Introduction of quinoa in Burkina Faso: review of the preliminary activities

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Abstract

Smallholder farmers in Burkina Faso face a number of constraints to production and food availability. Rural poverty remains a challenge and the prevalence of chronic malnutrition is very high. Quinoa's high nutritional potential and great ability to adapt to diverse environmental conditions make it an excellent alternative crop in the face of emerging challenges to food production in Burkina Faso. FAO's project '' Technical assistance for the strengthening of the food system of quinoa in Burkina Faso'' has successful implemented a platform for an effective introduction and promotion of quinoa production. Local keys stakeholders together with FAO jointly participated in the implementation of the project. The Institute of Environment and Agricultural Research (INERA) conducted research on introduced quinoa varieties for adaptation to local agro-ecological conditions. To facilitate the introduction of quinoa into the habit of the population, Institute of Research in Applied Science and Technology (IRSAT) has developed quinoa-based local dishes and has evaluated them for taste tests. The project, set for one year, has strengthened the partnership between stakeholders which has produced interesting results. Puno and Titicaca were identified as the best adapted varieties out of the 7 quinoa varieties evaluated. Over 14 quinoa-based local dishes were developed which were well appreciated by tasters. Thirty extension agents, composed of 17 males and 13 females, were trained in quinoa production technique, harvest and post-harvest operations. The development of an efficient and sustainable quinoa production requires concerted efforts and partnership with all the stakeholders at both national and international levels.

Keywords: Burkina Faso, quinoa, stakeholder, introduction, production.

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Résumé

Les petits agriculteurs du Burkina Faso sont confrontés à un certain nombre de contraintes en matière de production et de disponibilité de nourriture. La pauvreté rurale reste un défi et la prévalence de la malnutrition chronique est très élevée. Le fort potentiel nutritionnel du quinoa et sa grande capacité à s'adapter à diverses conditions environnementales en font une excellente culture alternative face aux nouveaux défis de la production alimentaire au Burkina Faso. Le projet de la FAO intitulé «Assistance technique pour le renforcement du système alimentaire du quinoa au Burkina Faso» a permis de mettre en place avec succès une plateforme pour une introduction et une promotion effectives de la production de quinoa. Les principaux acteurs locaux avec la FAO ont participé conjointement à la mise en œuvre du projet. L'Institut de l'environnement et de la recherche agricole (INERA) a mené des recherches sur les variétés de quinoa introduites pour l'adaptation aux conditions agro-écologiques locales. Pour faciliter l'introduction du quinoa dans les habitudes de la population, l'Institut de Recherche en Sciences Appliquées et Technologiques (IRSAT) a mis au point des plats locaux à base de quinoa et les a évalués à travers des tests de dégustation. Le projet, prévu pour un an, a renforcé le partenariat entre les acteurs, conduisant à des résultats intéressants. Puno et Titicaca ont été identifiés comme étant les variétés les mieux adaptées parmi les 7 variétés de quinoa évaluées, 14 plats locaux ont été élaborés à base de quinoa et ont été bien appréciés par les dégustateurs. Trente agents de vulgarisation, composés de 17 hommes et de 13 femmes, ont été formés à la technique de production du quinoa, à la récolte et aux opérations après récolte. Le développement d'une production de quinoa efficace et durable nécessite des efforts concertés et un partenariat avec l'ensemble des acteurs aussi bien nationaux qu'internationaux.

Mots-clés : Burkina Faso, quinoa, acteur, introduction, production.

Introduction

Quinoa in Africa

Quinoa (*Chenopodium quinoa* Willd), domesticated and cultivated in Andean region over 5 000 years ago, is now worldwide distributed. Quinoa cultivation area has spread from 6 countries including Bolivia, Peru, Colombia, Ecuador, Argentina and Chile to more than fifty countries (BAZILE and BAUDRON, 2015). The production and experimentation on quinoa have moved forwards in many countries in America, Australia, Europe and Asia but Africa is hanging behind with only one country, Morocco, as a producer. In sub-Saharan Africa, quinoa was introduced in Kenya in the late 1990s and recently in Malawi in 2012 (MALIRO and GUWELA, 2015), but experimentation started in West-Africa in Mali in 2007 (COULIBALY *et al*., 2015). It is also noted that five countries in Africa (Ethiopia, Kenya, Lesotho, Zambia and South Africa) out of the thirty countries throughout the world, conserve quinoa and its wild relatives in gene banks (ROJAS *et al*., 2015).

Technical assistance for the strengthening of the Food system of Quinoa in West Africa

The project ''Technical assistance for the strengthening of the food system of Quinoa'' is a follow-up to the 38th Session of the UNFAO conference that took place early 2013, which emphasized on introduction and promotion of quinoa production and use of quinoa as a staple food

in Africa. The countries targeted in Western and Central Africa were: Burkina Faso, Cameroun, Niger, Senegal, Chad, Togo and Ghana.

The project aimed to build the capacities of countries in the selection of adapted varieties from trials, production, evaluation, management, utilization, and marketing of quinoa under diverse farming systems and agro ecological regions prevailing in the country. It was also to strengthen the regional collaboration, coordination, information and knowledge exchange in quinoa production, post-harvest handling, processing, utilization and management. Furthermore, the project assisted the countries in developing national and regional sustainable strategies for production, as well as, integration of quinoa in the prevailing cropping patterns and farming systems. The project was initially planned to start in 2014 for one year but it has been officially launched in March 2015 in Ghana.

Quinoa as alternative crop in Burkina Faso

Burkina Faso is a landlocked country and one of the poorest countries in the world. Almost half (47 percent) of rural households live in poverty. Smallholder farmers face a number of constraints in the production and food availability, among others: limited, erratic and declining rainfall, particularly in northern part of Burkina Faso; soil degradation exacerbated by low use of soil conservation techniques; limited access to inputs, especially improved seeds and poor access to post-harvest storage techniques (ELLEN and GARDNER, 2009). Soils are generally vulnerable to water and wind erosion, and poor in nutritional components. Rural poverty remains a challenge and the prevalence of chronic malnutrition is very high. Identifying stress-tolerant alternative crops with high nutritive value is therefore seen as an important strategy to improve agricultural production and sustain the livelihoods of the poor farmers – especially those dependent on marginal quality land and water resources.

Quinoa's great ability to adapt to weather variations and its efficient use of water make it an excellent alternative crop in the face of emerging challenges to food production in Burkina Faso as well as in most West Africa countries particularly in the Sahel Region.

Besides the use for human consumption, quinoa grain has other uses as livestock and poultry feed. The whole plant can be used as green fodder and harvest residues as feed for animals. Thus, the nutritious features of quinoa, its wide adaptability, rusticity, and numerous uses, makes it an attractive choice as an alternative crop to address food as well as nutritional challenges in Burkina Faso. In addition, quinoa is a potential alternative export crop for many African countries like Burkina Faso as the demand for quinoa grain in United States, Europe, and Asia is growing (MALIRO and GUWELA, 2015).

Innovation platform for introduction of quinoa

The implementation of the ''Technical assistance for the strengthening of the food system of quinoa'' project in Burkina Faso has first established a quinoa innovation platform. Key stakeholders including research institutes, National Seed Service (SNS), seeds growers, farmers and FAO were organised in a platform to set up strategies for a successful introduction and promotion of quinoa in Burkina Faso. Research institutes were composed of Institute of Environment and Agricultural Research (INERA) and Institute of Research in Applied Science and Technology (IRSAT). INERA was responsible to conduct evaluation of introduced quinoa cultivars across

different agro-ecological zones in the country and to identify the high performing and adapted cultivars. The role of IRSAT was to assess the nutritional value of the cultivars and carried out research on quinoa utilisation. The quinoa innovation platform process was managed by SNS jointly with FAO.

II. Morphological and Agronomic performance of quinoa in Burkina Faso

2.1. Cultivars introduced

Quinoa experiments started in Burkina Faso in 2015 with 5 cultivars including Blanca de junin, *Amarilla Sacaca, Amarilla Marangani, Salecedo INIA, Kancolla* originated from Peru and 2 cultivars, Puno and Titicaca, obtained from University of Copenhague, Denmark. The seeds of all the above cultivars were obtained through FAO.

2.2. Seeds quality

The seeds were assessed in the laboratory of INERA for the presence of pathogen agents (fungi, bacteria, insects). The results have indicated that the seeds were infested by fungi mainly by Fusarium spp, Aspergillus spp and Rhizopus spp which were present in almost all the seeds lots (table I). However other fungi including *Corynespora cassiicola, Colletotrichum graminicola, Pyriculatia oryzae* and *Rhizoctonia solani* were noted in some seeds. The entomology experiments revealed no presence of insects in the seeds lots.

Table I. Identification of fungi in the introduced seeds.

Fungi	Amarilla Marangani	Amarilla Sacaca	Blanca de junin	Salcedo INIA	Kancolla	Titicaca	Puno
Aspergillus spp	Yes	yes	yes	Yes	yes	Yes	yes
Fusarium spp	Yes	yes	yes	Yes	yes	Yes	no
Rhizoctonia spp	Yes	yes	yes	Yes	yes	No	no
Corynespora spp	No	yes	yes	No	yes	No	no
Colletotrichum spp	No	no	yes	No	yes	No	no
Pyriculatia spp	No	no	yes	Yes	no	No	no
Ulocladium spp	No	no	no	No	no	Yes	no

2.3. Seed germination

The germination rate of 3 introduced quinoa seeds, Salcedo INIA, *Amarilla marangani*, and *Kancolla*, assessed in blotting paper (photo 1) was more than 80% while Blanca de juin, *Amarilla sacaca* and *Titicaca* had a germination rate of less than 50% (table II). *Puno* had about 63%.

The high germination rate obtained was different when soil was used as substrate, only *Salcedo* INIA had an average of 50% of plants emerged (figure 1). The cultivars Puno and Titicaca were not included in this test because of the late arrival of the seeds but were included in the field evaluation.

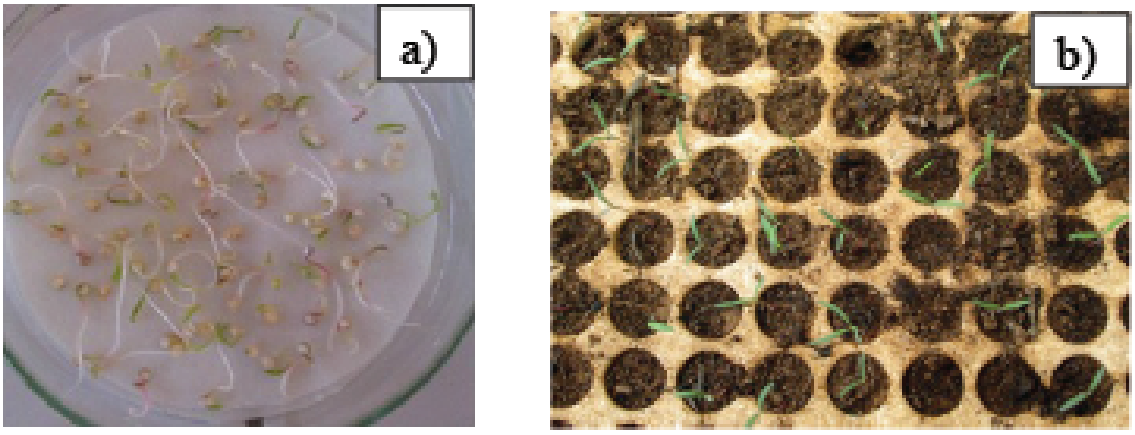

Photo 1. Germination test using different substrates (blotting paper (a), soil (b)).

Table II. Germination rate of quinoa seed.

Replication	Kancolla	Amarilla marangani	Salcedo inia	Blanca de junin	Amarilla sacaca	Titicaca	Puno
R1	82	94	94	50	32	27	63
R2	88	92	97	34	45	32	68
R3	87	89	97	44	40	39	58
R4	81	94	98	51	44	21	61
Total	338	369	386	179	161	119	250
Germination (%)	84.5	92.25	96.5	44.75	40.25	29.75	62.5

Hundred (100) seeds were used in each replication

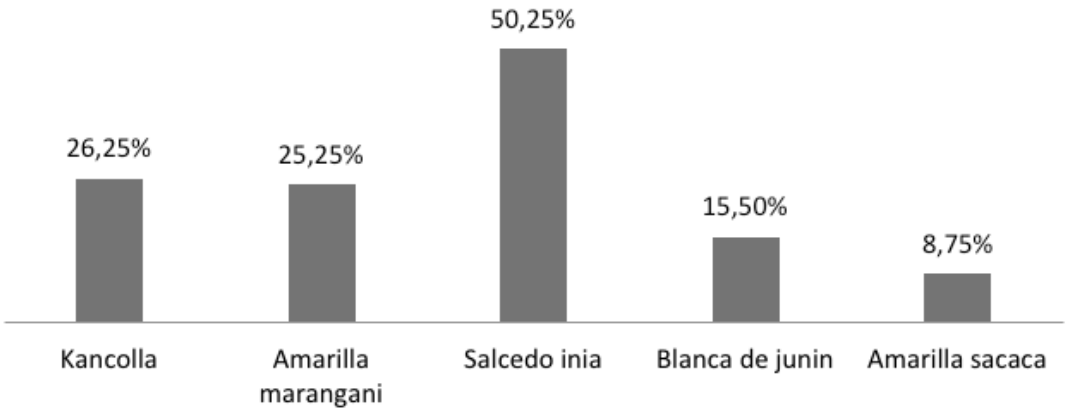

Figure 1. Plant emergence of 5 quinoa cultivars from Peru.

2.4. Quinoa evaluation in rainfed condition

The evaluation was carried out in 2015 under rainfed condition at Farako-Bâ research station (11°06'N; 4°20'W; 405 m.a.s.l). The trial was implemented three times (April 17th, June 30th, and August 20th) but only the trial of August 20th was successful in which plants germinated could be monitored. A set of factors including low seed germination rate in the soil, high temperature, high competition of weed making difficult to identify quinoa plant, presence of ants and others unidentified insects, explained the unfruitful results of the two first trials (April 17th, June 30th).

Results of the trial of August 20th laid out in a randomized complete block design (RCBD) with 3 replications showed that plant density was very low due to low seed germination. In average it varied from 2 plants for *Amarilla sacaca* to 16 plants for *kancolla* (figure 2).

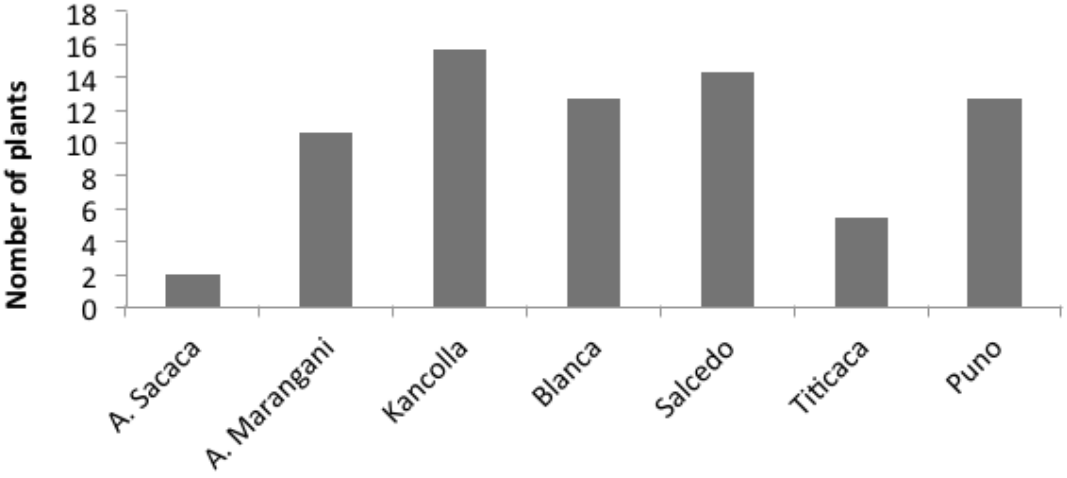

Figure 2. Average plant number across 3 replications in a RCBD

All the cultivars evaluated had plants with branches. The average number of branches was high for *Blanca* de *junin* (17 branches per plant) compared to other cultivars, *Salcedo INIA* had plants with less branches (8 branches per plant) (figure 3). The length and the width of the leaf limb of quinoa varieties were recorded during the flowering time. Results showed that the leaves of *Blanca* de *junin* are larger than the others varieties followed by *Amarilla marangani* (data not presented). *Puno* and *Titicaca* had small leaves.

The plants of all the cultivars were affected by wind and rain reducing progressively the plant density in course of the trial. The root and stem lodging were severe due to low plant density making the plants more susceptible. *Puno* and *Titicaca* were found very susceptible to lodging. Different pests were observed on the quinoa varieties evaluated. At early stage, ants were noted, other insects were observed on the panicles. Fungi diseases appeared during the vegetative stage.

2.5. Evaluation in off-season

The trials were implemented in three research stations: Vallée du kou (10°20'N; 4°20'W; 300 m a.s.l), Farako-Bâ (11°06'N; 4°20'W; 405 m a.s.l) and Saria (12°16'N; 2° 9'W; 300 m a.s.l). There were no seed germination in the trial at Vallée du kou although a replanting was done. The trials at Saria and

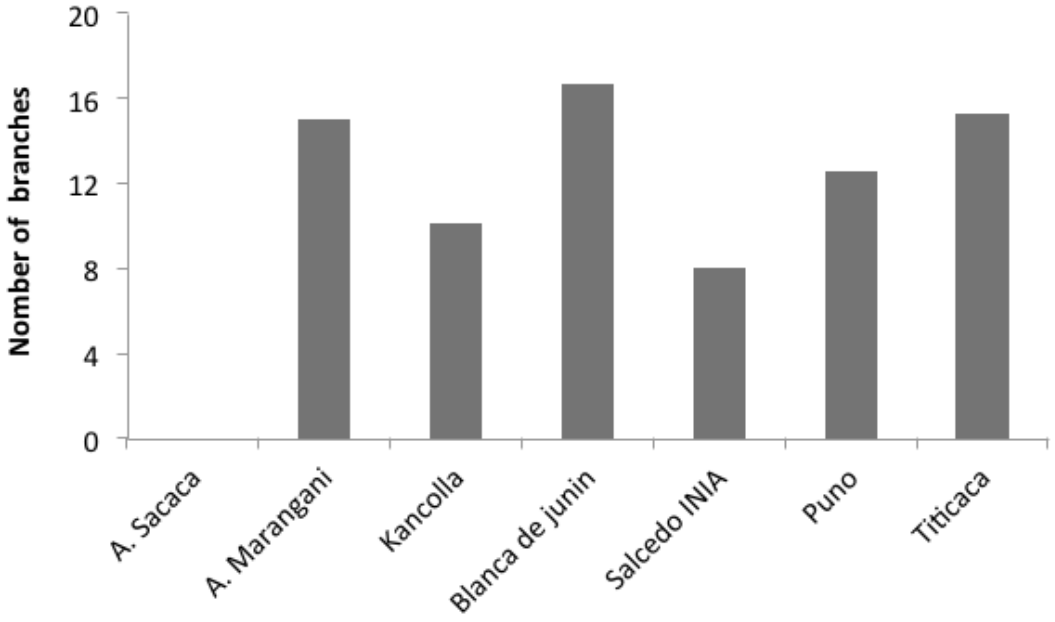

Figure 3. average branches number per plant across 3 replications in a RCBD.

Farako-Bâ were conducted successfully until to the maturity, however the plant density of the cultivars from Peru was very low, varied from 1 to 4 plants per repetition (data not shown), so the results highlighted here refer only to *Puno* and *Titicaca* which had a relatively good plant density.

The trial at Farako-Bâ was set up on December 1st 2015 and harvested on March 14th 2016. Results presented in table 3 showed that the panicle characteristic of *Titicaca* was more developed than *Puno*. The average grain yield per plant of *Titicaca* was 27.06 g/plant compared to 17.09 g/plant for *Puno*. The 1000 grains weight indicated that the grains of *Titicaca* weighted more than the grain of *Puno*.

Table III. Average performance of traits measured of Titicaca and Puno at Farako-Bâ.

Cultivars	**Titicaca**				**Puno**			
Replication	**R1**	**R2**	**R3**	**Mean ± S.E**	**R1**	**R2**	**R3**	**Mean ± S.E**
Plant height (cm)	78.25	71.45	69.5	73.067 ± 2.7	63.35	59.6	63.65	62.2 ± 1.3
No. of branches per plant	16.5	11.9	14	14.133 ± 1.3	12.4	12.7	13	12.7 ± 0.2
Panicle width (cm)	5.47	4.81	5.3	5.193 ± 0.2	5.43	3.23	2.62	3.76 ± 0.9
Panicle length (cm)	33.25	30.1	33	32.117 ± 1.0	26.05	23.85	25.8	25.23 ± 0.7
grain yield per plant (g/plant)	30.53	20.56	30.1	27.063 ± 3.3	18.33	19.36	13.57	17.09 ± 1.8
1000 grains weight (g)				2				1.33
Total grains weight harvested (g)				420.9				1567.1

At Saria, results of descriptive statistic of traits measured summarized in the table 4 indicated that *Puno* had early flowering and maturity time compared to *Titicaca*. Panicle characteristic of *Puno* and *Titicaca* tend to be similar. However *Puno* developed more branches than *Titicaca*. Grain yield per plant of *Titicaca* (26.31 g) was lower compared to the grain yield per plant of Puno (30.70 g), but *Titicaca* grains (3.40 g) weighted more than *Puno* grains (2.10g).

The performance of the two varieties was different across the two sites. At Farako-Bâ, *Titicaca* has a superior morphological and agronomic performance compared to *Puno* whereas at Saria *Puno* had the high performance. However the total grain weight of both varieties were higher in Saria compared to Farako-Bâ. The yield performance of both cultivars at Saria and of *Titicaca* at Farako-Bâ was higher to the value of 26.5 g obtained from the highest yield per plant genotype, Narino, in Kenya (OYOO *et al*., 2015).

Table IV. Average performance of traits measured of *Titicaca* and *Puno* at Saria.

Cultivars	**Titicaca**				**Puno**			
Replication	**R1**	**R2**	**R3**	**Mean ± S.E**	**R1**	**R2**	**R3**	**Mean ± S.E**
Flowering (days)	77	70	73	73.33 ± 2.0	68	67	67	67.33 ± 0.3
Maturity (days)	96	96	96	96 ± 0.0	91	91	91	91 ± 0.0
Plant height (cm)	63.3	70.2	53.4	62.3 ± 4.9	63.2	77.1	74.9	71.73 ± 4.3
No. of branches per plant	17.6	15.7	12.3	15.2 ± 1.6	17.6	19.1	17.4	18.03 ± 0.5
Panicle width (cm)	7	7.2	4.6	6.27 ± 0.8	7.6	8.3	5.8	7.23 ± 0.7
Panicle length (cm)	22.4	27.3	21.1	23.6 ± 1.9	22.3	28.9	26.3	25.83 ± 1.9
grain yield per plant (g/plant)	24.97	31.86	22.12	26.31 ± 2.9	24.51	40.05	27.53	30.70 ± 4.8
1000 grains weight (g)				3.4				2.1
Total grains weight harvested (g)				751.1				2457.9

III. Acceptability of quinoa in Burkina Faso

A review of literature on the composition, chemistry, functional, and nutritional properties of quinoa seed presents quinoa as a complete food due to its protein quality (ABUGOCH, 2009). The protein in quinoa contains all eight essential amino acid needed for human growth and development. It is an important source of minerals and vitamins, and has also been found to contain compounds like polyphenols, phytosterols, and flavonoids with possible nutraceutical benefits. Such nutritive value makes quinoa a relatively cheap yet excellent alternative grain used in people's diets and to fortify various food products (MALIRO and GUWELA, 2015). Yet the great nutritional properties of quinoa seed does not guarantee that it will be accepted as a new food by the local population. To anticipate the adoption of quinoa in Burkina Faso, IRSAT has developed local dishes with quinoa seeds (table V, photo 2). Some of the dishes when prepared with local cereals are consumed both in rural and urban areas. Tô is the main dish consumed all over the country, usually prepared with sorghum or maize flour.

Table V. Dishes developed with quinoa by IRSAT

No	Name of the Dishes	Main constituents
1	Gnongon	quinoa, millet, cowpea, groundnut
2	Crepe with quinoa[1]	quinoa, eggs, milk
3	Crepe with quinoa[2]	quinoa, rice, eggs, milk
4	Crepe with quinoa[3]	quinoa, rice, wheat, eggs, milk
5	Biscuit with coconut	quinoa, coconut, eggs, milk,
6	Biscuit	quinoa, eggs, milk
7	Quinoa yogurt	quinoa, yogurt
8	Quinoa degue	quinoa, millet, yogurt
9	Rice of quinoa	quinoa (eaten with a side-sauce)
10	Quinoa with lentils	quinoa, lentils
11	Fried quinoa	quinoa (prepared in a sauce)
12	Bean with quinoa	quinoa, bean
13	Tô of quinoa	quinoa (eaten with a side-sauce)
14	Quinoa porridge	Quinoa

a) Crepe with quinoa

b) Gnongon with a side-sauce

Photo 2. Two dishes developed by IRSAT using quinoa seed

A hedonic test was realised with 9 dishes of the 14 developed. All of the dishes tested were sensorial well appreciated by 24 panellists (table VI). Analyse of the test result shows that dishes that combined quinoa seed with others products are more preferred than dishes made only with quinoa. For instance quinoa biscuit with coconut was rated very good by 45.83 % of participant compared to 12.5 % for quinoa biscuit only. This explain also why dishes with quinoa cooked like rice (rice of quinoa, quinoa with tomato side-sauce) did not receive a very good mark by the majority of participants.

Table VI. Result of hedonic test with 9 dishes developed with quinoa seeds.

No	Dish names	Very good		good		acceptable		Not appreciation	
		Freq.	Perc.	Freq.	Perc.	Freq.	Perc.	Freq.	Perc.
1	Crepe with quinoa	20	83.33	4	16.67	0	0	0	0
2	Gnongon	15	62.5	8	33.33	1	4.17	0	0
3	Quinoa with lentils	15	62.5	7	29.17	1	4.17	1	4.17
4	Quinoa yogurt	14	58.33	4	16.67	0	0	6	25
5	Quinoa degue	12	50	4	16.67	2	8.33	6	25
6	Quinoa biscuit with coconut	11	45.83	8	33.33	1	4.17	3	12.5
7	Rice of quinoa	6	25	13	54.17	1	4.17	4	16.67
8	Quinoa with tomato side-sauce	5	20.83	10	41.67	4	16.67	5	20.83
9	Quinoa biscuit	3	12.5	12	50	4	16.67	5	20.83

Freq=Frequency; Perc=Percentage

Crepe with quinoa, 'gnongon', quinoa with lentils were the three best dishes rated by 83.33 %, 62.50 % and 62.50 % of participants respectively. 'Gnongon' is a local dish prepared with millet flour, cowpea leaves, and groundnut consumed more often in villages and cities.

IV. Capacity building in quinoa production

The project has organised a training workshop to strengthen the capacity of keys stakeholders in quinoa production. Scientists in plant breeding, pathology, entomology, seed regulatory etc have developed and delivered in two days a comprehensive modules on quinoa to 30 trainees. They were composed of 17 male and 13 females selected in five regions across the country: Hauts-Bassins, Centre, Centre-Est, Boucle du Mouhoun and Est. Participants were mainly composed of seed inspectors but also seed growers and farmers. Quinoa seed cannot be released and grown by farmers in Burkina Faso unless it is registered in the national catalogue. Therefore it was important to start training seed inspectors before the process of adaptation and releasing of quinoa varieties get completed. The training held by scientists from INERA was focused on 9 points: a) general of overview on quinoa (taxonomy, centre of origin and diversification, biodiversity, capacity of adaptation); b) characteristics of the 7 quinoa cultivars introduced; c) cultural practices; d) diseases of quinoa; e) insect and others quinoa pests; f) harvest and post-harvest; g) quinoa nutritional values; h) uses of quinoa and i) field visit. Another important aspect of the training was the exchange with the stakeholders on the steps that need to be taken for a successful introduction and promotion in Burkina Faso.

V. Challenges and futures considerations

The preliminary evaluations have been a bit challenging due to many factors that affected the success of the trials. The most challenging factor was the no germination of the seed in the field. INERA have received few information on the seeds introduced, those from Peru are likely to be farmer seeds or certified seeds, the seeds also transit through different conditions before reaching the final destination. These might affect the seeds viability and germination. Moreover study showed quinoa requires short day lengths for early flowering and cool temperatures for excellent growth; and high temperatures (above 35°C) tended to cause plant dormancy or pollen sterility (AAFRD, 2005). These requirements might have not been met during some of the present trials which caused some failures. Nonetheless some major conclusions can be drawn from the experiments: the performance of quinoa under wet condition was very poor due to the high susceptibility to lodging, high disease and weed pressure. Dry season, particularly from October to December, seems to be the best period to plant quinoa in Burkina Faso. From the evaluations carried out, cultivars introduced from Denmark, *Puno* and *Titicaca*, could be selected as the best adapted genotypes, this because of their earliness, high seeds viability and germination in the field, and an average grain yield potential per plant. Out of the 5 cultivars introduced from Peru, *Amarilla marangani* appeared to be the best genotype, it had a high yield potential per plant but the low seed germination rate and the long cycle of maturity are limiting factors. Another challenge was the low seed yield harvested which limited the evaluation of the nutritional profile and the cooking test of each cultivars introduced. These tests were carried out with unidentified quinoa seeds bought in the market.

Results of initial experiments showed that quinoa can grow well in two locations representing two different agro-ecological zones of Burkina Faso. However more quinoa cultivars from Andean region and/or new cultivars developed in others countries need to be evaluated in many locations in order to capture all the variability within and between agroecological zones and also evaluated under different seasons of Burkina Faso. These evaluations will allow selections of more cultivars adapted to specific local conditions and cropping seasons that prevail in Burkina Faso. Meanwhile, in the perspective of promoting quinoa and raising awareness to farmers, the selected cultivars (*Puno* and *Titicaca*) could be evaluated in farmers' field. Although the best agronomic practices for quinoa production adapted to local condition need to be developed since it has appeared in the course of the field evaluation that the seed bed preparation, sowing date and condition and weed control are important factors that affect the production similar observations were also made in others studies (COULIBALY *et al*., 2015; JACOBSEN, 2015; BENLHABIB *et al*., 2015). The cooking test has shown that quinoa can be easily process to some of the local dishes, in addition the hedonic test revealed that those dishes are well appreciated. Such outcomes forecast an easy adoption of quinoa by local population although others factors influencing the adoption like socioeconomic factors need to be considered. Furthermore, it is essential to explore agribusiness opportunities and market-oriented development for quinoa in Burkina Faso.

Conclusion

Quinoa has been successfully introduced in Burkina Faso thanks to FAO's project '' Technical assistance for the strengthening of the food system of quinoa in Burkina Faso'' and the active participation from project coordination (FAO, SNS), research institutes (INERA, IRSAT) and other stakeholders. At the end of the first step it has been concluded that the production of quinoa is feasible under Burkina Faso conditions if appropriate early-maturing cultivars, and agronomic practices to control weed and diseases are used; and the processing of quinoa seed into local dishes is possible and appreciated.

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