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Comparison of Yield and yield components among different Varieties of Rice

Wakil Ahmad Sarhadi[1], Shamsruhaman Shams[1], Ghulam Mohammad Bahram[2] & Mohammad Bahman Sadeghi[*3]
[1]Department of Agronomy, Agriculture Faculty, Kabul University, Afghanistan
[2]Department of Agricultural Economic, Agriculture Faculty, Kabul University, Afghanistan
[3]Department of Biotechnology and Seed Production, Agriculture Faculty, Kabul University, Afghanistan
[*]Corresponding Author

Abstract

The demand for aromatic rice is increasing in Afghanistan and the surrounding countries. Aromatic rice due to its good taste, aroma and soft texture after cooking is favorable to consumers. In the present study, some important morphological and agronomic characters such as panicles number per plant, grains number per panicle, 1,000-grain weight, grain length and grain width, for eleven native Afghan rice cultivars and three foreign cultivars as check, were analyzed. In this research, the grains number per panicle was ranged between 69 ± 10.8 (mean ± standard deviation) in Luke Qasan and 175 ± 59.4 in Izayoi (check). Also 1,000-grain weight was ranged between 20 ± 0.7 in Torishi and 32 ± 3.5 in Pashadi Konar. Aroma was also estimated by tasting individual grains, cooking test, 1.7% KOH sensory test, gas chromatography-mass spectrometry-selected ion monitoring (GC-MS-SIM) and polymerase chain reaction (PCR) analysis. Mean comparison by Duncan's method in 5% confidence level was used. Finally cluster analysis for assessment of aroma were performed by Ward's method and cultivars divided to three clusters included : 1) Lawangi and Sarda Bala 2) Torishi, Sela Takhar and Sela Doshi 3) Surkha-Bala, Germa Bala, Surkhamabain, Surkha-Daraz-Baghlan, Pashadi Konar, Koshihekari (Check), Izayoi (Check), Fajer (Check) and Luke Qasan. This study showed that Afghan native rice cultivars such as Surkha-Bala, Surkhamabain, Sela Takhar, Sela Doshi and Pashadi Konar with the desirable agronomic characters such as thin and slender grains, and favorable aroma can be used for further improvement of aromatic rice in breeding.

Key words: Aromatic rice, Sensory test, Cluster analysis and yield components.

Introduction

Biodiversity is a broad term that is related to the value of ecosystems consisting of humans, plants, animals, water, soil, and other microorganisms in the surrounding environment that allow for a high quality of life to be maintained. The term can be referred to, for instance, the different plants, animals, and other living organisms which exist in a particular area or regions of the world (Sidiqi et al. 2014). Four center of rice had been supported by IRRI before invasion of Soviet Union in Afghanistan (Sharuqi, 1977). The conservation and protection of this national treasure (bio-diversity) is the responsibility of the present and future Afghan generations. Rice is the second most important crop in Afghanistan. The demand for aromatic rice is very high in this country and the surrounding regions. The demand for aromatic rice is very high in Afghanistan and the surrounding regions. Aromatic long grain rice, represented by Jasmine and Basmati, has a heady, perfumed fragrance and a flavor that can compliments the hot and complex seasonings of Thai and Indian cuisine. Some desirable aromatic rice cultivars such as Bala, Lawangi and Pashadi have been introduced from Afghanistan (Sarhadi et al. 2008). Most popular (Basmati) aromatic rice is dry, light and fluffy when cooked, like any well-behaved long grain. In Asian cultivated rice (*Oryza sativa* L.), aroma is one of the most valuable traits in grain quality and 2-acetyl-1-pyrroline (2-ACP) is the main volatile compound contributing to the characteristic popcorn-like odour of aromatic rices (Bradbury et al. 2005; Sarhadi et al. 2008).The aroma and dormancy are important traits for breeding quality rice. In the previous studies, for the detection of aroma, either grain or leaf samples were used (Berner and Hoff, 1986; Widjaja, 1996). A number of aromatic rice cultivars are known in various countries. In Inidia, Pakistan, Thailand, Bangladesh, Nepal, Iran, Afghanistan, Myanmar, and Indonesia as well, these rice cultivars are the most prized (Haryanto et al. 2008). The genetic diversity of modern rice cultivars has been reduced due to intensive breeding efforts and more diverse germplasm would enhance the selection efficiency of desirable varieties in the rice breeding programs (Akiyama and Takahashi and Kinoshita, 1977; Dilday, 1990; Cuevas-Perez et al. 1992; Harlan, 1992; Doganlar et al. 2000; Zheng, 2002; Hien et al. 2007). We also studied the diversity of agronomic traits to find out desirable cultivar for rice breeding program in Afghanistan. Rice selection for high yielding varieties was focused on maturity 120 days such as Sita, and Rimke from India (Chaudhary and Sahia, 1993; Luo et al. 2001). Aroma in rice is also characterized by such methods as the 1.7% KOH sensory test (Sood and Siddiq, 1978). The challenges of rice cultivation in Afghanistan are recognized low quality and quantity, releasing of un-certified seeds to farmers and extinction of traditional varieties. Objectives of this research were to find out high yielding rice cultivars, finding good morphological and agronomical rice features, classification of aroma level, feasibility to climate, recognize the desirable quantitative and qualitative rice and conservation of rice genetic resources.

Materials and Methods

1. Plant materials

Eleven Afghan local cultivars, namely (Surkha-Bala, Germa Bala, Surkhamabain, Lawangi, Surkha-Daraz-Baghlan, Sarda Bala, Sela Takhar, Sela Doshi, Pashadi Konar, Torishi and Luke Qasan. One Iranian cultivar (Fajr), and two

Japanese cultivars Koshihekari (non-aromatic), and Izayoi (aromatic) were used in this study (Table 1). Eleven Afghan rice varieties and three foreign rice varieties for check, were obtained from cereal research department in ministry of agriculture, irrigation and livestock (MAIL), Afghanistan.

2. Methods

2.1. Field experiment

All the plant materials were grown under the same conditions in Agriculture Faculty of Kabul University green house and field as well. Rice seeds were sown in pots using the soil treated with fungicide. The field experiment for varietal evaluation was performed in a completely randomized block design with three replications. Each replication was consisted of 21 plots, and 5 plants per each plot were grown in the pots. Ten seedlings at three weeks after sowing were randomly transplanted in a space of 20 x 20 cm in the field. These ten plants of each cultivar were selected for measurement and analysis. Nitrogen (N), phosphorus (P) and potassium (K) at a rate of 70N-40P-70K kg ha^{-1} were applied at three times as follows: One-third of N along with P and K before transplanting, 1/3 of N 20 days after transplanting, and further 1/3 of N 50 days after transplanting.

2.2. Measurement and analysis of agronomic traits

Panicles number per plant was recorded after full heading stage. Multi Auto Counter (Daizen Ginken Japan) was used to count the number of grains per panicle. For 1000-grain weight, a random sample of 1,000 well-developed grains from each replication, whole grains dried to 14% moisture content is weighed on a precision electronic balance (FA-2000 Japan) to give the 1000-grain weight. Grain length and width were measured by using vernier calipers (IBPRG-IRRI, 1980). Analysis of variance (ANOVA) and Duncan's multiple-comparison test were applied to clarify the significant difference of agronomic characters among rice cultivars. Statistical analysis was applied using past software to find genetic relationship by cluster analysis. The diversity of morphological and agronomic characters was calculated using the Shannon-Weaver index H (Hutchenson, 1970), as an "alpha-diversity". It is the sum over all species in a sample, of the probability of each individual being a member of that species, times the natural logarithm of that probability.

$$H = \sum_{i=0}^{N} P_i \ln P_i$$

Where: N is the number of phenotypic classes for each character

The minus sign in front of the summation is added because probabilities have values between 0.0 and 1.0. The logarithm of such a number is negative. The index for each character was analyzed using unweighted pair group average distances method (UPGAM).

$$P_i = \frac{individuals \quad of \quad species_i}{individuals \quad total}$$

2. 3. Sensory test

In the sensory test, 100 mg of young rice leaves at the heading stage were weighed, cut into small pieces and placed in Petri dishes. Then 10 ml of 1.7% KOH solution was added onto the leaves. The Petri dishes were covered and left for one hour at room temperature. The evaluation was done by the average-score from (0 to 1.5) and scored from 0 to 0.5 as (-) for non-aroma, from 0.5 to 1 as (±) for light aroma and from 1 to 1.5 as (+) strong aroma by smelling and observation of the six panelists. Polished kernels of each cultivar were used for tasting the kernel and the cooking test. Fifty kernels of each cultivar were chewed by a panel of analysts having the ability to distinguish between aromatic and non-aromatic rice. For the cooking test, 500 g of grain of each cultivar were weighed and then cooked. The cooked rice was tasted by a panel of six persons and the averaged grade was scored as (+) for strong aromatic, (±) light aromatic and (-) for non-aromatic rice.

2. 4. Phenol reaction

Ten hulled rice seeds from each cultivar were selected and placed into separate Petri dishes. Fifteen grams of crystal phenol were mixed well with 1,000 ml of water. The phenol solution was added onto seeds, then covered and left for 1 hr at room temperature. Finally the solution was removed and seeds were left for three hours at room temperature to dry well. The dried seeds were estimated for color changing.

Results and Discussion

1. Characterization of agronomic traits in Afghan native rice cultivars

Various aspects of the morphological and agronomic characters of Afghan endogenous cultivars have been subjected to extensive studies for rice genetic resources conservation in Afghanistan. Morphological and agronomic characters have been studied in connection with their physiological and ecological implications. Aromatic rice cultivars are desirable in quality and fetch much higher price than non-aromatic rice cultivars. Most aromatic rice cultivars are traditional with tall culm, low yield, photosensitive, susceptible to diseases, pests and lodging. The genetic diversity of improved rice cultivars has been reduced due to intensive selections (Dilday, 1990; Cuevas-Perez et al. 1992). Morphological and agronomic characters have a number of limitation including low polymorphism, low heritability, late expression and vulnerability to environmental influences (Smith and smith, 1992). However, morphological characterization is the first step in the classification and evaluation of germplasm (Smith and Smith 1989; Smith et al.

1991). Quantitative characters are important for plant description and are influenced by consumer preference, socio-economic scenario and natural selection (Kurlovich, 1998).

2. Yield components

Paddy rice yield consists of three components, namely, number of panicles per plant, number of grains per panicle and 1000-grain weight (Hoshikawa, 1989; Luo et al. 2001; Kang et al. 2007; Haryanto et al. 2008). These three components determine the paddy rice yield, which is the main objective of most breeding programs. In the present study, panicles number per plant in Afghan rice cultivars ranged from 8 to 14, while in control cultivars ranged from 9 to 10. Afghan cultivars had larger number of panicles per plant than control, indicating that the local cultivars have larger panicles number per plant. Panicles number per plant was not correlated with the grains number per panicle, because Sarda Bala (14 ± 3.6) and Germa Bala (13 ± 2.6) with the largest number of panicles per plant showed the lowest number of grains per panicle. Grains number per panicle in Afghan native rice cultivars ranged from 69 to 169 and the difference was as many as 1000 grains weight. Most Afghan cultivars had more than 100 grains per panicle, and this character is desirable for breeding program. The 1,000-grain weight ranged from 20 to 32 g and Pashadi Konar and Surkhamabain from Afghanistan had the heaviest grain (32 g) (Table 2). Duncan's multiple-comparison test was applied to compare the significant difference of agronomic characters at 5% level among rice cultivars. A significant difference was between Sarda Bala with larger panicles number per plant (14) and Surkha-Bala with smaller panicles number per plant (8), while there was no significant difference between Sarda Bala and the others. There was no significant difference between Izayoi with larger grains number per panicle (175) and Luke Qasan and Germa Bala with (69) and (74) grains number per panicle, respectively, while there was a significant difference between Izayoi and the others (Table 2).

3. Analysis of aroma using KOH sensory, Phenol, cooking and chewing tests

Buttery et al. (1983) identified the characteristic aroma compound in steam volatile oils of cooked aromatic rice as 2-acetyl-1-pyrroline (2-ACP). Eluting aroma from leaves with dilute KOH (Sood and Siddiq, 1978) has been used to identify aromatic plants. Important aroma compounds have been detected in young rice plant tissue (Leung et al. 1998). In the present research, leaf tissue after the reaction with 1.7% KOH (Sood and Siddiq, 1978) was sniffed. The results of four tests showed that Surkha-Daraz-Baghlan, Surkhamabain, Germa Bala, Pashadi Konar, Lawangi, Sela-Doshi a Fajer, were scored + (strong aromatic), Sela-Takhar, Izayoi, and Torishi were scored ± (light aroma), and Sarda Bala and Koshihekari were scored – (Non-aromatic). The parallel results of these four tests 1.7% KOH sensory, Phenol, cooking and chewing tests showed in Table 3. cluster analysis for assessment of aroma were performed by Ward's method and cultivars divided to three clusters included : 1) Lawangi and Sarda Bala 2) Torishi, Sela Takhar and Sela Doshi 3) Surkha-Bala, Germa Bala, Surkhamabain, Surkha-Daraz-Baghlan, Pashadi Konar, Koshihekari (Check), Izayoi (Check), Fajer (Check) and Luke Qasan (Figure 1). The applicability of the above-mentioned tests in developing countries, whereas GC-MS-SIM and molecular marker are not widely available in Afghanistan and the surrounding regions is useful.

Conclusion

Aromatic rice is highly prized by most rice consumers. Native and improved aromatic rice cultivars cultivate in many countries (Fitzgerald et al. 2008). The rice world market ranks aromatic rice at the top. For the 4-5 million ton of aromatic rice worth is 2-2.5 billion US dollar. Thai Jasmine rice shares almost half-half with Basmati rice from India and Pakistan with small players likes USA, Vietnam, and recently Cambodia (FAO, 2000). The lucrative market will become more competitive in near future from new players like USA, Australia and Vietnam that has launched new plant type that combines high grain yield with aromatic quality. Rice aroma is the most attractive characteristic to consumers (Haryanto et al. 2008). Because of its soft, fluffy and sweet aromatic cooked rice. In this study, original materials from Afghanistan and other Asian countries were used to evaluate agronomic and aroma characters. The obtained results can help breeders for the improvement of aromatic rice in Afghanistan and in other countries. Prevention from extinction of Afghan endogenous is the main objective of this research and over than twenty endogenous rice cultivars have been collected by this study. These local cultivars are useful for improvement of high-yielding and qualitative rice cultivars at breeding program in Afghanistan. The genetic diversity of modern rice cultivars has been reduced due to intensive breeding efforts (Dilday, 1990; Cuevas-Perez et al. 1992). Genetic uniformity could become a problem for the selection of germplasm to develop improved varieties. A more diverse germplasm would enhance the selection efficiency of desirable varieties in the rice breeding programs. Based on the results, a huge diversity of morphological and agronomic traits was detected among Afghan endogenous rice cultivars, and can be used as a good source of genetic germplasm for breeding programs in Afghanistan. This study showed that Afghan native rice cultivars such as Surkha-Bala, Surkhamabain, Sela Takhar, Sela Doshi and Pashadi Konar in addition to Iranian native rice cultivars such as Fajr and Izayoi with the desirable agronomic characters with thin and slender grains, and favorable aroma can be used for further breeding of aromatic rice. Demand for the above-mentioned characters is very high in Afghanistan and surrounding regions. Comparative analysis of aroma by using 1.7% KOH sensory, phenol, cooking and chewing tests has not been reported yet. In the present study, aromatic and non-aromatic rice were classified by using these four methods. Application of these sensory tests is available and applicable for distinguishing between aromatic and non-aromatic rice in Afghanistan. GC-MS-SIM and PCR methods are new methods for breeders to streamline the breeding process and reduce the development time for the improvement of new cultivars. Although these two methods are not available at present in Afghanistan, our results suggest the availability of these methods in the future. These findings will provide the necessity of international cooperation and can be used as a base for rice breeding program in Afghanistan in the future. Consequently, this study is a rare challenge and gave new finding, and enhances the possibility of international cooperation especially among Asian countries. Research on these materials had not been done yet, but these materials with the high diversity of agronomic characters and favorable aroma introduced in breeding programs by this research. This study can be used as a base for the improvement of aromatic rice cultivars in the near future in Afghanistan and the surrounding regions.

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Table 1. Research Materials from different zones of Afghanistan and countries as well.

Cultivar	Origin
Surkha-Bala	Afghanistan
Germa Bala	Afghanistan
Surkhamabain	Afghanistan
Lawangi	Afghanistan
Surkha-Daraz-Baghlan	Afghanistan
Sarda Bala	Afghanistan
Sela Takhar	Afghanistan
Sela Doshi	Afghanistan
Pashadi Konar	Afghanistan
Koshihekari (Check)	Japan
Izayoi (Check)	Japan
Fajer (Check)	Iran
Torishi	Afghanistan
Luke Qasan	Afghanistan

Table 2. Duncan comparison mean (5% confidence level) of the yield components and agronomic characters among Afghan native rice cultivars and check cultivars.

Cultivars	Panicles number per plant [a)]	Grains number per panicle [a)]	1000-grain wt. (g) [a)]	Grain length (mm) [b)]	Grain width (mm) [b)]
Surkha-Bala	8 ± 1.5 a[€]	153 ± 16.4 ab	24 ± 1.5 b	10.1 ± 0.2 defg	2.4 ± 0.0 ab
Germa Bala	13 ± 2.6 ab	74 ± 11.5 a	29 ± 1.5 bcd	10.1 ± 0.3 defg	2.6 ± 0.2 abc
Surkhamabain	9 ± 2.5 ab	151 ± 23.0 ab	32 ± 0.4 d	10.8 ± 1.0 fg	2.4 ± 0.1 ab
Lawangi	11 ± 0.4 ab	123 ± 28.0 ab	27 ± 1.1 bc	9.3 ± 0.3 cd	2.2 ± 0.2 a
Surkha-Daraz-Baghlan	11 ± 2.0 ab	99 ± 25.2 ab	30 ± 2.3 cd	10.7 ± 0.2 fg	2.7 ± 0.2 bc
Sarda Bala	14 ± 3.6 b	144 ± 15.5 ab	26 ± 1.5 bc	10.4 ± 0.4 efg	2.5 ± 0.0 ab
Sela Takhar	11 ± 1.5 ab	169 ± 53.9 c	25 ± 1.5 bc	10.6 ± 0.4 efg	2.3 ± 0.0 ab
Sela Doshi	11 ± 1.5 ab	157 ± 26.2 bc	24 ± 2.1 b	9.4 ± 0.4 de	2.5 ± 0.0 ab
Pashadi Konar	9 ± 0.3 ab	148 ± 21.0 ab	32 ± 3.5 d	11.0 ± 0.3 g	2.5 ± 0.1 ab
Koshihekari (Check)[c]	9 ± 1.5 ab	125 ± 8.6 ab	25 ± 2.0 bc	7.0 ± 0.1 a	3.2 ± 0.2 c
Izayoi (Check)[c]	9 ± 1.5 ab	175 ± 59.4 c	24 ± 1.3 b	9.7 ± 0.8 def	3.0 ± 0.0 c
Fajer (Check)[c]	10 ± 2.0 ab	149 ± 32.6 ab	27 ± 1.3 bc	10.2 ± 0.2 defg	2.6 ± 0.0 abc
Torishi	11 ± 0.6 ab	114 ± 19.2 ab	20 ± 0.7 a	8.2 ± 0.3 bc	2.5 ± 0.0 ab
Luke Qasan	11 ± 1.3 ab	69 ± 10.8 a	20 ± 3.1 a	7.3 ± 0.3 ab	3.6 ± 0.3 c

a) Sixty plants of each cultivar were used for analysis; b) Twenty grains of each cultivar were used for analysis;
[c]) Check: Standard cultivars, [€]) The values express means ± standard deviations.

Table 3. Application of chemical test for aroma level and response to phenol in rice cultivars.

Cultivar	Origin	Phenol (1.5%)[*]	KOH (1.7 %) response[**]	Chewing test	Cooking test	Index
Surkha-Bala	Afghanistan	+	±	+	+	1.5
Germa Bala	Afghanistan	+	+	+	+	1.5
Surkhamabain	Afghanistan	+	+	+	+	1.5
Lawangi	Afghanistan	+	+	+	+	0.5
Surkha-Daraz-Baghlan	Afghanistan	+	+	+	+	1.5
Sarda Bala	Afghanistan	-	-	-	-	0.5
Sela Takhar	Afghanistan	±	±	±	±	1
Sela Doshi	Afghanistan	+	+	+	+	1
Pashadi Konar	Afghanistan	+	+	+	+	1.5
Koshihekari (Check)	Japan	-	-	-	-	1.5
Izayoi (Check)	Japan	±	+	±	±	1.5
Fajer (Check)	Iran	+	+	+	+	1.5
Torishi	Afghanistan	±	±	±	±	1
Luke Qasan	Afghanistan	+	+	+	+	1.5

[*] 1.5 % Phenol test: + (Strong response), ± (Weak Response) and – (No response).
[**] 1.7 % KOH test: + (Strong aroma), ± (Light aroma) and – (Non-aroma).

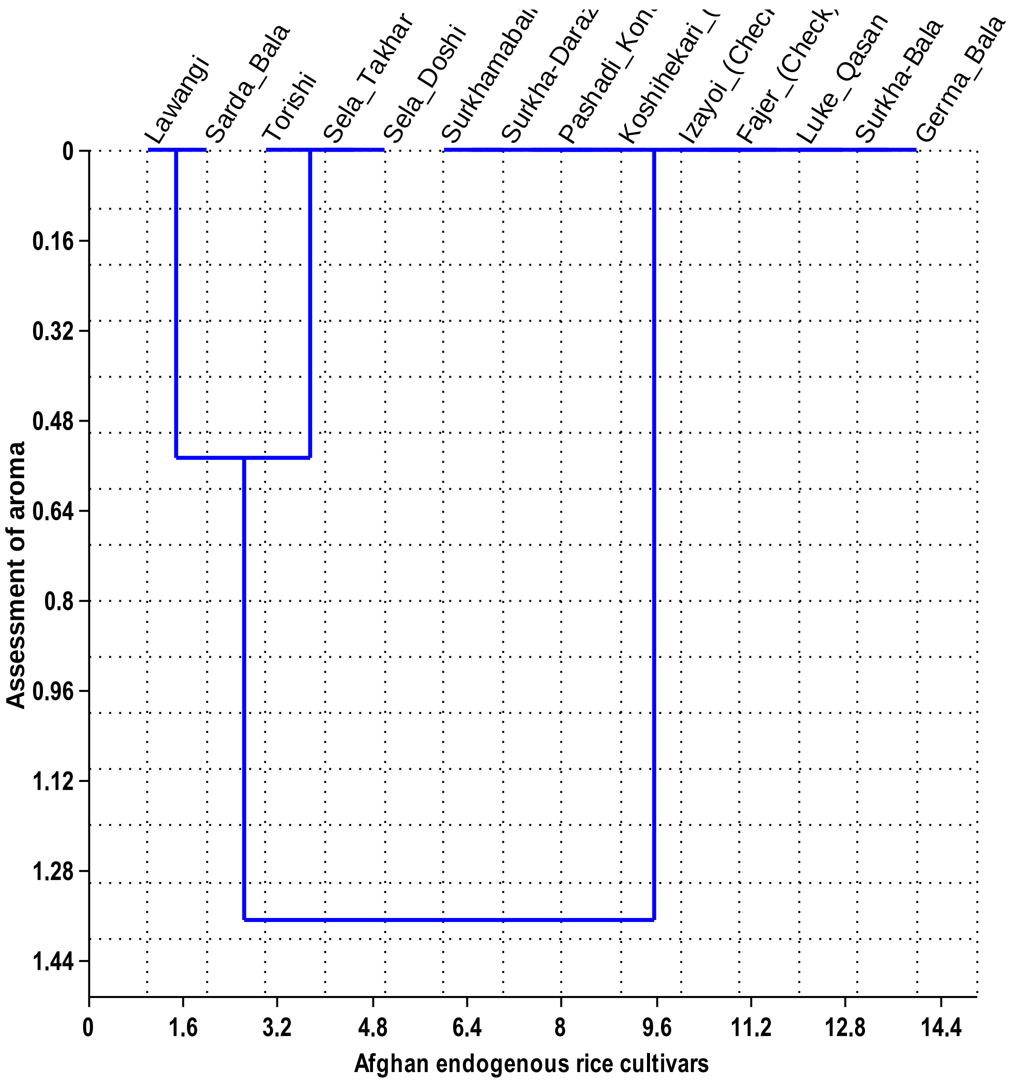

Figure 1. Assessment of aroma in Afghan endogenous rice cultivars.