highly by farmers who, at least in three locations preferred much more another recently released variety, namely Rijaw (Pato).

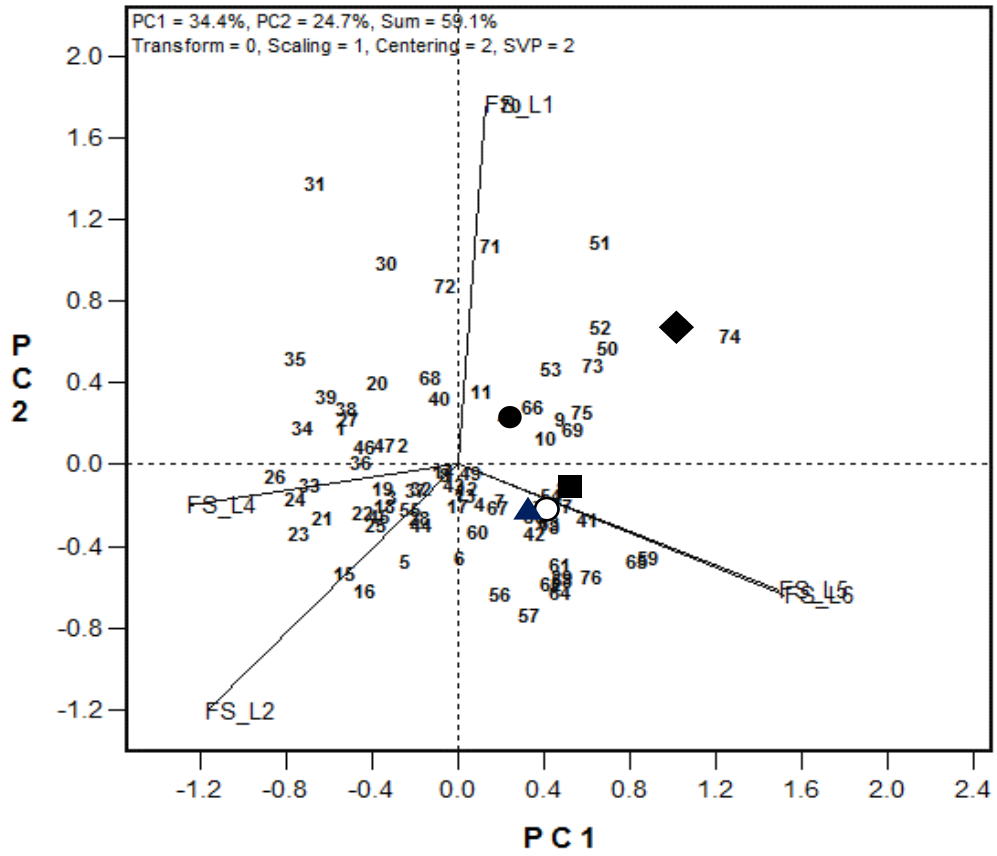
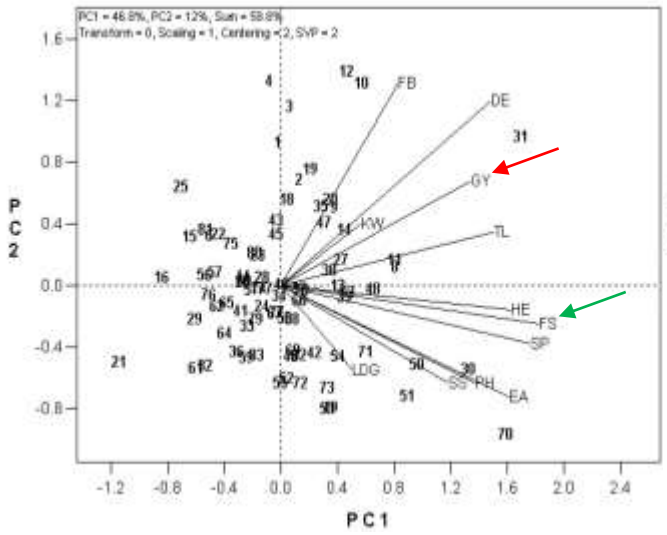
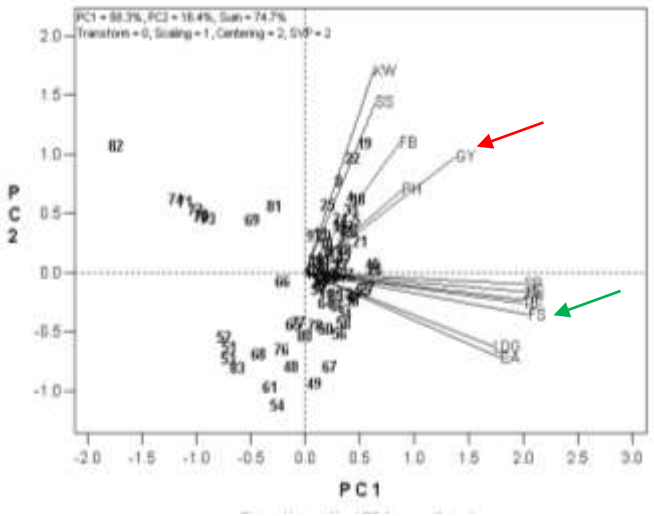


Fig. 6. Biplot of farmers' preferences for 83 breeding lines of wheat measured in 5 locations in Fars province (L1 = Shiraz- Kodyan; L2 = Shiraz- Hemat Abad; L3 = Abadeh- Mohammed Abad; L4 = Nour Abad- Doshman Ziari and L5 = Nour Abad- Mahour) in 2011-2012. Symbols are as follows: close circle = Kal Heydari, open circle = Sardari, square = Hammam-4, triangle = Azar 2 and diamond = Rijaw (Pato).

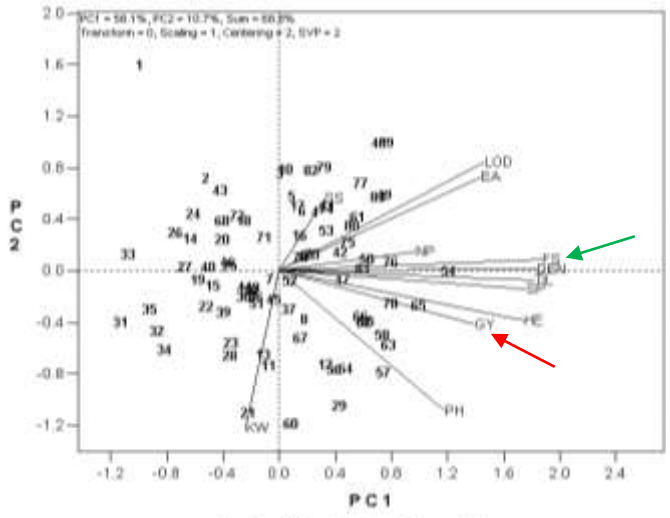
The spreading of the lines suggests that grain yield was not the main selection criterion: in fact as shown in Figure 7 and with the exception of Nour Abad- Doshman, in which the farmers score (FS, shown with a green arrow) is closely correlated with grain yield (shown by a red arrow), but even more closely correlated with plant height, in all other locations farmers score is more closely correlated to other traits such as plant height, tillering and spike length.



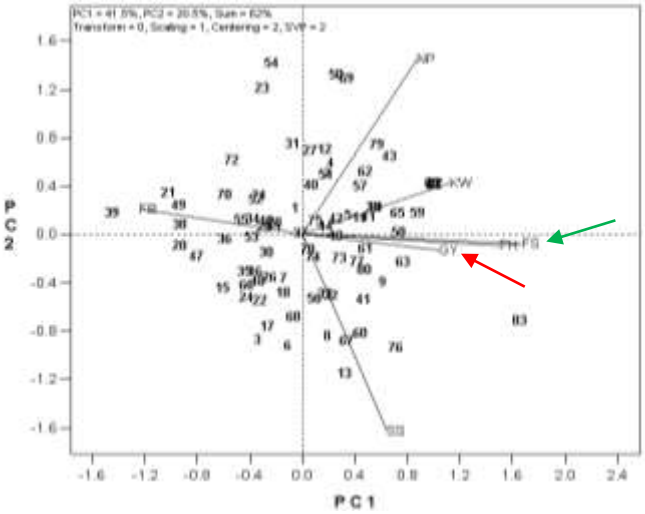
Shiraz Kodyan



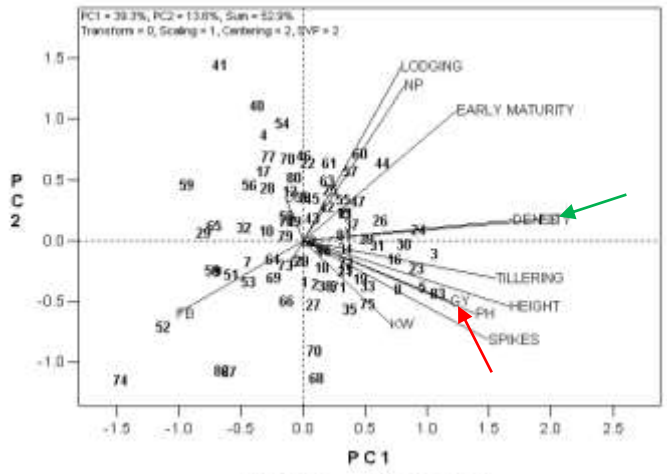
Shiraz Hemat Abad



Nour Abad- Mahour



Nour Abad- Doshman Ziari



Abadeh- Mohammad Abad

Fig. 7. Biplots of farmers' by traits preferences for 83 breeding lines of wheat measured in 5 locations in Fars province (L1 = Shiraz Kodyan; L2 = Shiraz Hemat Abad; L3 = Abadeh Mohammed Abad; L4 = Nour Abad Doshman Ziari and L5 = Nour Abad Mahour) in 2011-2012.

At the end of the first year nearly all lines (namely 73) were selected in either one village or another. The majority of lines were selected only in one village (19 lines) or two villages (43 lines). Few lines were selected in three villages (9 lines) and even less in four (2 lines).
Farmers in Nour Abad- Mahour asked to add three landraces typical of the area, namely Zagros, Kouhdasht and Niknejad.

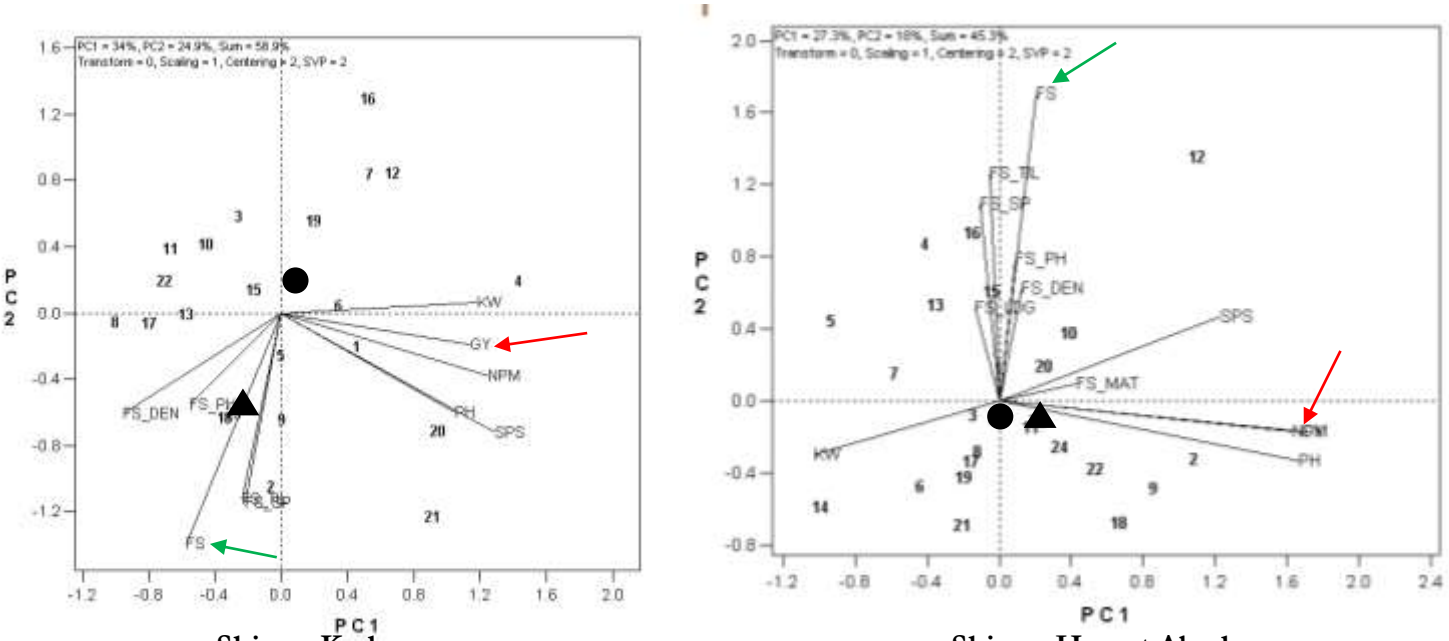
Second year (2012 – 2013)

The lines selected were used to design the second stage trials which were planted in November 2012 in four of the six villages used in the first year, namely Shiraz- Kodyan, Shiraz- Hemat Abad, Nour Abad- Doshman Ziari and Nour Abad- Mahour.

Table 2. Average grain yield in 2013, grain yield of the best line, of the best check and of the widely grown landrace Kal Heydari in PPB trials evaluated in four locations in Fars province.

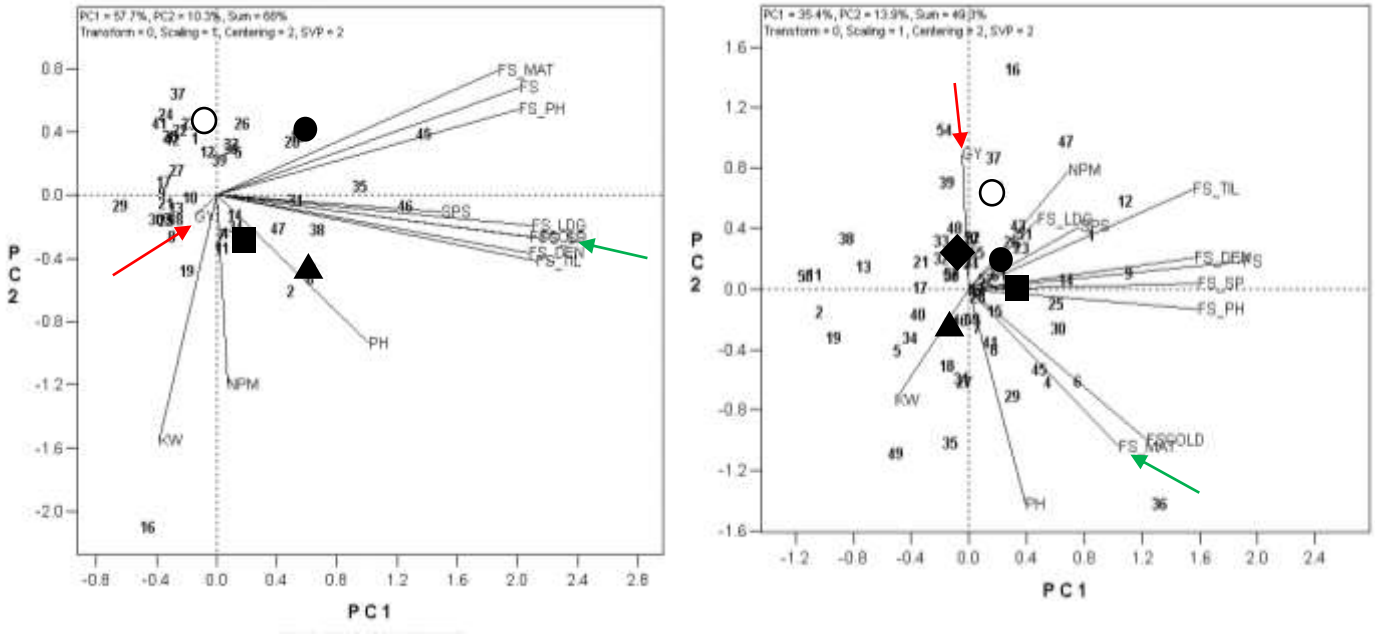
Location	Mean Yield	Best line	Best check	Kal Heydari
Shiraz- Kodyan Abad	695.9	964.7	651.8	718.5
Shiraz- Hemat Abad	306.1	568.2	244.1	317.4
Nour Abad- Doshman Ziari	1831.6	3630.1	2263.8	2041.7
Nour Abad- Mahour	459.2	904.5	503.4	580.8

In all four locations there were lines out yielding both the best check as well as the widely grown landrace Kal Heydari (Table 2). In the two Shiraz locations (Fig. 8) a number of lines were scored by farmers better than both Kal Heydari and the released variety Azar-2, used as improved check in both locations.



Shiraz- Kodyan **Shiraz- Hemat Abad**

Fig. 8. Biplots of farmers' by traits preferences for the wheat breeding lines tested for the second year in Shiraz- Kodyan and in Shiraz- Hemat Abad (the red arrow indicated grain yield, the green arrow the farmers' preference. Symbols are as follows: close circle = Kal Heydari and triangle = Azar 2.



Nour Abad- Mahour **Nour Abad- Doshman Ziari**

Fig. 9. Biplots of farmers' by traits preferences for the wheat breeding lines tested for the second year in Nour Abad- Mahour and Nour Abad- Doshman Ziari (the red arrow indicated grain yield, the green arrow the farmers' preference. Symbols are as follows: close circle = Kal Heydari, open circle = Sardari, square = Hammam-4, triangle = Azar 2 and diamond = Rijaw (Pato).

A similar situation was found in the second area (Nour Abad, Fig.9) with farmers scoring three lines in Nour Abad- Mahour and six lines in Nour Abad- Doshman Ziari higher than the recently released varieties Azar-2 and Hammam-4 and the landrace Kal Heydari, respectively.

Third year (2013 – 2014)

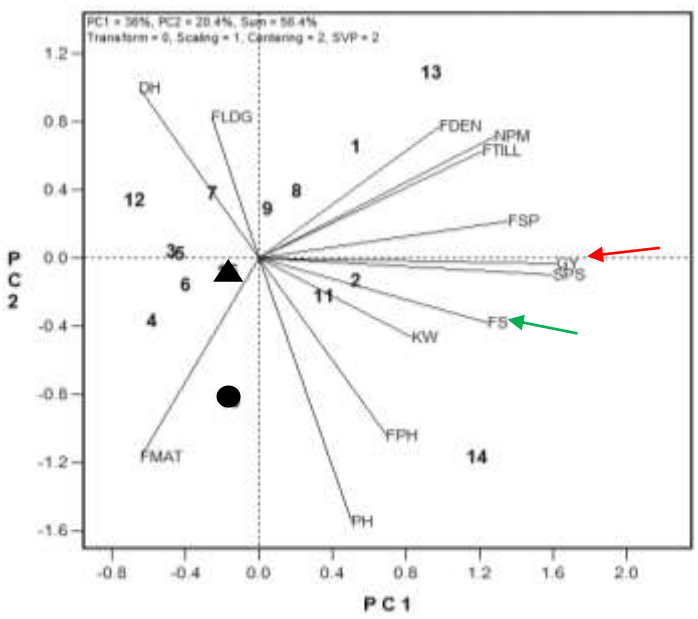
At the end of the second year a total of 63 different lines (excluding the checks) were selected: 13 lines were selected in Shiraz- Kodyan, 18 in Shiraz- Hemat Abad, 40 in Nour Abad- Doshman Ziari and 32 in Nour Abad- Mahour. 30 lines were selected only in one village, 29 lines in two villages and 4 lines in three villages.

All the third year trials were planted according to a fully replicated (two replications) design in rows and columns.

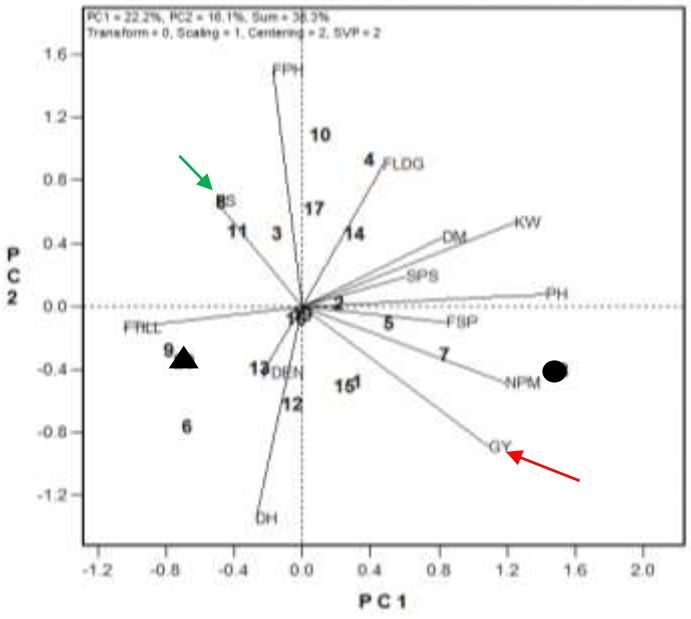
Table 3. Average grain yield in 2014, grain yield of the best line, of the best check and of widely grown landrace Kal Heydari in PPB trials evaluated in four locations in Fars province.

Location	Mean Yield	Best line	Best check	Kal Heydari
Shiraz- Kodyan	313.7	336	315.8	315.8
Shiraz- Hemat Abiad	401.8	551.8	551.8	551.8
Nour Abad- Doshman Ziari	2109.6	2885.4	2525.8	2280.9
Nour Abad- Mahour	1854.5	2399.5	2010.9	1760.2

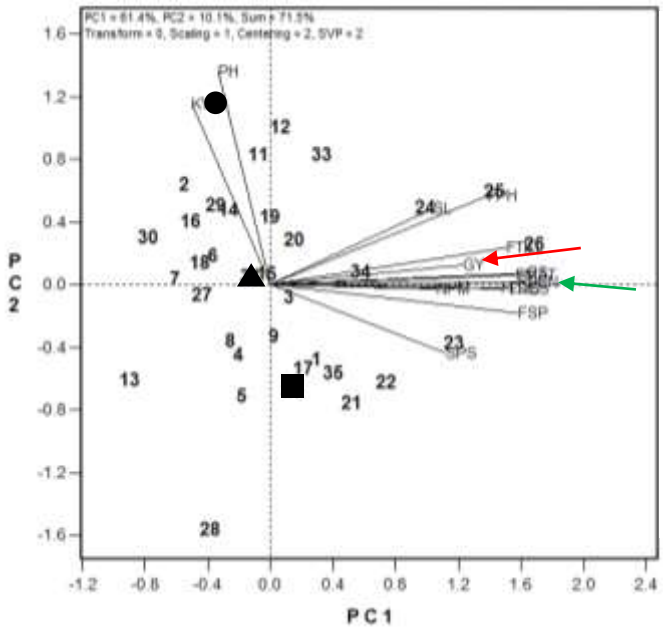
In Shiraz area, Kal Heydari did very well being either the best line or the best check, while in Nour Abad- Doshman Ziari and Nour Abad- Mahour the best check was always one the recently released varieties, although in both locations it was out yielded by a number of lines (Table 3).



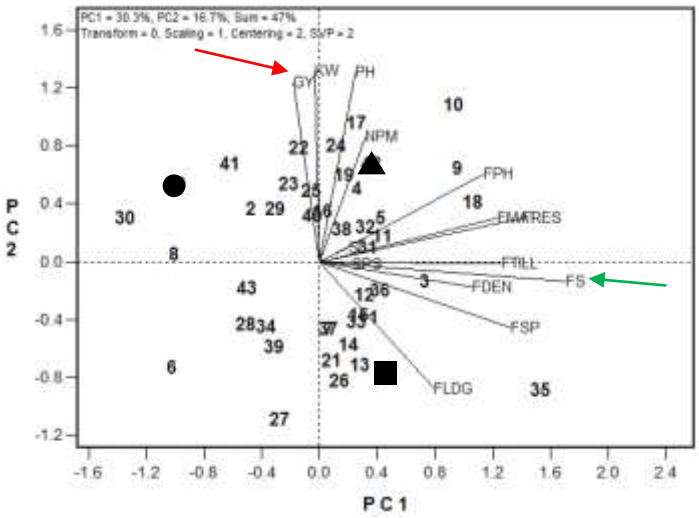
Shiraz- Kodyan



Shiraz- Hemat Abad



Nour Abad- Mahour



Nour Abad- Doshman Ziari

Fig. 10. Biplots of farmers' by traits preferences for the wheat breeding lines tested for the third year in Shiraz- Kodyan, Shiraz- Hemat Abad, Nour Abad- Mahour and Nour Abad- Doshman Ziari (the red arrow indicated grain yield, the green arrow the farmers' preference, Symbols are as follows: close circle = Kal Heydari, open circle = Sardari, square = Hammam-4, triangle = Azar 2 and diamond = Rijaw (Pato).

In Shiraz- Kodyan, grain yield, number of seed per spike and 1000 kernel weight were the traits in which farmers were more interested: a number of lines such as 13, 14, 1, 2 and 11 yielded more than both Kal Heydari and Azar-2 (Fig. 10).

In Shiraz- Hemat Abad, farmers had a strong preference for plant height and lodging resistance rather than for grain yield. As a consequence, Kal Heydari which was the highest yielding was only ranking 16th out of 20 for farmers' preference which was much higher for entries such as 10, 11, 3 and 17.

In Nour Abad area we observed a similar difference among locations for farmers' preferences: in Nour Abad- Mahour farmers selected mainly for grain yield, spike length and seed per spike. Kal Heydari was ranking low for both grain yield and farmers' score. Entries 22, 23, 24, 25 and 26 were both the highest yielding and the most preferred by the farmers. In Nour Abad- Doshman Ziari farmers had a stronger preference for tillering, spike length and lodging resistance than for grain yield. Kal Heydari was nearly at the bottom for farmers' preferences. Farmers gave the highest score to line 35 which was ranking only 35th out of 44 for grain yield.

Combined three years results

At the end of the first three years of PPB on wheat, we conducted a combined analysis in each of the four locations to evaluate the stability of performance of the breeding materials during the three cropping seasons.

To compare lines across locations in those cases where they were selected in more than one location, line numbers were coded in such a way that the same code corresponds to the same line.

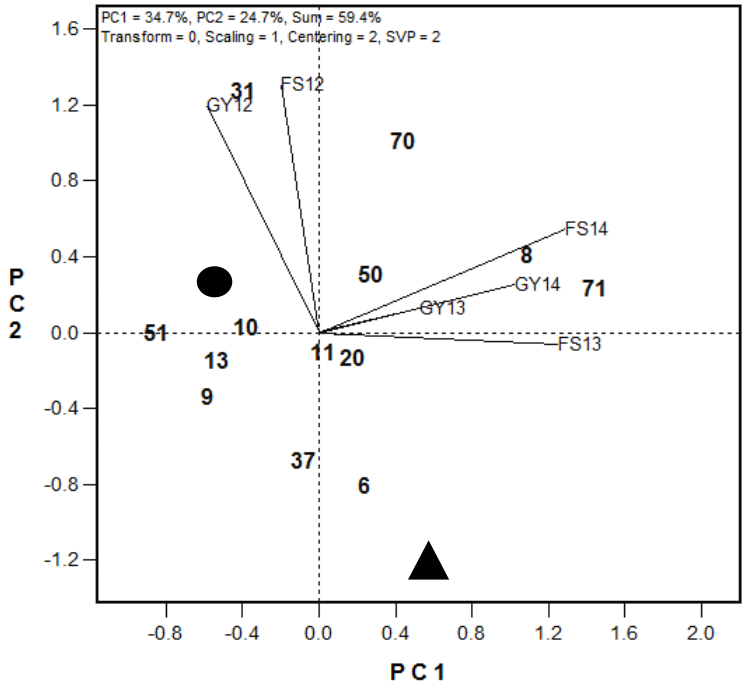
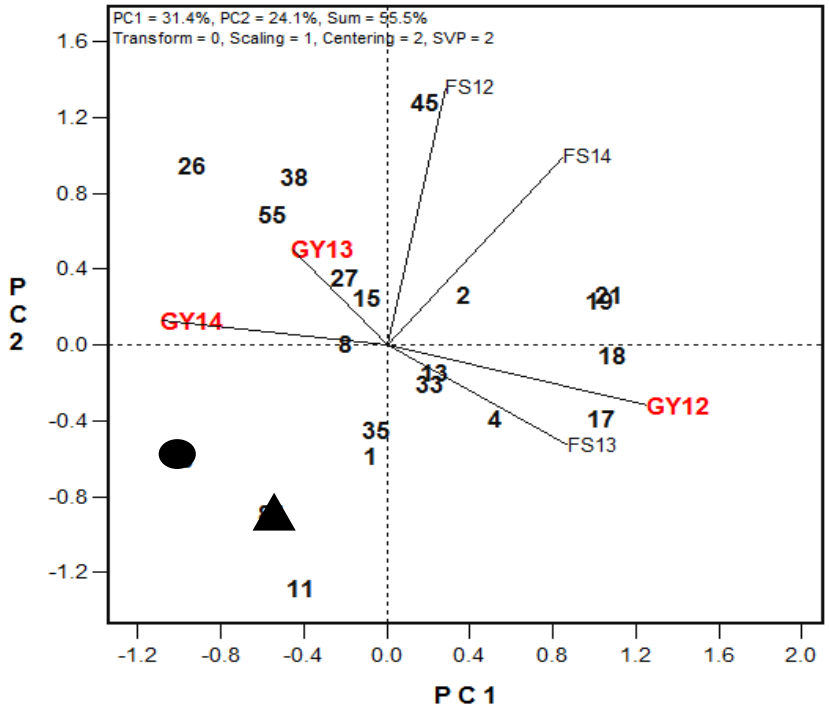


Fig.11. Biplots of farmers' preferences and grain yield for the 15 wheat breeding lines and checks tested for the three years in Shiraz Kodyan. Symbols are as follows: close circle = Kal Heydari, triangle = Azar 2.

In Shiraz- Kodyan, where the two checks used throughout the three years were Kal Heydari and Azar-2, lines 70, 8, 50 and 71 appears as the one which better combine yield and farmers preference with maximum yield advantages of 14% over Kal Heydari and of 41% over Azar 2, and a farmer preference higher 1 to 6% in the case of Kal Heydari and of 2 to 8% in the case of Azar-2 (Table 4).

Table 4. Mean grain yield during three years (mean gy) in Shiraz- Kodyan, % yield advantage over Kal Heydari (% Ky), % yield advantage over Azar-2 (% Az), mean farmers preference (mean fs), % fs advantage over Kal Heydari (% Ky), and % fs advantage over Azar-2 (% Az). The line number is the same as in Figure 11.

Line	NAME	mean	%	%	mean	%	%
6	ZANDER//ATTILA/3*BCN	445.6	0.97	1.20	3.19	0.96	0.98
8	Tix53/89-2//2098-W2-21/Sardari IRW2000-01 - 021-0MAR-	523.2	1.14	1.41	3.35	1.01	1.02
9	Tix53/89-2//2098-W2-21/Sardari IRW2000-01 - 021-0MAR-	412.8	0.90	1.11	3.31	0.99	1.01
10	Ning 83/Rashid//F9,10/Maya"S"/3/1d1189/Mlt//Tui IRW2000-	514.1	1.12	1.39	3.31	1.00	1.01
11	F134.71/NAC//ZOMBOR	481.1	1.05	1.30	3.36	1.01	1.03
13	UNKN/HATUSHA//BEZ/SDV1	463.9	1.01	1.25	3.28	0.99	1.00
20	Rio Blanco/Bai Quan#3039//Sabalan IRW2000-01 - 075-0MAR-	433.3	0.94	1.17	3.31	0.99	1.01
31	CH75479/4/338-K1-1//TJB368.251/BUC/3/KINACI97	445.9	0.97	1.20	3.50	1.05	1.07
37	PYN/BAU//BONITO	472.1	1.03	1.27	3.26	0.98	1.00
48	Kal Heydari	459.2	1.00	1.24	3.33	1.00	1.02
50	KS82142/PASTOR CMSW97WM00399S-0P-0YC-0YE-3YE-	512.0	1.12	1.38	3.44	1.03	1.05
51	Un-11	459.0	1.00	1.24	3.41	1.02	1.04
70	PFAU/SERI.1B//AMAD/3/WAXWING	456.4	0.99	1.23	3.53	1.06	1.08
71	WBLL1*2/BRAMBLING	494.8	1.08	1.34	3.39	1.02	1.04
81	Azar-2	370.6	0.81	1.00	3.27	0.98	1.00



In **Fig. 12. Biplots of farmers' preferences and grain yield for the 20 wheat breeding lines and checks tested for the three years in Shiraz Hemat Abad. Symbols are as follows: close circle = Kal Heydari, triangle = Azar 2.**

Shiraz- Hemat Abad, where the two checks used throughout the three years were the same as in Shiraz- Kodyan, there was a strong line x years cross over interaction as shown by the vector of grain yield in 2012 opposite to those of 2013 and 2014 (Figure 12). This means that there is not a line which is consistently yielding more that the general average every year. However, as average, all lines except one (line 55) out yielded both Kal Heydari and Azar-2 by between 6 and 85%, and by between 9 and 117%, respectively (Table 5).

In the case of farmers' preferences, the interaction although large, allowed to identify lines 18, 19, 21 and 2 as those which were consistently scored by farmers higher than the average. These also had large yield advantage over both checks.

In Nour Abad- Mahour, in addition to the four checks Kal Heydari, Sardari, Azar-2 and Hammam-4, farmers added three local varieties, Zagros, Kouhdasht and Niknejad, during the second year. Therefore, for these we only have two years data and will not be used in the comparisons with the other checks and/or lines for which we have three years data.
Using the data from three years, and ignoring Zagros, Kouhdasht and Niknejad, Kal Heydari had the highest average grain yield among the checks (Table 6) and the highest farmers' preference, and therefore will be used as the reference check in this location.

Table 5. Mean grain yield during three years (mean gy) in Shiraz- Hemat Abad, % yield advantage over Kal Heydari (% Ky), % yield advantage over Azar-2 (% Az), mean farmers preference (mean fs), % fs advantage over Kal Heydari (% Ky), and % fs advantage over Azar-2 (% Az). The line number is the same as in Figure 12.

There was a large lines x years interaction for grain yield, although not as large as in Shiraz Hemat Abad, and, as observed in Shiraz Hemat Abad, a lower lines x years interaction for farmers' preferences (Fig 13).

Line Nr	NAME	mean gy	% Ky	% Az	mean fs	% k	% Az
1	SABALAN/4/VRZ/3/OR F1.148/TDL//BLO	1003.7	1.46	1.71	3.53	1.03	0.95
2	F130-L-1-12//PONY/OPATA	1167.7	1.69	1.99	3.54	1.03	0.95
4	ZARGANA-6	1247.6	1.81	2.12	3.64	1.06	0.97
8	Tix53/89-2//2098-W2-21/Sardari IRW2000-01 - 021-0MAR-0MAR-0MAR-3MAR-0MAR	1201.4	1.74	2.04	3.45	1.00	0.93
11	F134.71/NAC//ZOMBOR	940.3	1.36	1.60	3.38	0.98	0.90
13	UNKN/HATUSHA//BEZ/SDV1	1156.3	1.68	1.97	3.49	1.02	0.94
15	RioBlanco/Rose	978.7	1.42	1.66	3.61	1.05	0.97
17	F132/T. tauschii squarosa	1209.5	1.75	2.06	3.50	1.02	0.94
18	CHAM-6/GHURAB'S'//JADIDA-2	1132.3	1.64	1.93	3.80	1.11	1.02
19	NJ8611//G.C.W1/SERI/3/G.C.W1/SERI/4/FLORKWA-2	1276.5	1.85	2.17	3.64	1.06	0.98
21	Rio Blanco/Bai Quan#3039//4848 Mashad/Tui"S" IRW2000-01 - 077-0MAR-0MAR-0MAR-8MAR-0MAR	1121.6	1.63	1.91	3.75	1.09	1.01
26	M374/Sx//2897/P-24)/3/Seri/4/Seri IRW2000-01 0MAR	888.6	1.29	1.51	3.50	1.02	0.94
27	Zcl/3/Pgfn//Cno67/Son64(Es86-8)/4/Kauz/5/Trk13/6/Seafallh IRW2000-01 - 119-0MAR-0MAR-0MAR-4MAR-0MAR	826.1	1.20	1.40	3.53	1.03	0.95
33	CROC-1/AE.SQUARROSA (224)//OPATA/3/PASTOR	1242.0	1.80	2.11	3.51	1.02	0.94
35	Sabalan/84.40023//Seafallah IRW2000-1047-0MA-0MA-0SN-0SN-2SN	991.0	1.44	1.69	3.54	1.03	0.95
38	Na160/Hn7//Buc/3/Falke	787.4	1.14	1.34	3.54	1.03	0.95
45	Seafallah/3/Sbn//Trm/K253 IRW2000-1191-0MA-0MA-0SN-0SN-4SN	732.6	1.06	1.25	3.68	1.07	0.98
48	Kal Heydari	689.8	1	1.17	3.44	1	0.92
55	Anza/3/Pi//Nor/Hys/4/Sefid/5/Fenkang15/Sefid	642.8	0.93	1.09	3.61	1.05	0.97
81	Azar-2	588.1	0.85	1	3.37	0.98	0.9

Table 6. Mean grain yield during three years (mean gy) and farmers' preferences (mean fs) in Nour Abad- Mahour of four checks, Kal Heydari, Sardari, Azar-2 and Hammam-4 and three local landraces, Zagros, Kouhdasht and Niknejad.

Line Nr	NAME	mean gy	mean fs
48	Kal Heydari	900.4	11.76
78	Sardari	865.9	11.33
81	Azar-2	863.4	11.28
83	Hammam-4	812.7	11.54
84	Zagros	1423.1	11.40
85	Kouhdasht	1170.9	11.77
86	Niknejad	1393.8	10.78

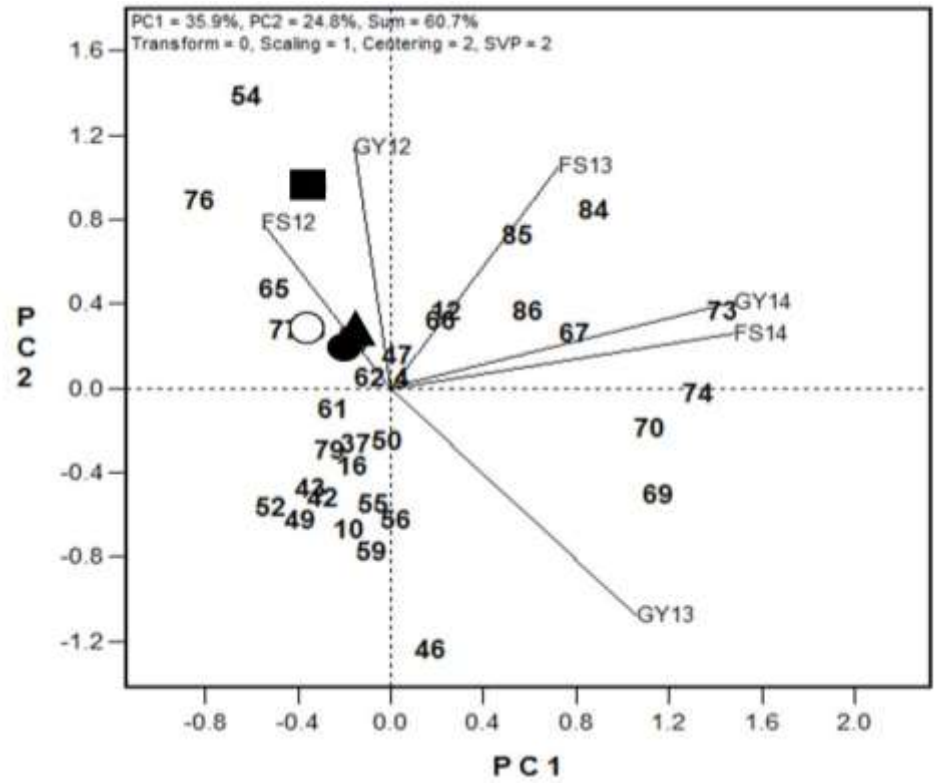


Fig. 13. Biplots of farmers' preferences and grain yield for the 35 wheat breeding lines and checks tested for the three years in Nour Abad- Mahour. Symbols are as follows: close circle = Kal Heydari, open circle = Sardari, square = Hammam-4, and triangle = Azar 2.

The best 10 lines for average grain yield (highlighted in yellow) and the best 10 lines for average farmers' score (highlighted in green) are shown in Table 7.

The two lines with the best combination of average grain yield and average farmers' score were lines 73 and 74 with a 31% and a 24% yield advantage over Kal Heydari, respectively, and a slightly better farmers' preference (5% and 2%, respectively) than Kal Heydari.
Table 7 shows a number of lines with a similar large yield advantage over Kal Heydari, such as line 70 (+28%), line 69 (+27%), and line 67 (+24%), but they all had a slightly lower farmers' preference than Kal Heydari.

Table 7. In yellow the top 10 lines with the highest average grain yield (mean gy), in green the top 10 lines with the highest average farmer's score (mean fs) during three years in Nour Abad- Mahour. In blue are the lines in the top 10 for both mean gy and mean fs, and in brown the checks Kal Heydari, Hammam-4, Sardari and Azar-2.

Line Nr.	NAME	mean gy	% Ky	mean fs	% Ky
54	Sabalan/Tui"s"/3/Snb//Pco/Pvn	782.8	0.87	12.60	1.07
74	W15.92/4/PASTOR//HXL7573/2*BAU/3/WBLL1	1116.5	1.24	12.38	1.05
59	JAGGER//SARDARI-HD58/FOW1	833.0	0.93	12.09	1.03
73	ATTILA*2/PBW65//BERKUT	1177.5	1.31	12.02	1.02
66	Ardabil-material-49	920.9	1.02	11.93	1.01
85	Kouhdasht	1170.9	1.30	11.77	1.00
48	Kal Heydari	900.4	1.00	11.76	1.00
65	TX90V7912/ABILENE	910.2	1.01	11.66	0.99
76	ARWYT-TC-1-45	674.8	0.75	11.63	0.99
50	KS82142/PASTOR CMSW97WM00399S-0P-0YC-0YE-3YE-0YE-1YE-0YE	904.5	1.00	11.56	0.98
83	Hammam-4	812.7	0.90	11.54	0.98
69	PRL/2*PASTOR/4/CHOIX/STAR/3/HE1/3*CNO79//2*SERI	1145.4	1.27	11.45	0.97
84	Zagros	1423.1	1.58	11.40	0.97
78	Sardari	865.9	0.96	11.33	0.96
70	PFAU/SERI.1B//AMAD/3/WAXWING	1151.3	1.28	11.30	0.96
81	Azar-2	863.4	0.96	11.28	0.96
86	Niknejad	1393.8	1.55	10.78	0.92
67	HUW234+LR34/PRINIA//PFAU/WEAVER	1119.7	1.24	10.70	0.91

In Nour Abad- Doshman Ziari, there was a large lines x years interaction for both grain yield and farmers preferences (Figure 14). While farmers' preferences in 2012 were associated with grain yield of the same year, in the other two years farmers' preferences and grain yield went into opposite directions. In a situation like the one in Figure 14 is very difficult to identify a single line which can be recommended.

The best 10 lines for average grain yield (highlighted in yellow) and the best 10 lines for average farmers' score (highlighted in green) are shown in Table 8.

Because of the data standardization in the biplot analysis, the position of a line in the biplot does not necessarily match with the ranking for either grain yield or farmers' preferences based on the average of the three years. This is why the first three lines for grain yield, lines 51, 76 and 83 occupy different positions on the biplot as shown by the red, green and blue arrows, respectively.

Among the lines that showed the best combination of grain yield and farmers' preference are the recently released variety Hammam-4 (line nr 83), and lines 63, 41 and 54. However, they were equal in yield to Sardari or superior by maximum a mere 5%. Also in terms of farmers' preferences, all the four lines were only slightly superior to Sardari, which, by occupying a position close to the origin, was close to average for both grain yield and farmers' preferences most of the years.

The GGE biplot analysis allows also to analyses more precisely the stability of the lines across the three years within each of the four locations (Figure 15). The interpretation of this feature of the GGE biplot is straightforward: the lines are aligned along the red vector according to their mean values with those towards the arrow having the higher mean and those on the opposite side the lower. Thus, in the case of Shiraz- Kodyan, line 71 has the highest combinations of means.

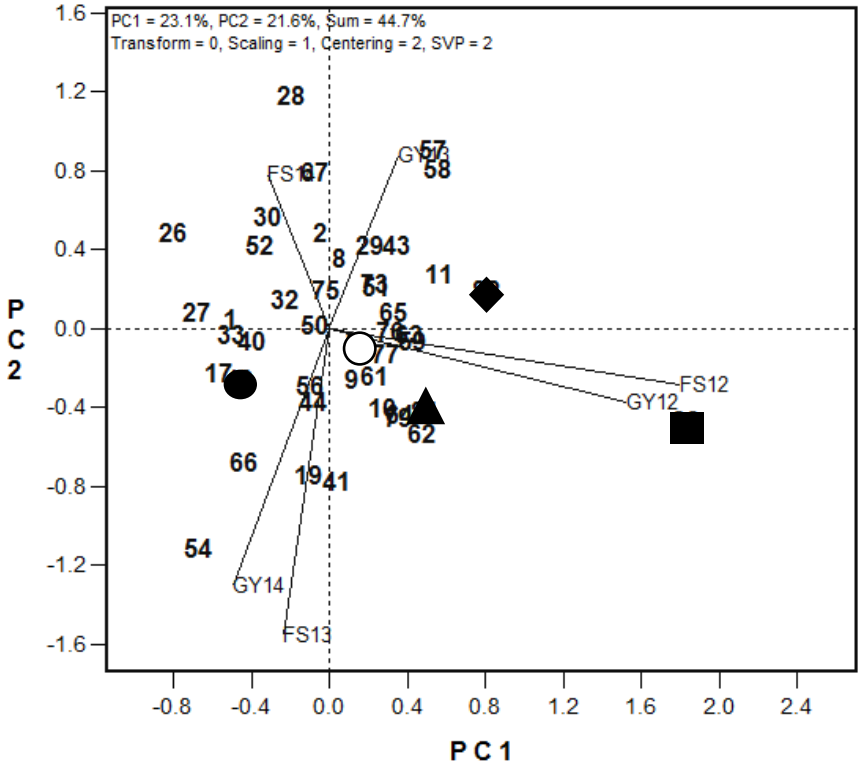
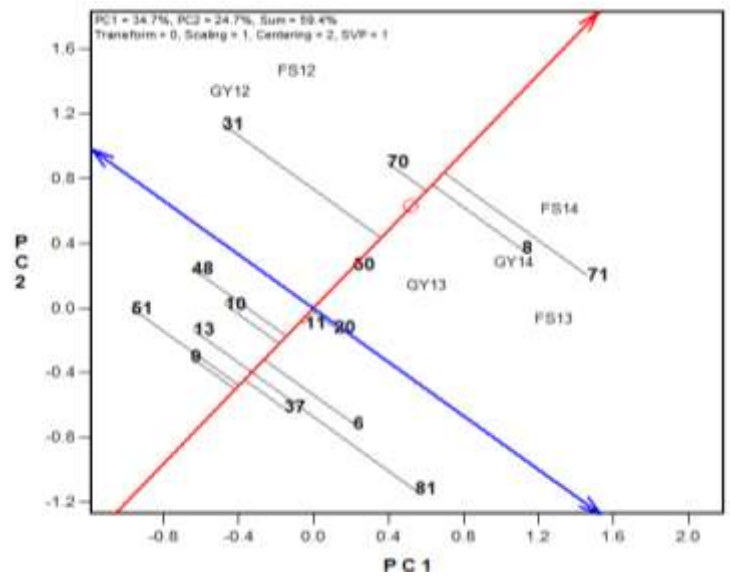


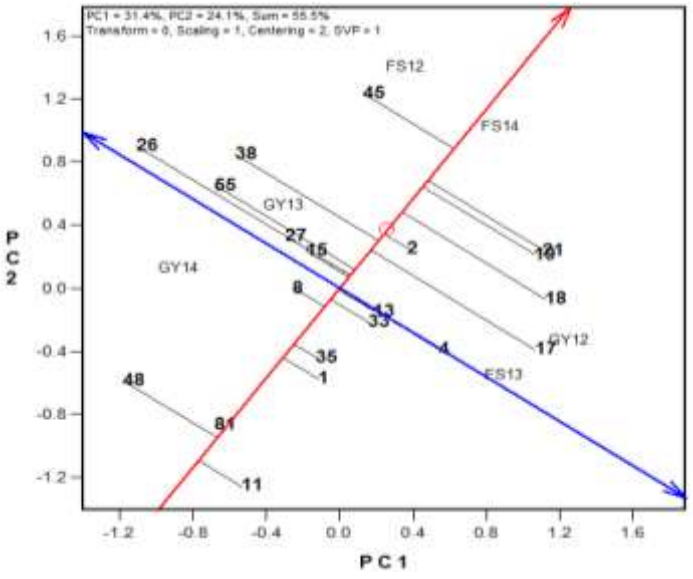
Fig. 14. Biplots of farmers' preferences and grain yield for the 44 wheat breeding lines and checks tested for the three years in Nour Abad- Doshman Ziari. Symbols are as follows: close circle = Kal Heydari, open circle = Sardari, square = Hammam-4, diamond = Rijaw (Pato), and triangle = Azar 2.

Table 8. In yellow the top 10 lines with the highest average grain yield (mean gy), in green the top 10 lines with the highest average farmer's score (mean fs) during three years in Nour Abad- Doshman Ziari. In blue are the lines in the top 10 for both mean gy and mean fs, and in brown the checks Kal Heydari, and Rijaw (Pato).

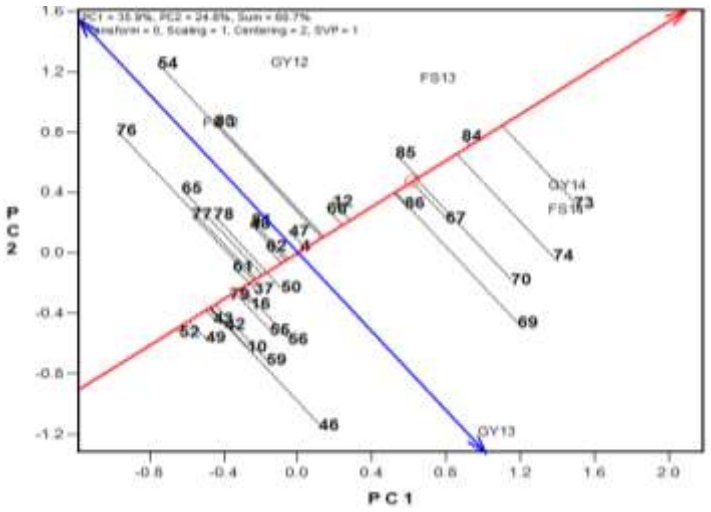
Codes	NAME	Mean gy	% Ham	% Sar	mean fs	% Ham	% Sar
51	Un-11	2091.7	1.04	1.09	9.78	0.95	0.97
76	ARWYT-TC-1-45	2050.9	1.02	1.07	9.99	0.97	0.99
83	Hammam-4	2001.8	1.00	1.05	10.24	1.00	1.02
40	Mahdavi/Sabalan IRW2000 -1127-OMAR-OMAR-OMAR-2MAR-OMAR	1997.7	1.00	1.05	9.92	0.97	0.98
63	SARA-BW-F6-06-85-86-2-5	1959.4	0.98	1.03	10.22	1.00	1.01
62	Sbn/1-64-199//Saulesku26/Roller IRW2000-1243-0MA-0MA-0SN-0SN-1SN	1951.1	0.97	1.02	10.15	0.99	1.01
41	Sabalan/Tui"s"/3/Snb//Pco/Pvn IRW2000-1112-OMA-0SN-0SN-3SN	1941.3	0.97	1.02	10.40	1.01	1.03
56	NWT/3/TAST/SPRW//TAW12399. TCI98--0026-0AP-0AP-OMAR-6MAR-OMAR	1923.6	0.96	1.01	10.02	0.98	0.99
78	Sardari	1911.0	0.95	1.00	10.09	0.98	1.00
54	Sabalan/Tui"s"/3/Snb//Pco/Pvn	1907.1	0.95	1.00	10.27	1.00	1.02
81	Azar-2	1905.3	0.95	1.00	10.15	0.99	1.01
43	Azadi/Azar//Sardari IRW2000-1030-0MA-0MA-0SN-0SN-1SN	1802.6	0.90	0.94	10.27	1.00	1.02
48	Kal Heydari	1792.1	0.90	0.94	9.38	0.92	0.93
64	NE92614(=CENTURA/RL8200003)/IKE	1772.1	0.89	0.93	10.33	1.01	1.02
10	Ning 83/Rashid//F9,10/Maya"S"/3/1d1189/Mlt//Tui IRW2000-01 - 179-0MAR-0MAR-0MAR-4MAR-0MAR	1707.2	0.85	0.89	10.86	1.06	1.08
82	Rijaw (Pato)	1688.4	0.84	0.88	9.91	0.97	0.98
73	ATTILA*2/PBW65//BERKUT	1624.8	0.81	0.85	10.22	1.00	1.01
66	Ardabil-material-49	1588.5	0.79	0.83	10.23	1.00	1.01



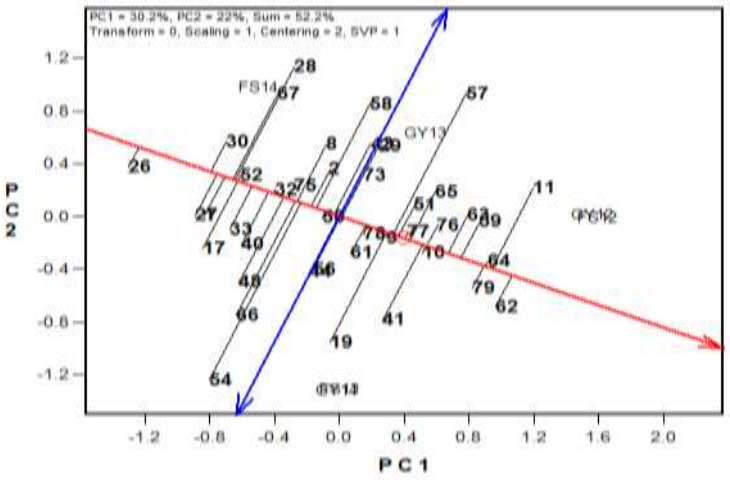
Shiraz Kodyan



Shiraz Hemat Abad



Nour Abad Mahour



Nour Abad Doshman Ziari

Fig. 15. Mean vs Stability biplots of farmers' preferences and grain yield for the wheat breeding lines and checks tested for three years in four locations in Fars province.

The distance of a given line from the red line is a measure of the stability: the closer it is the more stable it is.

Therefore in the case of Shiraz- Kodyan the three lines with the highest means are 71, 8 and 70 but line 70 is by far the one with the best combination of mean and stability. In Shiraz Hemat Abad, lines 45, 19, 21 and 18, none of which was particularly stable as a consequence of the large line x

years interaction. Line 2, which was in top group for both grain yield and farmers' preferences (Table 5) and was much more stable than the other lines.
In Nour Abad- Mahour the lines that best combined high average grain yield, higher farmers' preference and stability, were the three lines added during the second year, namely 84, 85 and 86. Among the rest of the lines, line 66 was slightly better than Kal Heydari (nr 48) for both grain yield and farmers preferences and more stable.
Eventually, in Nour Abad- Doshman Ziari lines 62, 64 and 79 are clearly those with the best combination of high yield and stability.

Conclusions

After the first three years of conducting a PPB program on bread wheat for the rainfed areas of Fars, the main conclusion are:

1. A number of lines, different in each location, have been identified for which seed multiplication and distribution to farmers can start;
2. Many more lines have been identified with a number of positive attributes which could be used in the breeding program of DARI for further cycles of PPB;
3. Eight staff members of the Department of Agriculture of Fars province are now fully familiar with the process and associated methodologies;
4. The program has now a strong Institutional support as shown by its survival to the change of the top managers at the Department of Agriculture of Fars province;
5. One staff member of CENESTA is fully familiar with the data compilation and verification and has established all the necessary contacts for follow up.
6. At the time of writing this report the program is continuing into its fourth year as an indication of its acceptance in the Province and to acquire additional information particularly in those locations affected by large genotype x years interaction.

APPENDIX I

Entry	NAME
1	SABALAN/4/VRZ/3/OR F1.148/TDL//BLO
2	F130-L-1-12//PONY/OPATA
3	ERYT1489.87 (DONSKAYA POLUKARLIKOVAYA/OLVIA)/3/2*AGRI/BJY//VEE
4	ZARGANA-6
5	SAULESKU #44/TR810200
6	ZANDER//ATTILA/3*BCN
7	Tix53/89-2//2098-W2-21/Sardari IRW2000-01 - 021-0MAR-0MAR-0MAR-2MAR-0MAR
8	Tix53/89-2//2098-W2-21/Sardari IRW2000-01 - 021-0MAR-0MAR-0MAR-3MAR-0MAR
9	Tix53/89-2//2098-W2-21/Sardari IRW2000-01 - 021-0MAR-0MAR-0MAR-7MAR-0MAR
10	Ning 83/Rashid//F9,10/Maya"S"/3/1d1189/Mlt//Tui IRW2000-01 - 179-0MAR-0MAR-0MAR-4MAR-0MAR
11	F134.71/NAC//ZOMBOR
12	VORONA/HD24-12//GUN
13	UNKN/HATUSHA//BEZ/SDV1
14	059E//Jagger/Pecos
15	RioBlanco/Rose
16	NWT//TAST/SPRW/3/TAW12399.75
17	F132/T. tauschii squarosa
18	CHAM-6/GHURAB'S'//JADIDA-2
19	NJ8611//G.C.W1/SERI/3/G.C.W1/SERI/4/FLORKWA-2
20	Rio Blanco/Bai Quan#3039//Sabalan IRW2000-01 - 075-0MAR-0MAR-0MAR-3MAR-0MAR
21	Rio Blanco/Bai Quan#3039//4848 Mashad/Tui"S" IRW2000-01 - 077-0MAR-0MAR-0MAR-8MAR-0MAR
22	Ning 83/Rashid//F9,10/Maya"S"/3/1d1189/Mlt//Tui IRW2000-01 - 179-0MAR-0MAR-0MAR-4MAR-0MAR
23	Azar2/87Zhong291-143
24	Azar2/87Zhong291-99
25	Azar2/87Zhong291-89
26	M374/Sx//2897/Porsuk/3/Plk70/Lira/5/ Jup/4/Cllf/3/Ii14.53/Odin//Ci1/6/Lov26//Lfn/Sdy(Es84-24)/3/Seri/4/Seri
27	Zcl/3/Pgfn//Cno67/Son64(Es86-8)/4/Kauz/5/Trk13/6/Seafallh IRW2000-01 - 119-0MAR-0MAR-0MAR-4MAR-
28	Sabalan//Cno79/Prl"S"/3/Pf82200/4/Ebvd99-1 IRW2000-01 - 175-0MAR-0MAR-0MAR-2MAR-0MAR
29	KS82W422/SWM754308//KS831182/KS/3/MV17
30	ZANDER//ATTILA/3*BCN
31	CH75479/4/338-K1-1//TJB368.251/BUC/3/KINACI97
32	VORONA//PRL/VEE#6/3/KAUZ*2/YACO//KAUZ
33	CROC-1/AE.SQUARROSA (224)//OPATA/3/PASTOR
34	RAN/NE701136//CI13449/CTK/3/CUPE/4/F134.71/NAC/5/MV17 TCI972217-0SE-0YC-0YE-3YE-0YE-
35	Sabalan/84.40023//Seafallah IRW2000-1047-0MA-0MA-0SN-0SN-2SN
36	F10S-1//ATAY/GALVEZ87
37	PYN/BAU//BONITO
38	Na160/Hn7//Buc/3/Falke
39	TIRCHMIR1//71ST2959/CROW/4 TCI98--0097-0AP-0AP-OMAR-7
40	Mahdavi/Sabalan IRW2000 -1127-OMAR-OMAR-OMAR-2MAR-OMAR
41	Sabalan/Tui"s"/3/Snb//Pco/Pvn
42	son64/?
43	Azadi/Azar//Sardari IRW2000-1030-0MA-0MA-0SN-0SN-1SN
44	Son64/4/Wr51/mida//Nt.h/3/K117/5/Anza/3/Pi//Nor/Hys/4/Sefid IRW2000-1169-0MA-0MA-0SN-0SN-1SN
45	Seafallah/3/Sbn//Trm/K253 IRW2000-1191-0MA-0MA-0SN-0SN-4SN
46	Shahi/Prl"S"//Fenkang15/Sefid IRW2000-1226-0MA-0MA-0SN-0SN-1SN
47	Kauz//Prl/Vee#b/6/Cigunea/4/Anaz/3/Pi//Nor/Hys/5/Shahi IRW2000-1022-0MA-0MA-0SN-0SN-1SN
48	**Kal Heydari (local check)**
49	SARA-BW-F6-06-85-86-2-5
50	KS82142/PASTOR CMSW97WM00399S-0P-0YC-0YE-3YE-0YE-1YE-0YE
51	Un-11
52	Sar/soc/aroofen
53	Cno67/Mfd//Mon"s"/3/Seri/4/Shanghi8/5/Shahi (Lr64...Sfe)
54	Sabalan/Tui"s"/3/Snb//Pco/Pvn

55	Anza/3/Pi//Nor/Hys/4/Sefid/5/Fenkang15/Sefid
56	NWT/3/TAST/SPRW//TAW12399. TCI98--0026-0AP-0AP-OMAR-6MAR-OMAR
57	KS82W409/SPN//TAM106/TX78V3630-0SE-0YC-0E-3YE-0YE-2YM-0YM
58	PONY/OPATA/5/CA8055/4/ROMTAST/BON/3/DIBO//SU92/CI13645
59	JAGGER//SARDARI-HD58/FOW1
60	SUBEN-1/3/AGRI/NAC//MLT/4/KIRGIZ95
61	SARA-BW-F6-06-85-86-3-1
62	Sbn/1-64-199//Saulesku26/Roller IRW2000-1243-0MA-0MA-0SN-0SN-1SN
63	SARA-BW-F6-06-85-86-2-5
64	NE92614(=CENTURA/RL8200003)/IKE
65	TX90V7912/ABILENE
66	Ardabil-material-49
67	HUW234+LR34/PRINIA//PFAU/WEAVER
68	PBW343*2/KUKUNA/5/CNO79//PF70354/MUS/3/PASTOR/4/BAV92
69	PRL/2*PASTOR/4/CHOIX/STAR/3/HE1/3*CNO79//2*SERI
70	PFAU/SERI.1B//AMAD/3/WAXWING
71	WBLL1*2/BRAMBLING
72	BABAX/LR42//BABAX/3/ER2000
73	ATTILA*2/PBW65//BERKUT
74	W15.92/4/PASTOR//HXL7573/2*BAU/3/WBLL1
75	maragheh-84-85-1006-2
76	ARWYT-TC-1-45
77	SONMEZ
78	Sardari (Land race)
79	Ohadi (A land race from Iranian gene bank - released recently)
80	Rasad (Selected among Sardari population and release as a new cltv.)
81	Azar-2
82	Rijaw (Pato) (released recently)
83	Hammam-4 (released recently)