Vegetables open new avenues for farmers' livelihood improvement: promising results from Hoima, Uganda

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Joshua Mwanguhya[1], David Baguma[1], Annet Kiiza[1], Elizabeth Kabakoyo[1], Tobias Recha[2], Ronnie Vernooy[3]

[1]East West Seed Knowledge Transfer, Uganda
[2]The Alliance of Bioversity International and CIAT, Uganda
[3]The Alliance of Bioversity International and CIAT, The Netherlands

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Cover photo: Hoima farmers at the farmers' field day (March 2020) sharing the results of the vegetables pilot project. Credit: Bioversity International/R. Vernooy

Table of Contents

List of abbreviations

Bulindi-ZARDI	Bulindi Zonal Agricultural Research and Development Institute
CCAFS	CGIAR Research Program on Climate Change, Agriculture and Food Security
EWS-KT	East West Seed Knowledge Transfer
FAO	Food and Agriculture Organization of the United Nations
PCA	Principal Component Analysis
WCDI	Wageningen Center for Development Innovation

1. Introduction

Vegetables are a protective food: they supply essential nutrients, vitamins and minerals that are necessary for the correct balance and functioning of the human body. They are one of the best sources to overcome micronutrient deficiencies. However, vegetables are generally sensitive to environmental extremes; high temperatures and limited soil moisture are the major causes of low yields (Koundinya et al., 2014). Climate change impacts are making vegetable production more challenging, in particular for small and marginal farmers who have limited capacity to deal with climate-related risks (FAO, 2009).

East West Seed Knowledge Transfer (EWS-KT) and the Alliance of Bioversity International and CIAT, in collaboration with the Wageningen Center for Development Innovation (WCDI, part of Wageningen University and Research in the Netherlands), the World Vegetable Centre and the National Agricultural Research Organization (NARO) of Uganda are implementing a one-year pilot project on vegetable production in Hoima district, Kyabigambire sub-county, Uganda. The project started in October 2019. Hoima District is where the Alliance and NARO already collaborate on participatory crop improvement, conservation of agrobiodiversity and adaptation to climate change, with the support of the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). The pilot project is being implemented under the umbrella of a larger research project titled *Resilient Seed Systems for Climate Change Adaptation and Livelihood Security in East Africa*. The main objective of this novel collaborative initiative is to help resource-poor farmers to cope better with climate change through increased availability and diversity of climate-smart vegetable varieties. Second, the pilot project aims to strengthen farmers' capacity to make better use of vegetable crop diversity for multiple livelihood purposes (Recha et al., 2019).

The methodology of the pilot project combines the EWS-KT farmer training approach (https://kt.eastwestseed.com/)[1] and Bioversity International's crowdsourcing or Tricot methodology (van Etten et al. 2016, 2019)[2]. The targeted portfolio of vegetables includes traditional (e.g. green leafy vegetables) and modern crops and varieties (e.g. tomato, onion, sweet pepper, cabbage, pumpkin) based on farmers' interests and marketing opportunities, sourced from EWS-KT, the World Vegetable Centre and farmers' own gardens and fields. Farmers test vegetables on their own farm with the technical support of EWS-KT, the Alliance and NARO. In parallel, a so-called *vegetable learning site* is managed at the NARO-Bulindi station (in Hoima district) where farmers from all over the district can observe the growing of the targeted vegetables. EWS-KT and NARO manage this learning site.

This is the second progress report, which presents the first results of the pilot project, based on farmers' vegetable growing activities on their farm. It covers the period from October 2019 to March 2020. The COVID-19 outbreak has brought a temporary halt to field activities but we are hopeful that they can be resumed later in 2020.

2. Pilot activity highlights

Situational analysis and motivational tour

In October 2019, an inception meeting was held to introduce the pilot project to all stakeholders, after which a situational analysis was conducted in the Hoima district. Of 13 key farmers selected to participate in the pilot project six hosted tomato, two hosted

[1] For a short video about the approach, see: https://www.youtube.com/watch?v=aOzMXVCNWCc

[2] For more information, see: https://www.bioversityinternational.org/e-library/publications/detail/the-crowdsourcing-approach/

cabbage, one hosted sweet pepper, three hosted eggplants and one-hosted onion (photos 1 and 2). Before starting vegetable production on their own farm, the selected farmers traveled to Gulu and Lira in the north of Uganda to learn about farmers' experiences in vegetable production, supported by the EWS-KT team (Guijt and Reuver, 2019).[3] This learning visit inspired the group and offered a clear example of how to organize demonstration plots on their own farm (Recha et al., 2019). As a first step of the pilot project, farmers established seed nurseries (photos 3 and 4).

Photos 1-2. Demonstration plots for dry season production and testing of different varieties of tomato (top) and onion (bottom) for climate change adaptation and livelihood improvement, Hoima, Uganda. Bioversity International/R. Vernooy

[3] To learn more about the EWS-KT work in the north of Uganda see: https://issdafrica.org/2020/06/23/webinar-report-creating-demand-for-quality-seed-in-northern-uganda/

 

Photos 3 and 4. Vegetable seed nurseries (Hoima). Bioversity International/R.Vernooy

Farmers' field days

Organizing a farmers' field day is an EWS-KT knowledge transfer approach that brings a group of farmers together at one or more vegetable demonstration sites. During these events, farmers are given the opportunity to learn about all stages of vegetable production from fellow key farmers who are hosting demonstration (pilot) plots. On 4–5 March 2020, over 700 farmers from eight villages in Hoima district came together to learn about the Hoima vegetable pilot (photos 5 and 6). The event provided an opportunity for farmers and experts to share knowledge and skills in vegetable production (photo 7). Key farmers and experts explained the different technologies showcased in the demonstration sites and handed out crop guides in the local language developed by EWS-KT for further reading. The technologies are based on five key production steps, including seedling production, soil and water conservation, fertilization, crop protection and safe use of pesticides. The EWS-KT training/learning approach was tested on-farm with tomato, green cabbage, eggplant and green pepper. During the event, farmers were also able to interact and share views and ideas about the different observable crop traits and compare how the different varieties of each crop were performing. The farmers' field days were covered by several media:

In a CCAFS program in a blog called *Learning to grow vegetables: a novel way to transfer knowledge in Hoima, Uganda*. Available at:
https://ccafs.cgiar.org/news/learning-grow-vegetables-novel-way-transfer-knowledge-hoima-uganda#.Xt4NvtOP5mA

in the national press newspaper article titled: *He ditched tobacco for vegetables*. Available at:
https://www.monitor.co.ug/Magazines/Farming/He-ditched-tobacco-vegetables/689860-5499526-view-asAMP-13mbk2/index.html

and on a national Ugandan TV news broadcast: *Hoima takes up climate resilient vegetables*. Available at:
https://youtu.be/IPYpcWJRjIs

Photos 5 and 6. Farmers from Hoima learn about the production of cabbage (top) and eggplant (bottom) during the farmers' field days. Bioversity International/R. Vernooy

Photo 7. A pilot farmer demonstrates the spacing recommended for the production of eggplant. Bioversity International/R.Vernooy

Establishment of a learning plot

A learning plot was set up at Bulindi Zonal Agricultural Research and Development Institute (Bulindi-ZARDI), close to the main road, to showcase different climate-smart agronomic technologies of different vegetable crops: African eggplant, African night shade, amaranth, cabbage, eggplant, Ethiopian mustard, pumpkin, sweet pepper and tomato (photos 8 and 9). This learning site is open for all farmers to visit, make observations and learn through interaction with NARO experts. A farmers' field day at the learning plot was envisioned to take place in April 2020, but due to the COVID-19 outbreak, it had to be cancelled.

Photos 8 and 9. The vegetable learning site at NARO-Bulindi, including the seedling house (bottom). Bioversity International/R.Vernooy

3. Implementation strategy

A crowdsourcing approach was used to implement the pilot project. This approach enables farmers to make more informed seed choices in the face of rising temperatures, drought and other extreme weather events. In addition, by accelerating and improving recommendations of the most suitable varieties for a specific region, it allows farmers to contribute to a broader understanding of how varieties respond to climate shifts. To ensure proper implementation of this approach, the triadic methodology (tricot) was used, as elaborated by van Etten et al. (2016). The following steps were taken:

- The research team identified 18 promising crop varieties to be evaluated of five crops: tomato, cabbage, onion, sweet pepper and eggplant.
- The research team selected 13 dedicated pilot farmers, from different locations in the Hoima district, who were interested in improving their farming activities through the introduction of vegetables.
- The research team prepared trial packages, each of which included seed samples of three varieties of each crop, which were distributed to the participating (pilot) farmers.
- Every pilot farmer was responsible for her/his own trial and made various observations during growth and after harvest, based on the following questions: Which variety germinated first? Which one was growing well? What was the disease incidence? Which one had the highest yield? Which one the lowest? The (pilot) farmers marked these observations on an observation card with the help of an EWS-KT field officer.
- The EWS-KT field officer collected the data from all the pilot farmers and passed them on to the research coordinator for analysis.
- The research coordinator compiled and analyzed the data from all trials, using Microsoft Excel and XLSTAT software.
- The research coordinator provided every pilot farmer with feedback through the field officer about the results of the varieties used and about obtaining a fresh supply of seed.
- The research team and the farmers are evaluating the Tricot methodology in order to improve the implementation process during the next cropping cycle.

4. Criteria for farmer selection and crop distribution

The pilot study adopted EWS-KT farmer selection criteria where key farmers had to be passionate, committed, and own their land; the land would need to be near a water source that can be used for irrigation; visibility of the demonstration site is very important; and the demonstration plot should be located in a populated area of targeted farmers.

Crop distribution in different parishes of Kyabigambire sub-county was influenced by farmer crop preference, since each demo-plot host was given an opportunity to select which crop to test and to select varieties suitable for their farm, with the aim of rolling out the pilot on a commercial scale in the second cropping cycle. Table 1 presents the crop choice by site (village).

Table 1. Selected demo sites and chosen crops in Kyabigambire sub-county, Hoima, Uganda

	Village	Parish	Crop of interest
1	Kiranga	Kyabanati	Onion
2	Kikoro	Bulindi	Cabbage
3	Kibaire	Bulindi	Eggplant
4	Mpalangasi	Kibugubwa	Cabbage
5	Luhungu	Kisabagwa	Tomato
6	Kisabagwa	Kisabagwa	Tomato
7	Chalugumba	Bulindi	Tomato
8	Nyakakonge	Bulindi	Tomato
9	Kisagala	Bulalu	Eggplant
10	Katikara	Kisabagwa	Tomato
11	Kikungu	Bulindi	Tomato
12	Kibaire	Bulindi	Eggplant
13	Nyakakonge	Bulindi	Sweet pepper

5. Variety testing and data collection

The pilot evaluated 18 varieties of different crops, a breakdown of which is presented in Table 2. Unfortunately, only two cabbage varieties were tested due to challenges in sourcing these varieties.

Table 2. Crop varieties under trial in the first crop cycle of the first season, Hoima, Uganda

Tomato varieties	Eggplant varieties	Sweet pepper varieties	Onion varieties	Cabbage varieties
Padma F1	Arjani F1	Kaver	Super yali	Indica F1
Imara	Munira	Kaveri	Red creole	Gloria
Cal-j	Long purple	Local variety	Local variety	
Kipato	Local variety			
Riogrand				
Tengeru				

Observation scoring and analysis

A 5-point Likert scale was used to score variety performance based on observed parameters: 1=Very poor, 2=Poor, 3=Fair, 4=Good and 5=Very good (Appendix 1). In addition, observable parameters scored (Appendix 1) were: seedling germination percentage, drought tolerance, crop maturity, pest and disease resistance, crop yield, fruit/bulb size, fruit shelf life and fruit marketability. After tallying the responses, average (mean) observation scores were determined. The mean gives the overall average response, helping to determine which varieties performed well on specific attributes and which varieties performed better or worse on all parameters. Table 3 presents the variety scoring for the first season's first crop cycle (October 2019 – March 2020)

Biplots (showing samples and variables in the same graph) and clustering analysis were conducted using XLSTAT (https://www.xlstat.com/en/) to show the varieties with similar attributes and determine their level of dissimilarities (see the Principal Component Analysis (PCA) results presented in Figures A1A-E, Annex 2).

Results in Table 3 show how all five crops preformed with respect to the eight crop variety attributes scored by the pilot farmers. For tomato, Imara and Padma F1 varieties were considered better by the farmers with a mean score of 4 compared to the rest. Figure A1A shows that these two varieties have good yields, pest and disease resistance and good growth vigour. In addition, Padma F1 has good water use efficiency, has colourful and tasty fruits, while Imara is susceptible to pests and has a short shelf life. However, the cluster dendrogram in Figure 1 shows that Padma F1 and Kipato are closely related on the dissimilarity index in terms of attributes compared to the other six varieties. They are clustered together due to their ability to resist diseases, having vibrant growth vigour, high yielding capabilities and well-shaped fruits, but Kipato might not be such a good option for farmers due to its low market demand.

Crop variety-scoring results

Table 4. Variety scoring for the first season's first crop cycle, Hoima, Uganda (October 2019 – March 2020)

	Cabbage		**Eggplant**			**Onion**			**Sweet pepper**			**Tomato**					
Variety	Gloria	Indica	Arjani F1	Long purple	Munira	Super Yali	Red Creole	Local variety	Kaver	Kaveri	Local variety	Cal-J	Imara	Kipato	Padma F1	Riogrand	Tengeru
Germination	5	5	5	4	4	4	5	5	5	5	4	3	5	5	5	4	4
Overall plant growth	5	4	5	3	4	5	3	5	5	5	4	3	4	5	5	4	3
Water use/drought tolerance	2	3	2	3	3	1	3	3	4	3	4	5	1	2	4	4	4
Pest incidence	3	3	3	4	4	3	4	5	3	3	5	3	3	3	3	1	4
Pest and disease incidence	3	2	3	4	4	1	3	3	3	4	5	1	4	3	4	1	2
Overall maintenance	3	4	3	4	4	1	3	3	3	5	3	4	4	3	3	5	3
Shape of fruit	5	5	4	3	3	4	5	2	4	5	3	2	5	5	4	3	2
Expected/actual yield	4	5	4	3	4	5	4	3	3	3	5	2	4	3	5	2	3
Appearance	4	5	5	4	5	5	3	3	5	5	5	4	4	4	5	5	4
Shelf life	4	4	4	4	4	3	4	4	3	3	5	4	5	3	4	4	4
Taste	3	4	5	3	4	5	4	2	4	5	4	5	3	3	5	5	4
Expected market price	5	4	4	4	4	4	2	4	4	4	5	4	5	4	4	3	4
Mean variety score	**4**	**4**	**4**	**4**	**4**	**3**	**4**	**4**	**4**	**4**	**4**	**3**	**4**	**3**	**4**	**3**	**3**

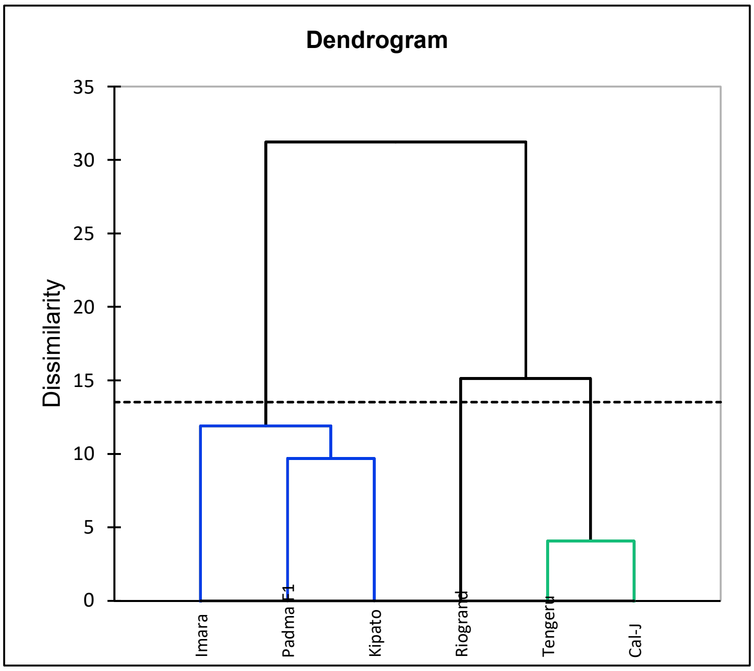

Figure 1. Tomato cluster dendrogram

The performance of the three varieties of eggplant was very competitive across the pilot farmers with a mean score of 4 across all varieties (Table 3). A local check called Long Purple performed vigorously against two improved varieties Arjani F1 and Munira. All the three varieties showed good pest and disease resistance, good yields, easy maintenance with good growth vigour and all three were tasty. The only shortfall was the poor shelf life of Arjani F1 and Munira (Figure A1B).

Sweet pepper and onions presented interesting findings where local checks that were provided by pilot farmers performed competitively against improved varieties. In Table 3, a local variety of sweet pepper had the equivalent mean performance of Kaveri and Kaver. These varieties had almost all the required characteristics, but the local variety outperformed the two improved ones in terms of pest and disease resistance and better expected market price. The onions had a similar trend, with the local variety out-competing the improved variety Super Yali. This local variety is characterised by high germination percentage, vigorous growth, long shelf life and good market price.

Regrettably, only two cabbage varieties, Gloria and Indica were compared, because the third variety was not secured within the required timeframe of the trial. Both had a mean score of 4, although for varied attributes (Table 3). Indica had a better shape, had high yields and was also easy to manage (Figure A1C). Gloria had vigorous growth and better market demand, although poor taste compared to Indica.

From the results we observe that:

- Three tomato varieties, Imara, Padma F1 and Kipato, are all important to farmers. Their attributes vary entirely depending on the taste and preference of individual farmers. The individual farmer's knowledge and the production purpose will play a key role in deciding on which variety to plant. We cannot clearly isolate a single variety to be the best. More data on these three varieties should be collected for further evaluation to determine any statistical differences in terms of their performance and farmers' choices.
- The local variety of eggplant performed competitively against the improved varieties. All three varieties could be promoted in Hoima for nutritional diversity. However, a

nutritional analysis might help to better determine which of the three is richest in vitamins and the most nutrient-dense variety can then be promoted and produced on a larger scale by farmers.

- The local varieties of onion and sweet pepper also performed competitively against the improved varieties. It is therefore recommended that they are promoted for production as much as the improved varieties. The local onion variety should play a key role in breeding, to make use of its attributes and produce elite lines. Super Yali variety might face more climate related challenges compared to red creole and the local variety and might attract less interest from farmers.
- Both cabbage varieties performed well, with almost no difference in terms of preference. The two varieties complement each other's shortcomings and could be promoted together in Hoima. However, further testing and evaluation is recommended to see if any differences appear.

It should be noted that these are single season results and a second round of trials may increase the confidence in the accuracy of analysis and farmers' preferences.

6. Cost benefit analysis

Table 4: Cost benefit analysis of crops grown in the 1st cropping cycle in Hoima

Crop	Area (m²)	Total Production (Kg)	Cost (USD)	Return (USD)	Benefits (USD)
Tomato	250	639	32	264	233
Sweet pepper	250	576	27	226	199
Onion	250	628	24	237	214
Egg plant	250	585	26	228	201
Cabbage	250	1,334	19	269	250

Table 4 gives a simple average cost/benefit calculation of production across the different crops, including costs incurred in demonstrations and returns and profits realized by the farmers. Because farmers sold varieties together, a cost/benefit analysis by variety could not be made. The analysis gives a clear picture that vegetable production is very profitable and can improve household income with the use of modern agronomic practices and use of resilient varieties that are high yielding.

7. General observations about the first season

- Pilot farmers have gained knowledge about the different variety traits of vegetable species, which are key considerations for climate change adaptation and for their farm/enterprise development. Their exposure to different varieties on their own farm and those of other pilot farmers has increased their knowledge about the performance of varieties under more or less similar agro-ecological conditions, allowing the identification of best performers according to a number of criteria.

- Pilot farmers have improved their knowledge and skills of the whole vegetable production process (resulting in very good harvests). According to their testimonials, this has been largely due to theoretical and practical training sessions conducted by the research team led by EWS-KT, which were complemented by the farmers' field days. Farmers are now able to use good agronomic practices to grow vegetables in a much better and more profitable way.

Photo 9. A pilot farmer benefits from a second tomato harvest on her demonstration plot. Bioversity International/R. Vernooy

- The majority of these farmers have realized the importance of raising seedlings in leaf pots instead of using the traditional ground nursery seedling production system. Leaf pots are easy to make, environment friendly and also cheaper, lowering the cost of production.

- The EWS-KT crop guides distributed to local agro-input shops and farmers have been a key source of technical information on vegetable production; farmers were very appreciative of how easy to use they were.

- There is a need to continue working closely with local agro-input dealers to enhance adoption of improved vegetable production technologies promoted by the research team.

- Implementation of Integrated Pest Management from the very beginning of the season yields good results for farmers and reduces production costs through lower pesticide use.

- It is essential to have regular meetings with key farmers to address expectations and challenges they could be facing, but also to remind them of their roles and responsibilities concerning hosting the demonstration sites.

8. Challenges and recommendations

Table 4 presents the main challenges that arose during the first crop cycle and the responses of the research team.

Table 4. Challenges faced during the first crop cycle and Way forward

Challenge	Recommendation
Responsiveness to the high expectations by farmers from the vegetable pilot in terms of expected benefits	Clear and transparent communications with farmers during inception period before their engagement in activities
Developing the entrepreneurial spirit of farmers to engage in off-season vegetable production	Showcasing viable pilots on farms with some access to water during the dry season
Lack of enough water for production during the dry season	Training farmers in soil and water conservation techniques to make sure that there is efficient utilization of available resources
Ups and downs in the commitment of some key farmers	Timely monitoring of the activities of the pilot farmers and responding to questions they have
Occurrence of pests and diseases	Training farmers in crop protection and Integrated Pest Management
Outbreak of Covid-19 pandemic	Deployment of community-based trainers as the pilot basis to reach farmers during the lockdown

After participating in a series of knowledge transfer events (farmer field days and learning site visits), a number of non-pilot farmers have shown interest and adopted some of the technologies as shown in Table 5.

Table 5. Adoption of technologies by Hoima non-pilot farmers in 2020

Location	Technology adopted	Crop grown	Area covered
Bulindi village	Raised beds, trellising	Tomato	$500m^2$
Kigawa village	Raised beds, trellising	Eggplant, tomato, onion	1/2 acre
Kyabigambire village	Raised beds, mulching, trellising	Cabbage, tomatoes	0.4 acre
Nyakakonge village	Raised beds, trellising	Nakati, eggplants, sweet pepper, cabbage , tomato	0.3 acre
Kibugubwa village	Raised beds	Sweet pepper, tomato, eggplant	0.3 acre
Buyimba mabale village	Raised beds	Tomato, African eggplant, eggplant, cabbage	0.4 acres
Nyamirima village	Raised beds, trellising, mulching	Tomato	0.2 acre
Nyamirima village	Raised beds, trellishing, mulching	Tomato	0.3 acre
Kihunga village	Raised beds, trellising	Cabbage, tomato	0.5 acre
Kihunga village	Raised beds, trellising, mulching	Tomato	0.3 acre
Kisemba village	Raised beds, trellising, mulching	Tomato	0.2 acre
Bulindi village	Trellising, mulching, raised beds	Tomato	0.5 acre

9. Next steps

Following the successful completion of the first season with 13 pilot farmers, we plan to work with a total of 20 pilot farmers for the second crop cycle, 13 of whom will grow varieties they have selected for commercial production. These farmers have 50% of their total production costs supported by the project. Seven new pilot farmers will be added and will use the same trial implementation strategy as the first group of (pilot) farmers.

To maximize outreach, the research team will set up another learning plot that will be open to anyone interested in vegetable production. More crop guides will be distributed to agro-input dealers. Last but not least, a new round of farmer field days will be organized at all demonstration sites.

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11. Appendix 1. Variety assessment tool

Variety attribute	Crop grown		
	Variety A	Variety B	Variety C
Seedling germination percentage			
Drought tolerance			
Crop maturity			
Pest and disease resistance			
Crop yield			
Fruit/bulb size			
Shelf life			
Fruit marketability			

Likert scale

1. Very bad
2. Bad
3. Average
4. Good
5. Very good

12. Appendix 2. Biplots

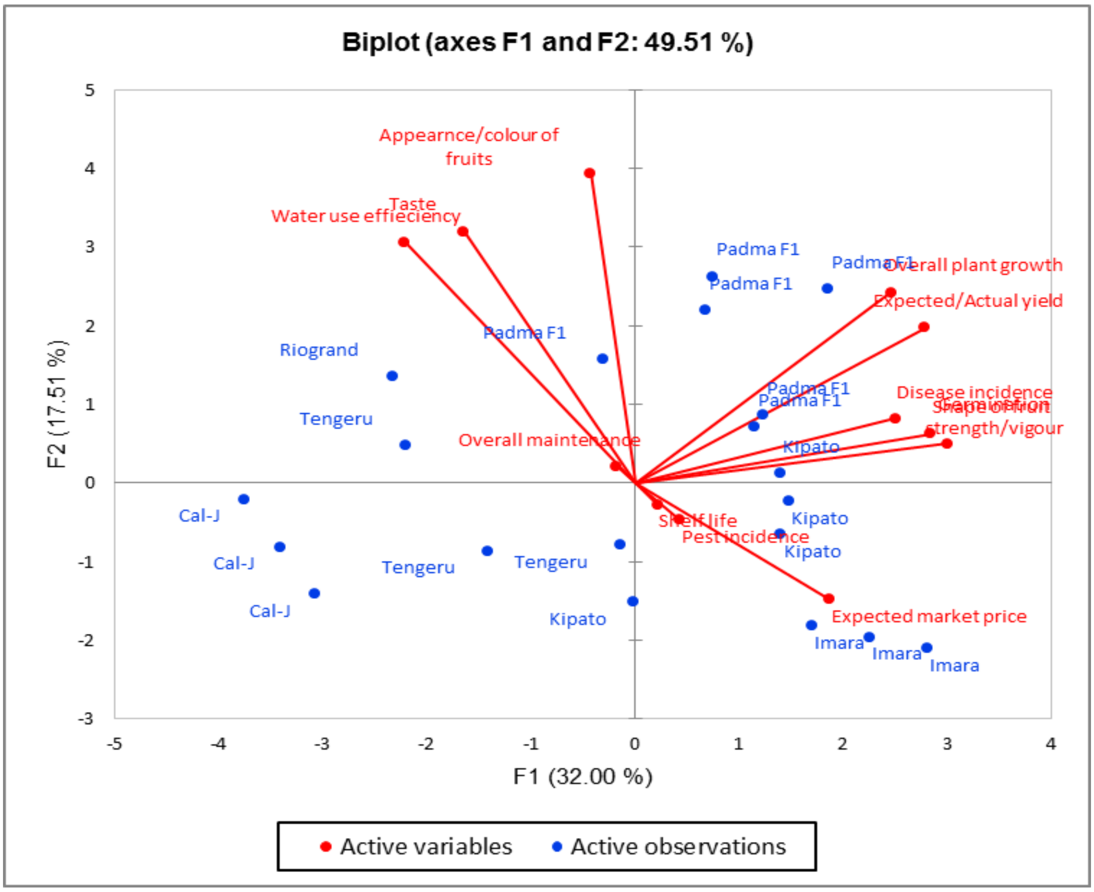

Figure A1A. Tomatoes PCA

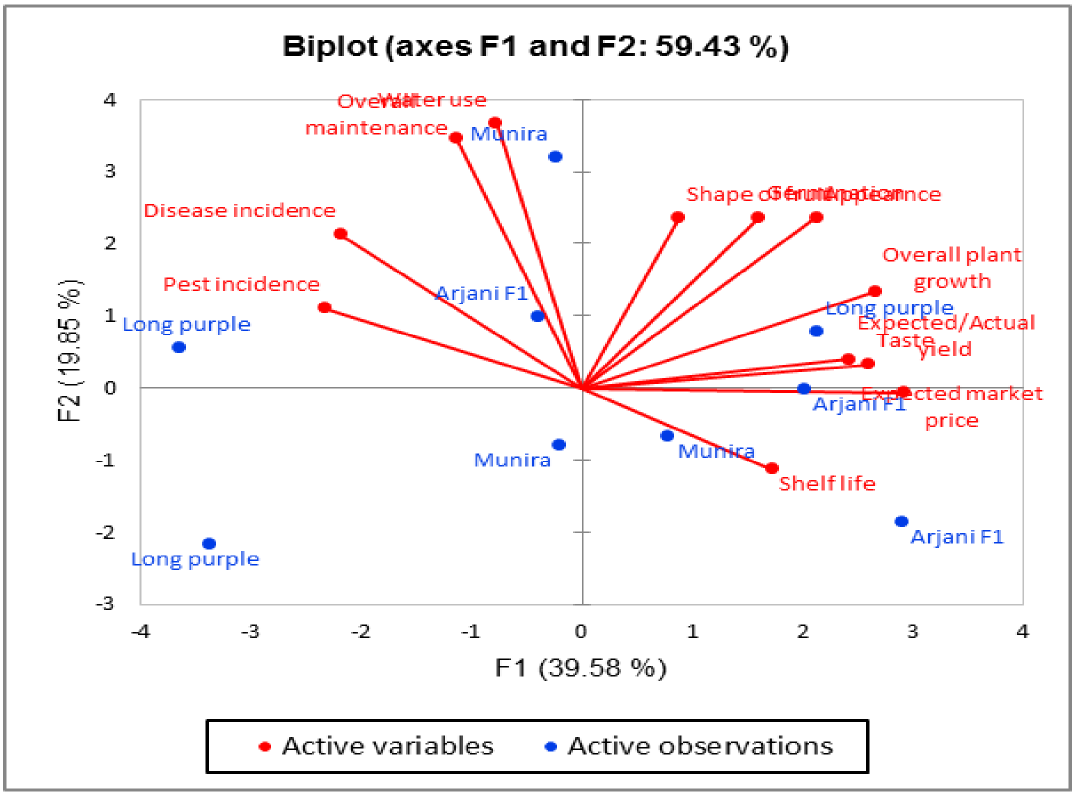

Figure A1B. Eggplant PCA

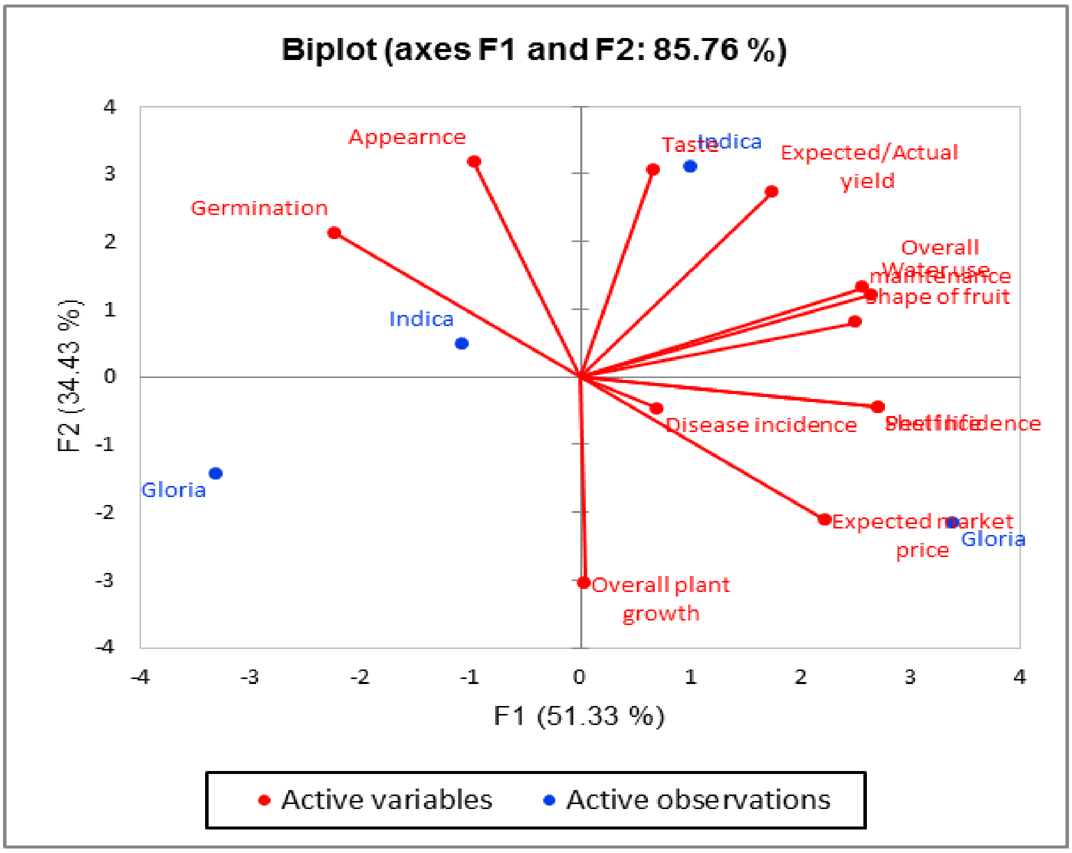

Figure A1C. Cabbage PCA

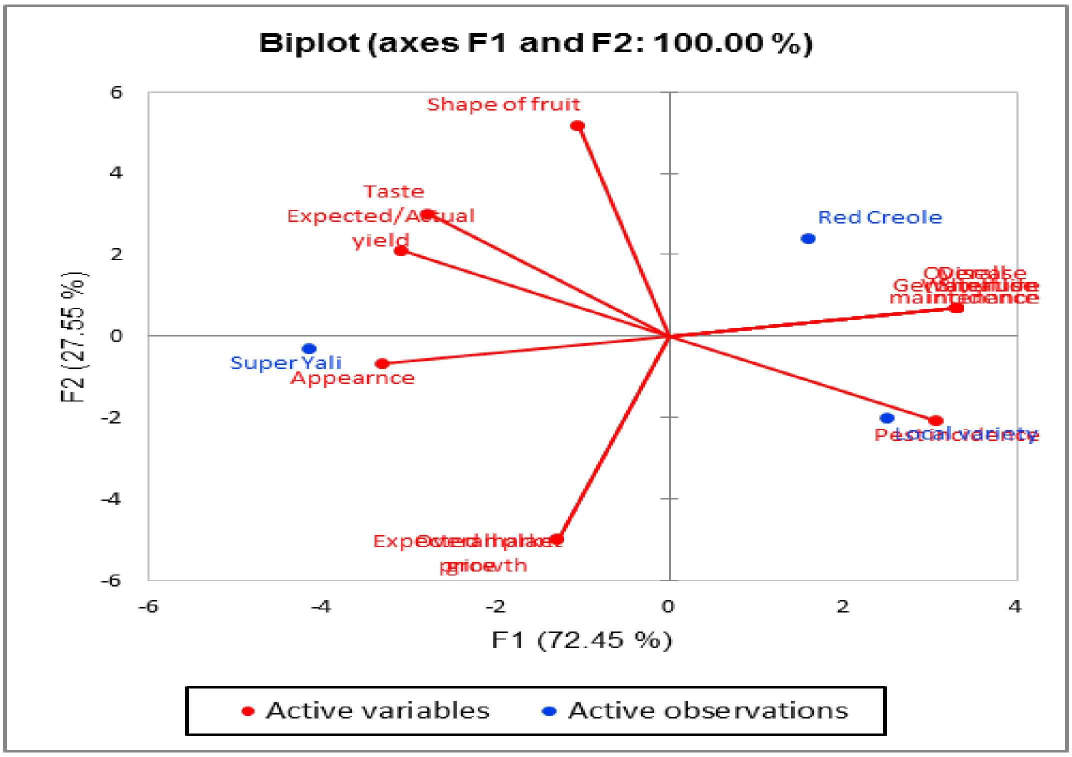

Figure A1D. Onions PCA

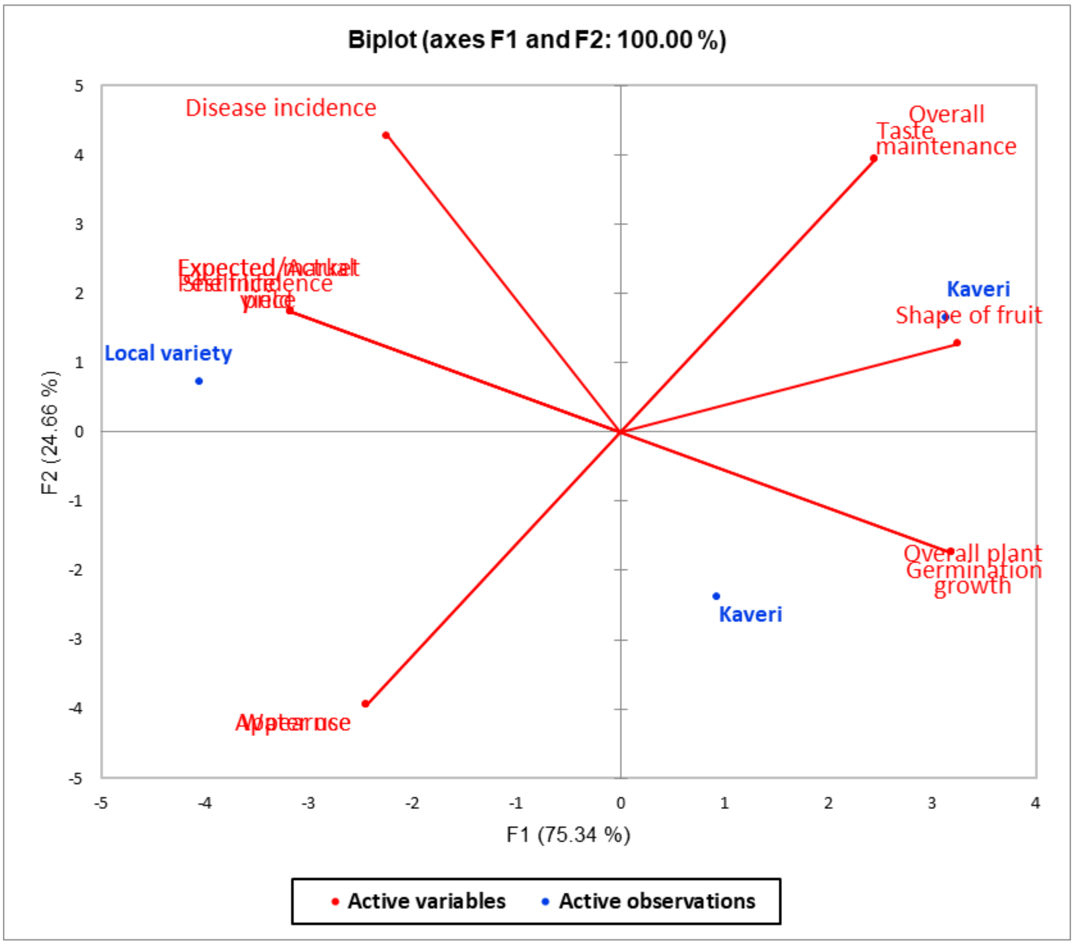

Figure A1E. Sweet pepper PCA