Global Research in Environment and Sustainability
September 2023, Vol. 1, No. 7, pp. 93-123.

Data Collection Procedures for Selected Horticultural Crops Prepared for Junior Researchers

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Abstract:
The document you are going to cover during this reading time is known as data collection procedures for selected horticultural crops that implemented under horticultural crop research division of Werer research center. It is the document which teach you how to prepare data collection procedures, data sheet and basic knowledge you have obtained during field observation, and come up with scientific conclusion that bring some benefits to your society. Many junior researchers do not fully understand the way in which data collection procedures are plan and conducted data collection to generate very simple information that can be understood by ordinary peoples. The paper contains data collection procedures with its important descriptions. Therefore, these materials are intended to help junior researchers assigned to horticultural research division. I hope it will prove a valuable contribution in data collection procedures and skill of junior researchers and I encourage the reader to provide constructive feedback in order to move this integration forward.

INTRODUCTION

Statistics concerns itself mainly with conclusions and predictions resulting from chance outcomes that occur in carefully planned experiments or investigations. The objective of statistical inference is to draw conclusions about a population using a sample from that population. Most of the methods that are used in statistics and in experiments assume that random samples are used (Montgomery, 1991). The values of the statistics will vary from sample to sample. Values we estimate from samples are called statistics while corresponding values of the population are known as population parameters. The population mean, is a fixed value, while its estimates from a sample of size n, the sample means vary from sample to sample. The same is true for the population variance, standard deviation, and range. Statistics obtained from samples vary from sample to sample. If the population contains N elements and a sample of n of them is to be selected, then if each of the N! /[(N-n)! n!] Possible samples have an equal probability of being chosen, the procedure employed is called random sampling (Montgomery, 1991).

A population is the whole set of measurements or counts about which we want to draw conclusion. Populations are described by characteristics called parameters and parameters are fixed values. If only one variable is of interest, the population can be called as a univariate. For example, the heights of all male students in universities form a univariate population. Notice that a population is a set of measurements, not the individuals or objects on which the measurements or counts are made. A sample is a sub set of a population, a set of some of the measurements or counts that comprises the population. Samples are described by sample statistics. We calculate sample statistics to estimate population parameters. The essential nature of a sample is that it should be representative. This means that a sample should be a small-scale replica of the population that might affect the conclusion of the study. Accuracy and precision are used synonymously in everyday speech, but in statistics they are defined more rigorously. Precision is

the closeness of repeated measurements and accuracy is the closeness of a measured or computed value to its true value. Therefore, developing data collection procedures for horticultural crops including vegetables, fruits and root and tuber crops are a pre-requisite for the newly employed junior researchers. I hope that this paper data collection procedures for horticultural crops. is used for researchers in adopting uniform definitions of data procedures and, thereby, enable them to generate a standardized, authentic and uniform data so that a sound database networking may be developed for exchange and utilization of information.

ONION DATA COLLECTION PROCEDURES

Background

Onion (*Allium cepa* L.) is a vegetable crop of major commercial importance though out the world. Onion is a recent introduction in the country but rapidly becoming a popular vegetable crop among consumers (FAO & WARC, 2006). In Ethiopia there are different agro-ecologies suitable for growing of onion. However, the production is concentrated to the central rift valley of the country (WARC, 2006).

1. **Bulb Dry Weight (BDW):** the average dry matter weight of the mature bulb expressed in grams.
2. **Days to Maturity (DTM):** the actual number of days from seedling emergence to a day at which more than 90% of the plants attained physiological maturity.
3. **Total Soluble Solids (TSS):** the amount of total soluble solids present in the bulb will be estimated using refractometer Bellingham and Stanley limited, UK (model 60/70) and expressed as percentage.
4. **Days to bolting:** Number of days when 50% of flower shoots appeared in cultivars
5. **Days to flowering:** Number of days when 50% the inflorescence showed open flowers.
6. **Days to harvest:** Number of days from planting to last date of seed harvest
7. **Fresh Weight above Ground (FWAG):** the total fresh weight of above ground biomass of physiologically mature plant recorded in grams.
8. **Dry Weight above Ground (DWAG):** the total dry weight of aboveground biomass of physiologically mature plant recorded in grams.
9. **Germination percentage**: The number of germinated seeds from 100 seeds raised on a petridish.
10. **Neck diameter (ND):** average thickness measured at the narrowed point and expressed in cm.
11. **Bulb length (BL):** the height of the mature bulb measured in cm.
12. **Bulb diameter (BD):** the average size measured at the widest point in the middle portion of the bulb and expressed in cm.
13. **Number of cloves per bulb (CB):** the total number of cloves per plant counted after harvest.
14. **Weight of cloves (WC):** the average weight of cloves measured in grams.
15. **Number of seeds per umbel**: This will be calculated as followes =seed yield/plant X 1000seeds/1000seed weight and divided by number of flower stalks per plant
16. **Plant height (PH):** the height measured in cm from the ground level to the top of the mature leaf.
17. **Number of leaves per plant (NLPP):** the total number of healthy leaves taken at physiological maturity.
18. **Leaf diameter (LD):** the diameter of the longest leaf measured by caliper at maturity and expressed in cm.

19. **Leaf length (LL):** the average length of the longest leaf expressed in cm at physiological maturity.
20. **Plant Height (PH):** the distance measured in cm from the soil surface to the tip of the mature leaf in the plant.
21. **Leaves per Plant (LP):** total number of leaves per plant recorded at physiological maturity.
22. **Leaf Length (LL)**: the average length of the longest leaf expressed in cm at physiological maturity.
23. **Leaf Diameter (LD**): the diameter of the longest leaf at the time of maturity expressed in cm.
24. **Neck Thickness (NT):** average wall thickness measured at the narrowest point expressed in cm.
25. **Bulb Length (BL):** the height of the mature bulb measured in cm.
26. **Bulb Diameter (BD):** the average size measured at the widest point in the middle portion of the mature bulb expressed in cm.
27. **Yield Per Plant (YPP):** the average weight of mature bulb expressed in gram.
28. **Biological Yield Per Plant (BYPP):** the total yield at the time of maturity expressed in grams
29. **Harvest Index Per Plant (HIPP):** the ratio of mature bulb yield per plant to the biological yield expressed in grams.
30. **Seed yield/plant:** The weight taken in grams from 5 plants
31. **Thousand seed weight:** Estimate will be based on average weight of 250 seeds drawn randomly from the bulked seeds of five plants in each replication.
32. **Total number of flower stalks per plot and per plant**: All number of flower stalks with seed heads and aborted flowers in each plot and the average number of flower stalks/ plant counted at first harvest
33. **No. of flowers /umbel:** The mean number of flowers on an umbel counted at full flowering from 5 plants /plot
34. **Flower stalk height**: Height measured in centimeter from the bulb to the umbel.
35. **Total seed yield/plot:** The sum of seed yield of all harvest.
36. **Umbel diameter in (cm):** Diameter of the inflorescence at full flowering measured in centimeter using vernier caliper.
37. **Weight and number of cloves by size category (WCC):** weight of cloves categorized as heavy, medium and lightweight, expressed in grams.
38. **Yield per plant (YPP):** the average weight of mature bulb expressed in grams.
39. **Biological yield per plant (BYPP):** the total yield at the time of maturity expressed in grams.
40. **Harvest index per plant (HIPP):** the ratio of total bulb yield per plant to the biological yield expressed in percentage.
41. **Dry weight above ground (DWAG):** the total dry weight of above ground biomass of physiologically mature plant recorded in grams.
42. **Bulb dry weight (BDW):** the average dry matter weight of the mature bulb after being oven dried at 80 oC for 48 hours and expressed in grams.
43. **Days to maturity (DTM):** the actual number of days from planting to a day at which more than 90% of the plants attained physiological maturity.

SHALOT DATA COLLECTION PROCEDURES

Background

Shallot (Alliums cepa var. aggregatum Don; Syn: Allium cepa varascalonicum, Backer) belongs to the genus Allium and family Alliaceae. The genus Allium is distributed from the tropics to subarctic belt, but a region of high species diversity stretches from the Mediterranean basin to Central Asia and Pakistan (Fritsch and Friesen, 2002). As shallot and its relative species are generally open pollinated crops and have cultivated for long time, a number of land races and natural hybrids either intraspecific or interspecific probably are to be on the increase (Arifin and Okubo, 1996). The majority of shallot genotypes are clonally propagated, even where seed production is possible, to maintain the unique quality traits and population homogeneity of highly heterogeneous plant (Currah and Proctor, 1990).

1. **Plant height (PH):** the distance measured in cm from the ground level to the top of matured leaf.
2. **Number of leaves per plant (NLPP):** total number of leaves taken at physiological maturity.
3. **Leaf diameter (LD):** the diameter of the longest leaf taken at maturity. It will be measured using caliper and expressed in cm.
4. **Number of lateral branches per plant (NLBP):** the total number of lateral growths per plant and taken at physiological maturity.
5. **Number of bulb splits per plant (NSPP):** the total number of bulblets per plant counted after harvest.
6. **Days to maturity (DTM):** taken as the actual number of days from emergence to 90 percent of the plants attained physiological maturity.
7. **Bulb diameter (BD):** the average size of bulbs measured at the widest point (middle portion) of matured bulb; it will be measured using caliper and expressed in cm.
8. **Total yield per plant (TYPP):** the average weight of matured bulb expressed in grams.
9. **Marketable yield per plant (MYPP):** recorded as the average weight of matured bulbs greater than 20 mm in diameter.
10. **Biological yield per plant (BYPP):** recorded as the total bulb yield, above ground parts and roots at the time of maturity expressed in gram.
11. **Harvest index per plant (HIPP):** expressed as the ratio of total bulb yield per plant to the biological yield in percentage.
12. **Bulb dry weight (BDW):** the average dry weight of the mature bulbs after oven dries for 12 hours at 110 degrees Centigrade and expressed in gram.
13. **Total soluble solid (TSS):** the amount of total soluble solids presents in the bulb, recorded from the juice of sample bulbs estimated using hand refractometer and values expressed in percent.
14. **Pungency (PCY):** bulbs will be evaluated for pungency by measuring enzymatically produced pyruvic acid and values will be expressed in µ mole pyruvic acid g-1 fresh weight.
15. Fresh **bulb weight (kg):** Fresh weight of bulbs will be taken immediately after harvesting and cutting the tops for bulbs that did not receive curing treatment and after curing for those that received curing treatment.
16. **Skin thickness (mm):** In order to determine skin thickness 30 bulbs (10 bulbs each representing small, medium, and large bulbs) will be taken from each plot. Change in the skin thickness will be measured using a digital calliper (FOWLER Sylvac 107884) in a biweekly interval and the difference between the initial and successive measures will be used as a loss in skin thickness parameter.

17. **Dry matter (%):** A homogenate will be prepared from bulbs of each plot. For determination of percent dry matter 25g of the homogenate will be taken and oven dried (Wagtechn Gp/ 120/ SS/ 100/ DIG oven) at a temperature of 700C for 48 hrs. Then the weight will be measured using digital balance (METTLER TOLEDO) and percent dry matter will be calculated using a formula
    DW= [(FW CW) - CW] [(DW CW) - CW] x 100 Where: DW= dry weight, CW=container weight, FW= fresh weight
18. **Total soluble solids (%):** The TSS will be determined using the procedures described by Will bekar et al. (1999). Aliquot juice will be extracted using a juice extractor and 50 ml of the slurry centrifuged for 15 minutes. The TSS will be determined by hand refractometer (ATAGO TC-1E) with a range of 0 to 320 Brix and resolutions of 0.20 Brix by placing 1 to 2 drops of clear juice on the prism, will behed with distilled water and dried with tissue paper before use. The refractometer will be standardized against distilled water (0% TSS)
19. **Weight loss of bulbs (%):** Determined using the methods described by Will bekar et al. (1999). The measurement will be based on the difference in weight of bulbs at the beginning and mid of each month of 30 bulbs (10 small, 10 medium, and 10 large sized) taken from each treatment randomly. The difference between the initial weight and successive weights gave the weight loss percentages. WL (%) = W x100 Wi i □Wf Where, Wi = initial weight, Wf = final weight
20. **Number of bulbs sprouted (%):** Percentage of bulbs sprouted will be cumulative, which will be based on the number of bulbs sprouted in biweekly storage period. The incidence of sprouting will be ascertained by counting the number of bulbs sprouted at the beginning and mid of each month. The sprouted bulbs will be discarded after each biweekly count to avoid double counting. Bulbs that sprouted and rotted at the same time will be classified as sprouting.
21. **Number of rotten bulbs (%):** The measurement of percentage bulbs rotted will be cumulative and will be based on the number of bulbs rotted in biweekly storage period. The incidence of rotting will be determined by counting the number of bulbs rotted at the beginning and mid of each month. The rotted bulbs will be discarded after each biweekly count to avoid double counting. Type of organism that caused storage rot will be identified by culturing the rotten bulbs following the procedure described by Solomon (1985).

TOMATO DATA COLLECTION PROCEDURES

Background

Tomato (Lycopersicon esculentum) is an important short duration vegetable crop worldwide which belongs to family Solanaceae. It was originated from the wild plants which were first present in Andean states of Peru and Chile. Tomato is very healthy and nutritional crop because tomato is rich in vitamin A, B and C, amino acid, iron, minerals and phosphorus. Tomato plays very important role in bone growth, cell division, upholding surface linings of eyes, regulation of respiratory system and immune system. It is also useful in maintaining bones, capillaries and teeth. Tomato fruit is use as salads, cooked in sauces, soup and meat or fish dishes etc. [PAR, 2016].

Tomato Growth parameters measured included:

1. **Plant height (cm)** from the ground to the tip of the plant;
2. **Stem diameter (mm**) will be measured 10 cm from the ground and
3. **Internode lengths (cm),** measured between the trusses.

4. **Relative water content (RWC)** is the appropriate measure of plant water status in terms of the physiological consequence of cellular water deficit.
5. **Leaf number (LN)**: The total numbers of leaves counted at weekly intervals starting from crop emergence till 50% of the plants got bloomed
6. **Plant height (PH)**: The heights (cm) of plants that received the respective treatments will be measured from the ground level to the highest point at blooming stage.
7. **Number of branches per plant (NBP)**: the number of primary and secondary branches of each plant of each treatment at blooming stage will be recorded.
8. **Height of branches per plant (HBP)**: mean height (cm) of primary lateral shoots of each plant of each treatment at blooming stage will be recorded.
9. **Leaf length (LL)**: the average length of three leaves (cm) from the upper, middle and lower part of the plant will be measured at blooming stage.
10. **Leaf width (LW)**: the average size of three leaves (cm) at the widest point from the upper, middle and lower part of the plant will be measured at blooming stage.
11. **Days to 50% flowering (DF)**: This will be recorded when approximately 50% of the flower clusters on the plant had some flowers that will be in bloom.
12. **Days to maturity (DM)**: This will be recorded when approximately 70% of the plants had attained physiological maturity.
13. **Number of clusters per plant (CP)**: the number of clusters per plant counted at physiological maturity.
14. **Number of fruits per cluster (FC)**: the total numbers of fruits per cluster counted at physiological maturity.
15. **Total number/weight of fruits**: this is the sum total number/weight of fruits of successive harvests (eight harvests).
16. **Marketable and unmarketable fruit number and weight**: at each harvest, fruits will be categorized as marketable and unmarketable fruits of each treatment. Fruits, which will be cracked, damaged by insect, diseases, birds and sunburn, etc. will be considered as unmarketable fruits while fruits, which will be free of damage, will be considered as marketable.
17. **Fruit size:** diagonal section of the fruit measured by caliper
18. **Fruit volume**: ten randomly selected fruits from ten plants in a plot will be taken and floated in a water jar and their displacement will be recorded. Average fruit volume will be taken by subtracting the initial water level in the jar from the final and by the number of fruits immersed.
19. **Fruit juice content** the juice content of tomato will be extracted using a juice extractor (Kenwood). The intact tomato weight will be recorded prior to juice extraction. After extraction, extracted juice will be measured using a graduated glass cylinder and expressed in milliliter of juice per kilogram of fruit weight (ml/kg).
20. **Weight Loss (WL)** Weight loss (WL) will be determined using the methods described by Pirouani et al. (1997) and will bekar et al. (1999). The percentage weight loss will be calculated for each sampling interval using the formula given below and the cumulative WL will be expressed as percentage for the respective treatments.

$$WL\ (\%) = \frac{W_i - W_f}{W_i} x\ 100$$

Where, W_i = initial weight W_f = Final weight

Tomato Chemical Analysis

21. **Total Soluble Solids (TSS**): The TSS will be determined following the procedures described by Will bekar et al. (1999). An aliquot of juice will be extracted using a juice extractor (Type 6001x, USA). An Atago N, hand refractometer with a range of 0 to 32°Brix and resolutions of 0.2°Brix will be used to determine TSS by placing 1 to 2 drops of clear juice on the prism. Between samples the prism of the refractor meter will be beheld with distilled water and dried with tissue paper before use. The refractometer will be standardized against distilled water (0 percent TSS).
22. **Ascorbic Acid Analysis (AA)** The ascorbic acid content of the fruits will be determined by the 2, 6-dichlorophenol indophenols method (AOAC, 1970). The aliquot of 10 ml tomato juice will be diluted to 50 ml with 3 percent metaphosphoric acid in a 50 ml volumetric flask. The aliquot will be titrated with the standard dye to a pink end point (persisting for 15 second). The ascorbic acid content will be calculated from the titration value, dye factor and volume of the sample.

$$Ascorbic\ acid\ (mg\ ascorbic\ acid\ /100g) = \frac{Titre\ x\ dye\ \ factor\ x\ volume\ made\ up}{Volume\ of\ \ sample}\ x\ 100\%$$

23. **pH and Titratable Acidity (TA)** Tomato juice will be extracted from the sample with a juice extractor (Type 6001x, USA) and clear juice will be used for the analysis. An aliquot of juice will be extracted according to Nunes and Enond (1999). The pH value of the tomato juice will be measured with a pH meter. The TA of tomato will be measured according to the methods described by Maul et al. (2000). The titratable acidity expressed as percent citric acid, will be obtained by titrating 10 ml of tomato juice to pH 8.2 with 0.1N NaOH. The TA will be calculated from the following formula

$$TA\ (\%) = \frac{Titre\ x\ 0.1N\ \ NaOH\ x\ 0.67}{1000}\ x\ 100$$

24. **Sugar Analysis** Reducing and total sugars will be estimated by using the techniques of Somogyi et al. (1945) as cited by Tilahun (2002). Clear juice (10 ml) will be added to 15 ml of 80 percent ethanol, mixed and heated in a boiling water bath until the ethanol odor goes off. After extraction, 1ml of saturated Pb $(CH_3COO)_2.3H_2O$ and 1.5 ml of $NaHPO_4$ will be added and the contents will be mixed by gentle shaking. After filtration, the extract will be made up to 50 ml with distilled water. An aliquot of 1ml extract will be diluted to 25 ml with 1ml copper reagent in a test tube and heated for 20 minutes in a boiling water bath. After heating, the contents will be cooled under running tap water without shaking. Arsenomolybdate color reagent (1 ml) will be added, mixed, made up to 10 ml with distilled water and left for about 10 minutes to allow color development, after which the absorbance will be determined by a spectrophotometer at 540 nm in a Jenway model 6100 spectrophotometer. For total sugar determination, sugar will be first hydrolyzed with 1N HCl by heating at 70°C for 30 minutes. After hydrolysis, total sugar will be determined following the same procedure employed for the reducing sugar. A blank will be prepared using distilled water.

$$\mathrm{Re}ducing\ or\ total\ \ sugars = \frac{1}{Slope}\ x\ \frac{Sample\ ABS\ \ O.D}{Weight\ of\ \ sample}\ x\ \frac{Volume\ made\ up}{aliquant\ taken}\ x\ \frac{1}{1000}$$

Where,
Slope = 0.00148
ABS = absorbance of sample
Subjective quality analysis

The marketable quality of tomato fruits will be subjectively assessed according to Mohammed et al. (1999). The descriptive quality attributes will be determined by observing the level of visible mould growth, decay, shriveling or dehydration and the surface appearance characteristics such as smoothness and shine of the fruits. The percentage of marketable fruits during storage will be calculated as follows

$$Marketable\ tomato\ \ fruits\ (\%) = \frac{Number\ of\ \ marketable\ tomato\ \ fruits}{Total\ number\ of\ \ tomato\ \ fruits}\ x\ 100$$

Identification of Dominant Decay Microorganisms
Microbiological identification and determination of infection level will be carried out on every sampling date. Dominant microorganisms causing post-harvest decay of tomato fruits will be determined. Fungi will be isolated in a general-purpose medium potato dextrose agar (PDA) and will be identified based on colony and microscopic characters. Isolation of bacteria will be carried out on yeast extract dextrose calcium carbonate (YDC) medium. The population of microorganisms will be determined on a 1-4 rating scale, where 1 refers to low microbial population and 4 refers to very high population.

PEPPER DATA COLLECTION PROCEDURES

Background
Pepper (Capsicum spp) is a new world crop that belongs to the Solanaceae family. The genus Capsicum is the second most important vegetable crop of the family after tomato (Rubatzky and Yamaguchi, 1997). Pepper is a dicotyledonous woody perennial small shrub in suitable climatic conditions, living for a decade or more in the tropics. It is with erect sometimes prostrate growth habit that may vary in certain characteristics depending on type of species (Bosland and Votava, 1999).

Growth Characters

1. **Plant height (cm):** Plant height measurement will be made from the soil surface to the top most growth points of above ground plant part. The measurement will be taken as the length from nine plants of central rows of each plot at the last harvesting time.
2. **Days to 50% flowering:** Is the number of days where 50% of the selected plants started blooming beginning from the days of transplanting.
3. **Number of flowers per plant**: The number of flowers of the nine sample plants at 100% flowering stage from each plot will be counted.
4. **Days to first harvest:** The number of days from transplanting to the date of first harvest will be recorded from nine sample plants selected from central rows.
5. **Canopy diameter (cm):** The mean values will be taken at fruit maturity at both locations by measuring diameter of the plant (North to South and East to West dimension of the above ground part of sample plants).
6. **Number of branches per stem**: Numbers of primary, secondary and tertiary branches per stem of randomly selected nine middle row plants at final harvest will be counted.

7. **Dry weight content per plant (g):** Mean values of the dry weight content (shoots and roots). The samples will be dried in an oven at 1050C until constant weight will be reached.

Yield And Yield Related Parameters

8. **Number of fruits per plant**: Mean number of red ripe fruits of individual plants from central rows for each plot at each harvest will be recorded.
9. **Average number of seed per pods:** Seeds of randomly picked ten marketable pods from sample plants will be counted and recorded.
10. **Seed weight (g):** Seed extracted from ten marketable pods will be weighed using sensitive balance and mean values will be calculated.
11. **Marketable yield (t/ha):** The marketable yield of nine sample plants will be determined at each harvesting by sorting dried fruits according to color, shape, shininess, firmness and size of the fruits. After drying, the dried marketable fruits will be separated, the weight of the respective categories will be recorded and converted to t/ha.
12. **Unmarketable yield (t/ha):** Is the yield which will be obtained by sorting the diseased, discolored, shrunken shape and small sized, totally unwanted pods by consumers from marketable dried pods will be recorded at each harvest and converted to t/ha.
13. **Total dry fruit yield (t/ha):** Weight of total (marketable and unmarketable) fruits harvested at each successive harvesting from the sample plants will be recorded and summed up to estimate yield per hectare.

Quality Parameters

14. **Fruit pericarp thickness (mm):** Pericarp of ten marketable fruits from each plot will be measured using venire caliper and mean values will be recorded.
15. **Fruit dry weight content (g):** of five plants from each plot will be taken. The samples will be dried in an oven at 1050C until constant weight will be reached.
16. **Fruit length (cm):** Length of ten marketable fruits from each plot for each variety will be measured at red and dried stage using venire caliper and mean values will be taken.
17. **Fruit diameter (cm):** Fruit wall will be measured from ten marketable fruits of sample plants from each plot at red ripe and dried stage using venire caliper and mean values will be recorded.

Disease Reaction

18. **Pest and Disease Incidence (%):** The number of infected plants will be considered and percentage of plants infected with bacterial wilt incidence estimated as suggested by Agrios (2005): Disease Incidence (%) = Number of infected plants per plot*100/ Total number of plants per variety

JUTEMALLOW DATA COLLECTION PROCEDURES

Background

Jute mallow *(Corchorus olitorius L)* consists of 50-60 species, of which about 30 are found in Africa (Schippers, 2002 and Kemei et.al, 1997) and used as a vegetable popularly in the world. It is the most frequently cultivated and most common species found in Africa. Africa is the primary centre of diversity of this genus, which occurs throughout the continent (Kemei et.al, 1997).

1. **Length of Plants (cm):** will be measured from the ground level to the tip of the stem.
2. **Length of roots (cm):** Will be measured from the ground level to the tip of root.
3. **Weight of fresh plants per plot (g):** will be measured without petioles in plot based.
4. **Fresh weight of leaves (g):** will be measured without petioles.

5. **Fresh weight of roots (g):** will be measured soon after harvest without any external particles.
6. **Dry weight of leaves (g):** dried in an oven at 105°c for 48 hours and then weighed.
7. **Dry weight of roots (g):** dried in an oven at 105°c for 48 hours and then weighed.
8. **Number of leaves per plant:** counting the whole leaves at consuming stage.
9. **Pigmentation on the stem:** will be estimated by looking to stem color
10. **Number of branches per plant:** will be counted at the end of the harvesting date.
11. **Pod yield (g):** the weight of all pods per plant.
12. **Number of pods per plant**: sum of the number of pods from all picking for a particular plant.
13. **Average pod weight (g):** obtained by dividing the pod yield per plant by the number of pods of that plant.
14. **Pod length (cm):** measured from the base of the pod (without including the calyx) to its apex.
15. **Pod diameter (cm):** measured by a Vernier at the base of the fruit.
16. **Number of seeds per pod:** samples of 10 mature pods will be taken from each plot. The pods will be longitudinally opened and the number of seeds in each pod will be counted.
17. **1000 – Seed weight (g):** samples from each plot of 1000 dry ripe seeds from each plot will be counted and weighed.
18. **Seed yield / unit area (kg / plot):** Total seed yield per plot
19. **Fresh leaves yield / unit area (kg / plot):** total leaf yield per plot

WATER MELON DATA COLLECTION PROCEDURES

Background

Watermelon belongs to the family Cucurbitaceae and the genus Citrullus and it's the only cultivated species of this genus (Bisognin, 2002). It is believed to have originated in Africa (Simmonds, 1979) but is now widely spread throughout the tropics and the Mediterranean (Tindall, 1983). Wild watermelon (Citrullus colocynthis) is a native of arid soils in Africa. Watermelon is thought to have been domesticated in Africa at least 4000 years ago and now grown worldwide, particularly in regions with long, hot summers (Robertson, 2004). Watermelon is one of the most widely cultivated crops in the world (*Huh et al.,* 2008). Its global consumption is greater than that of any other cucurbit. It accounts for 6.8% of the world area devoted to vegetable production (Guner and Wehner, 2004; Goreta *et al.,* 2005).

Reproductive Growth and Yield

1. **100 seed weighs:** weight of 100 seeds
2. **Fruit length**: average length of fruit longitudinal
3. **Fruit weight:** average weight of fruit
4. **Fruit girth:** average diameters using calipers
5. **Fruit number (Marketable and unmarketable):** total fruit number per plant
6. **Length of primary/ Main vine:** length from ground to the tip of main vine
7. **Number of flowers:** total number of flowers per plant
8. **Number of fruits per plant (Marketable and unmarketable):** total number of fruits per plant
9. **Fruit yield per plant (Marketable and unmarketable):** weight of fruit per plant
10. **Number of leaves:** total number of leaves per plant
11. **Number of secondary vine/ Number of branches on the main vine:** number of secondary vines arise from main vine.

12. **Number of seeds per fruit:** Self-pollinated fruits from putative tetraploid plants will be harvested at mature stage. The number of seeds present in each fruit will be counted and expressed as average number of seeds per fruit for tetraploids in each variety.
13. **pulp weight:** weight of soft tissue per fruit
14. **Seed length (mm):** Length of ten randomly selected seeds per tetraploid line will be recorded using digital Vernier caliper and expressed as average seed length.
15. **Seed width (mm):** Width of ten randomly selected seeds per tetraploid line will be recorded using digital Vernier caliper and expressed as average seed width.
16. **Total number of female flowers per plant**: number of male flowers per plant
17. **Total Soluble Solids (TSS**) The TSS will be determined following the procedures described by Will bekar et al. (1999). An aliquot of juice will be extracted using a juice extractor (Type 6001x, USA). An Atago N, hand refractometer with a range of 0 to 32°Brix and resolutions of 0.2°Brix will be used to determine TSS by placing 1 to 2 drops of clear juice on the prism. Between samples the prism of the refractor meter will be will behed with distilled water and dried with tissue paper before use. The referactrometer will be standardized against distilled water (0 percent TSS).

OKRA DATA COLLECTION PROCEDURES

Background

Okra (Abelmoschus esculentus) is one of the important vegetables with tremendous nutritional values. The edible portion (fresh fruits) contains 86.1% moisture, 9.7% carbohydrates, 2.25% protein, 1.0% fibre, 0.2% fat and 9% ash in addition to vitamins A, B, C and iodine (Kochhar, 1981). The fruits are consumed as vegetables, raw, cooked or fried in stews, gumbos and cecole dishes together with other vegetable. The dried and powdered or dehydrated okra is used in thickening soups, as emulsifier for salad dressing and as flavouring in preparing food products (Nonneck, 1989).

Crop Phenology and Growth Traits

1. **Days to 50%emergence:** Number of days from sowing to 50% seedling emergence.
2. **Days to first flowering:** The number of days taken from the date of sowing to onset of first flower appears on the plant in each plot.
3. **Days to 50% flowering:** The number of days taken from the date of sowing to the day on which 50 % of the plants in each plot produce flower.
4. **Days to maturity:** The average number of days from sowing to the date of first harvest of 10 sample plants of the plot will be recorded.
5. **Plant height (cm):** The height of 10 plants measured from the ground level to the tip at the time of final harvest and the average will be considered for statistical analysis.
6. **Stem diameter (mm):** Stem diameter at the basal region of plants will be measured using vernier calipers at the time of final harvest.
7. **Number of primary branches per stem:** The total number of primary branches per plant will be counted at final picking and average of 10 plants will be calculated.
8. **Number of internodes:** The total number of internodes per plant will be counted at final picking and average of 10 plants will be calculated.
9. **Internode's length (cm):** The length of the internodes between the 5 th and 6th node will be measured at time of maturity before the first tender fruit harvest.
10. **Leaf length (cm):** The length of 15 leaves on the main stem from each plot will be sampled randomly from 9 th and 11th node taken at the time of flowering. As the leaves from 7th node onwards are representative of the shape and the size of the variety. Leaves will be

measured from the attachment of the base of the leaves and petiole to the tip of the leaves using ruler.

11. **Leaf width (cm):** The width of 15 leaves on the main stem from each plot will be sampled randomly from 9 th and 11th node at the time of flowering. Leaves will be measured from the widest part of the leaf.
12. **Number of epicalyxes**: The number of epicalyxes flowers taken five flowers per plant from 10 plants at flowering stage from each genotype.

Fruit Character and Yield

Fruits will be harvested two times per week and number and weight of all tender fruits will be recorded in each harvest. Five randomly tender fruits from each harvest in each lot which a totally not less than fifty tender fruits from each plot will be used to record tender fruit characteristics while mature pods which produced between the 6th and 20th nodes will be harvested at the end of the growing season to estimate mature pod length, seed number/pod and 100 seed weight.

13. **Peduncle length (cm):** Pedicel length of the five fruits per plant prior to picking will be measured at fully matured stage.
14. **Fruit length (cm):** The length of five tender fruits per plot in each harvest will be measured from the base of calyx to the tip of the fruit. The average will be calculated by dividing the sum of all tender fruit's length by the total number of fruits measured.
15. **Fruit diameter (mm):** the five tender fruits per plot which fruit length will be measured as indicated above will be also used to measure tender fruits diameter of with the help of a venire caliper at the center of the fruit and the average will be calculated like that of the fruit length.
16. **Average fruit weight (g):** Each of five tender fruits per plot that will be used to measure fruit length and width will be weighed using sensitive balance and the average weight of tender fruit will be calculated and recorded accordingly.
17. **Number of tender fruits per plant:** Fruits of ten plants in each plot at each harvest will be counted and summed at the end of the harvest and the average number of tender fruits per plant will be calculated and considered for statistical analysis.
18. **Number of ridges on fruit:** The number of ridges will be counted and the average also will be calculated from five tender fruits per plot at each harvest that will be used to measure fruit length and width.
19. **Yield per plot (kg):** Weight of tender fruits from each plot in each harvest will be recorded and summed to record yield per plot.
20. **Yield per hectare (t/ha):** This will be estimated from the 10 plants tender fruit yield in each plot.
21. **Number and weight of matured pods per plant:** Matured pods of the two plants next to the side plants/border plants in each plot will be harvested, counted and weighted to estimate and record number and weight (g/plant) of matured pods per plant.
22. **Dry weight of matured pods per plant (g/plant):** All the harvested matured pods of the two plants next to the side plants/border plants in each plot will be dried, weighted and the average dry weight of matured pods per plant will be calculated and recorded.
23. **Number of seeds per pod:** Ten fully matured and dried pods will be collected randomly from the two plants in each plot as indicated above and seeds will be extracted, counted and average number of seeds per pod computed.
24. **Hundred seed weight (g):** Seeds extracted from ten matured pods as indicated above will be kept in open air under sun and the dried 100 seeds will be randomly counted and weighted to estimate 100 seeds weight.

Qualitative Traits

The qualitative traits will be recorded on plot basis according to International Plant Genetic Resources Institute (IPGRI, 1991) descriptor list for okra species as follows.

25. **Plant habit:** This will be identified how the plants in each plot branched and described as: 1) Densely branched at apex (DBA), 2) Densely Branched Base (DBB) 3) Densely branched all over (DBO). 4. Non branched growth habit (NB)
26. **Flower color:** red coloration of petals base will be assessed at both side and described as 1) red color inside only or 2) red color at both sides.
27. **Leaf color**: This will be assessed from leaves lamina and ribs and described as 1) totally green and 2) green with red vein.
28. **Leaf petiole color:** It will be assessed from petioles color at both side and described as 1) Green, 2) Red above but green below and 3) Red on both sides.
29. **Pod color:** Main color of the pods will be observed at harvesting stage and described as 1) Green and 2) Red. 3. Green yellow
30. **Stem color:** This will be assessed from stems color of plants at first harvest stage and described as: 1) Green 2) Green with red patch and 3) Red or Purple. Color chart will be used for all color identification of pod, stem and leaf (Okra http://w3schools.Com/ html/html colorfullasp).
31. **Shape of leaf:** This will be assessed from leaves of plants that will be produced up to the first harvest and described as 1) oval undulate 2) heart-shaped 3) broadly ovate 4) star shaped (palmately lobed) 5) palmately triangular lobes 6) palmately lobed with dentate margins 7) palmately lobed with serrated margins and 8) linear-oblong or tri angular lobes.
32. **Position of fruits on main stem:** The positions of fruits on the main stem of the accessions will be observed and it will be described in five distinct variations as 1) Erect 2) Intermediate 3) Horizontal 4) slightly falling and 5) Totally falling.
33. **Fruit pubescence:** this will be observed at harvesting stage and described as 1) smooth and 2) rough.
34. **Fruit shape:** This will be assessed from fruit at harvest stage and described as with shape scores of 1, 2, 3, 4, 12, 14 and 15, according to the descriptor (IPGR, 1991).

CARROT DATA COLLECTION PROCEDURES

Background

Carrot (*Daucus carota* L.) is a widely grown root vegetable of the Apiaceae family. The first certain recorded use of carrot roots as a vegetable was in the 10th century in what is today known as Afghanistan. Orange carrots first appeared as a genetic variant in Europe in the 16th century and these more refined orange carrots quickly spread around the world, and by the early 20th century they became the predominate carrots in most growing regions of the world (www.seedalliance.org). Carrot is an important source of alpha- and beta-carotene, the precursors of vitamin A in human nutrition in many countries worldwide.

1. **Average root length**: Samples will be taken from treatment plots and the root length will be measured using a ruler and expressed in centimeters.
2. **Average root juice content**: Carrot juice will be extracted from the sample with a juice extractor (Type 6001x model No. 31JE35 6x.00777 U.S.A.) and clear juice will be used for measuring average root juice content.
3. **Average root base diameter**: The average root base diameter will be determined by measuring the base diameter of the root with the help of a verneer caliper.

4. **Core diameter**: The cores of the roots will be taken out using knives and average core diameter will be determined by measuring the core of the root at middle portion with the help of a verneer caliper.
5. **Bolting dates:** A shoot will be described bolted when the first visible flower bud appear. The dates will be recorded when 50% of the plants had visible flower buds.
6. **Flowering dates:** The date when 50% of the plants had open flowers on the primary umbel.
7. **Number of days to seed harvest:** The number of days from sowing to the day when the second order umbels (secondary) will be harvested.
8. **Seedstalk height at flowering**: It will be measured from the root crown to the top of the primary umbel. The mean will be calculated by dividing the total height by the number of plants.
9. **Number of umbels per umbel order per plant:** The total number of umbels per umbel order will be recorded at harvest and divided by the number of plants to calculate the number of umbels per umbel order per plant.
10. **Number of umbellets per umbel:** For primary umbels, the total number of umbellets will be divided by the number of plants. For secondary and tertiary umbels, total number of umbellets will be calculated from 5 randomly selected umbels from each order in each plant and divided by the number of plants.
11. **Fresh root weight**: Immediately after harvest, the total carrot roots obtained from each treatment plot will be taken and their fresh weight will be measured with the help of an analytical balance. Then after mixing the replications of each treatment, ten randomly selected carrot samples from each treatment will be taken to measure the fresh weight of individual roots to determine average root weight.
12. **Average root volume**: The average root volume will be measured by taking random samples from each treatment and immersing in a beaker containing known amount of water. The volume of the root will be determined by observing the displacement of the water by the root, so that the difference will be taken as the volume of the root.
13. **Leaf Number**: Ten randomly selected carrot plants per experimental plot will be taken for leaf counting every 15 days up to the time of harvesting. In the process the number of true leaves will be counted and recorded
14. **Seed weight per umbel:** Total seed weight of each umbel order will be divided by the number of umbels in each umbel order.
15. **Seed weight per plant:** Total seed weight divided by the number of plants.
16. **One thousand seed weight:** Weight of 200 seeds from the representative sample multiplied by 5.
17. **Root dry weight:** Total root dry weight divided by the number of plants.
18. **Shoot dry weight:** The total dry weight of above ground plant material including the seed divided by the number of plants. This value plus the mean root dry weight per plant will give the biological yield.
19. **Root-to-shoot ratio:** The quotient of mean root dry weight and mean shoot dry weight.
20. **Harvest index:** The quotient of the seed weight and the biological yield.
21. **Germination percentage**: The proportion of the number of seeds that have produced seedlings classified as normal under the conditions and within the period specified.
22. **Vigour index**: The sum of the number of seedlings removed daily from the germination test divided by the sum of the number of days.

SWEET POTATO DATA COLLECTION PROCEDURES

Background

Sweet potato *(Ipomoea batatas (L.)* Lam.) is a member of the Convolvulaceae family (Purseglove, 1972). Approximately 900 different species of Convolvulaceae in 400 genera have been identified around the world. Yen (1974) and Austin (1978, 1988) recognized 11 species in the section batatas, which includes sweet potato. The closest relative of the sweet potato appears to be *Ipomoea trifida* that is found wild in Mexico, and *Ipomoea tabascana.* Sweet potato has a chromosome number of 2n = 90. Since the basic chromosome number for the genus *Ipomoea is* 15, sweet potato is considered to be a hexaploid.

1. **Days to emergence:** It will be recorded when 50% of the vine cuttings sprout.
2. **Number of branches (Number plant^{-1}):** The average number of branches/stems emerging from the main stem. This will be counted at maturity.
3. **Vine length (m):** The length of the vine from the base of the plant to the terminal tip at which the maximum height is attained.
4. **Shoot fresh weight (g/plant):** Includes fresh mass of vines and leaves. It will be recorded by taking random samples of five plants per plot.
5. **Shoot dry weight (g/plant):** Includes dry mass of vine and leaves. It will be recorded at physiological maturity. The above ground biomass will be harvested by cutting vines close to the soil surface and putting them in a forced air circulation oven at 80^{o}C for 12 to 24 hours until a constant weight is attained.
6. **Days to physiological maturity:** It will be recorded when the vines of 50% plant population in each plot turned yellowish.
7. **Root fresh weight (g/plant):** Storage roots, pencil roots, fibrous roots and parts of stem remaining underground will be dug out and weighed.
8. **Root dry weight (g/plant):** Underground plant parts will be first air-dried and the roots sliced in to small pieces, and further dried in a ventilated oven at 80 ^{o}C until a constant weight is obtained.
9. **Biomass yield:** It will be determined by summing up the shoot fresh weight and root fresh weight.
10. **Harvest Index:** Harvest index will be calculated from each sample as the ratio of dry mass of roots (economic yield) to total biomass (biological yield) at harvest as described by (Chan, 1996).
11. **Average root number (number plant^{-1}):** It will be recorded by counting the actual number of roots collected from five randomly selected mature plants at harvest and dividing the total number of roots by five.
12. **Average root weight (g plant^{-1}):** It will be determined by dividing the total fresh roots weight per plant to the total number of roots.
13. **Marketable root number (count ha^{-1}):** the number of marketable roots per plot (it includes the number of clean, uninfected storage roots that fall in the size range of 100 g to 500 g) (Yohannes, 2007) and converted to hectare.
14. **Unmarketable root number (count ha^{-1}):** the number of unmarketable roots per plot (it includes all storage roots other than marketable roots) and converted to hectare.
15. **Total root number (count ha^{-1}):** It is the number of marketable and unmarketable roots that are taken from harvestable plot and converted to hectare.
16. **Marketable root yield (t ha^{-1}):** the weight of clean, uninfected storage roots that fall in the size range of 100 g to 500 g. It will be recorded by weighing all the fresh marketable roots harvested from the plot using sensitive balance and calculated on the basis of ton ha^{-1}.

17. **Unmarketable root yield (t ha^{-1}):** the weight of unmarketable roots per plot (it includes all storage roots other than marketable roots such as small size, rotten and green) and it will be calculated on the basis of ton ha^{-1}.
18. **Total root yield (t ha^{-1}):** it is the sum of marketable and unmarketable roots yield taken from harvestable plot and calculated on the basis of ton ha^{-1}.
19. **Percent root dry matter yield:** This will be estimated as a ratio of the weight of dried root and fresh root, expressed as percentage (**RDM (%) = [WDR / WFR] x 100)** Where; RDM (%) = Root Dry Matter Percentage, WDR = Weight of Dried Root and WFR = Weigh of Fresh Root
20. **Top-to-Root Ratio or Shoot-to-Root Ratio:** it will be determined by dividing the above ground dry biomass to the total root dry biomass at maturity.
21. **Leaf area:** it is the total one-sided area of leaf tissue and measured using leaf area meter.
22. **Leaf Area Index (LAI):** it will be determined by dividing the total one-sided area of leaf tissue per unit ground surface area as defined by Watson (1947).
23. **Leaf Number (count hill^{-1}):** numbers of the hall plants per hill will be counted.
24. **Vine length:** the height of plant from the base of the plant to the terminal tip at which the maximum height will be attained (m).
25. **Internode's diameter (mm):** it will be measured at harvest between the fourth and fifth nodes from the tip with the aid of caliper.
26. **Internode's length (cm):** it will be measured at harvest between the fourth and fifth nodes from the tip with the aid meter.
27. **Chlorophyll contents:** it will be measured at two and half month after planting between the fourth and fifth nodes from the tip with the aid of SPADS.
28. **Specific gravity:** it will be determined by collecting a sample of 5 kg roots from each plot randomly. It will be will behed and dried and determined using the weight in air and water method as described by Fong and Redshaw (1973).
    Sg = WA / (WW – WA)
    Where; WA = Weight in Air, WW = Weight in Water and Sg = Specific gravity.
29. **Nutrient Uptake:** it will be calculated based on plant samples collected for estimation of dry matter accumulation at harvest maturity. Total uptake of N and P will be calculated separately by the following formula: Uptake of N or P g plant^{-1} = (N% or P% × dry matter g plant^{-1}) /100

POTATO DATA COLLECTION PROCEDURES

Background

Potato (Solanum tuberosum L.) is one of the most important tuber crops in the world (Albiski et al. 2012) and is a critical crop in terms of food security (Birch et al. 2012). The crop is an essential source of starch, antioxidants, protein, vitamins, macro and micronutrients, polyphenols, carotenoids and tocopherols in the human diet (Brown 2005).

1. **Days to tuber initiation:** It will be recorded when the stolon tip attains a size at least twice the diameter of the stolon (Ewing and Struik, 1992). For this purpose, three plants per plot will be tagged and tuber initiation monitored every second day.
2. **Plant height:** Measured from the base of the stem to shoot apex at maturity from those tagged plant samples used for leaf area measurement.
3. **Total leaf area and leaf area index:** To determine leaf area and leaf area index, five plants (hills) from each subplot will be randomly selected and tagged. The leaf area and leaf area index will be measured 30 days after the last treatment application date. Individual leaf area of the potato plants will be estimated from individual leaf length using the following

formula developed by Firman and Allen (1989) and leaf area index will be determined by dividing the total leaf area of a plant by the ground area covered by a plant.
{Log 10 (leaf area in cm2) =2.06xlog 10(leaf length in cm)-0.458}

4. **Biomass yield:** To determine dry mass of aboveground parts (stem, branch, and leaves) and underground parts (root, stolon, and parts of the stem remaining underground) five randomly selected plants will be harvested from each treatment category at about six weeks after pollination (CIP, 1983) when the vines will be still green but had practically cease growth. Both above and underground parts dry mass will be determined after drying the samples in an oven at 720C to a constant mass.
5. **Days to physiological maturity:** It will be recorded when the haulms of 50% plant population
in each plot turned yellowish.
6. **Tuber yield and number:** Tubers from second, fourth and sixth rows (five plants in each rows) of each subplot will be harvested on the same date according to the maturity date of the cultivars. Tubers which will be rotten, green and weighing less than 60 g will be considered unmarketable tubers while determining marketable and unmarketable tuber yield and number.
7. **Average tuber mass:** It will be determined by dividing the total fresh tuber yield to the respective total number of tubers.
8. **Harvest index:** It will be calculated as the ratio of dry mass of tubers to the dry mass of total
biomass. Dry mass of tubers will be determined by multiplying the total fresh tuber yield by the respective dry matter percentage.
9. **Specific gravity:** At harvest, a representative tuber sample from each subplot will be taken and will behed. Tuber specific gravity will be determined by weighing in air and under water
method (Murphy and Goven, 1959).
10. **Dry matter content:** To determine dry matter content of the tubers, the samples will be predried at a temperature of 600C for 15 hour and followed by 1050C for 4 hours. Tuber dry matter content is the ratio between dry and fresh mass expressed as a percentage.

CASSAVA DATA COLLECTION PROCEDURES

Background

Cassava (*Manihot esculenta*) is the fourth most important source of food calories for humans in the tropics (Roca and Thro, 1992). It grows exclusively as food in 39 African countries, stretching through a wide belt from Madagascar in the south-east to Senegal in the Northwest (IITA, 1990). It is a staple food for more than a tenth of the world's populations, and in tropical countries it is the third source of calories after maize and rice (Sis, 2013).

Descriptors to be Scored at Three Months After Planting

1. **Color of apical leaves:** Record color that the most frequent occurrence as Light green, Dark green, Purplish green and Purple
2. **Pubescence on apical leaves:** Record the most frequent occurrence of leaf apical shoot.

Descriptors to be Scored at Six Months After Planting

1. **Leaf retention:** Measure 5–6 months after planting. Visually score for leaf retention using a scale of 1–5. 1 = Very poor retention 2 = Less than average retention 3 = Average leaf retention 4 = Better than average retention 5 = Outstanding leaf retention

2. **Shape of central leaflet:** Leaf taken from a mid-height position and check its shape: 1 Ovoid 2 Elliptic-lanceolate 3 Obovate-lanceolate 4 Oblong-lanceolate 5 Lanceolate 6 Straight or linear 7 Pandurate 8 Linear-piramidal 9 Linear-pandurate 10 Linear-hostatilobalate
3. **Petiole color:** Leaf taken from a mid-height position check for its petiole color: 1 Yellowish-green 2 Green 3 Reddish-green 5 Greenish-red 7 Red 9 Purple
4. **Leaf color:** Observe a leaf from the middle of the plant and recorded leaf color: Light green, Dark green, purple green and Purple
5. **Number of leaf lobes:** Assess on five leaves and take the predominant number of lobes: Three lobes, Five lobes, Seven lobes, Nine lobes and Eleven lobes
6. **Length of leaf lobe:** Measure from the intersection of all lobes to the end of the middle lobe. Express in cm and record to one decimal place.
7. **Width of leaf lobe:** Measure from the widest part of the middle lobe. Express in cm, and record to one decimal place.
8. **Ratio of lobe length to lobe width of central leaf lobe:**
9. **Lobe margins:** Observe from the middle third of the plant: Smooth and Winding
10. **Petiole length:** Observe from the middle third of the plant. Measure two leaves/ plant. Express in cm.
11. **Color of leaf vein:** Observe near the base of the lobes, on the upper side of the leaf, on the central lobe from a leaf from the middle of the plant: Green, Reddish-green in less than half of the lobe, Reddish-green in more than half of the lobe and all red
12. **Orientation of the petiole:** Take a general picture across the row and observe the middle plant part and express as Inclined upwards, Horizontal, Inclined downwards and Irregula
13. **Flowering:** At least one flower on each plant. Scoring should be repeated at regular intervals until harvest to determine whether flowering occurs.
14. **Pollen:** Scored at the same time as flowering for presence and absence of pollen

Descriptors to be Scored at Nine Months After Planting

1. **Prominence of foliar scars:** Observe from the middle third of the plant for Semi-prominent and Prominent
2. **Color of stem cortex:** Make a small shallow cut and peel back the epidermis and check its color: Orange, Light green and Dark green
3. **Color of stem epidermis:** Peel epidermis back and look at underside of epidermis (skin): Cream, Light brown, Dark brown and Orange
4. **Color of stem exterior:** Observe on the middle third of the plant: Orange, Greeny-yellowish, Golden, Light brown, Silver, Gray and Dark brown
5. **Distance between leaf scars:** Measure from the middle of stem on the middle third of the plant, where the scars are not flat express in cm.
6. **Growth habit of stem:** check plant growth weather Straight or Zig-zag
7. **Color of end branches of adult plant:** Observation to be taken on top 20 cm of plant: Green, Green-purple and Purple
8. **Length of stipules:** Observation from upper third of plant for long or short stipules
9. **Stipule margin:** Observation from upper third of plant whether Entire or Split or forked

Descriptors to be Scored at Harvest

1. **Fruit:** observe whether it has fruit or not and recorded accordingly
2. **Seed:** observe whether it form seed or not and recorded accordingly

3. **Plant height:** Measure vertical height from the ground to the top of the canopy average of three plants Express in cm.
4. **Height to first branching:** Measure vertical height from ground to first primary branch. Zero = no branching. Ignore side branching. Express in cm. average over three plants.
5. **Levels of branching:** Record number of divisions of branching. Zero (0) for no branching Ignore if side branching
6. **Branching habit:** Observed at the lowest or first branching: Erect, Dichotomous, Trichotomous and Tetrachotomous
7. **Angle of branching:** Measure at first primary branching (not side branches). Record the angle measured, later divide the angle by two.
8. **Shape of plant:** Record the most frequent occurrence on the plot: Compact, Open, Umbrella and Cylindrical
9. **Number of storage roots/plant:** Record from each of three plants.
10. **Number of marketable roots/plants:** Record the number of roots from three plants with length greater than 20 cm.
11. **Extent of root peduncle:** Main roots only: Sessile, Pedunculate, Mixed
12. **Root constrictions:** Measure on a mature root. This can be affected by nematodes and/or cassava brown streak diseases: Few to none, Some and Many
13. **Root shape:** Record the most frequent occurrence: Conical, Conical-cylindrical, Cylindrical and Irregular
14. **External color of storage root:** Record the most frequent occurrence: White or cream, Yellow, Light brown and Dark brown
15. **Color of root pulp (parenchyma):** Record the most frequent occurrence: White, Cream, Yellow, Orange and Pink
16. **Color of root cortex:** Record the most frequent occurrence: White or cream, Yellow, Pink and Purple
17. **Cortex: ease of peeling:** check whether it is Easy or Difficult to peel
18. **Texture of root epidermis:** Record the most common root type. Please touch the root! As if is Smooth, Intermediate or Rough
19. **Root taste:** test raw root only: Sweet, Intermediate or Bitter
20. **Cortex thickness:** Measure from three roots, at the proximal (closest to stem), mid- and distal (furthest from stem) ends. Use calipers if available. Check if Thin, Intermediate or Thick express mm
21. **Dry matter content:** Heritability for DM in cassava is relatively high; 0.87 broad sense heritability and 0.51 – 0.67 narrow sense heritability (Kawano et al. 1987). Estimation of DM and starch content in cassava is based on the principle of a linear relationship between specific gravity with DM and or starch content. Percentage DM = 158.3x – 142, while starch content = 112.1x – 106.4; where x = specific gravity. Specific gravity is measured according to the following methodology: Compute specific gravity at Ww / (Wa – Ww) where Ww = weight of root in water and Wa = weight of root in air
22. **Starch content:** starch content = 112.1x – 106.4; where x = specific gravity.
23. **Harvest index:** Harvest index (HI), defined as the proportion of the fresh root weight in biomass, is a valuable trait in cassava breeding. As opposed to selections based solely on fresh root yield, HI-based selections are stable across evaluation stages and will truly represent genotype yield potential under monoculture. It is likely that true genetic progress in cassava will be achieved through utilization of HI (Kawano 1990). The assessment of HI is relatively simple and straightforward.
    HI = Weight of roots / (Weight of roots + weight of aboveground biomass)

24. **Cyanogenic potential:** 1. There are large effects of environments on root cyanogens; nevertheless, both broad and narrow sense heritabilities for CNP are high, ranging between 0.87–1.07. 2. Because CNP varies considerably between plants, analysis will be done using 4 plants/clone, and on 3 roots per plant. 3. Materials required include knives, glass tubes (12 cm long with tightly fitted rubber stops) and the scoring scale. 4. Consumables required include filter papers (Whatman No. 1.6 cm x 1 cm) picric acid anhydrous sodium carbonate, and toluene. Please note that both picric acid and toluene (methylbenzene or phenyl methane) are hazardous chemicals, and NEED TO BE HANDLED WITH EXTREME CARE AND WITH APPROPRIATE PROTECTION. 5. For each root sample, make a cross-sectional cut at the mid-root position. 6. Pinpoint the mid position between the peel and the center of the parenchyma (root flesh) and make a 1 cm3 cube cut. 7. Place the cut root cube into a glass tube and add 5 drops of toluene onto it; tightly seal the glass tube with the stopper. 8. Take a strip of Whatman filter paper and dip it into freshly prepared alkaline picrate mixture until saturated. 9. Suspend the picrate-saturated filter paper above the cut root cube in the glass tube; ensure that the tube is tightly fitted with the rubber stopper. 10. After 10–12 hours, score for color intensity using the 1–9 scale.
25. **Postharvest deterioration:** 1. randomly select five commercially sized roots (minimum length 18 cm) to represent each clone. 2. Cut off a section about 1 cm from both the proximal and distal ends; cover the distal end with cling film. 3. Store the roots under ambient conditions. 4. After 7 days make seven 2-cm transversal slices starting from the proximal end. 5. Score each slice on a scale of 1–10, corresponding to the percentage of the cut surface showing discoloration (with 1 = 10% and 10 = 100%). 6. Take average of the seven slices to represent the deterioration of the root.

DATE PALM DATA COLLECTION PROCEDURES

Background

Phoenix dactylifera is a palm with a long and interesting history. Its origin goes back to ancient times, well before written history. It is a member of the genus *Phoenix,* which contains about one dozen species of palms. Although other species in this genus produce fruits that are eaten by birds and other animals, *Phoenix dactylifera* is the only *Phoenix* species cultivated for its fruit. The date palm is the characteristic vegetation found in the oases of arid areas in the Middle East.

1. **Average Bunch weight:** will be calculated by weighting bunch averaged over five bunches
2. **Average Fruit Length:** the height of the fruit measured in cm averaged over 30 sample from different bunch and cluster.
3. **Average Fruit Weight:** the weight of the fruit measured in gm averaged over 30 sample from different bunch and cluster.
4. **Average Fruit Width:** the width of the fruit measured in caliper averaged over 30 sample from different bunch and cluster.
5. **Average length of cluster:** the height of the cluster measured in cm averaged over 30 sample from different bunch at different point eg. Lower, middle and tip.
6. **Average number of clusters per bunch:** number of the cluster averaged over 30 sample of different bunch.
7. **Average number of Fruits per Cluster:** number of the fruit averaged over 30 sample of cluster from different bunch.
8. **Average Seed Length:** the height of the seed measured in cm averaged over 30 sample from different bunch and cluster.

9. **Average Seed Weight:** the weight of the seed measured in gm averaged over 30 sample from different bunch and cluster.
10. **Average Seed Width:** the width of the seed measured in caliper averaged over 30 sample from different bunch and cluster
11. **Canopy Diameter:** distance between the longest opposite two leaves round the main stem measured by meter
12. **Fruit Color:** color of fruit observed at different stages eg. Kimiri, Khalal, Rutab and Tamar stages.
13. **Date Harvest:** Number of days from pollination to last date of fruit harvest
14. **Date of pollinated:** the time of first day of pollination takes place
15. **Date of Spathe Emergency:** the time in which the spathe emerges between leaf and stem.
16. **Date of Spathe Flower:** the time in which the spathe crack to show spathe
17. **Number of Fruit per Bunch:** total number of fruits of bunch averaged over three bunches in kg
18. **Number of leafs pruned per plant:** number of the leaves pruned per tree annually based
19. **Number of Leafs per plant:** number of the leaves per tree
20. **Plant Height:** the height of the plant measured in meter from ground level to the growth tip of the plant
21. **Pulp Thickness:** the thickness of pulp measured by calipers after seeds are removed from fruit after harvest
22. **Steam Circumference:** the round length of the tree measured in meters at breast height of middle height man
23. **Steam Diameter:** the diameter of the tree measured in caliper at breast height of middle height man
24. **Total bunch number per plant:** total number of bunches annually produced by a single plant
25. **TSS:** An aliquot of juice will be extracted using a juice extractor (Type 6001x, USA). An Atago N, hand refractometer with a range of 0 to 32°Brix and resolutions of 0.2°Brix will be used to determine TSS by placing 1 to 2 drops of clear juice on the prism. Between samples the prism of the refractor meter will be beheld with distilled water and dried with tissue paper before use. The refractometer will be standardized against distilled water (0 percent TSS).
26. **Weight of Fruit per Bunch:** the weight of the fruit measured in km of each bunch produced by plant.
27. **Weight of fruit per cluster:** weight of the fruit averaged over 30 sample of cluster from different bunch at different point eg. Lower, middle and tip.
28. **Spathe length:** length of spathe at the time spathe opening of both male and female plants: take average of all spathes produced by plants
29. **Spathe diameter:** diameter of spathe at the time spathe opening of both male and female plants: take average of all spathes produced by plants in both sides of spathe at widest and narrow independently
30. **Offshoot produced per year:** number of offshoots annually produced by plant
31. **Weight of pollen per spathe:** weight of pollen produced by one spathe
32. **Number of male spathes per plant:** total number of spathes produced by plant
33. **Average length of male Custer:** length of male cluster sampled at different point eg. Lower, middle and tip.
34. **Number of male clusters per spathe:** number cluster produced in one spath

35. **Yield (marketable and unmarketable per bunch:** marketable, unmarketable and total yield per bunch and per plant in kg
36. **Number of aborted fruits:** number of fruits aborted before mature that remain in covering nets
37. **Percent of aborted fruit:** it is calculated by dividing aborted number of fruits by total number of fruit and multiplied by hundred expressed in percentage
38. **Leaf length:** the height of the middle leafs averaged over 30 leaves

MANGO DATA COLLECTION PROCEDURES

Background

Mango, *Mangifera indica* L., is the most economically important fruit crop in the Anacardiaceae family. Mangifera contains about 30 species, up to 15 other species produce edible fruit, including the water mango M. laurina, and M. sylvatica, the wild, forest mango from which M. indica is thought to have descended. Mango tree is erect, 30 to 100 ft (roughly 10-30 m) high, with a broad, rounded canopy which may, with age, attain 100 to 125 ft (30-38 m) in width, or a more upright, oval, relatively slender crown. In deep soil, the taproot descends to a depth of 20 ft (6 in), the profuse, wide-spreading, feeder root system also sends down many anchor roots which penetrate for several feet. The tree is long-lived, some specimens being known to be 300 years old and still fruiting.

Vegetative Data

1. **Tree height(m):** the height of the plant measured in meter from ground level to the growth tip of the plant
2. **Canopy spread (m):** distance between the longest opposite two branches round the main stem measured by meter
3. **Number of branches:** total number of branches from the main stem
4. **Height to first branching:** Measure vertical height from ground to first primary branch. Zero = no branching. Ignore side branching. Express in cm. average over three plants.
5. **Girth measurement (cm):** the diameter of the tree measured in caliper at Above union and Below union

Yield Data

6. **Marketable yield:** marketable yield per plant in kg expressed as
    a. Number
    b. Weight (kg)
7. **Un-marketable yield:** unmarketable yield per plant in kg expressed as
    a. Number
    b. Weight (kg)
8. **Total yield:** total yield per plant (the sum of marketable and unmarketable yield) in kg expressed as
    a. Number
    b. Weight (kg)
9. **Fruit size:** fruit length and diameters expressed in cm
    a. Length (cm)
    b. Diameter (cm)
10. **Reason for un-marketability:** any reason for unmarketable (under sized, mechanical damage, diseased or physiological disorder)

Fruit Appearances and Quality Data

11. **Fruit weight per tree:** weight of individual marketable, unmarketable and total in kg per tree
12. **Skin color:** skin color of individual fruit per tree
13. **Firmness:** fruit firmness by pressing fruits between two figures
14. **Marketability:** any fruit free from any disease, mechanical damage, physiological disorder and unrotten.
15. **Disease sign, symptom or lesion (+/-):** recorded any disease or insect pest symptom or sign throughout the growth period of the plant
16. **TSS:** An aliquot of juice will be extracted using a juice extractor (Type 6001x, USA). An Atago N, hand refractometer with a range of 0 to 32°Brix and resolutions of 0.2°Brix will be used to determine TSS by placing 1 to 2 drops of clear juice on the prism. Between samples the prism of the refractor meter will be beheld with distilled water and dried with tissue paper before use. The refractometer will be standardized against distilled water (0 percent TSS).
17. **TTA**
18. **pH:** pH level of fruit juice
19. **Juice (fresh) weight**: fresh weight of juice in gm after removal of seed and peal
20. **Seed weight:** weight of fresh seed just after extract from fruit expressed in gm.

ANANAS DATA COLLECTION PROCEDURES

Background

Pineapple (*Ananas comosus* var. *comosus* (L.) Merril) belongs to the bromeliaceae, monocotiledonae family, originated from warm climates in the Americas, being the main producers: Thailand, Brazil, Philippines, india and China. Brazil is actually the second main pineapple producer, being Thailand the main producer (FA0, 2010). In Brazil, the main producing states are Pará, Paraíba and Minas Gerais (IBGE, 2011). Cultivars most grown in Brazil are 'Pérola' and 'Smooth Cayenne' (CRESTANI, 2010). Between the two cultivars, 'Pérola' is the most planted due to its good acceptance on the domestic market and its pleasant taste, being the ideal cultivar for fresh fruit consumption.

1. **Biotic Stress Susceptibility:** Specify the infestation or infection using 1 - 9 scale. Note: For Additional information as common name(s) of disease(s)/pest(s) and causal rganism(s) may be appended in the biotic notes descriptor. 1 Very low or no visible sign of susceptibility 3 Low 5 Intermediate 7 High 9 Very high
2. **Crown foliage attitude:** 1 Erect 3 Semi-erect 5 Horizontal 7 Drooping
3. **Crown leaf color:** 1 Greenish/green 2 Green with yellow mottling 3 Green with red mottling 4 Reddish orange 5 Red 6 Dark red 7 Purplish/pinkish 8 Dark red-purple/pink 9 Silvery white 99 Others
4. **Crown shape:** To be recorded on ripe fruit 1 Cone 2 Oblong blocky 3 Acron (heart shaped) 4 Long conical 5 Lengthened cylindrical 6 Lengthened cylindrical with bunchy top 99 Others
5. **Date of first flowering (dd/mm/yyyy):** To be recorded when untreated and unforced plant shows first flower open
6. **Distribution of spines:** To be observed on middle leaves 1 Spines behind tip or near base only 2 Spines behind tip and near base 3 Spines along all margins 4 Spines occur irregularly along both margins
7. **Eye depth:** To be recorded on ripe fruit 3 Shallow 5 Medium 7 Deep
8. **Eye pattern (eye profile):** To be recorded on ripe fruit 3 Flat 5 Normal 7 Prominent

9. **Foliage attitude:** 1 Upright 3 Slightly open 5 Open 7 Spreading 9 Drooping
10. **Fruit diameter (cm):** To be recorded as average of same 5 fruits
11. **Fruit firmness:** To be recorded on ripe fruit 3 Soft 5 Intermediate 7 Firm
12. **Fruit length (cm):** To be recorded as average of 5 random mature fruits
13. **Fruit shape:** To be recorded on maturity of fruit. 1 Square like 2 Oval 3 Round 4 Conical 5 Long conical 6 Pyramidal 7 Cylindrical slight taper 8 Cylindrical sharp taper 9 Pyriform 10 Reni form 99 Others
14. **Fruit skin thickness (mm):** To be recorded as average of same 5 fruits
15. **Fruit weight (g):** To be recorded as average of same 5 fruits
16. **Leaf length (cm):** To be recorded as average of 10 random leaves below the fruit
17. **Leaf width (cm):** To be recorded as average of same 10 leaves
18. **Middle leaf color:** To be recorded as upper surface color of the 15th leaf from the top of the plant. 1 Green 2 Green with yellow mottling 3 Green with red mottling 4 Reddish orange 5 Red 6 Dark red 7 Purplish/pink 8 Dark red purple/pink 9 Silvery white 99 Others
19. **Number of aerial suckers:** 0 None 3 Few 5 Medium 7 Abundant
20. **Number of leaves per plant:** To be recorded as average of 10 random plants
21. **Number of peduncle slips:** 0 None 3 Few 5 Medium 7 , Abundant
22. **Number of underground suckers (ratoons):** 0 None 3 Few 5 Medium 7 Abundant
23. Peduncle color: To be recorded at mature fruit stage 1 Green 2 Greenish yellow/red mottling 3 Dark green 4 Red 5 Reddish orange 6 Dark red 7 Dark red purple 8 Purplish pink 9 Silvery white 99 Others
24. **Peduncle length (cm):** To be recorded as average of 10 random peduncles at mature fruit stage
25. **Peduncle width:** To be recorded as average of same 10 peduncles at mature fruit stage
26. **Petal color:** To be recorded during flowering 1 White 2 Yellow 3 Cream 4 White purple 5 Purple 99 Others
27. **Petal fusing:** To be recorded during flowering 3 Free 5 Imbricate 7 Adnate
28. **Petal orientation:** To be recorded during flowering 1 Open 9 Closed
29. **Plant habit (without fruit):** 3 Erect 5 Normal 7 Procumbent
30. **Plant height (cm):** To be recorded from ground level to fruit crown top
31. **Plant spread (cm):** To. be measured as canopy diameter (average of East - West and North – South dimensions)
32. **Presence of seeds:** 0 Absent 1 Present
33. **Presence of spines on crown leaves:** 1 Smooth 2 Spines at tip 3 Spiny serrate 4 Piping
34. **Productivity status:** To be recorded at the time of harvest 3 Low 5 Medium 7 High
35. **Pulp aroma:** To be recorded on ripe fruit 3 Mild 5 Moderate 7 Strong
36. Pulp color: To be recorded on ripe fruit 1 White 2 Light cream 3 Cream 4 Pale yellow 5 Golden yellow 6 light orange 7 Deep orange Pineapple (Ananas comosus (L.) Merrill) 99 Others
37. **Pulp fibrousness:** To be recorded on ripe fruit 0 Absent 3 Low 5 Medium 7 High
38. **Pulp texture:** To be recorded on ripe fruit 3 Smooth 5 Medium 7 Rough
39. **Ripe fruit color homogeneity:** 3 Poor 5 Medium 7 Good
40. **Ripe fruit color:** 1 Green 2 Silvery green 3 Yellow with green mottling 4 Dull yellow 5 Bright yellow 6 Golden yellow 8 Reddish orange 9 Brownish 99 Others
41. **Seed color:** 1 Grey 2 Brown 99 Others
42. **Seediness (seed crowdness):** To be recorded on ripe fruit 3 Few 5 Medium 9 Very seedy
43. **Stem girth (mm):** To. be measured at the base of plant
44. **Total soluble solids (%):** To be measured with refractometer

BANANA DATA COLLECTION PROCEDURES

Background

Banana (Musa acuminata cv.) is a commercially significant tropical fruit with innumerable varieties (Prabha and Bhagyalakshmi, 1998). Ten of the major bananas producing countries accounted for about 75% of world production in 2003, whereas India, Ecuador, Brazil and China provided almost 50% of the total production in that year (Zhang et al., 2005).

Data from mother plants (first plant), daughter plants (second plant) and granddaughter plants (third plant) depending on your study

1. **Biotic Stress Susceptibility:** Specify the infestation or infection using 1-9 scale. Banana (Musa paradisiaca L.) Note: For Additional information as common name(s) of disease(s)/pest(s) and causal organism(s) may be appended in the biotic notes descriptor. 1 Very low or no visible sign of susceptibility 3 Low 5 Intermediate 7 High 9 Very high
2. **Bract apex shape:** To be recorded during flowering 1 Pointed 2 Slightly pointed 3 Intermediate 4 Obtuse 5 Obtuse and split
3. **Bract behavior:** To be recorded at just before bract falling 1 Revolute (rolling) 2 Not revolute (not rolling)
4. **Bunch weight per plant:** Before harvest, take a photo of the mature bunch. Harvest the mature bunch by cutting the peduncle above the proximal hand and weigh the bunch, including the rachis, using scales (kg). To be recorded as average of 3 random plants
5. **Date of First Fruiting:** the number of days in which the fruit emerge from Peduncle.
6. **Date of Harvesting:** Number of days from planting to last date of fruit harvest
7. **Date of Inflorescence/ Date of shooting:** At shooting, record the approximate date that the inflorescence emerges from the pseudo stem and is still in an erect position.
8. **Date of Last Fruiting:** the number of days in which the last fruit formed on Peduncle.
9. **Date of Sucker emergency:** Number of days from planting to the date of sucker formation
10. **External bract color:** To be recorded on the dorsal side during flowering stage 1 Yellow 2 Green 3 Orange red 4 Red 5 Red purple 6 Purple 7 Purple brown 8 Blue
11. **Finger circumference (mm):** Measure the circumference of the finger at its widest point, using a tape measure (mm).
12. **Finger diameter (mm):** Measure the lateral diameter of the finger, from the left to the right side (not from the ventral to the dorsal side), at the widest point, using calipers (mm).
13. **Fruit apex:** To be recorded on ripe fruit Pointed 2 Prominently pointed 3 Blunt tipped 4 Bottle-necked 5 Rounded
14. **Fruit length:** the height of the fruit measured in cm averaged over each bunch. To be recorded as average of 10 random middle fingers. Measure the length of the finger, along the external (dorsal) arc, excluding the pedicel and the fruit tip, using a tape measure (mm).
15. **Fruit shape:** To be recorded on ripe fruit Straight, straight at the distal part, Curved, Curved in "S" shape
16. **Fruit skin color:** To be recorded on ripe fruit 1 Yellow 2 Bright yellow 3 Orange 4 Grey spots 5 Orange red, red or pink / pink purple 6 Red purple 7 Br6wnfrusty browr:l. 8 Black 99 Others (Specify in the 'Remarks' descriptor)
17. **Fruit weight:** the weight of the fruit measured in gm averaged over each bunch. To be recorded as average of same 10 fingers
18. **Hand weight per bunch:** total weight of hands per each bunch. Average over five hands
19. **Internal bract color:** To be recorded on the ventral side during flowering 1 Whitish 2 Yellow 3 Orange red 4 Red 5 Purple, 6 Purple brown 7 Pi'1k purple

20. **Leaf blade base shape:** To be recorded on mature leaf 1 Both sides rounded 2 One side rounded, one side pointed 3 Both sides pointed
21. **Leaf habit:** To be recorded on mature leaf: 1 Erect 2 Intermediate 3 Drooping
22. **Leaf length:** the height of the middle leaves averaged over all leaves from leaf seize to the tip of leafs
23. **Leaf width:** the maximum width of leaf measured by cm
24. **Male bud shape:** To be recorded as the shape of the male bud t -r·' \. 1 2 3 4 5 2 Like a top Lanceolate Intermediate Ovoid Rounded
25. **Male bud:** The male bud contains the male flowers enclosed in their bracts. It is sometimes called the bell. As the fruits mature, the rachis and male bud continue to grow. In some cultivars, the male bud ceases to grow after the fruits have set and can be more or less exhausted by the time the bunch reaches maturity. The presence or absence of the male bud is one of the traits used to distinguish cultivars.
26. **Midrib dorsal surface color:** To be recorded on mature leaf 1 Yellow 2 Light green 3 Green 4 Pink purple 5 Red purple 6 Purple to blue 99 Others (Specify in the 'Remarks' descriptor)
27. **Number of fingers per hand:** Count how many fingers are in the hand. Collect the data from three fingers in the middle section of the outer whorl of the hand.
28. **Number of functional leaves per plant:** On a monthly basis, at shooting and at harvest, count the number of functional leaves. A functional leaf has 50% or more of the leaf surface area as green, healthy, photosynthetic tissue. Consider all leaves between, and inclusive of, the newest leaf and the oldest standing leaf.
29. **Number of hands per bunch:** Count total number of hands produced per bunch. To be recorded as average of 3 random bunches
30. **Number of suckers per plant:** To be recorded as average of 5 random plants at flowering stage
31. **Peduncle hairiness:** To be recorded at the time of harvest 0 Smooth/glabrous 1 Pubescent
32. **Peduncle length (cm):** To be recorded on ripe fruit 3 Short « 30) 5 Medium (30 - 60) 7 Long (> 60)
33. **Peel thickness (mm):** Remove the peel of the finger and measure the thickness of the peel, using calipers (mm).
34. **Petiole base blotches:** To be recorded on mature leaf 1 Sparse blotching 2 Small blotches 3 Large blotches 4 Extensive pigmentation 5 Without pigmentation
35. **Petiole canal shape:** To be recorded on mature leaf 1 Open 2 Partially closed 3 Closed
36. **Petiole length (cm):** To be recorded on mature leaf 3 Short < 40) 5 Medium (40 - 60) 7 Long (> 60)
37. **Pigmentation of the underlying pseudo stem:** To be recorded after removing the outermost sheath from the pseudo stem
38. **Plant height at harvest:** To be recorded from the base of pseudo stem to the emerging point of the peduncle in meter. Peduncle is the peduncle is the stalk that supports the inflorescence and attaches it to the rhizome.
39. **Position of fruits on the crown (fruit series):** 1 Uniseriate 2 Biseriate
40. **Presence of male axis (rachis):** 0 Absent 1 Present
41. **Pseudo stem color:** To be recorded without removing the external sheaths. The color of oldest dry sheaths should not be considered eg. Green yellow, Medium green, Green, Dark green, Green red and Red
42. **Pulp color:** To be recorded on ripe fruit 1 White 2 Cream 3 Ivory 4 Yellow 5 Orange 6 Pinkish 99 Others (Specify in the 'Remarks' descriptor)

43. **Pulp diameter (mm):** Remove the peel of the finger and measure the lateral diameter of the fruit pulp, from the left to the right side (not from the ventral to the dorsal side), at the widest point, using calipers (mm).
44. **Pulp taste:** To be recorded on ripe fruit 1 Astringent 2 Mild 3 Sweet 4 Highly sweet 5 Sweet and acidic 99 Others (Specify in the 'Remarks' descriptor)
45. **Pulp texture:** To be recorded on ripe fruit 3 Firm 5 Intermediate 7 Soft
46. **Rachis appearance:** To be recorded at the end of flowering 1 Barren 2 With persistent flowers 3 With persistent bracts Banana (Musa paradisiaca L.) 4 With both persistent flowers and bracts
47. **Rachis hand:** To be recorded at the end of flowering 1 Falling vertically (Pendulous) 2 At an angle (Oblique) 3 With a curve 4 Horizontal 5 Erect
48. **Rachis length (cm):** The rachis is the stalk of the inflorescence from the first fruit to the male bud. It can be bare or covered with persistent bracts. The scars on the rachis indicate where the bracts were attached. They are called nodes.
49. **Steam girth:** At shooting, measure the circumference of the pseudo stem of the plant at 1 m from the ground and at 20 cm from the ground, using a tape measure (cm).
50. **Tallest sucker height:** At shooting and at harvest, on the tallest sucker, measure the distance from the pseudo stem base at the ground to the intersection of the petioles of the two youngest leaves (leaf ranks "1" and "2"), using a measuring pole or sliding ruler (cm).
51. **Tallest sucker number of functional leaves:** At shooting and at harvest, count the number of functional leaves of the tallest sucker. A functional leaf has 50% or more of the leaf surface area as green, healthy, photosynthetic tissue. Consider all leaves between, and inclusive of, the newest leaf and the oldest standing leaf.
52. **Tip of male bud:** To be recorded during flowering 1 Imbricate 2 Non-imbricate
53. **Total soluble solids (%):** To be measured with refractometer

CITRUS DATA COLLECTION PROCEDURES

Background

The leading acid citrus fruit, because of its very appealing color, odor and flavor, the lemon, *Citrus limon* Burm. f. (syns. *C. limonium* Risso, *C. limonia* Osbeck, *C. medica* var. *limonium* Brandis), is known in Italy as*limone;* in most Spanish-speaking areas as *limón, limón agria, limón real,* or *limón francés;* in German as *limonen;* in French as *citrónnier;* in Dutch as *citroen.* In Haiti, it is *limon France;* in Puerto Rico, *limon amarillo.* In the Netherlands Antilles, *lamoentsji,* or *lamunchi,* are locally applied to the lime, not to the lemon as strangers suppose.

1. **Adherence of epicarp to mesocarp:** To be recorded on mature fruit 3 Slight 5 Moderate 1 Strong
2. **Adherence of segments to each other:** To be recorded on mature fruit 3 Slight 5 Moderate 7 Strong
3. **Arrangement of flowers:** To be recorded during flowering 1 Solitary 2 In an inflorescence 3 Both
4. **Attachment of fruit to tree:** To be recorded on mature fruit 3 Weak 5 Medium 7 Strong
5. **Biotic Stress Susceptibility:** Specify the infestation or infection using 1-9 scale. Note: For Additional information as common name(s) of disease(s)/pest(s) and causal organism(s) may be appended in the biotic notes descriptor. 1 Very low or no visible sign of susceptibility 3 Low 5 Intermediate 7 High 9 Very high
6. **Branch density**: sparse, Medium, Dense

7. **Bud color:** To be recorded just before flowering 1 White 2 Yellow 3 Green 4 Pink 99 Others (Specify in the 'Remarks' descriptor)
8. **Date of end of flowering (dd/mmlyyyy):** To be recorded when 85-90% flower buds have opened
9. **Date of fruit maturity (dd/mmlyyyy):** To be recorded when 50% fruits attain maturity
10. **Date of start of flowering (dd/mm/yyyy):** To be recorded when 5% flower buds have opened
11. **Flower type:** To be recorded at flowering stage 1 Hermaphrodite 2 Male 3 Female 99 Others (Specify in the 'Remarks' descriptor)
12. **Fruit acidity (%):** To be recorded on mature fruit
13. **Fruit apex shape:** To be recorded on mature fruit 1 Mammiform 2 Angular 3 Convex 4 Truncate 5 Depressed 3 Truncate 6 Collared with neck 99 Others (Specify in the 'Remarks' descriptor)
14. **Fruit base shape**: To be recorded on mature fruit 1 Necked 2 Convex 3 Truncate 4 Concave 5 Concave collared 6 Collared **with** neck **99** Others (Specify in **the** 'Remarks' descriptor)
15. **Fruit length (cm):** To be recorded as average of same 5 fruits
16. **Fruit shape**: To be recorded on mature fruit 1 Spheroid 2 Ellipsoid 3 Pyriform 4 Oblique 5 Oblate 6 Ovoid-oblique 7 Ovoid **99** Others (Specify in the 'Remarks' descriptor)
17. **Fruit skin color:** To be recorded on mature fruit 1 Yellow 2 Green 3 Orange 99 Others (Specify in the 'Remarks' descriptor)
18. **Fruit skin surface:** To be recorded on mature fruit 1 Smooth 2 Rugose 3 Papillate 4 Pitted 5 Bumpy 6 Longitudinal grooved and ridges 7 Hairy
19. **Fruit weight (g):** To be recorded as average of same 5 fruits
20. **Fruit width (cm):** To be recorded as average of same 5 fruits
21. **Inflorescence position:** To be recorded during flowering 1 Axillary 2 Terminal 3 Both
22. **Juice aroma:** To be recorded on mature fruit 3 Mild 5 Moderate 7 Strong
23. **Juice color:** To be recorded on mature fruit 1 White 2 Pale yellow 3 Yellow 4 Greenish 5 Orange 6 Reddish 99 Others (Specify in the 'Remarks' descriptor)
24. **Juice content**: To be measured as volume (ml) per weight (g) basis
25. **Juice taste:** To be recorded on mature fruit 1 Very poor 3 Poor 5 Fair 7 Good 9 Excellent
26. **Leaf length (cm):** To be recorded as average of 10 random mature leaves (including petiole)
27. **Leaf margin:** To be recorded on mature leaf 1 Crenate 2 Dentate 3 Entire 4 Wavy 99 Others (Specify in the 'Remarks' descriptor)
28. **Leaf or leaflet shape:** To be recorded on mature leaf 1 Elliptic ~ Ovate 3 Obovate 4 Lanceolate 5 Orbicular 99 Others (Specify in the 'Remarks' descriptor)
29. **Leaf persistency:** 1 Evergreen 2 Deciduous 3 Semi persistent
30. **Leaf type:** To be recorded on mature leaf 1 Trifoliate 2 Simple
31. **Leaf width (cm):** To be recorded as average of same 10 leaves from the wider part
32. **Mesocarp color:** To be recorded on mature fruits 1 White 2 Yellow 99 Others (Specify in the 'Remarks' descriptor)
33. **Nature of oil glands:** To be recorded on mature fruit 1 Inconspicuous 2 Conspicuous 3 Very conspicuous
34. **Number of flower buds per inflorescence:** To be recorded as average of 10 random inflorescences
35. **Number of fruit segments:** To be recorded as average of 5 random fruits
36. **Number of fruits per cluster:** To be recorded as average of 5 random clusters
37. **Number of fruits per tree:** To be recorded as average of 3 random trees

38. **Number of oil glands Citrus *(Citrus* species)**: To be recorded as number of glands per square centimeter on fruit surface
39. **Number of petals per flower:** To be recorded as average of 10 random flowers
40. **Number of seeds per fruit:** To be recorded as average of same 5 fruits
41. **Petal color:** To be recorded just after flowering 1 White 2 Yellow 3 Purple 99 Others (Specify in the 'Remarks' descriptor)
42. **Petiole wing shape:** To be recorded on mature leaf 1 Cordiform 2 Deltoid 3 Obovate 99 Others (Specify in the 'Remarks' descriptor)
43. **Productivity status:** To be recorded at the time of *harvest* 3 Low 5 Medium 7 High
44. **Pulp color:** To be recorded on mature fruit 1 Yellow 2 Green 3 Orange 4 Pink 5 Red 99 Others (Specify in the 'Remarks' descriptor)
45. **Pulp texture:** To be recorded on mature fruit 3 Tender 5 Firm 7 Tough
46. **Seed color:** To be recorded on mature fruit 1 Cream 2 Yellow 3 Green 5 Brown **99** Others (Specify in the 'Remarks' descriptor)
47. **Seed length (mm):** To be recorded as average of 20 random seeds
48. **Seed shape:** To be recorded on mature fruit 1 Fusiform 2 Clavate 3 Cuneiform 4 Ovoid 5 Deltoid 6 Globose 7 Semi – spheroid 99 Others (Specify in the 'Remarks' descriptor)
49. **Seed weight (g):** To be recorded as average of same 20 seeds
50. **Seed width (mm):** To be recorded as average of same 20 seeds
51. **Total soluble solids (%):** To be measured with refractometer
52. **Tree habit:** Upright, Spreading, Compact, Drooping
53. **Tree height (m) :** to be measured from ground level to the tip of the highest shoot
54. **Tree shape:** Ellipsoid, Spheroid, Ellipsoid – oblate, Citrus (Citrus species), Others (Specify in the 'Remarks' descriptor)
55. **Tree spread (m):** To be measured as canopy diameter (average of East - West and North· South dimensions)
56. **Trunk - rootstock diameter ratio:** 1 Smaller «1.0), 2 Same (1.0), 3 Larger (>1.0)
57. **Trunk girth (cm) :** to be measured at 20 cm above the ground level in case of trees raised from seed! Layering/cutting and at 15 cm above the graft union in grafted/budded ones

PAPAYA DATA COLLECTION PROCEDURES

Background

Cultivation of fruits played a pivotal role in diversification of agriculture along with food and nutritional security of ever-growing population. Papaya (Carica papaya) is a tropical fruit having commercial importance because of its high nutritive and medicinal value. India leads the world in papaya production with an annual output of about 3.6 million tonnes (Anonymous, 2009). It is used as ripened fruit and vegetable and easy to digest. Papaya in prepared from dried latex of its raw fruits is used in meat tendering, manufacturing chewing gum, cosmetics, for degumming silk and to give shrink resistance to wool. In addition, it is also used in pharmaceutical, textile and garment industries, cleaning paper and adhesive manufacturing, sewage disposal and so on (Anonymous, 2002).

1. **Plant height (cm):** To be recorded from ground level to apical meristem just before first fruit harvest
2. **Trunk girth (cm):** To be measured as canopy diameter (average of East - West and North· South dimensions) during active growth period
3. **Stem pigmentation:** To be recorded just before first fruit harvest 1 Only or mostly basal 2 Only or mostly lower 3 Only or mostly central 4 Only or mostly upper 5 Indiscriminate

4. **Leaf teeth shape:** To be recorded on mature leaf. 1 Straight 2 Convex 3 Concave 99 Others (Specify in the 'Remarks' descriptor)
5. **Leaf petiole color:** To be recorded on mature leaf. 1 Pale green 2 Normal green 3 Dark green 4 Green and shades of red purple 5 Red purple 99 Others (Specify in the 'Remarks' descriptor)
6. **Leaf petiole length (cm):** To be recorded as average of 5 random mature middle leaves
7. **Leaf length (cm):** To be recorded as average from base of middle leaflet of same 5 leaves
8. **Leaf width (cm):** To be recorded as average from base of middle leaflet of same 5 leaves
9. **Flower type:** To be recorded during flowering. 1 Solitary 2 Inflorescence 3 Both
10. **Inflorescence density on trunk:** To be recorded during flowering 3 Sparse 5 intermediate 7 Dense
11. **Inflorescence stalk colour:** To be recorded during flowering. 1 Greenish 2 Purplish/ pinkish 3 Dark red purple/pink 99 Others (Specify in the Hemarks' descriptor)
12. **Inflorescence main axis length (cm):** To be recorded as average of 5 basal inflorescences
13. **Date of first female flowering (ddlmm/yyyy):** To be recorded as date when first female flower appears
14. **Sex form:** 1 Staminate flower and few hermaphrodite flowers 2 A few staminate flowers and many hermaphrodite flowers 3 A few staminate, many hermaphrodites and few pistillate flowers 4 Hermaphrodite flowers only 5 Mostly hermaphrodite and few pistillate flowers 6 Few hermaphrodites and many pistillate flowers 7 Only pistillate flowers 8 Only staminate flowers
15. **Female flower color:** To be recorded on completely developed and open flower 1 White 2 Cream 3 Yellow 4 Deep yellow to orange 5 Greenish 6 Dark green 7 Yellow/green and red purple shades 8 Red purplish (pinkish) 9 Dark red purple (pink) 99 Others
16. **Hermaphrodite flower color:** To be recorded on completely developed and open flower 1 White 2 Cream 3 Yellow 4 Deep yellow to orange 5 Greenish 6 Dark green 7 Yellow/green and red purple shades 8 Red purplish (pinkish) 9 Dark red purple (pink) 99 Others
17. **Male flower corolla tube color:** To be recorded on completely developed and open flower 1 White 2 Cream 3 Yellow 4 Deep yellow to orange 5 Greenish 6 Dark green 7 Yellow/green and red-purple shades 8 Red purplish (pinkish) 9 Dark red purple (pink) 99 Others
18. **Days to first fruit set:** To be recorded as number of days from planting to first fruit set
19. **Number of fruits per plant:** To be recorded as average of 5 random plants
20. **Height to first fruit (cm):** To be recorded as average of same 5 plants
21. **Fruit shape:** To be recorded on fully developed fruit 1 Globular 2 Round 3 High round 4 Elliptic 5 Oval 6 Oblong 7 Oblong – ellipsoid 8 Oblong blocky 9 Elongate10 Lengthened cylindrical 11 Pear shaped (pyriform) 12 Club 13 Blossom end tapered 14 Acron (heart shaped) 15 Reni form 16 Turbinate inferior 17 Plum shaped 99 Others
22. **Fruit skin color:** To be recorded as overall colour of the skin of ripe fruit 1 Yellow 2 Deep yellow to orange 3 Yellowish green 4 Green 5 Red purple 99 Others
23. **Fruit skin thickness:** To be recorded on ripe fruit 3 Thin 5 Medium thick 7 Thick
24. **Fruit length (cm):** To be recorded as average of 5 random fruits
25. **Fruit width (cm):** To be recorded as average of same 5 fruits
26. **Fruit weight (g):** To be recorded as average of same 5 fruits
27. **Stalk end fruit shape:** 1 Depressed 2 Flattened 3 Inflated 4 Pointed
28. **Pulp color:** To be recorded on ripe fruit. 1 Light yellow 2 Bright yellow 3 Deep yellow to orange 4 Red 5 Reddish orange 6 Scarlet 99 Others
29. **Pulp thickness (mm):** To be recorded as average of same 5 fruits

30. **Central cavity shape:** To be recorded on fruit transverse section at maximum diameter. 1 Irregular 2 Round 3 Angular 4 Slightly star shaped 5 Star shaped 99 Others
31. **Pulp aroma:** To be recorded on ripe fruit 3 Mild 5 Moderate 7 Strong
32. **Total soluble solids (%):** To be measured with refractometer
33. **Organoleptic test:** To be recorded as a combined assessment of flavour, sweetness and aroma of ripe fruit 3 Poor 5 Intermediate 7 Good 9 Excellent
34. **Number of seeds per fruit:** To be recorded as average of same 5 fruits
35. **Seed color:** To be recorded on ripe fruit 1 Tan 2 Greyish yellow 3 Grey 4 Brown black 5 Black 6 Variable 99 Others
36. **Productivity status:** To be recorded at the time of harvest 3 Low 5 Medium 7 High
37. **Biotic Stress:** Susceptibility Specify the infestation or infection using 1 - 9 scale. Note: For Additional information as common name(s) of disease(s)/pest(s) and causal organism(s) may be appended in the Biotic notes descriptor 1 Very low or no visible sign of susceptibility 3 Low 5 Intermediate 7 High 9 Very high