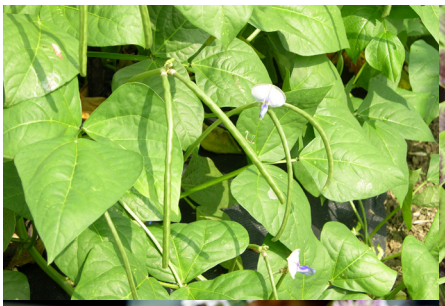
AVRDC
The World Vegetable Center

HORTI

International Cooperators' Guide

Protocols for Fruit, Leaf and Bulb Type Vegetable Cultivar Testing



Fekadu F. Dinssa
Omary Mbwambo
John Macharia
Agatha Aloyce
Oshingi Shilla

AVRDC – The World Vegetable Center

Horticultural Research and Training Institute (HORTI) Tengeru, Tanzania

International Cooperators' Guide

Protocols for Fruit, Leaf and Bulb Type Vegetable Cultivar Testing

Fekadu F. Dinssa[1], Omary Mbwambo[1], John Macharia[1], Agatha Aloyce[2] and Oshingi Shilla[1]

[1]AVRDC – The World Vegetable Center

[2]Horticultural Research and Training Institute (HORTI) Tengeru, Tanzania

August 2015

With financial support from the VINESA and HORTINLEA projects

VINESA = Improving Income and Nutrition in Eastern and Southern Africa by Enhancing Vegetable-based Farming and Food Systems in Peri-urban Corridors, supported by Australian Center for International Agricultural Research (ACIAR).

HORTINLEA = Horticultural Innovations and Learning for Improved Nutrition and Livelihood in East Africa, GlobE Project, Subproject 6: Variety Development and Seed Systems, sponsored by the Federal Ministry of Germany for Economic Cooperation and Development (BMZ)/ Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

Published by
AVRDC – The World Vegetable Center
P.O. Box 42 Shanhua, Tainan 74199
Taiwan
T +886 6 583 7801
F +886 6 583 0009
E info@worldveg.org

avrdc.org

AVRDC Publication: 15-793

Suggested citation
Dinssa FF, Mbwambo O, Macharia J, Aloyce A, Shilla O. 2015. *Protocols for Fruit, Leafy and Bulb-Type Vegetable Cultivar Testing*. AVRDC – The World Vegetable Center. Shanhua, Taiwan. Publication 15-793. 19 p.

Table of Contents

Summary

These protocols were prepared in collaboration with the **VINESA** project sponsored by the Australian Centre for International Agricultural Research (ACIAR) and the **HORTINLEA** project sponsored by the Federal Ministry for Economic Cooperation and Development (BMZ)/Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Germany.

VINESA set up four Best Practice Hubs (BPHs)—one each in Ethiopia, Malawi, Mozambique and Tanzania—as centers for crop trials/experimentation, demonstration of improved technologies, and training. These hubs are planted with elite lines from AVRDC breeding programs and national agricultural research systems selected for their yield, market acceptance and nutritional value to enrich local vegetable seed supply and distribution systems in each country. Crops being evaluated and demonstrated include improved cultivars and advanced lines of both traditional and global vegetables. The BPHs aim to increase small-scale vegetable farmers' access to research innovations and serve as centers for participatory testing and evaluating new crop cultivars, farming practices and technologies.

The HORTINLEA project is a multi-partner project consisting of 14 subprojects focusing on the entire value chain for African traditional vegetables. AVRDC is mainly involved in subproject 6, which deals with variety development and seed systems, and is responsible for generating and distributing breeding lines and providing agronomic recommendations to other project partners.

Members of VINESA's Production Taskforce in collaboration with the HORTINLEA project in charge of crop technology evaluation and production issues prepared the protocols. The mandate of the Production Taskforce is to address country cross-cutting and learning issues to maintain a regional focus and avoid duplication; draw from regional options to address country-specific needs; and enable learning and information exchange between the four countries. The Production Taskforce coordinates cultivar testing and associated crop management trials primarily in VINESA focus countries. Robust experimental protocols are necessary to enable project teams to validate and promote use of improved cultivars and integrated crop and pest management practices for increased and safer production and consumption of vegetables. The protocols in this guide are for two fruit vegetables (African eggplant and peppers), five leafy vegetables (amaranth, African nightshade, Ethiopian mustard, spider plant, and vegetable cowpea) and one bulb vegetable (onion). The protocols cover various agronomic practices starting with choice of land to experimental designs and crop management. Guidelines for data collection from sowing to harvesting have been provided for each crop. However, these protocols may require some modification to suit specific local agronomic recommendations.

By following these protocols with modifications as required, the BPHs will contribute to the overall objectives of VINESA and HORTINLEA: generating knowledge, transferring know-how, and strengthening research-to-delivery capacity and linkages to enhance the contribution of vegetable research to livelihood and nutrition impacts in Eastern and Southern Africa.

1. INTRODUCTION

The protocols allow comparison of data collected in multi-environment (locations, years, and seasons) vegetable cultivar trials. They also can be applied for a single environment trial. Major vegetable crops include: (1) fruit type: African eggplant (*Solanum* spp.), hot and sweet peppers (*Capsicum annuum* L.); (2) leafy type: amaranth (*Amaranthus* spp.), African nightshade (*Solanum* spp.), Ethiopian mustard (*Brassica carinata* A. Braun), spider plant (*Cleome gynandra* L.) and vegetable cowpea (*Vigna unguiculata* (L.) Walp.); and (3) bulb type: onion (*Allium cepa* L.). A protocol for tomato already has been developed by AVRDC's tomato breeding program and is available on the AVRDC website (http://avrdc.org).

2. PROTOCOL

2.1 Fruit type vegetables

African eggplant, hot and sweet peppers

2.1.1 Choice of land

Select a well-drained area with fairly uniform fertility and slope.

2.1.2 Number of entries

The number of entries depends on the number of replications used, but a minimum of six entries are required for evaluation using the design and replication pattern described in section 2.1.3. The maximum number of entries in each replication depends on the uniformity of experimental plots; however, it is best not to go beyond 20 entries. The 6-20 entries should include one or two locally popular cultivar(s) in a target location.

2.1.3 Experimental design

A randomized complete block design (RCBD) with three replications is recommended (See Appendix 1 for a field layout example with 10 entries). A detailed planting plan is provided for each crop. Appendix 2 provides a sample of a data collection sheet.

2.1.4 Spacing

African eggplant

Spacing of 50 cm is used between plants within rows, and 60-75 cm between rows/ridges. The rows of each plot can either be on raised beds 20 cm high or on raised ridges 30 cm high, with furrows in-between for irrigation. At AVRDC Eastern and Southern Africa, each entry per plot is grown in 2 rows. A minimum of 12 plants per row are used, of which 10 plants per row will be harvested. Each plot measures 6 m long and 1.2-1.5 m wide.

Plate 1: African eggplant

Peppers (sweet and hot peppers)

Note: This guide provides brief step-by-step cultural practices for raising seedlings, transplanting and field management. Additional cultural practices for sweet pepper (Berke et al. 2003) and chili pepper (Berke et al. 2005) are available at http://203.64.245.61/fulltext_pdf/E/2001-2005/e03417.pdf. A guide for pepper seed multiplication (Berke 2000) is available at http://203.64.245.61/web_crops/pepper/pepper%20seed.pdf.

Spacing of 40 cm is used between plants within rows and 60 cm between rows/ridges. The rows of each plot can either be on raised beds 20 cm high or on raised ridges 30 cm high, with furrows in-between for irrigation. Each entry is grown in 2 rows per plot with the minimum number of 12 plants per row. Each plot measures 4.8 m long and 1.2 m wide. Data is collected from 20 inner plants. Any change in plot dimensions should be reflected in the data collection sheet.

2.1.5 Cultural practices

Cultural practices include nursery preparation, transplanting, fertilizer application, irrigation, weeding, control of non-target pests as required, and harvesting.

Nursery preparation and seedling raising: If seeds are sown in trays, planting media should be sterilized after mixing forest soil/compost, manure, sand, and rice husks (whenever available) in a ratio of 3:2:1:1. When a nursery is prepared in beds, land should be well-ploughed and mixed with decomposed cow dung, chicken manure or compost at a rate of 3-5 kg/m^2. The nursery should be in a flat area with well-drained, fertile soil that is free of shade, and it should be near a water source. It should not previously have been used to grow crops such as tomato, African eggplant, African nightshades and peppers over the last 2 to 3 years or seasons to avoid disease inoculum build-up in the soil. Seeds should be sown in rows, 15-20 cm apart with 1 cm spacing between seeds within a row. After sowing, cover the seeds with a thin layer of soil followed by watering. Thin the seedlings to 1-2 cm spacing between plants. Weeding should be done whenever necessary to avoid competition with seedlings. Regular watering is necessary, but avoid waterlogging.

Transplanting: About three weeks after sowing, harden seedlings by slightly reducing the frequency of watering and shading. Seedlings for transplanting are ready in four to six weeks, or when they have 4-7 true leaves.

Plate 2: Sweet pepper

Plate 3: Hot pepper

Fertilizer application: Fertilizer types and rates largely depend on local recommendations. This protocol is based on types of fertilizers used and rates of application at AVRDC in Arusha, Tanzania, and should be replaced by recommendations from each location during implementation. (Note that this has to be reflected in the data collection sheet.) Depending on the soil fertility level, fertilizer or manure can be applied in varying quantities. For good management in low nutrient soils, African eggplant and peppers should be fertilized with 400 kg/ha of NPK (20:10:10; to be prorated to your local fertilizer ratio) and 120 kg N/ha of urea or any nitrogen-based fertilizer. From the 400 kg/ha NPK, 200 kg/ha should be applied as a basal application during transplanting or as a side-dress one week after transplanting. The remaining 200 kg/ha NPK should be applied two weeks after the first application. Application of urea should be divided into three splits, with the first application together with the first NPK application (one week after transplanting is preferred), the second application three weeks after the first or when fruit formation begins, and the third application three weeks after the second application. Chicken manure or cow dung can be used whenever available.

Irrigation: The irrigation method used depends on the structure (furrow or drip) available. Irrigate the plots one or two times per week, depending on soil type and weather conditions. In the rainy season, irrigation is applied only as required.

Weed control: Control weeds by hand-uprooting or hoeing to keep the plot weed-free.

Harvesting: Varies with crop type and intended use—for consumption at green stage, red dry stage, or for seed.

African eggplant

Most communities consume unripe fruits, which are light green, yellowish or green. Harvesting is done repeatedly at about two-week intervals and lasts for 2-3 months, although it can last longer depending on moisture, nutrient availability, and genotype. Indeterminate types usually can be harvested more times than determinate types. To extract seed for use in subsequent trials or breeding nurseries, harvest when the fruit has turned red (for open-pollinated lines).

Peppers

Depending on the cultivar and market demand, peppers can be harvested when the fruits become green, red or yellow for both sweet and hot (chili) peppers. Under commercial production, hot pepper stays in the field until late maturity for drying and grinding into powder for use in making different types of sauces. Harvesting is usually done every 1-2 weeks once harvesting has begun, and can last for 2-3 months.

2.1.6 Data collection

Researchers should keep a record of the basic characteristics of the trial site such as the soil type (nitosol, cambisol and vertisol, etc.), slope, altitude, longitude, latitude, seasonal and long-term rainfall, and minimum and maximum temperatures. Also include management practices employed, if they differ from what has been presented for each crop in this guide. Record missing data for each trait per plot in each replication. Provide reasons for missing data: whether due to treatment or non-treatment effects. This information can be useful for explaining genotype performance in different environments. Information on plant characteristics, reactions to biotic stresses, and yield and its components should be collected for each crop:

African eggplant

1. Sowing date.
2. Transplanting date.
3. Number of rows per plot.
4. Number of plants planted per row.
5. Space between plants within row (cm).
6. Space between adjacent rows (cm).
7. Plot size (m^2).
8. Fertilizer types and rates with dates of application.
9. Days to 50% flowering: Number of days after transplanting when 50% of the plants in a plot have open flowers.
10. Days to 50% fruit maturity: Number of days after transplanting when 50% of the plants in plots have mature fruits ready to harvest for consumption, or for seed extraction.
11. Average plant height (cm) of 10 randomly selected plants per plot at 50% maturity measured on the main stem.
12. Number of plants harvested at every harvest.
13. Number of marketable (worth selling) fruits harvested on each harvesting date.
14. Number of non-marketable fruits (fruits with defects) harvested on each harvesting date. Record causes of defects: insect pests, diseases, physiological disorders, environmental effects such as sunscald, etc.
15. Marketable fruit yield (kg/plot) on each harvesting date.
16. The total marketable yield, non-mar ketable yield, and the total marketable and non-marketable number of fruits are obtained by adding the respective quantities of individual harvests. The yield per harvested plot (kg/plot) can be converted into tons per hectare using the following simplified formula:

$$\textbf{Yield (t/ha)} = \frac{\textbf{10 x harvested plot yield (kg)}}{\textbf{Harvested plot area (m}^2\textbf{)}}$$

17. Fruit weight (g/fruit): measured on 20 mature fruits per plot sampled randomly from the second harvest.
18. Fruit length and width (cm): Obtained respectively from average length and width of the same 20 fruits sampled randomly from the second harvest for fruit weight measurement.
19. Number of seeds per fruit: Average number of seeds per fruit from 20 fruits sampled randomly from physiologically mature fruits.
20. Seed yield (kg/plot): The weight of dry seeds (6-8% moisture content) obtained per harvested plot when the plant is allowed to reach physiological maturity for seed extraction; use the formula used for fruit yield above to convert into t/ha.
21. Disease Incidence (e.g. viral, bacterial and fungal, %): Record the number of infected plants (plants showing symptoms) against the total number of plants per plot; this helps to calculate the percentage of infected plants per plot. Also record severity as “none (0 on a 0-5 scale)”, “mild (1-3)”, or “severe (4-5)”. Whenever possible specify the name of the disease.
22. Insect pests (%): Record the number of infested plants (plants showing symptoms) against the total number of plants per plot; this helps to calculate the percentage of infested plants per plot. Also record severity as “none (0 on a 0-5 scale)”, “mild (1-3)”, or “severe (4-5)”. Record the type of insect.

Peppers

1. Sowing date.
2. Transplanting date.
3. Number of rows per plot.
4. Number of plants planted per row.
5. Space between plants within row (cm).
6. Space between adjacent rows (cm).
7. Plot size (m^2).
8. Number of plants per plot.
9. Fertilizer types and rates with dates of application.
10. Days to 50% flowering: Number of days after transplanting when 50% of the plants in a plot have open flowers at the first node, check the plot three times per week.
11. Average plant height of 10 randomly selected plants per plot at 50% flowering.
12. Number of plants harvested at every harvest.
13. Days to 50% fruit maturity: Number of days after transplanting when 50% of the plants per plot have mature fruits ready to harvest for consumption.
14. Number of marketable fruits harvested on each harvesting date.
15. Number of non-marketable fruits harvested on each harvesting date. Record causes of defect—pests, diseases, physiological disorders, environmental effects such as sunscald, etc.
16. Marketable fruit yield (kg/plot) on each harvesting date.
17. Non-marketable fruit yield (kg/plot) on each harvesting date.
18. Fruit weight (g/fruit): Sample of 20 mature fruits sampled randomly from the second harvest.
19. Fruit length (cm): Average length (cm) of 20 fruits sampled randomly from the second harvest.
20. Fruit width (cm): Average width (cm) of 20 fruits sampled randomly from the second harvest.
21. Number of seeds per fruit: Average number of seeds from 20 fruits sampled randomly from physiologically mature fruits on the second harvest.
22. Seed yield (g/fruit) from physiologically mature fruits.
23. Seed yield (kg/plot): Average weight of dry seeds from all fruits harvested per plot.
24. 200 seed weight (g): measured on 200 dry seeds.
25. Disease incidence (e.g. viral, bacterial and fungal, %): Record the number of infected plants (plants showing symptoms) against the total number of plants per plot; this helps to calculate the percentage of infected plants per plot. Also record severity as “none (0 on a 0-5 scale)”, “mild (1-3)”, or “severe (4-5)”. Specify the name of the disease if possible.
26. Insect pest (%): Record the number of infested plants (plants showing symptoms) against the total number of plants per plot; this helps to calculate the percentage of infested plants per plot. Also record severity as “none” (0 on a 0-5 scale), “mild” (1-3), or “severe” (4-5). Record the type of insect.

2.2 Leafy type vegetables

Experimental protocols for five traditional African leafy vegetables (amaranth, African nightshade, Ethiopian mustard, spider plant and vegetable cowpea) are provided in this guide.

2.2.1 Choice of land

Select a well-drained area with fairly uniform fertility and slope.

2.2.2 Number of entries

The suggested number of entries is from 6 to 20, which should include one or two locally popular cultivars at each location. This number is for the design and number of replications given below.

2.2.3 Experimental design

A randomized complete block design (RCBD) with three replications is recommended (Appendix 1 shows a field layout example with 10 entries). Detailed planting plans are given for each crop.

An example of a data collection sheet is provided in Appendix 2.

2.2.4 Spacing

Amaranth and spider plant

For both crops, spacing is 25 cm between plants within rows and 60 cm between rows/ridges within beds. In these crops, 24 plants are planted per each of 2 rows for a total of 48 plants per plot. Data is collected from the inner 44 plants. Each plot measures 6 m long and 1.2 m wide. Any change in plot dimensions used in each environment should be reflected in the data sheet.

Plate 4: Amaranth

Plate 5: Spider plant

African nightshade and Ethiopian mustard

Spacing between plants within rows and between rows/ridges within beds is 40 and 60 cm, respectively. For yield trials, the minimum number of plants per row is 15. Each entry per plot is planted in 2 rows. Data is collected from 26 inner plants. Each plot measures 6 m long and 1.2 m wide. Any change in plot dimensions should be reflected in the data sheet.

Plate 6: African nightshade

Plate 7: Ethiopian mustard

Vegetable cowpea

Spacing between plants within rows is 15 cm and between rows/ridges within beds is 30 cm. Each entry is sown directly in the field in 4 rows in every plot. The number of plants per row can go as high as 40, depending on seed availability. Each plot is 6 m long and 1.2 m wide. Data will be collected from two central rows; one plant should be left on each end as a border.

Plate 8: Vegetable cowpea

2.2.5 Cultural practices

Cultural practices for the five traditional vegetables listed above include nursery preparation, transplanting, irrigation, fertilizer application, weeding and harvesting.

Nursery preparation and characteristics:
Cowpea is directly sown in the field. For the other three crops, if seeds are sown in trays, planting media should be sterilized after mixing forest soil/compost, manure, sand, and rice husks (if available) in a ratio of 3:2:1:1.

When the nursery is prepared in beds, land should be ploughed well, mixed with cow dung, chicken or decomposed manure at a rate of 3-5 kg/m^2. The nursery should be in a flat area, with well-drained, fertile soil, free of shade, and near a water source. Crops of the same type should not have been grown in the space during the past 2 to 3 years or seasons. Seeds should be sown in rows 15-20 cm apart with 1 cm spacing between seeds within a row. After sowing, cover the seeds with a thin layer of soil followed by watering. Thin the seedlings down to 1-2 cm spacing between plants. Weeding should be done whenever necessary to avoid competition with seedlings. Regular watering is necessary, but avoid waterlogging.

Transplanting: About three weeks after sowing, harden seedlings by slightly reducing the frequency of watering and shading. The seedlings for transplanting are ready in three weeks for amaranth and spider plant, and within four weeks for African nightshade and Ethiopian mustard, or when they have 3-5 true leaves. For vegetable cowpea, seeds are sown directly in the field, 2-3 seeds per hill, and then thinned three weeks later to one plant per hill.

Fertilizer application: Fertilizer types and rates largely depend on local recommendations. This protocol is based on types and rates of fertilizers used at AVRDC in Arusha, Tanzania; it can be adjusted for your local conditions. Depending on soil fertility level, fertilizer or manure can be applied in varying quantities. For good management in low nutrient soils, the recommended fertilizer rate used at AVRDC is given below by crop.

Irrigation: The irrigation method depends on the structure (furrow or drip) available. Irrigate the plots one or two times per week, depending on soil type and weather conditions. During the rainy season, irrigation is supplemental and applied only as required.

Weed control: Weeds are controlled by hand-uprooting and hoeing to keep the plot weed-free.

Amaranth and spider plant

Apply a total of 200 kg NPK/ha (20:10:10; to be prorated to your local fertilizer ratio), and 120 kg N/ha urea or any nitrogen-based fertilizer. All of the NPK should be applied as a basal application during transplanting or as a side-dress one week after transplanting or three weeks after seedling emergence if seed was broadcast. Urea application should be divided in two splits, one with NPK one week after transplanting, and the second application just before flower formation begins.

African nightshade

A total of 250 kg NPK/ha (20:10:10; to be prorated to your local fertilizer ratio), and 120 kg N/ha urea or any nitrogen-based fertilizer is applied. All of the NPK should be applied as a basal application during transplanting or as a side-dress one week after transplanting. Urea application should be divided in two splits, with the first application applied together with the NPK, and the second application three to four weeks after the first application to extend the vegetative phase.

Ethiopian mustard

Apply a total of 200 kg NPK/ha (20:10:10) and 90 kg N/ha urea or any nitrogen-based fertilizer. All of the NPK should be applied as a basal application during transplanting or as a side-dress two weeks after transplanting. Apply urea in two splits, one with NPK; make the second application just before flower formation begins.

Harvesting: For most African traditional leafy vegetables, harvesting should start four weeks after sowing or three weeks after transplanting and continues biweekly for continuous harvesting. A single harvest by uprooting is also possible.

2.2.6 Data collection

Researchers should keep a record of the basic characteristics of the trial site and the management practices employed when conducting a cultivar trial. Record the altitude, latitude, longitude and soil type of the experimental location, and provide seasonal and year-round rainfall and temperatures. Information on plant characteristics, reactions to biotic stresses, and yield and its components should be collected for each crop:

Amaranth

1. Sowing date.
2. Transplanting date.
3. Number of rows per plot.
4. Number of plants planted per row.
5. Space between plants within row (cm).
6. Space between adjacent rows (cm).
7. Plot size (m^2).
8. Fertilizer types and rates with dates of application.
9. Growth habit: Erect or Prostrate.
10. Number of plants harvested per plot.
11. Plant height (cm): At first and last marketable harvest.
12. Number of branches per plant: Counted on five randomly taken plants per plot at each harvest.
13. Days to 50% flowering: Number of days after transplanting when 50% of the plants in a plot have open flowers.
14. Plant height at flowering (cm): Height measured from ground level to the apex.
15. Plant height at grain maturity (cm): Height measured from ground level to the apex.
16. Marketable fresh vegetative yield (kg/plot): Total marketable vegetative yield harvested per plot. This is the sum of all harvests in a repeat cutting system, and the total uprooted biomass after non-marketable part is removed in the case of one-time clear harvesting.
17. Seed yield (g/plot): Amount of dry seed obtained per plot.
18. 200 seed weight (g): The weight of 200 dry seeds counted carefully.
19. Disease incidence (e.g. viral, bacterial and fungal, %): Record the number of infected plants (plants showing symptoms) against the total number of plants per plot; this helps to calculate the percentage of infected plants per plot. Also record symptoms as “none (0 on a 0-5 scale)”, “mild (1-3)”, or “severe (4-5)”. Specify the name of the disease if possible.
20. Insect pest incidence (%): Record the number of infested plants (plants showing symptoms) against the total number of plants per plot; this helps to calculate the percentage of infested plants per plot. Also record severity as “none” (0 on a 0-5 scale), “mild” (1-3), or “severe” (4-5). Record the type of insect.

African nightshade

1. Sowing date.
2. Transplanting date.
3. Number of rows per plot.
4. Number of plants planted per row.
5. Space between plants within row (cm).
6. Space between adjacent rows (cm).
7. Plot size (m^2).
8. Fertilizer types and rates with dates of application.
9. Growth habit: Upright, Intermediate, Prostrate or Mixture.
10. Number of plants harvested per plot at each harvest.
11. Plant height (cm): At first and last marketable harvest.
12. Number of branches per plant: Counted on five random plants per plot at each harvest.
13. Days to 50% flowering: Number of days after transplanting when 50% of the plants in a plot have open flowers.
14. Plant height at flowering (cm): Height measured from ground level to the apex
15. Plant height at berry maturity (cm): Height measured from ground level to the apex.
16. Total biological vegetative yield (kg/plot): This is for uproot harvesting system, and is the total biomass yield including marketable and non-marketable yields.
17. Marketable fresh vegetative yield (kg/plot): Total marketable vegetative yield harvested per plot. This is the sum of all harvests in repeat cutting system,

and the total uprooted biomass after non-marketable part is removed in the case of uprooting.

18. Seed yield (kg/plot): Amount of dry seed obtained per plot.
19. 200 seed weight (g): The weight of 200 dry seeds counted carefully.
20. Disease incidence (e.g. viral, bacterial and fungal, %): Record the number of infected plants (plants showing symptoms) against the total number of plants per plot; this helps to calculate the percentage of infected plants per plot. Also record severity as "none" (0 on a 0-5 scale), "mild" (1-3), or "severe" (4-5). Specify the name of the disease if possible.
21. Insect pest incidence (%): Record the number of infested plants (plants showing symptoms) against the total number of plants per plot; this helps to calculate the percentage of infested plants per plot. Also record severity as "none" (0 on a 0-5 scale), "mild" (1-3), or "severe" (4-5). Record the type of insect.

Ethiopian mustard

1. Sowing date.
2. Transplanting date.
3. Number of rows per plot.
4. Number of plants planted per row.
5. Space between plants within row (cm).
6. Space between adjacent rows (cm).
7. Plot size (m^2).
8. Fertilizer types and rates with dates of application.
9. Growth habit: Upright, Prostrate, Intermediate or Mixture.
10. Number of plants harvested per plot at each harvest.
11. Plant height (cm): At first and last marketable harvest.
12. Number of branches per plant: Counted on five random plants per plot at each harvest.
13. Days to 50% flowering: Number of days after transplanting when 50% of the plants in a plot have open flowers. Check plots three times per week.
14. Plant height at flowering (cm): Height measured from ground level to the apex.
15. Plant height at grain maturity (cm): Height measured from ground level to the apex.
16. Fresh vegetative yield (kg/plot): Total marketable vegetative yield harvested per plot. This is the sum of of marketable parts from all harvests in repeat cutting system, and the total uprooted biomass after the non-marketable part has been removed in the case of one-time clear harvesting.
17. Seed yield (g/plot): Amount of dry seed obtained per plot.
18. 200 seed weight (g): The weight of 200 dry seeds counted carefully.
19. Disease incidence (e.g. viral, bacterial and fungal, %): Record the number of infected plants (plants showing symptoms) against the total number of plants per plot; this helps to calculate the percentage of infected plants per plot. Also record severity as "none" (0 on a 0-5 scale), "mild" (1-3), or "severe (4-5). Specify the name of the disease if possible.
20. Insect pest incidence (%): Record the number of infested plants (plants showing symptoms) against the total number of plants per plot; this helps to calculate the percentage of infested plants per plot. Also record severity as "none" (0 on a 0-5 scale), "mild" (1-3), or "severe (4-5). Record the type of insect.

Spider plant

1. Sowing date.
2. Transplanting date.
3. Number of rows per plot.

4. Number of plants planted per row.
5. Space between plants within row (cm).
6. Space between adjacent rows (cm).
7. Plot size (m^2).
8. Fertilizer types and rates with dates of application.
9. Growth habit: Upright, Intermediate, Spread or Mixture.
10. Number of plants harvested per plot at each harvest.
11. Plant height (cm): At first and last marketable harvest.
12. Number of branches per plant: Counted on five random plants per plot at each harvest.
13. Days to 50% flowering: Number of days after transplanting when 50% of the plants in a plot have open flowers).
14. Plant height at flowering (cm): Height measured from ground level to the apex.
15. Plant height at grain maturity (cm): Height measured from ground level to the apex.
16. Fresh vegetative yield (kg/plot): Total marketable vegetative yield harvested per plot. This is the sum of all harvests in a repeat cutting system, and the total uprooted biomass after the non-marketable part is removed in the case of one-time clear harvesting.
17. Seed yield (kg/plot): Amount of dry seed obtained per plot.
18. 200 seed weight (g): Weight of 200 randomly taken seeds counted carefully.
19. Disease incidence (e.g. viral, bacterial and fungal, %): Record the number of infected plants (plants showing symptoms) against the total number of plants per plot; this helps to calculate the percentage of infected plants per plot. Record severity as “none” (0 on a 0-5 scale), “mild” (1-3), or “severe” (4-5). Specify the name of the disease if possible.
20. Insect pest incidence (%): Record the number of infested plants (plants showing symptoms) against the total number of plants per plot; this helps to calculate the percentage of infested plants per plot. Record severity as “none” (0 on a 0-5 scale), “mild” (1-3), or “severe” (4-5). Record the type of insect.

Vegetable cowpea

1. Sowing date.
2. Number of rows per plot.
3. Number of plants planted per row.
4. Space between plants within row (cm).
5. Space between adjacent rows (cm).
6. Plot size (m^2).
7. Growth habit: Erect or Twining
8. Number of plants harvested per plot for vegetable use at each harvest, usually 3-4 harvests per growing period.
9. Total fresh vegetative yield (kg/plot): Total marketable vegetative yield as the sum of all individual harvests per plot.
10. Plant height (cm): At first and last marketable harvest.
11. Days to 50% flowering: Number of days after sowing when 50% of the plants in a plot have open flowers. This is measured from one row allowed to grow to give seed from the two central rows of the four rows planted per plot.
12. Plant height at 50% flowering (cm).
13. Days to 50% pod setting.
14. Days to physiological maturity scored when pods turn brown or straw colored, but before cracking to release seed.
16. Seed yield (kg/plot): Weight of dry seeds harvested per plot.
17. Pod length and width (cm) measured on 10 randomly obtained pods during pod harvest.

18. Pod weight (g/pod): Average of the weight of 100 pods randomly taken during pod harvesting.
19. Number of seeds per pod: Average number of seeds from 100 pods sampled randomly during pod harvesting.
20. 200 seed weight (g): The weight of 200 dry seeds sampled randomly during seed yield measurement.
21. Disease incidence (e.g. viral, bacterial and fungal, %): Record the number of infected plants (plants showing symptoms) against the total number of plants per plot; this helps to calculate the percentage of infected plants per plot. Record severity as "none" (0 on a 0-5 scale), "mild" (1-3), or "severe" (4-5). Specify the name of the disease if possible.
22. Insect pest incidence (%): Record the number of infested plants (plants showing symptoms) against the total number of plants per plot; this helps to calculate the percentage of infested plants per plot. Record severity as "none" (0 on a 0-5 scale), "mild" (1-3), or "severe" (4-5). Record the type of insect.

2.3 Bulb type vegetable

Only onion is considered in this protocol.

2.3.1 Choice of land

Select a well-drained area with fairly uniform fertility and slope.

2.3.2 Number of entries

The suggested number of entries is from 5 to 20, which should include one or two locally popular varieties at each location.

2.3.3 Experimental design

A randomized complete block design (RCBD) with three replications is recommended. Appendix 1 shows a field layout with 10 entries. A data collection sheet is given in Appendix 2.

2.3.4 Spacing

May vary with recommendations in different environments, but 10 cm between plants within rows and 15 cm between rows within beds is used at AVRDC in Arusha. Each entry per plot is planted in 6 rows. Data is collected from 4 inner rows with one plant per row left as a border at each end. Each plot measures 6 m long and 1 m wide. Any change in plot dimensions used in each environment should be reflected in the data sheet.

2.3.5 Cultural practices

Nursery preparation and characteristics:
For sowing seed in trays, planting media should be sterilized after mixing forest soil/ compost, manure, sand, and rice husks (when available) in a ratio of 3:2:1:1. When a nursery is prepared in beds, plough the soil well and add cow dung, chicken or decomposed manure at the rate of 3-5 kg/m^2. The nursery should be in a flat area, with well-drained, fertile soil, free of shade, and near a water source. Crops of the same type should not have been grown in the space during the past 2 to 3

Plate 9: Onion

years or seasons. Seeds should be sown in rows, 15-20 cm apart with 1 cm spacing between seeds within a row. After sowing, cover the seeds with a thin layer of soil followed by watering. Thin the seedlings to 1-2 cm spacing between plants. Weeding should be done whenever necessary to avoid competition with seedlings. Regular watering is necessary.

Transplanting: About three weeks after sowing, harden seedlings by slightly reducing the frequency of watering and shading. The seedlings are ready for transplanting in four weeks.

Fertilizer application: Fertilizer types and rates largely depend on local recommendations. This protocol is based on types and rates of fertilizers used at AVRDC in Arusha, Tanzania; it can be adjusted for your local conditions. Depending on soil fertility level, fertilizer or manure can be applied in varying quantities. A total of 120 kg N/ha of urea or any other nitrogen-based fertilizer is applied. Urea application should be divided in two splits, with the first application applied one week after transplanting, and the second application about four weeks after the first application or when bulb formation begins. Apply NPK once one week after transplanting.

Irrigation: The method depends on the structure (furrow or drip) available. Irrigate the plots one or two times per week, depending on soil type and weather. In the rainy season, irrigate only as required.

Weed control: Control weeds by hand-uprooting or hoeing.

Harvesting: Onion is ready for harvest three to four months after transplanting. Neck fall is the indication of maturity. The best time to harvest onion is when 60 to 70% of tops have fallen over.

2.3.6 Data collection

1. Sowing date
2. Transplanting date
3. Transplant survival (%)
4. Number of plants in each plot
5. Number of leaves/plant
6. Days to maturity (days): Time from transplanting to bulb neck falling.
7. Plant height at maturity (cm)
8. Neck thickness (cm)
9. Bulb length (cm): Longitudinal diameter from roots toward the leaves.
10. Bulb width (cm): Diameter from a cross section of the bulb (equatorial).
11. Bolting (%): The percentage of plants in a plot that have developed flower stalks.
12. Bulb yield (g/plot): Weight of total bulbs harvested per plot
13. Bulb weight (g/bulb): Average weight of 10-15 randomly taken bulbs.
14. Doubling (% of onions with two bulbs)
15. Bulb shape
16. Bulb color
17. Bulb uniformity: Weight of 10-15 individual bulbs weighed separately ± standard error.
18. Disease incidence (e.g. viral, bacterial and fungal, %): Record the number of infected plants (plants with symptoms) against the total number of plants per plot to calculate the percentage of infected plants per plot. Record severity as “none” (0 on a 0-5 scale), “mild” (1-3), or “severe” (4-5).Specify the name of the disease if possible.
19. Insect pest incidence (%): Record the number of infested plants (plants showing symptoms) against the total number of plants per plot calculate the percentage of infested plants per plot. Record severity as “none” (0 on a 0-5 scale), “mild” (1-3), or “severe” (4-5). Record the type of insect.

3. CONCLUSION

The protocols presented in this field guide are useful for researchers involved in multi-location cultivar testing and other evaluation experiments. The experimental designs and field layouts given in this protocol help researchers conduct ***experiments that lead to statistically valid results***. However, specific cultural practices for each crop may vary with the environment. Follow local agronomic recommendations based on soil type, moisture level, irrigation type, tools used in field operations, available inputs, and others.

These protocols should be considered as a general guide to prepare location-specific protocols for different crops; they are not complete protocols applicable across countries and locations within a country. Most important for collaborative multi-location cultivar testing is that ***every partner needs to record specific changes made in a protocol used and clearly indicate these during data exchange***.

4. REFERENCES

AVRDC Genetic Resources and Seed Unit. 2008. Descriptor list for amaranths, African nightshade, Ethiopian mustard and cowpea.

AVRDC website. 2015. Guide to cultural practices of various vegetable crops. http://avrdc.org/how-to-guide/ Indigenous/

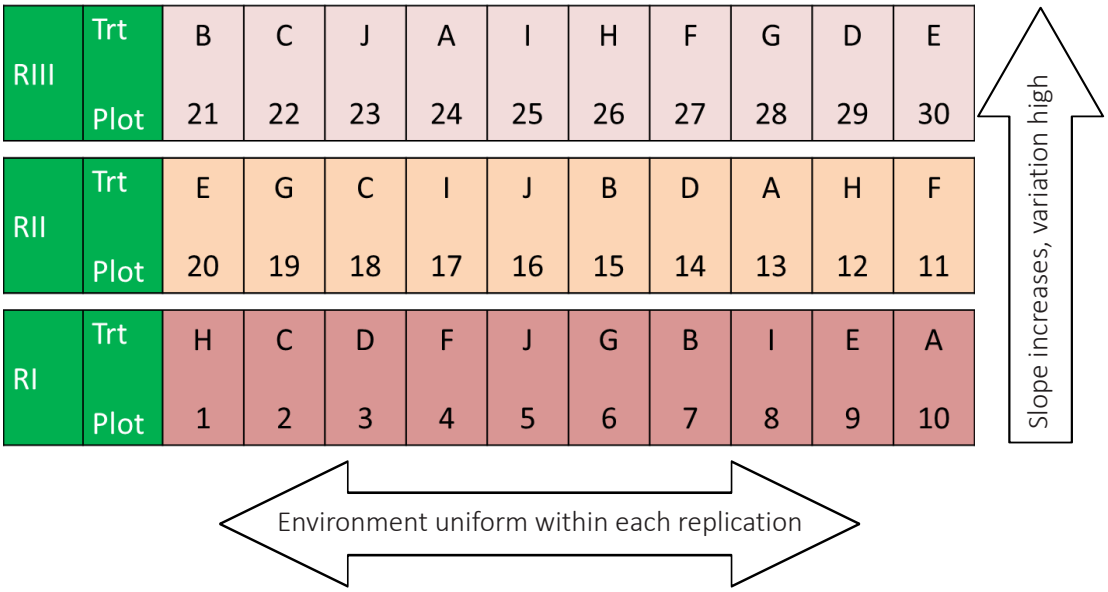
Berke TG. 2000. International Cooperators' Guide: Multiplying seed of pepper lines. AVRDC Pub #00-510. http://203.64.245.61/web_crops/pepper/pepper%20seed.pdf

Berke TG, Black LL, Morris RA, Talekar NS, Wang JF. 2003. International Cooperators' Guide: Suggested cultural practices for sweet pepper. AVRDC pub #99-497R. http://203.64.245.61/fulltext_pdf/E/2001-2005/e03417.pdf

Berke TG, Black LL, Talekar NS, Wang JF, Gniffke P, Green SK, Wang TC, Morris R. 2005. International Cooperators' Guide: Suggested cultural practices for chili pepper. AVRDC pub #05-620. http://203.64.245.61/fulltext_pdf/E/2001-2005/e03417.pdf

5. APPENDICES

Appendix 1. Sample field layout of 10 entries in RCBD in three replications, Trt = treatment or entry.



Appendix 2. Data collection sheet in Excel format for 10 entries evaluated in three replications in one environment; unit of measurement for each trait should be indicated during data collection.

Plot	Entry Code	Entry	Rep	Trait 1	Trait 2	Trait 3	Trait 4	Trait 5	Trait 6	Trait…n
1	8	H	1							
2	3	C	1							
3	4	D	1							
4	6	F	1							
5	10	J	1							
6	7	G	1							
7	2	B	1							
8	9	I	1							
9	5	E	1							
10	1	A	1							
11	6	F	2							
12	8	H	2							
13	1	A	2							
14	4	D	2							
15	2	B	2							
16	10	J	2							
17	9	I	2							
18	3	C	2							
19	7	G	2							
20	5	E	2							
21	2	B	3							
22	3	C	3							
23	10	J	3							
24	1	A	3							
25	9	I	3							
26	8	H	3							
27	6	F	3							
28	7	G	3							
29	4	D	3							
30	5	E	3							

NOTES

avrdc.org

AVRDC - The World Vegetable Center
Headquarters
PO Box 42
Shanhua, Tainan 74199
Taiwan

T +886 (0) 6 583-7801
F +886 (0) 6 583-0009
E info@worldveg.org