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Global strategy for agriculture and rural statistics

REGIONAL TRAINING COURSE ON SAMPLING METHODS FOR PRODUCING CORE DATA ITEMS FOR AGRICULTURAL AND RURAL STATISTICS

JAKARTA, INDONESIA ,29SEP-10 OCTOBER 2014.

Module 3: Sampling Methods for Horticultural Surveys

BASIC CONCEPTS, OBJECTIVES, UNITS OF MEASUREMENTS

Introduction

•Agriculture plays a vital role in the Indian economy. Over 70 percent of the rural households depend on agriculture as their principal means of livelihood.
• Agriculture along-with fisheries and forestry accounts for one-third of the nation’s Gross Domestic Product (GDP) and is its single largest contributor.
•Agricultural exports constitute one fifth of the total exports of the country.
• India is endowed with diverse agro-climatic conditions, rich soils and plentiful water, making it suitable for growing almost all type of temperate,
•sub-tropical and tropical fruits, vegetables and flowers.

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Horticulture sector is an important sub-sector of the Agriculture with its contribution of about 20% in the economy of Agriculture and Allied sectors.

It is the fastest growing sector within agriculture thanks to the economic prosperity that has provoked marked changes in the life styles and the consumption habits.

There has been a perceptible change in the consumption pattern characterized by declining share of food grains and the increasing share of non-food grain items in the consumption baskets particularly fruits and vegetables.

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Rapidly growing demand for horticulture commodities and products especially burgeoning market for processed fruits and vegetables as well as booming floriculture market is an evidence of the phenomenon that is expected to accelerate horticulture growth in the country.

Consequently, horticulture is set to assume a greater role and importance within the agriculture sector and eventually in the national economy.

In addition, there are tremendous opportunities to augment exports of horticulture commodities and products especially fruits and vegetables-both raw and processed- by way of strengthening existing markets as well as exploring fresh markets.

Due to enormous potential of horticulture-both on domestic as well as international front - as evident from burgeoning demand of horticulture commodities and products, it could become a key driver in stimulating agricultural growth that has been rather sluggish in the recent past.

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Potential advantages of horticultural farming in terms of yielding higher farm output and remunerative returns, is likely to encourage horticulture farming on a larger scale.

Numerous policy and development initiatives including massive financial and technical support available in the horticulture sector is likely to provide a greater impetus to the process of horticultural development in the country.

Higher horticulture growth within the crop husbandry is not only expected to push agricultural growth further but it is also expected to make substantial contribution in the national economy by unleashing substantial value addition through storage, processing, transportation and marketing of horticulture commodities and products.

Horticulture sector commands a large employment potential by way of supporting a series of direct and indirect activities related to area development, nurseries, cultivation and farming, crop maintenance, production, post-harvest management, trading, storage, processing, transportation, marketing and distribution of horticulture commodities and products.

Growth in horticulture sector is expected to provide fillip to employment.

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Besides, it is also a major driver of overall agricultural growth and development, holding the key potential in the11th Five Year Plan endeavour of broad-based and inclusive growth.

The 11th Plan Working Group on Crop Husbandry, Agricultural Inputs, Demand Supply Projections and Agriculture Statistics simulated the targeted 4% growth of agriculture sector during the 11th Plan, taking in to consideration 6% growth of horticulture sub sector.

Various development policies and programmes such as National Horticulture Mission (NHM) and the Technology Mission for the Development of Horticulture in North East and Hill Regions are the flag ship initiatives of the Government being implemented for the promotion and holistic development of horticulture sector.

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Fruits and vegetables account for nearly 90% of total horticulture production in the country.

The leading fruit producing States are Maharashtra, Andhra Pradesh, Tamil Nadu, Karnataka and Gujarat contributing nearly 60% of the production in the country.

Similarly, West Bengal, Uttar Pradesh, Bihar, Orissa, Tamil Nadu and Gujarat are the leading vegetable producing States accounting for nearly 2/3rd of the total vegetable production of the country.

India is now the second largest producer of fruits and vegetables in the world and is the leader in several horticultural crops, namely mango, banana, papaya, cashew nut, areca nut, potato and okra.

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In view of the commercial importance, it has become imperative to have proper planning for enhancing the productivity of horticultural crops.

One of the basic requirements for proper planning for increasing the production of these crops in the country is the availability of reliable statistics about their area and production at various levels (Tehsil, District, State).

No realistic targets for production of these crops can be fixed in the absence of reliable statistics about the area and yield rates.

Even a proper evaluation of the various developmental programmes taken in this direction is not possible in the absence of reliable statistics.

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Though India has emerged as a major producer of horticultural crops and the share of horticulture in Gross Domestic Product (GDP) of Agriculture Sector has increased, the database in this regard is weak, lacks authentic information and, therefore, does not provide suitable support for strategies for development.

One of the biggest constraints for prospective planning in the field of horticulture is the scarcity of reliable data, particularly relating to areas under cultivation, including the productivity and marketing of produce.

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The production of fruits and vegetables has attained significant importance in the recent past.

Although, India has emerged as a leading producer of these crops in the world, we do not have official estimates on large number of fruits and vegetables.

This is one of the major data gaps in the Agricultural Statistical System in India.

For preparation of various developmental programmes and for policy formulations etc., the availability of adequate, reliable and timely statistics on area, yield and production estimates of these crops is essential.

Concepts and definitions

Agricultural year: Agricultural year is defined as the period of 12 months from 1st July to 30th June.

Season: Agricultural year is divided into three non-overlapping seasons of four months duration each.

These are:- a) Autumn – July to October

b) Winter - November to February

c) Summer – March to June

Seasonal crops: Crops which are harvested during the period of four months in the season are defined as the seasonal crops of the respective season. Thus, paddy, pulses tapioca, etc. which are harvested during different periods of the year will be classified as Autumn paddy, autumn pulses, etc. according to the period of harvest. The seasonal crops for which the major period of harvest in that village falls within July to October will be autumn crops, November to February winter crops and March to June summer crops.

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Annual crops: Banana, sugarcane, plantain, pineapple and betel leaves are to be considered as annual crops for the purpose of the survey.

Perennial crops: Crops, which are standing for more than one year, are treated as perennial crops. Most of the perennial crops are tree crops.

Plot: A plot is defined as a patch or piece of land, which has separate survey sub-division number in the basic tax register.

Unit of observation: A unit of observation is defined as the area identified separately for area enumeration. It can be a plot or a group of plots (in the case of a survey sub-division number as in Litho map) or the land in possession of one cultivator.

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Tree of bearing age: A tree of bearing age may be regarded as a tree which has attained the age at which 95 percent of the trees are normally expected to bear fruits, irrespective of the fact whether or not the tree bears fruit during the particular year /season.

Bearing tree: A bearing tree(BT) is regarded as the one which has attained the bearing age and has also borne fruits during the season/year under survey.

Non-bearing tree: A tree of bearing age which fails to bear fruits during the season/year under survey due to any reasons such as disease, old age, withering of flowers etc. is regarded as non-bearing tree(NBT).

Young tree: A young tree (YT) is defined as a tree which has not attained the specified bearing age of the fruit.

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Orchard: A compact piece of land which is at least 1/10th of an hectare area in size or is having at least 12 trees planted on it, may be regarded as an orchard.

It may be clarified that in case of such fruit trees where distance between the trees is quite large say more than six meters as in the case of mangoes, the orchard will be defined according to the minimum number of 12 trees planted in it while, in such cases where the distance is less than six meters as in the case of bananas, papayas, grape vines etc., the orchard will be defined on the basis of the minimum area of 1/10th of an hectare.

Stray or scattered trees: Trees not planted in orchards, those planted in clusters of less than 12 trees or those in a piece of land less than 1/10th of an hectare as well as those planted in back-yard of houses, along the roads, river banks etc. are defined as stray or scattered trees.

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Young and bearing orchard: A young orchard is defined as the one in which at least 90% of the trees planted have not attained the bearing age during the year under survey, otherwise it will be regarded as a bearing orchard.

Average yield per bearing tree: The average yield per bearing tree is the average yield obtained from trees of bearing age which have borne fruit during the season/year under survey in terms of weight as well as count of fruits.

Extent of cultivation of fruits: Extent of cultivation of fruits includes:

total number of fruit trees categorized as bearing, non-bearing and young.

number of orchards categorized as bearing and young and

area under orchards.

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Vegetable field: A vegetable field is a compact piece of land in which vegetables are grown either as pure or in mixed form or as intercrops. For the purpose of survey the minimum size of such field in plains should be 0.05 hectare and in hilly areas it should be 0.02 hectare.

Pure vegetable field: A pure vegetable field is the one in which either a single vegetable crop is sown at a time or the number of plants of the main vegetable crop is more than 90 percent.

Mixed vegetable field: When two or more vegetable crops are sown in a field in such way that it is difficult to apportion the area under each crop and also, when percentage of any single crop does not exceed 90% of the total number of plants in the field then, such field will be regarded as mixed vegetable field. Vegetables sown in mixed form are harvested more or less during the same period.

Crop-cutting plot: For the purpose of estimating the production of vegetables, the random plot having a size of 5×5 sq. metres will be regarded as a crop-cutting plot. However, for conducting surveys in hill areas where cultivation of vegetables is done on terraces, the size of such plot may be smaller suiting the condition of the crop.

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Sowing date: Sowing date of any vegetable crop will be week and month during which the vegetable seeds are sown in the field or transplantation of seedlings takes place.

Period of harvesting: Period of harvesting of any vegetable crop will be regarded as total period between the first picking and the last picking when, either the crop is completely harvested or the vegetable field is ploughed for sowing the next crop.

Vegetable season: **Different vegetables are sown during different periods. In fact, for some of the vegetables, the total sowing and harvesting period may be less than 80 days. It is rather difficult to define the season for each and every vegetable. Sometime, the harvesting and sowing of vegetables in different fields goes on simultaneously. We may broadly divide the year into three seasons viz. winter season starting from October to February, summer from March to June and rainy from July to October.** In order to collect reliable data on the extent of cultivation of vegetables it is necessary to completely survey the selected villages during each of the three seasons. For a given vegetable, its season will be the one in which majority of the crop is harvested.

Methodology

A study was conducted in two States namely, Maharastra and Himachal Pradesh (H.P.) covering important fruits and vegetables. The area and production of fruits and vegetables for last four consecutive years in these two States under study can be seen in Table 3.1.

Table Area and production of fruits & Vegetables

State	Area (000' ha)				Production (000' MT)			
	2002-03	2003-04	2004-05	2005-06	2002-03	2003-04	2004-05	2005-06
Fruits								
Maharashtra	586.4	1265.0	1346.5	1618.7	8400.8	9769.7	10586.3	**11721.3**
Himachal Pradesh	165.1	201.8	207.3	182.7	480.4	588.2	720.6	**692.4**
Total (All India)	3787.9	4675.4	4963.8	5509.6	45203.1	45644.6	49294.8	**58740.3**
Vegetables								
Maharashtra	405.0	370.0	372.2	403.5	4768.9	4132.1	4044.4	**4809.7**
Himachal Pradesh	44.3	59.3	59.1	47.6	775.7	877.2	1013.5	**902.2**
Total (All India)	**6091.8**	**6308.9**	**6755.6**	**7164.0**	**84815.4**	**93165.0**	**101433.5**	**109049.6**

Importance of horticulture in Maharashtra

Maharashtra is one of the prominent horticulture producing states in the country, and large producer of fruits.
The horticulture sector itself has a significant share in the agrarian economy of the State with the contribution of about 26% in the State GDP for agriculture and allied sector.
During 2005-06, Maharashtra produced 10.6 million tonnes of fruits from 1.6 million ha. area (source: Indian Horticulture Data Base 2006-NHB).
State had 29.4% and 18% share in fruit area and production respectively in the country.
The area under vegetables during 2005-06 was 0.4 million ha. (5.6%) with 4.8 million tonnes (4.4%) production.
Maharashtra is amongst the leading producers of banana, citrus, grapes, guava, pomegranate, sapota, onion and tomato in the country.

Horticulture statistics system in Himachal Pradesh

Himachal Pradesh consists of 12 districts, has an area of 55,673 sq. kms. It's capital is Shimla.

The languages spoken in the State are Hindi & Pahari.

Himachal Pradesh is situated in the north-west corner of India and is surrounded by Jammu & Kashmir in the north, Uttar Pradesh in the south east, Haryana in the south and Punjab in the west.

In the east, it forms India's boundary with Tibet. The State is almost entirely mountainous with attitudes ranging from 460 to 6600 meters above sea level.

The most important rivers are Chenab, Ravi bias, Satluj and Yamuna.

Agriculture and horticulture are the mainstay of Himachal's economy as 71 percent of people are engaged in these persuits.

Irrigated area forms 26 percent of net area sown. A wide variety of fruits and cash crops like potato, ginger, vegetable seeds, apple and stone fruits are grown. Wheat, maize and paddy are the major cereal crops.

Coverage of the survey

A total of 10 districts out of a total number of 34 districts from Maharashtra and 4 districts out of a total number of 12 districts from Himachal Pradesh were selected for carrying out field survey on the basis of previous year's area figures under fruits and vegetables.
The important districts are those which taken together cover 70-80% of the total area under fruits and vegetables in the entire State.
The names of the selected districts from the two States are given below:
Maharashtra:
Ahmednagar, Amravati, Jalgaon, Nagpur, Nasik, Pune, Ratnagiri, Satara, Sindhudurg and Solapur
These 10 districts account for 63.52% of area under fruits and vegetables in the State.

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H.P.:
Kangra, Kullu, Mandi and Shimla
These 4 districts account for 72.29% of the total area under fruits and vegetables of the State.
Eight fruits and seven vegetables were covered in Maharashtra while three fruits and five vegetables were covered in H.P.
The fruits and vegetables covered under the study in both the states are as under:

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Fruits:
Maharashtra: Mango, Guava, Grape, Banana, Pomegranate, Sapota (Chikku), Citrus and Papaya
H.P.: Apple, Mango and Citrus
Vegetables:
Maharashtra: Onion, Tomato, Cauliflower, Cabbage, Okra, Brinjal and Peas
H.P.: Potato, Tomato, Cauliflower, Cabbage and Peas
Table 3.2 and Table 3.2(a) give district-wise number of taluks/tehsils, villages and area under fruits, vegetables and total area under fruits and vegetables in 2001-02
for Maharashtra and H.P. respectively which was utilized for planning the survey.

Table: District-wise distribution of area under fruits and vegetables (00’ha) in Maharashtra for the year 2001-02

District	Total no. of taluks	No. of villages	Area under		Total area under fruits & vegetables
			Fruits	Vegetables	
Satara	11	1705	82	2440	2522
Pune	14	1842	156	955	1111
Gondia	8	784	844	0	844
Thane	15	1714	236	524	760
Nasik	15	1908	329	418	747
Amravati	14	1665	557	68	625
Sindhudrg	8	735	580	0	580
Ratnagiri	9	1508	567	3	570
Bhandara	7	771	419	68	487
Nagpur	14	1615	318	131	449
Jalgaon	15	1476	395	47	442
Ahmednagar	14	1564	133	307	440
Beed	11	1243	39	292	331
Solapur	11	1127	145	122	267

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Raigadh	15	1834	239	14	253
Sangli	9	712	115	58	173
Yavatmal	16	1840	125	32	157
Wardha	8	996	107	31	138
Latur	10	911	42	92	134
Nanded	15	1534	110	18	128
Washim	6	696	56	59	115
Chandrapu	14	1460	65	48	113
Aurangabad	9	1391	86	16	102
Jalna	8	956	81	19	100
Kolhapur	5	488	69	30	99
Buldhana	13	1284	60	37	97
Osmanabad	8	711	11	76	87
Akola	7	855	51	36	87
Parbhani	9	820	63	23	86
Hingoli	5	567	62	4	66
Dhule	4	574	30	27	57
Nandurbar	4	934	0	26	26
Godchilroli	12	1519	2	9	11
Bombay	0	0	0	0	0
Total	357	43821	6174	6030	12204

Table District-wise distribution of area under fruits and vegetables (ha) in Himachal Pradesh for the year 2001-02

District	Total no. of tehsils	No. of villages	Area under		Total area under fruits & vegetables
			Fruits	Vegetables	
Lahul & Spiti	3	284	9943	883	10826
Kullu	6	166	9042	2674	11716
Shimla	17	2514	29680	13134	42814
Kangra	19	3600	6338	2183	8521
Mandi	16	2818	6559	5454	12013
Chamba	10	1052	1770	3604	5374
Sirmour	10	1056	2001	1007	3008
Kinnaur	6	228	2720	218	2938
Una	7	773	777	3399	4176
Solan	5	2381	544	901	1445
Bilaspur	4	961	349	412	761
Hamirpur	6	1629	72	169	241
Total	109	17462	69795	34038	103833

Sampling design for Horticulture survey

The sampling design adopted in the survey was stratified multistage random sampling.

First of all, important districts were identified for conducting survey on the basis of district-wise area figures under fruits and vegetables of the State.

A total of ten districts from Maharashtra and four districts from H.P. were selected on the basis of previous year's area figures (covering about 70-80% of the total area under fruits and vegetables in the entire State).

Taluk/tehsil-wise area figures under fruits and vegetables were used for stratifying the taluks/tehsils of the selected districts into two groups viz. high productive taluks/tehsils and low productive taluks/tehsils.
Table 3.4 and Table 3.4(a) give the taluk/tehsil-wise area figures of fruits and vegetables of selected taluks/tehsils of selected districts of Maharashtra and H.P. respectively for the year 2001-02 which was acquired from respective State Govts.

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High productive taluks/tehsils are those which constitute 60-70 percent of the total area under fruits and vegetables of the district and rest of the taluks/tehsils fall under low productive taluks/tehsils.

A sample of two taluks/tehsils was selected by simple random sampling without replacement (SRSWOR) from both the groups after rejecting taluks/tehsils contributing less than 5% of total area under fruits and vegetables of the district.

From each of the four selected taluks/tehsils, a sample of five villages was selected by SRSWOR. The selected villages were completely enumerated so as to record number of orchards under different fruits and cropping pattern with respect to vegetables.

An orchard for selection process should have minimum of 12 fruit trees of bearing age of a single fruit crop.

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For fruits survey, a sample of five orchards was selected from each selected village by SRSWOR. In case, there are more than one fruit crops available in the village then orchards of two major fruits were selected in proportion to the number of orchards for two major fruit crops in each of the village with a minimum of two orchards for each fruit crop.

Major fruit crops were decided on the basis of number of orchards of different fruits available in the village. From each selected orchard, a sample of three clusters each consisting of four trees of bearing age was selected randomly out of the total number of trees of bearing age. The yield of selected trees was collected through enquiry and yield of any four trees was collected through physical observation.

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For vegetable survey, a sample of 10 vegetable growers was selected out of qualified vegetable growers of a village.

For this, after complete enumeration of selected village, a list of qualified vegetable growers was prepared.

Qualified growers are those vegetable growers who have 0.1 ha and above gross cropped area under vegetables in case of Maharashtra and 0.01 ha and above in case of Himachal Pradesh.

Ranking of qualified vegetable growers was done as per gross cropped area and then qualified vegetable growers were divided into two groups after ranking.

If number of growers is odd, the first group will have one more grower than the second group. A total of six vegetable growers were selected from the first group and rest four from the second group.

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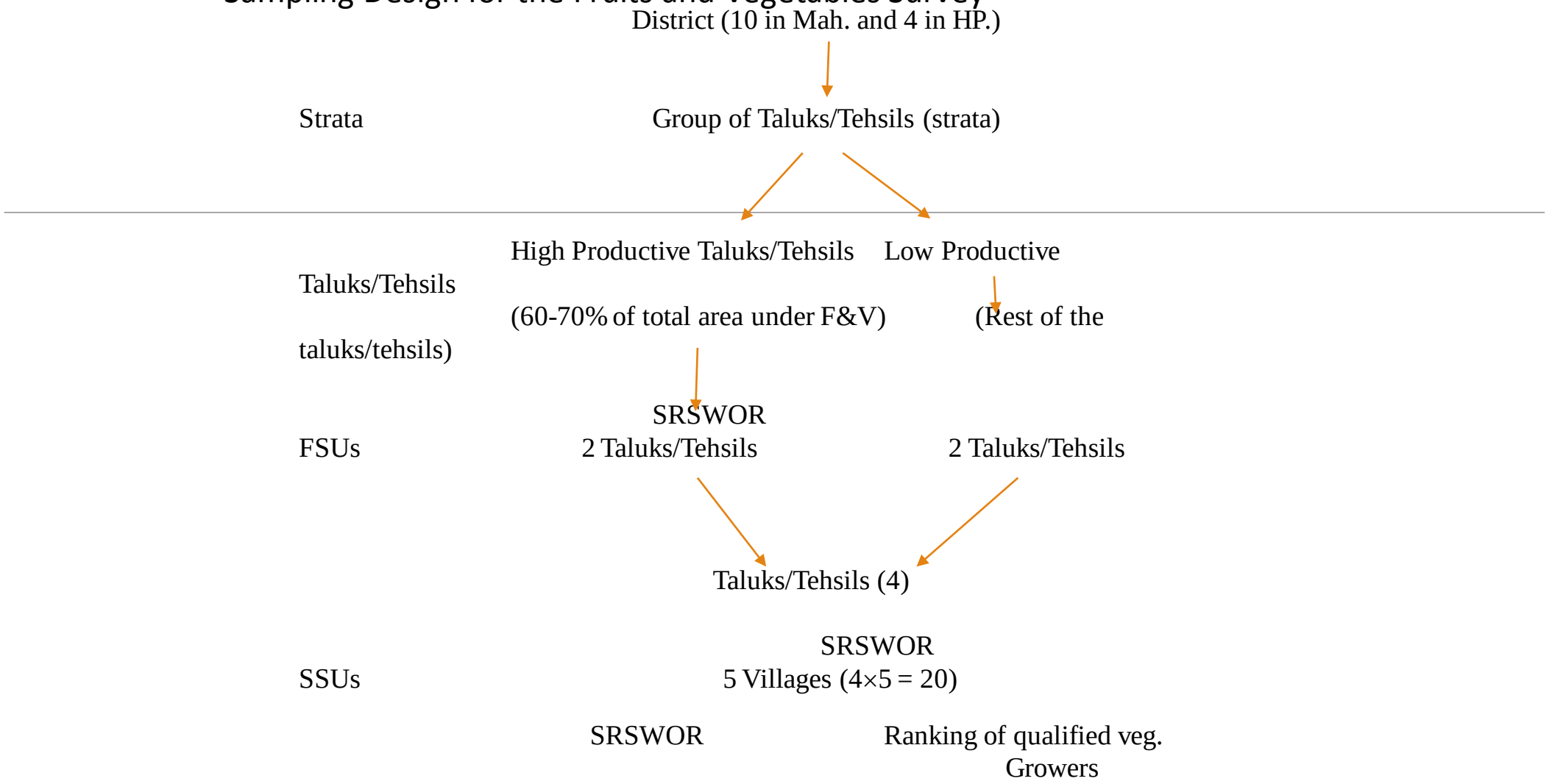
In case, total number of qualified vegetable growers in any village is less than or equal to ten, all the growers were selected for detailed survey enquiry.

The produce of all the vegetables crops grown by the selected vegetable grower was recorded through enquiry and physical observation was taken on the day of visit.

The Field Investigator (FI) was advised to get in touch with the grower of the selected field from time to time and ascertain the date of harvest. He must be present on the day of harvest.

He must locate the experimental plot of specified size (5mx5m) before the cultivator starts harvesting the field. In each selected field, the experimental plot of the specified size must be located at random beginning with South-West corner of the selected field.

Sampling Design for the Fruits and Vegetables Survey



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TSUs	5 Orchards	Divided into 2 groups
	SRSWOR	
	6 growers	4 growers
	(10 Vegetable growers out of qualified veg. growers)	
4^{th} Stage Units	3 Clusters of 4 trees (by enquiry)	
	Any 4 trees by actual observation	

Periodicity = Fortnightly

Table: Taluk-wise area (ha) figures of fruits and vegetables in Maharashtra for the year 2001-02

District	Name of the selected taluks	No. of villages	Area under		Total area under fruits & vegetables
			Fruits	Vegetables	
Pune	1. Khed	185	327	6603	6930
	2. haveli	101	1483	3273	4756
	3. Puraender	106	1139	3402	4541
	4. Shirur	116	1231	11666	12897
Satara	1. Wai	118	618	21216	21834
	2. Koregaon	138	702	104682	105384
Ahmednagar	1. Shrirampur	53	2842	2853	5695
	2. Kopargaon	78	151	4356	4507
	3. Newasa	128	677	1132	1809
	4. Rahuri	95	39	2166	2205
Jalgaon	1. Chopda	111	6354	2013	8367
	2. Raver	113	16412	312	16724
	3. Amalner	145	2213	1990	4203
	4. Chalisgaon	142	3806	1385	5191
Nasik	1. Dindori	156	6304	8839	15143
	2. Niphad	133	8578	11122	19700
	3. Surgana	189	2489	4109	6598
	4. Sinnar	128	651	3533	4184
Amravati	1. Amravati	110	5700	134	5834
	2. Chandubazar	147	8451	290	8741
	3. Warud	119	17501	126	17627
	4. Anjana gaon Surji	104	3784	504	4288

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Nagpur	**1. Narkhed**	**30**	**7347**	**1193**	**8540**
	2. Parseoni	109	1092	1659	**2751**
	3. Nagpur (rural)	135	1778	1641	**3419**
	4. Hinga	122	2213	603	**2816**
Solapur	1. Pandharpur	99	245	10055	**10300**
	2. Malshiras	116	1570	199	**1769**
Sindhudurg	1. Dodamarg	55	0	0	**0**
	2. Malwan	134	0	0	**0**
Ratnagiri	1. Ratnagiri	198	18147	155	**18302**
	2.Langai	120	14283	110	**14393**
Total		**3833**	**138127**	**211321**	**349448**

Table: Tehsil-wise area (ha) figures of fruits and vegetables in H.P. for the year 2001-02

District	Name of the selected tehsils	No. of villages	Area under		Total area under fruits & vegetables
			Fruits	Vegetables	
Shimla	Theog	399	2927	5140	**8067**
	Kotkhai	171	5050	521	**5571**
	Rampur	152	2327	542	**2869**
	Nankhari	85	2105	289	**2394**
Mandi	Thunag	168	599	1495	**2094**
	Mandi Sadar	369	629	379	**1008**
	Nihari	204	324	599	**923**
	Paddar	188	71	613	**684**
Kullu	Kullu	64	5309	1461	**6770**
	Anni	16	1341	293	**1634**
	Manali	18	909	84	**993**
	Banjar	30	428	422	**850**
Kangra	Nurpur	386	3488	203	**3691**
	Indaura	111	1338	134	**1472**
	Kangra	310	146	768	**914**
	Palampur	393	134	488	**622**
Total		**3064**	**27125**	**13431**	**40556**

Organization of field work of the survey

Discussions and a series of meetings were held with officials of Commissionerate of Agriculture, Pune and Directorate of Land Records (DLR), Shimla during the course of the study.

Seventeen (17) Field Investigators (FIs) were hired in Maharashtra and eight (8) were hired in H.P. with the help of respective State Govts.

The overall control of field work was with the State Governments while the technical control of the survey was with the Director, IASRI, New Delhi.

In Maharashtra, the administrative control of field work was with Chief Statistician, Commissionerate of Agriculture, Pune and in Himachal Pradesh, was with Director, Directorate of Land records, Shimla.

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Data collection work was done in two phases i.e. complete enumeration for three months and detailed survey for one year with the help of Commissionerate of Agriculture, Pune and Directorate of Land Records, Shimla. Schedules along with instruction manual were prepared for data collection.

Pre-testing of schedules pertaining to complete enumeration and detailed survey was carried out in both the states.

The field staff was given intensive training for filling different schedules, use of random number tables for selection of orchards and cluster of trees.

The training was also given on how to make a plot of 5x5 in case of vegetable crops. The training was given by scientists and field officers associated in the project

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A total of 40 taluks were selected from Maharashtra and 16 tehils from Himachal Pradesh.

Two taluks/tehsils were allotted to each Field Investigator. According to sampling plan, each FI was to enumerate 20 villages selected in two taluks/tehsils for the first phase of Survey.

For the second phase of the survey, i.e. detailed survey, 5 orchards and 10 vegetable growers were selected from each selected village.

Accordingly, each FI was allotted to collect detailed information using well designed and structured schedules from 100 orchards and 200 vegetable growers.

Supervision of data collection was done by the IASRI officials at regular intervals and all necessary support for this purpose was provided by the State Govts.

A visit was made by Monitoring officer, Sh. S. M. Mahajan in Pune district of Maharashtra State for assessment of field work.

Difficulties in organizing the survey and collection of data

For conducting this type of state-wise integrated survey covering both important fruits and vegetables crops grown in the State, a number of difficulties were experienced. These difficulties may be classified into three heads as under:

Administrative

Organizational and

Technical

In the administrative, lot of difficulties were faced in ad-hoc appointment of Field Investigators for data collection work.
For Maharashtra State, 17 Field Investigators were to be appointed for data collection work in the selected districts viz. Pune, Ahmednagar, Satara, Amravati, algaon, Nasik, Nagpur, Solapur, Ratnagiri & Sindhudurg.

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This work was entrusted to the State Govt. As per the administrative procedure, the State Govt. invited names from the State Employment Bureau and then the interviews were conducted at Pune.

The selected candidates were sent the offer of appointment and only ten field investigators joined on 15.9.2005, the date of imparting the training for the first phase of survey and four joined on 06.10.2005.
There were frequent resignations in between. Attempt was made to fill-up the vacant positions of FIs but the administrative procedure was so lengthy that, it took about 3 months for the next field investigator to join.
The period of data collection was three months for complete enumeration and one year for the detailed survey.

Contd.

Wherever, the FIs were not in place, the complete enumeration work could be completed by sending the Senior Research Fellows (SRFs) from IASRI, New Delhi who were recruited under the project at IASRI. Same difficulties were faced during detailed survey due to frequent resignations in between.

A meeting to discuss various issues related to the project specially engagement of state government staff in place of vacant positions of FIs in Maharashtra due to frequent resignations in between was held on 20 April, 2006 at Pune under the Chairmanship of Director, Horticulture, Pune. The State Govt. was kind enough to agree for engaging the State Govt. officials at our request to complete the survey in the districts, wherever, the FIs post became vacant. State govt. officials were identified and engaged for about three months in data collection work in the districts where FIs positions were vacant due to resignation.

As per plan, the detailed survey was to be completed by the end of December, 2006 but with great difficulty the data collection work could be completed in five districts of

Contd.

Maharashtra by the end of February, 2007 with the help of the engaged State govt. officials.

Data collection work could be completed in the last week of March, 2007 in one district and in one tehsil of another district.

The district-wise data on market arrival for last 10-15 years of important fruits and vegetables covered under study was not available on the concerned web sites and in any of the published sources.

The required data on market arrival could be acquired in time from Maharshtra State Agriculture Marketing Board, Pune but could be obtained with great difficulty by the end of June, 2007

from H.P. State Agriculture Marketing Board, Shimla.

On the organizational side, in certain selected tehsils where the selected villages were about 100 kms. away from Head Quarter (HQ), the field investigators could collect data with great difficulties.

Some of the selected villages were 3-5 kms away from pucca road.

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In fact, most of the field investigators took more than 6-8 months to collect the complete enumeration data with the result that the yield data of some fruits could not be collected by physical observation. The yield data of these fruits were collected by enquiry only.

The supervision of field work was entrusted to District Superintending Agriculture Officer posted in the district.

The district officers were so busy in their own work that they could not supervise the field work as planned and instead allotted the supervision work to agricultural Officer or Technical officers working with them. These officers did some supervision work.

The distance between selected villages in a tehsil varies from 10-100 kms, in many cases the field investigators could not get the yield harvested in his presence.

A proforma was kept with the orchardists/farmers with a request to fill up the yield data as and when harvesting took place. After the harvesting season was over the field investigators collected the filled-in proformae.

Contd.

The technical difficulties pertain to the implementation of the planning of the survey.

In the beginning as already mentioned ten districts were selected from Maharahstra and from each district four tehsils were to be selected.

The plan was to allot 2 tehsils to each field investigator. But at the final stage, only 17 field investigators were approved for Maharashtra and 8 for H.P.

The appointment of FIs was also delayed for three districts viz. Ratnagiri, Sindhudurg, Solapur with the result that from these three districts only the data of two tehsils from each district could be collected.

As planned, ten vegetables growers were to be selected from each village but as the selection of villages was random, in some villages ten vegetable growers were not available.

Contd.

Apart from the difficulties listed above, a large number of minor difficulties were experienced in data collection work.

These difficulties were solved after taking appropriate decisions from time to time.
During the course of the survey the field work was supervised at regular intervals.
Besides, imparting training to the hired FIs and HQ officials for both phases of survey, training for data collection was also imparted to the identified State govt. staff in five districts of Maharashtra for completing the remaining work of detailed survey due to resignation of FIs.
The filled-in schedules were scrutinized in both the states during supervision of field work and necessary suggestions were given for correction.
After the completion of field work, the filled-in schedules were scrutinized at length in both the states and corrections were made after discussion with FIs. Coding, data entry and
scrutiny of the collected data took lot of time. The data entry of the district-wise data on market arrival for last 10-14 years of important fruits and vegetables covered under study obtained by the end of June, 2007 could be done after June, 2007 only.

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The data analysis could be started after data entry and proper scrutiny of the entered data. The data analysis took lot of time as analysis was to be done for all important fruits and all important vegetables covered under the study for 10 selected districts of Maharashtra and 4 selected districts of H.P. for estimating area, production, productivity, number of bearing trees, number stray bearing trees etc. along with their percentage standard errors. The estimates were obtained for non-surveyed districts of both the States using market arrival data.

During data analysis some of the problems faced are as under:

- Even after frequent supervision and repeated training to the FIs, the data by observation on four selected trees could not be obtained in proper format.

(ii) There are missing observations which created problems as sample size within stratum becomes very small in case of a particular fruit/vegetable (fruit-wise/vegetable-wise analysis). Missing observations have been filled using proper technique.

Contd.

(iii) In some of the districts there are only two high productive tehsils/taluks and hence both tehsils/taluks have been taken for the study. In finding out estimate of variance, variance at fsu (tehsil/taluk) level becomes zero.

(iv) The schedules designed for farmers (in case of fruits & vegetables) are either partially filled or are blank in many cases as farmers did not cooperate (since they have to write down the produce wt. for all the pickings).

(v) Data for all the pickings have not been captured (by observation. on the day of harvest and by enquiry for the intervening period) in many cases mainly due to change in harvest date by the farmer.

(vi) In case of vegetables, the data by observation for the crop cut plot has been recorded for one or two pickings only in many cases.

(vii)The market arrival data obtained from the respective States are missing for many fruits/vegetables for some year and for some of the districts. The data in many cases do not seem to be correct.

As the sampling design is common for both fruits and vegetables surveys and is common for all fruits and vegetables, in many cases the ultimate sample size for a particular fruit/vegetable becomes less in a district which affects the reliability of the estimates in that district.

Estimation procedure for fruits

Estimation of number of trees and area under fruit crops in a district

Notations followed:

L = Total number of strata

T_h = Total number of taluks/tehsils in h-th stratum, h = 1, 2, . . . ,L

t_h = Number of taluks/tehsils selected from h-th stratum

V_{ht} = Total number of villages in t-th selected taluk/tehsil of h-th stratum, h = 1, 2,...,L and t = 1, 2, . . .,t_h

v_{ht} = Number of selected villages from t-th selected taluk/tehsil of h-th stratum

Contd.

R_{htvf} = Total number of orchards in v-th selected village from t-th selected taluk/tehsil of h-th stratum for f-th fruit, v = 1, 2, . . ., v_{ht}; f = 1, 2, . . .,F and F = Total number of fruit crops

r_{htvf} = Number of selected orchards in v-th selected village from t-th selected taluk/tehsil of h-th stratum for f-th fruit

B_{htvrf} = Total number of bearing trees in r-th selected orchard of v-th selected village from t-th selected taluk/tehsil from h-th stratum for f-th fruit, r = 1, 2, . . .,r_{htvf}

b_{htvrf} = Number of selected bearing trees in r-th selected orchard of v-th selected village from t-th selected taluk/tehsil from h-th stratum for f-th fruit

x_{htvrbf} = Value of the character under study e.g. number of trees, bearing or young, number of orchards etc. recorded on the basis of complete enumeration of v-th village selected from t-th taluk/tehsil of h-th stratum

An estimate of total for the character x (briefly we call it total unless otherwise stated) for h-th stratum for f-th fruit is given by

$$\hat{X}_{hf} = \frac{T_h}{t_h} \sum_{t=1}^{t_h} \frac{V_{htf}}{v_{htf}} \sum_{v=1}^{v_{htf}} x_{htvf}$$

$$= T \sum_{h=1}^{L} W_h \bar{y}_{hf}$$

Pooling of strata estimates to get district level estimate:

The estimates of all the strata in a district are added to get the estimate at district level.

$$\hat{X}_f = \sum_{h=1}^{L} \hat{X}_{hf} = T \sum_{h=1}^{L} W_h \bar{x}_{hf}$$

where

$$T = \sum_{h=1}^{L} T_h$$

$$W_h = \frac{T_h}{T}$$

and

$$\bar{x}_{hf} = \frac{1}{t_h} \sum_{t=1}^{t_h} \frac{V_{htf}}{v_{htf}} \sum_{v=1}^{v_{htf}} x_{htvf}$$

Contd.

Estimate of variance:
An estimate of variance of $\hat{X}_f$

is given by

$$\hat{V}\left(\hat{X}_f\right) = T^2 \sum_{h=1}^{L} W_h^2 \, \hat{V}\left(\bar{x}_{hf}\right)$$

where

$$\hat{V}\left(\bar{x}_{hf}\right) = \frac{1}{t_h}\left(1 - \frac{t_h}{T_h}\right)\frac{1}{t_h - 1}\sum_{t=1}^{t_h}\left(V_{htf}\,\bar{x}_{htf} - \bar{x}_{hf}\right)^2 + \frac{1}{T_h \times t_h}\sum_{t=1}^{t_h}\frac{1}{v_{htf}}\left(1 - \frac{v_{htf}}{V_{htf}}\right)s_{tf}^2$$

where

$$s_{tf}^2 = \frac{1}{v_{htf} - 1}\sum_{v=1}^{v_{htf}}\left(x_{htvf} - \bar{x}_{htf}\right)^2$$

and

$$\bar{x}_{htf} = \frac{1}{v_{htf}}\sum_{v=1}^{v_{htf}} x_{htvf}$$

Estimate of standard error of $\hat{X}_f$

$$\hat{S.E.}(\hat{X}_f) = \sqrt{\hat{V}(\hat{X}_f)}$$

Estimate of percentage standard error of $\hat{X}_f$

$$\%\hat{S.E.} = \frac{\hat{S.E.}(\hat{X}_f)}{\hat{X}_f} \times 100$$

Estimation of average yield per tree of fruit crops in a district

An estimate of average yield of the f-th fruit in the t-th taluk/tehsil of h-th stratum is given by

$$\bar{y}_{htf} = \frac{1}{v_{ht}} \sum_{v=1}^{v_{ht}} \bar{y}_{htvf}$$

where

$$\bar{y}_{htvf} = \frac{1}{r_{htvf}} \sum_{r=1}^{r_{htvf}} \bar{y}_{htvrf}$$

where $\bar{y}_{htvrf} = \frac{1}{b_{htvrf}} \sum_{b=1}^{b_{htvrf}} y_{htvrbf}$

An estimate of average yield of the f-th fruit in the h-th stratum is given by

$$\bar{y}_{hf} = \frac{\sum_{t=1}^{t_h} \hat{B}_{htf} \bar{y}_{htf}}{\sum_{t=1}^{t_h} \hat{B}_{htf}}$$

where $\hat{B}_{htf}$

the estimate of number of bearing trees of f-th fruit in the t-th taluk/tehsil of h-th stratum and is given by

$$\hat{B}_{htf} = V_{htf} \bar{b}_{htf}$$

Contd.

where b_{htvf} is the total number of bearing trees of f-th fruit in v-th selected village (complete enumeration) of t-th selected taluk/tehsil of h-th stratum. An estimate of overall average yield of the f-th fruit at district level is given by

$$\bar{y}_f = \sum_{h=1}^{L} \left(\frac{\hat{B}_{hf}}{\hat{B}_f} \right) \bar{y}_{hf}$$

where

$$\hat{B}_{hf} = \frac{T_h}{t_h} \sum_{t=1}^{t_h} \frac{V_{htf}}{v_{htf}} \sum_{v=1}^{v_{htf}} b_{htvf}$$

and

$$\hat{B}_f = \sum_{h=1}^{L} \hat{B}_{hf}$$

are the estimates of number of bearing trees of f-th fruit in h-th stratum and an estimate of total number of bearing trees at district level
(pooled over all strata) respectively.

An estimate of variance of

$\bar{y}_f$ is given by

$$\hat{V}(\bar{y}_f) = \sum_{h=1}^{L} \left(\frac{\hat{B}_{hf}}{\hat{B}_f} \right)^2 \hat{V}(\bar{y}_{hf})$$

where

$$\hat{V}(\bar{y}_{hf}) = \frac{1}{(\hat{B}_{hf})^2} \left(\frac{1}{t_h} - \frac{1}{T_h} \right) \sum_{t=1}^{t_h} \hat{B}_{htf}^2 (\bar{y}_{htf} - \bar{y}_{hf})^2$$

Estimate of standard error of

$\bar{y}_f$ is given by

$$\hat{S.E.}(\bar{y}_f) = \sqrt{\hat{V}(\bar{y}_f)}$$

Estimate of percentage standard error of

$\bar{y}_f$ is given by

$$\% \hat{S.E.}(\bar{y}_f) = \frac{\hat{S.E.}(\bar{y}_f)}{\bar{y}_f} \times 100$$

An estimate of total production of the f-th fruit at district level is given by

$$\hat{Y}_f = (\bar{y}_f) \times (\hat{B}_f)$$

where $(\hat{B}_f)$ is an estimate of total number of bearing trees of f-th fruit in the district.

$(\bar{y}_f)$ Is the estimate of overall average yield for f-th fruit at district level and

With the assumption that the average yield of bearing trees and total number of bearing trees are independent, an estimate of variance is given by

$$\hat{V}(\hat{Y}_f) = (\bar{y}_f)^2 \times \hat{V}(\hat{B}_f) + (\hat{B}_f)^2 \times \hat{V}(\bar{y}_f) - \hat{V}(\hat{B}_f) \times \hat{V}(\bar{y}_f)$$

$\hat{Y}_f$ is given by

Estimate of standard error (S.E.) of

$$\hat{S.E.}(\hat{Y}_f) = \sqrt{\hat{V}(\hat{Y}_f)}$$

Estimate of percentage standard error of $\hat{Y}_f$ is given by

$$\%\hat{S.E.}(\hat{Y}_f) = \frac{S.E.(\hat{Y}_f)}{\hat{Y}_f} \times 100$$

Estimation of area under vegetables crops in a district

Notations followed:

L = Total number of strata

T_h = Total number of taluks/tehsils in h-th stratum, h = 1, 2, . . . ,L

t_h = Number of taluks/tehsils selected from h-th stratum

V_{ht} = Total number of villages in t-th selected taluk/tehsil of h-th stratum, h = 1, 2, . . .,L and t = 1, 2, . . .,t_h

v_{ht} = Number of selected villages from t-th selected taluk/tehsil of h-th stratum

$a_{htv}^{c,s}$ = Value of the character under study i.e. area under c-th vegetable in s-th season on the basis of complete enumeration of v-th village selected from t-th taluk/tehsil of h-th stratum

An estimate of area under c-th crop in s-th season in t-th selected taluk/tehsil of h-th stratum is given by

$$\hat{A}_{ht}^{c,s} = \frac{V_{ht}}{v_{ht}} \sum_{v=1}^{v_{ht}} a_{htv}^{c,s}$$

An estimate of area under c-th crop in s-th season in h-th stratum is given by

$$\hat{A}_{h}^{c,s} = \frac{T_h}{t_h} \sum_{t=1}^{t_h} \frac{V_{ht}}{v_{ht}} \sum_{v=1}^{v_{ht}} a_{htv}^{c,s}$$

Pooling of strata estimates to get district level estimate:

The estimates of all the strata in a district are added to get the estimate at district level.

$$\hat{A}^{c,s} = \sum_{h=1}^{L} \hat{A}_{h}^{c,s} = T \sum_{h=1}^{L} W_h \bar{a}_{h}^{c,s}$$

where

$$T = \sum_{h=1}^{L} T_h$$

$$W_h = \frac{T_h}{T} \ ,$$

$$\bar{a}_{h}^{c,s} = \frac{1}{t_h} \sum_{t=1}^{t_h} \frac{V_{ht}}{v_{ht}} \sum_{v=1}^{v_{ht}} a_{htv}^{c,s}$$

Estimate of variance:

An estimate of variance of

$\hat{A}^{c,s}$ is given by

$$\hat{V}\left(\hat{A}^{c,s}\right) = T^2 \sum_{h=1}^{L} W_h^2 \, \hat{V}\left(\bar{a}_h^{c,s}\right)$$

where

$$\hat{V}\left(\bar{a}_h^{c,s}\right) = \left(\frac{1}{t_h} - \frac{1}{T_h}\right) \frac{1}{t_h - 1} \sum_{t=1}^{t_h} \left(V_{ht} \bar{a}_{ht}^{c,s} - \bar{a}_h^{c,s}\right)^2 + \frac{1}{T_h \times t_h} \sum_{t=1}^{t_h} \left(\frac{1}{v_{ht}} - \frac{1}{V_{ht}}\right) s_t^2$$

where

$$s_t^2 = \frac{1}{v_{ht} - 1} \sum_{v=1}^{v_{ht}} \left(a_{htv}^{c,s} - \bar{a}_{ht}^{c,s}\right)^2$$

and

$$\bar{a}_{ht}^{c,s} = \frac{1}{v_{ht}} \sum_{v=1}^{v_{ht}} a_{htv}^{c,s}$$

Estimate of standard error of

$\hat{A}^{c,s}$ is given by

$$\hat{S.E.}(\hat{A}^{c,s}) = \sqrt{\hat{V}(\hat{A}^{c,s})}$$

Estimate of percentage standard error of

$\hat{A}^{c,s}$ is given by

$$\%\hat{S.E.} = \frac{\hat{S.E.}(\hat{A}^{c,s})}{\hat{A}^{c,s}} \times 100$$

Total area under c-th vegetable crop in the district during the year is given by

$$\hat{A}^{c} = \sum_{s=1}^{3} \hat{A}^{c,s}$$

Estimate of variance under c-th vegetable crop in the district during the year is given by

$$\hat{V}\left(\hat{A}^{c}\right) = \sum_{s=1}^{3} \hat{V}\left(\hat{A}^{c,s}\right)$$

Estimate of standard error under c-th vegetable crop in the district during the year is given by

$$\hat{S.E.}(\hat{A}^{c}) = \sqrt{\hat{V}(\hat{A}^{c})}$$

Estimate of percentage standard error under c-th vegetable crop in the district during the year is given by

$$\%\hat{S.E.} = \frac{\hat{S.E.}(\hat{A}^{c})}{\hat{A}^{c}} \times 100$$

L = Total number of strata

T_h = Total number of taluks/tehsils in h-th stratum, h = 1, 2,...,L

t_h = Number of taluks/tehsils selected from h-th stratum

V_{ht} = Total number of villages in t-th selected taluk/tehsil of h-th stratum, h = 1, 2,...,L and t = 1, 2, . . .,t_h

v_{ht} = Number of selected villages from t-th selected taluk/tehsil of h-th stratum

P^c_{htv} = Total number of plots in v-th selected village of t-th selected taluk/tehsil from h-th stratum for c-th vegetable crop

p^c_{htv} = Number of selected plots in v-th selected village of t-th selected taluk/tehsil from h-th stratum for c-th vegetable crop

$A^{c,s}_{h,v}$ = Area under c-th vegetable crop in v-th village of h-th stratum harvested during s-th season

$A^c_{h,v}$ = Area under c-th vegetable crop in v-th village of h-th stratum

$\hat{A}_h^c$ = Estimated area under c-th vegetable crop in h-th stratum

$\hat{A}^c$ = Estimated area under c-th vegetable crop in the district

$y_{htvp}^{c,s}$ = Yield harvested from p-th plot of standard size having c-th vegetable crop in v-th selected village of t-th selected taluk/tehsil from h-th stratum during s-th seas

$\bar{y}_{htv}^{c,s} = \frac{1}{p_{htv}} \sum_{p=1}^{p_{htv}} y_{htvp}^{c,s}$

, average yield of c-th vegetable crop in s-th season in v-th selected village of t-th selected taluk/tehsil from h-th stratum

,

$\bar{y}_{ht}^{c,s} = \frac{1}{v_{ht}} \sum_{v=1}^{v_{ht}} \frac{1}{p_{htv}} \sum_{p=1}^{p_{htv}} y_{htvp}^{c,s} = \frac{1}{v_{ht}} \frac{1}{p_{htv}} \sum_{v=1}^{v_{ht}} \sum_{p=1}^{p_{htv}} y_{htvp}^{c,s}$ average yield of c-th vegetable crop in s-th season in t-th taluk/tehsil of h-th stratum

Estimates of total production for c-th crop in h-th Stratum:

Total production in v-th village during s-th season is given by

$$\hat{Y}_{htv}^{c,s} = 400 \times \bar{y}_{htv}^{c,s} \times A_{htv}^{c,s}$$

$\times$ (Since size of the plot is 5m X5m)

Total production in v-th village during the year is given by

$$\hat{Y}_{htv}^{c} = 400 \times \sum_{s=1}^{3} \left(\bar{y}_{htv}^{c,s} \times A_{htv}^{c,s} \right)$$

$\times$

$$\hat{Y}_{ht}^{c,s} = 400 \times \bar{y}_{ht}^{c,s} \times \hat{A}_{ht}^{c,s}$$

(Since size of the plot is 5mX5m

Total production in t-th taluk/tehsil during the year is given by

$$\hat{Y}_{ht}^{c} = 400 \times \sum_{s=1}^{3} \left(\bar{y}_{ht}^{c,s} \times \hat{A}_{ht}^{c,s} \right)$$

Total production for c-th crop in h-th stratum is given by

$$\hat{Y}_{h}^{c} = \frac{T_h}{t_h} \sum_{t=1}^{t_h} \hat{Y}_{ht}^{c}$$

An estimate of variance of $\hat{Y}_{h}^{c}$

$$\hat{V}\left(\hat{Y}_{h}^{c}\right) = \frac{T_h\left(T_h - t_h\right)}{t_h\left(t_h - 1\right)} \sum_{t=1}^{t_h} \left(\hat{Y}_{ht}^{c} - \frac{\hat{Y}_{h}^{c}}{T_h} \right)^2 + \frac{T_h}{t_h} \sum_{t=1}^{t_h} \left(\frac{V_{ht} - v_{ht}}{V_{ht} \times v_{ht}} \right) s_t^2$$

where

$$s_t^2 = \frac{1}{v_{ht} - 1} \sum_{v=1}^{v_{ht}} \left(\hat{Y}_{htv}^{c} - \frac{\hat{Y}_{ht}^{c}}{V_{ht}} \right)^2$$

$$\hat{Y}_{htv}^{c} = 400 \times \sum_{s=1}^{3} \left(\bar{y}_{htv}^{c,s} \times A_{htv}^{c,s} \right)$$

and

$$\hat{Y}_{ht}^{c} = \frac{V_{ht}}{v_{ht}} \sum_{v=1}^{v_{ht}} \hat{Y}_{htv}^{c}$$

Estimate of standard error of $\hat{Y}_{h}^{c}$

is given by

$$\hat{S.E.}\left(\hat{Y}_{h}^{c}\right) = \sqrt{\hat{V}\left(\hat{Y}_{h}^{c}\right)}$$

Estimate of percentage standard error of $\hat{Y}_{h}^{c}$

is given by

$$\%\hat{S.E.}\left(\hat{Y}_{h}^{c}\right) = \frac{\hat{S.E.}\left(\hat{Y}_{h}^{c}\right)}{\hat{Y}_{h}^{c}} \times 100$$

Pooling of strata estimates to get district level estimate:

An estimate of total production for c-th crop during the year in a district is obtained by adding the estimates of all the strata in the district which is given by

$$\hat{Y}^{c} = \sum_{h=1}^{L} \hat{Y}_{h}^{c}$$

Estimate of variance:

An estimate of variance of $\hat{Y}^c$

is given by

$$\hat{V}\left(\hat{Y}^c\right) = \sum_{h=1}^{L} \hat{V}\left(\hat{Y}_h^c\right)$$

Estimate of standard error of $\hat{Y}^c$

is given by

$$\hat{S.E.}\left(\hat{Y}^c\right) = \sqrt{\hat{V}\left(\hat{Y}^c\right)}$$

Estimate of percentage standard error of $\hat{Y}^c$

is given by

$$\%\hat{S.E.}\left(\hat{Y}^c\right) = \frac{S.E.\left(\hat{Y}^c\right)}{\hat{Y}^c} \times 100$$

Estimation of average yield of vegetable crops in a district

Average yield of c-th crop in the district is given by

$$\bar{y}^c = \frac{\hat{Y}^c}{\hat{A}^c} = \frac{\sum_{h=1}^{L} \hat{Y}_h^c}{\sum_{h=1}^{L} \hat{A}_h^c}$$

An approximate estimate of variance of

$\bar{y}^c$ can be obtained by a formula of variance of combined ratio estimate.

$$\hat{V}\left(\bar{y}^c\right) = \frac{1}{\left(\sum_{h=1}^{L} \hat{A}_h^c\right)^2} \sum_{h=1}^{L} \left[\hat{V}\left(\hat{Y}_h^c\right) - 2\,\bar{y}^c\, \mathrm{Cov}\left(\hat{Y}_h^c, \hat{A}_h^c\right) + \left(\bar{y}^c\right)^2 \hat{V}\left(\hat{A}_h^c\right) \right]$$

where

$\mathrm{Cov}\left(\hat{Y}_h^c, \hat{A}_h^c\right)$

denotes covariance between $\hat{Y}_h^c$

and

$\hat{A}_h^c$ and is given by

$$\mathrm{Cov}\left(\hat{Y}_h^c, \hat{A}_h^c\right) = \frac{T_h\left(T_h - t_h\right)}{t_h\left(t_h - 1\right)} \sum_{t=1}^{t_h} \left(\hat{Y}_{ht}^c - \frac{\hat{Y}_h^c}{T_t} \right) \hat{A}_{ht}^c$$

and

$$\hat{V}\left(\hat{A}_h^c\right) = \frac{T_t\left(T_t - t_h\right)}{t_h\left(t_h - 1\right)} \sum_{t=1}^{t_h} \left(\hat{A}_{ht}^c - \frac{\hat{A}_h^c}{T_h} \right)^2 + \frac{T_t}{t_h} \sum_{t=1}^{t_h} \left(\frac{V_{ht} - v_{ht}}{V_{ht} v_{ht}} \right) s_t^2$$

where

$$\hat{A}_{ht}^{c} = \frac{V_{ht}}{v_{ht}} \sum_{v=1}^{v_{ht}} a_{htv}^{c}$$

where

$$a_{htv}^{c} = \sum_{s=1}^{3} a_{htv}^{cs}$$

,

$$\hat{A}_{h}^{c} = \frac{T_h}{t_h} \sum_{t=1}^{t_h} \hat{A}_{ht}^{c}$$

and

$$s_t^2 = \frac{1}{v_{ht} - 1} \sum_{v=1}^{v_{ht}} \left(a_{htv}^{c} - \frac{\hat{A}_{ht}^{c}}{V_{ht}} \right)^2$$

Estimate of standard error of $\bar{y}^c$

is given by

$$\hat{S.E.}\left(\bar{y}^c\right) = \sqrt{\hat{V}\left(\bar{y}^c\right)}$$

Estimate of percentage standard error of $\bar{y}^c$

is given by

$$\%\hat{S.E.}\left(\bar{y}^c\right) = \frac{\hat{S.E.}\left(\bar{y}^c\right)}{\bar{y}^c} \times 100$$

Estimation of sample size (no. of villages to be selected in a district for fruits and vegetables survey)

As per technical programme of the pilot study, 20 villages per district have been selected for fruits and vegetables survey (integrated survey) to obtain district level estimates of area, production and productivity
of important fruits and vegetables in Maharashtra and Himachal Pradesh states using the developed estimation procedures. The percentage standard errors of the estimates obtained
for fruits are between 5 to 20 and for vegetables are between 5 to 30 percent at district level. Since only 20 villages per district were selected for the integrated survey and hence for individual crops the effective sample size i.e. number of villages per district comes out to be less than 20 which results high percentage standard errors of the estimates at district level.

In general, the desirable percentage standard errors of the estimates of the individual crops at district level should be around 10.

But due to special features of fruit and vegetable crops, survey approach is somewhat more complex and estimation procedures are somewhat different than other annual crops.

Therefore, to obtain 10 percent standard error in case of fruits and 15 percent standard error in case of vegetables at district level, the required sample size i.e. number of villages to be selected per district has been estimated. The procedure to estimate sample size is as follows:
Most commonly, we wish to control the relative error in the estimated population total or mean. With a simple random sample having mean

$\bar{y}$

$$\Pr\left(\left|\frac{\bar{y}-\bar{Y}}{\bar{Y}}\right| \geq r\right) = \Pr\left(\left|\frac{N\bar{y}-N\bar{Y}}{N\bar{Y}}\right| \geq r\right) = \Pr\left(\left|\bar{y}-\bar{Y}\right| \geq r\bar{Y}\right) = \alpha$$

where

α is a small probability. We assume that

$\bar{y}$ is normally distributed.
It's standard error is

$$\sigma_{\bar{y}} = \sqrt{\frac{N-n}{N}}\frac{S}{\sqrt{n}}$$

Hence,

$$r\,\overline{\overline{Y}} = t\,\sigma_{\bar{y}} = t\sqrt{\frac{N-n}{N}}\frac{S}{\sqrt{n}}$$

Solving for n gives

$$n = \left(\frac{t\,S}{r\,\overline{\overline{Y}}}\right)^2 \Bigg/ \left[1 + \frac{1}{N}\left(\frac{t\,S}{r\,\overline{\overline{Y}}}\right)^2\right]$$

Note that, the population characteristic on which n depends is its coefficient of variation $S/\overline{Y}$

. This is often more stable and easier to guess in advance than S itself.

As a first approximation, we take

$$n_0 = \left(\frac{t\,S}{r\,\overline{\overline{Y}}}\right)^2 = \frac{1}{C}\left(\frac{S}{\overline{\overline{Y}}}\right)^2$$

substituting an advance estimate of $S/\overline{Y}$

. The quantity C is the desired $(C.V.)^2$

Estimate of sample size is given by

$$n_o = \frac{1}{C\,\hat{\overline{Y}}^2}\,\hat{V}\left(\hat{\overline{Y}}\right)n$$

$$= n\frac{1}{(C.V._{des})^2}\left(\frac{S.E.\left(\hat{\overline{Y}}\right)}{\hat{\overline{Y}}}\right)^2$$

$$= n \frac{(C.V._{cal})^2}{(C.V._{des})^2}$$

where $C.V._{des}$ is the desired Coefficient of variation, $C.V._{cal}$ is the calculated Coefficient of variation, n is the sample size under study and n_0 is the desired sample size. Here, Percentage C.V. is nothing but percentage S.E.

Table Sample size (no. of villages per district) for district level estimates of total production of important fruits and vegetable crops

State	Crops	Districts	Calculated S.E. (%) (n=20)	Desired S.E. (%)	Estimated sample size (n_0)	Max. sample size (n_0)	Expected S.E. (%) (n_0=80)
Fruits							
Maharashtra	Mango	Ahmadnagar	16.14	10.00	52	52	8.07
		Pune	11.57		27		5.79
		Ratanagiri	13.14		35		6.57
		Sindhudurg	8.12		13		4.06
	Lime	Jalgaon	15.71		49	73	7.86
		Nagpur	19.17		73		9.59
		Pune	12.45		31		6.23
	Mosambi	Jalgaon	13.35		36	36	6.68
		Nagpur	8.58		15		4.29
	Orange	Amravati	16.53		55	55	8.27
		Nagpur	13.84		38		6.92
		Pune	14.19		40		7.10
	Guava	Ahmadnagar	10.83		23	80	5.42
		Pune	20.00		80		10.00
	Grape	Ahmadnagar	15.01		45	59	7.51
		Nasik	10.02		20		5.01
		Pune	9.27		17		4.64
		Solapur	17.19		59		8.60
	Banana	Amravati	19.21		74	74	9.61
		Jalgaon	10.56		22		5.28
		Pune	9.20		17		4.60
		Sindhudurg	9.30		17		4.65
	Sapota	Ahmadnagar	18.32		67	67	9.16
		Pune	11.32		26		5.66

Himachal Pradesh	Apple	Mandi	18.51		69	69	9.26
	Mango	Mandi	9.38		18	18	4.69
	Plum	Mandi	13.67		37	37	6.84

State	Crops	Districts	Calculated S.E. (%) (n=20)	Desired S.E. (%)	Estimated sample size (n_0)	Max. sample size (n_0)	Expected S.E. (%) (n_0=80)
Vegetables							
Maharashtra	Potato	Amravati	25.00	15.00	56	56	12.50
		Pune	18.49		30		9.25
	Tomato	Ahmadnagar	25.00		56	65	12.50
		Amravati	27.08		65		13.54
		Nasik	22.54		45		11.27
		Pune	20.01		36		10.01
		Solapur	10.01		9		5.01
	Cauliflower	Nasik	14.91		20	35	7.46
		Pune	19.86		35		9.93
	Cabbage	Nasik	13.40		16	23	6.70
		Pune	16.01		23		8.01
	Peas	Pune	24.82		55	55	12.41
	Onion	Ahmadnagar	23.64		50	50	11.82
		Amravati	9.33		8		4.67
		Jalgaon	13.34		16		6.67
		Nasik	11.58		12		5.79
		Pune	10.26		9		5.13
		Solapur	9.65		8		4.83
	Lady finger	Jalgaon	27.32		66	74	13.66
		Pune	28.84		74		14.42
		Solapur	18.57		31		9.29
	Brinjal	Ahmadnagar	18.76		31	77	9.38
		Amravati	29.34		77		14.67
		Nasik	8.16		6		4.08
		Pune	8.88		7		4.44
		Solapur	15.92		23		7.96
Himachal Pradesh	Potato	Mandi	19.28		33	33	9.64
	Peas	**Mandi**	**24.05**		**51**	**51**	**12.03**

Table Sample size (no. of villages per district) for district level estimates of total production of important fruits and vegetable crops

State	Crops	Districts	Calculated S.E. (%) (n=20)	Desired S.E. (%)	Estimated sample size (n_0)	Max. sample size (n_0)	Expected S.E. (%) (n_0=43)
Fruits							
Maharashtra	Mango	Ahmadnagar	16.14	15.00	23	23	11.01
		Pune	11.57		12		7.89
		Ratanagiri	13.14		15		8.96
		Sindhudurg	8.12		6		5.54
	Lime	Jalgaon	15.71		22	33	10.71
		Nagpur	19.17		33		13.07
		Pune	12.45		14		8.49
	Mosambi	Jalgaon	13.35		16	16	9.10
		Nagpur	8.58		7		5.85
	Orange	Amravati	16.53		24	24	11.27
		Nagpur	13.84		17		9.44
		Pune	14.19		18		9.68
	Guava	Ahmadnagar	10.83		10	36	7.39
		Pune	20.00		36		13.64
	Grape	Ahmadnagar	15.01		20	26	10.24
		Nasik	10.02		9		6.83
		Pune	9.27		8		6.32
		Solapur	17.19		26		11.72
	Banana	Amravati	19.21		33	33	13.10
		Jalgaon	10.56		10		7.20
		Pune	9.20		8		6.27
		Sindhudurg	9.30		8		6.34
	Sapota	Ahmadnagar	18.32		30	30	12.49
		Pune	11.32		11		7.72
Himachal Pradesh	Apple	Mandi	18.51		30	30	12.62
	Mango	Mandi	9.38		8	8	6.40
	Plum	Mandi	13.67		17	17	9.32

State	Crops	Districts	Calculated S.E. (%) (n=20)	Desired S.E. (%)	Estimated sample size (n_0)	Max. sample size (n_0)	Expected S.E. (%) (n_0=43)
Vegetables							
Maharashtra	Potato	Amravati	25.00	20.00	31	31	17.05
		Pune	18.49		17		12.61
	Tomato	Ahmadnagar	25.00		31	37	17.05
		Amravati	27.08		37		18.47
		Nasik	22.54		25		15.37
		Pune	20.01		20		13.65
		Solapur	10.01		5		6.83
	Cauliflower	Nasik	14.91		11	20	10.17
		Pune	19.86		20		13.54
	Cabbage	Nasik	13.40		9	13	9.14
		Pune	16.01		13		10.92
	Peas	Pune	24.82		31	31	16.93
	Onion	Ahmadnagar	23.64		28	28	16.12
		Amravati	9.33		4		6.36
		Jalgaon	13.34		9		9.10
		Nasik	11.58		7		7.90
		Pune	10.26		5		7.00
		Solapur	9.65		5		6.58
	Lady finger	Jalgaon	27.32		37	42	18.63
		Pune	28.84		42		19.67
		Solapur	18.57		17		12.66

HP

Brinjal	**Ahmadnagar**	**18.76**		**18**	**43**	**12.79**		
	Amravati	29.34		43		20.01		
	Nasik	8.16		3		5.57		
	Pune	8.88		4		6.06		
	Solapur	15.92		13		10.86		
Potato	Mandi	19.28		19	19	13.15		
Peas	Mandi	24.05		29	29	16.40		
Optimum sample size								**43**

Contd.

It can be observed from the Table that at district level, the total production of important fruits can be estimated with less than 15 percent standard error and the total production of important vegetables can be estimated with less than or equal to 20 percent standard error at 95 percent confidence interval, if 43 villages are selected from each selected district.

Contd.

The objective is fulfilled after successful completion of the study since, in the developed alternative methodology, not only the sampling design is very simple as compared to existing methodology, the sampling design is common for fruits and vegetables in the alternative methodology whereas, there is separate sampling design for fruits and vegetables in the existing methodology.

Moreover, the alternative methodology provides estimates for more than one fruit/vegetable at district level, whereas, the methodology used under CES-F&V provides estimates for a single fruit/vegetable at district level. In case of alternative methodology, no survey is required in less productive districts whereas survey is required in these districts in case of existing methodology. Hence, the developed alternative methodology is a simplified methodology as compared to existing methodology.

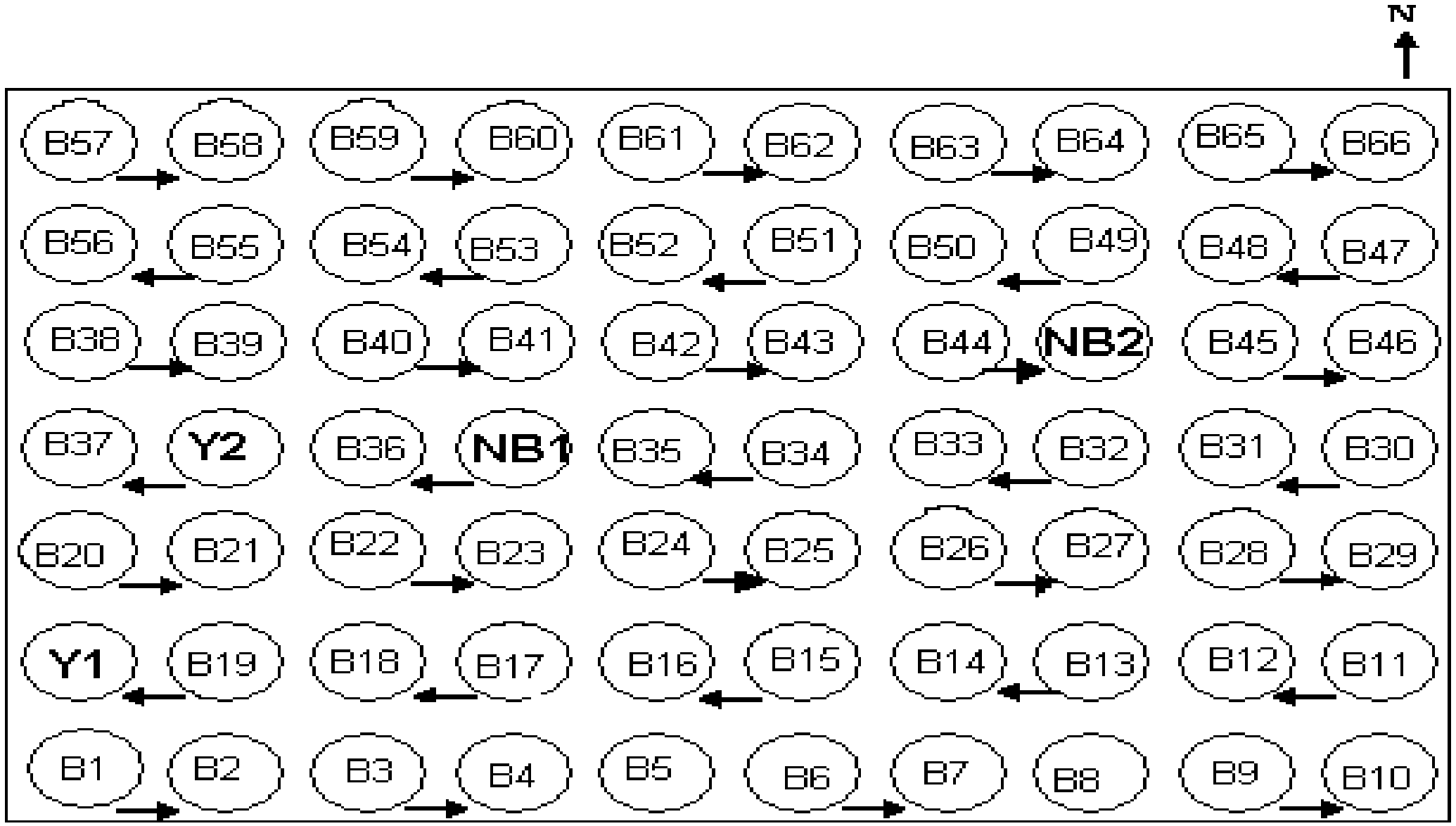
N

PROCEDURE OF CROP CUTTING:

Orange, Peach, Pear, Lime, Lemon, Mango, Guava, Cashew-nut, etc.

South west corner of the selected orchard should be located first. South west corner of the orchard is the corner where while standing facing the north the orchard should lie on the right hand side.

Fruit trees have to be counted in a serpentine fashion from southwest corner moving towards the length (customary) of the orchard. Numbering of trees should be done as per status of tree i.e. bearing, non-bearing and young (Fig.-1).



B=Bearing, NB=Nonbearing, Y=Young

MANGO ORCHARD
Figure-1: Step 1- Enumeration and Numbering the Trees

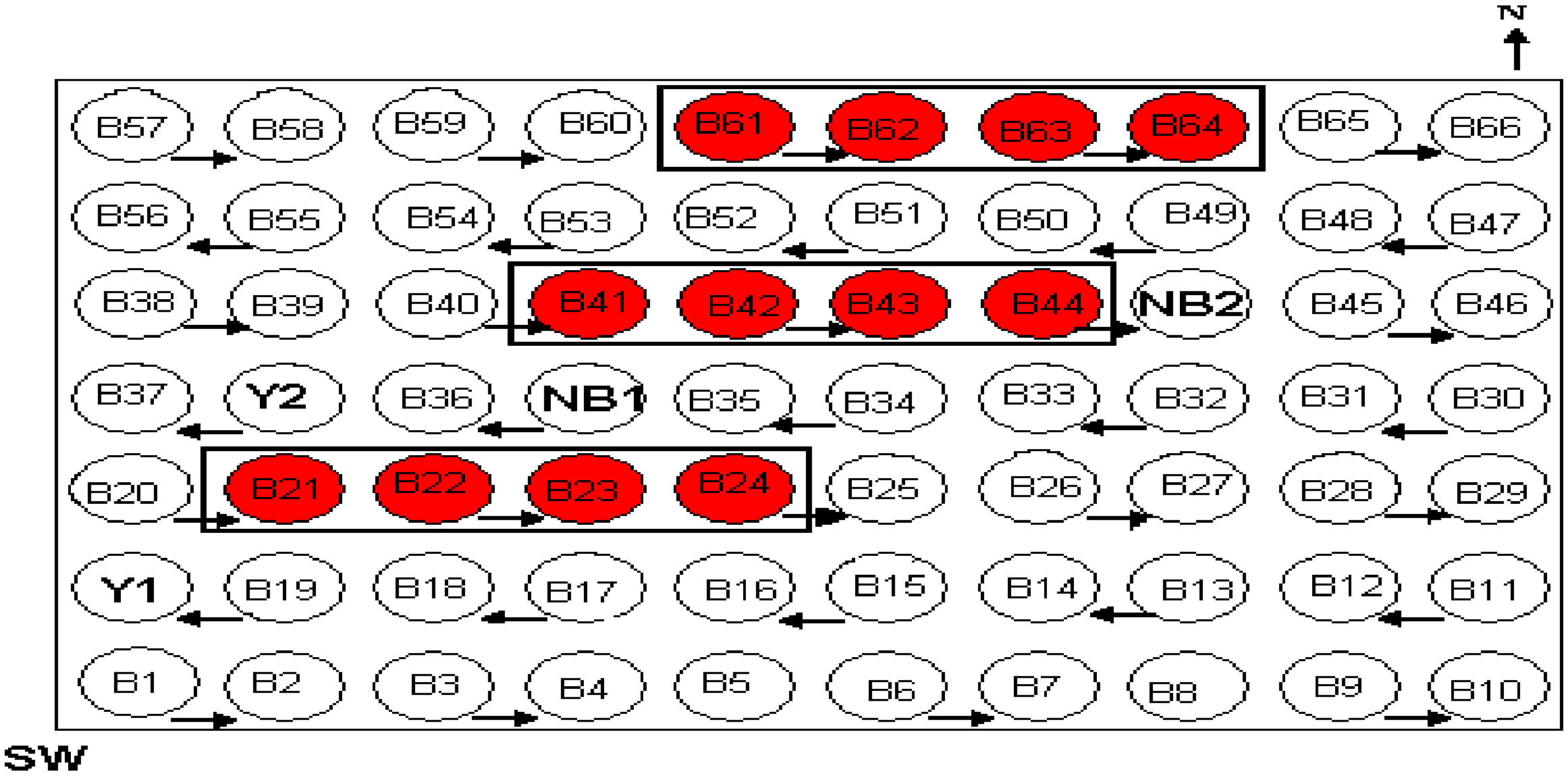
Selection of clusters:

All fruit bearing trees will be considered for making the cluster. A cluster consists of four fruit bearing trees. Therefore, all fruit bearing trees of the selected orchard will have to be divided by 4 to obtain the total number of clusters. There is a chance of having one or two or three trees in the last cluster. Out of total number of clusters, three clusters will be selected randomly for recording the produce Figure-2.

Example: As shown in figure-1, there are 66 fruit bearing trees which form 17 clusters (16 are complete clusters and 17^{th} cluster has two trees). Out of 17 clusters, three clusters have to be selected using two-digit random number table. Column number 1 of two digits is referred for selection of cluster.

Contd.

Since random number 11, 06 and 16 appear, therefore, clusters number 06, 11 and 16 are selected (Fig.-2). The cluster number 6 contains tree number 21, 22, 23 and 24. Cluster number 11 has tree number 41, 42, 43 and 44. Tree number 61, 62, 63 and 64 are in cluster number 16. Tree number 21, 22, 23 and 24 of cluster number six, tree number 41, 42, 43 and 44 of cluster number 11 and tree number 61, 62, 63 and 64 of cluster number 16 are to be observed for recording the yield. Each picking or harvesting of selected fruit trees of selected clusters has to be observed as per usual practice and recorded at the appropriate place.



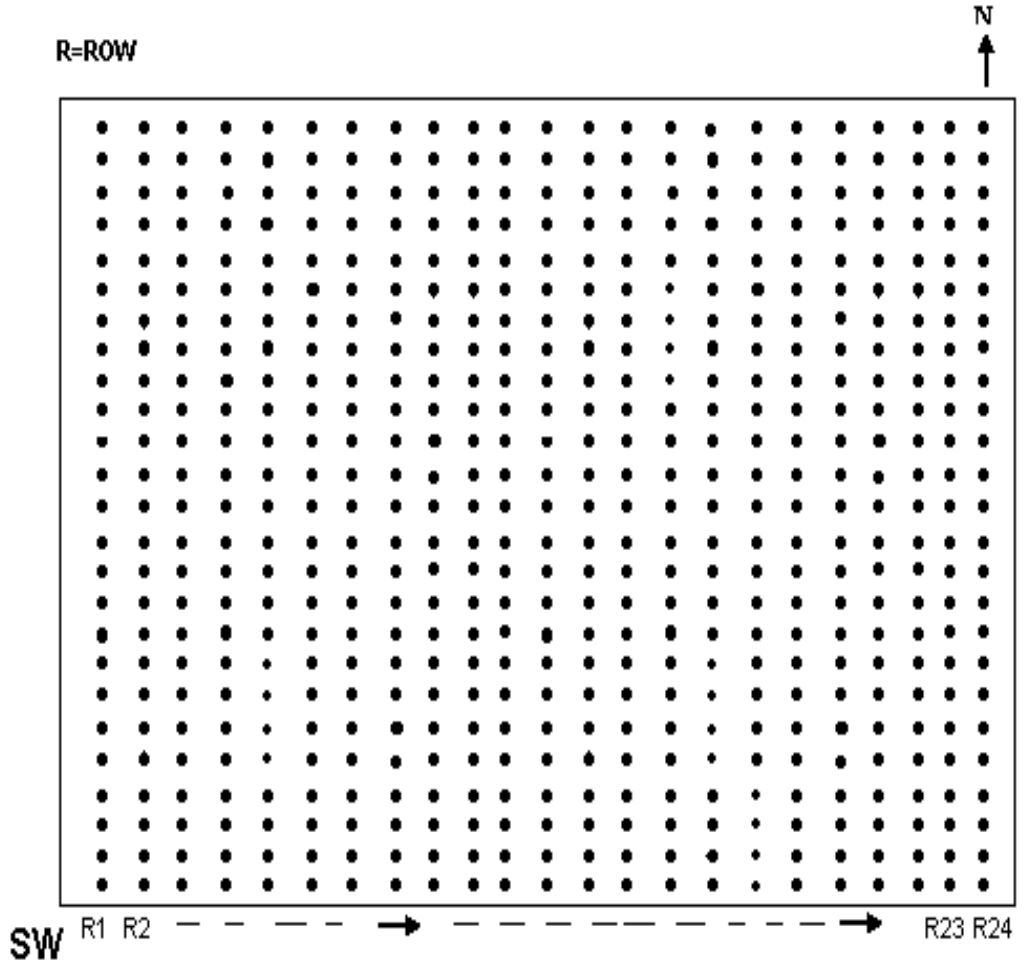
MANGO ORCHARD

Figure-2: Step 2- Selection of Cluster

2.2 BANANA, PAPAYA AND ARECANUT:

2.2.1 Enumeration of rows:

Starting from the south west corner of the selected orchard in the direction of length of the field, count the total number of rows in the orchard (Fig.-3).



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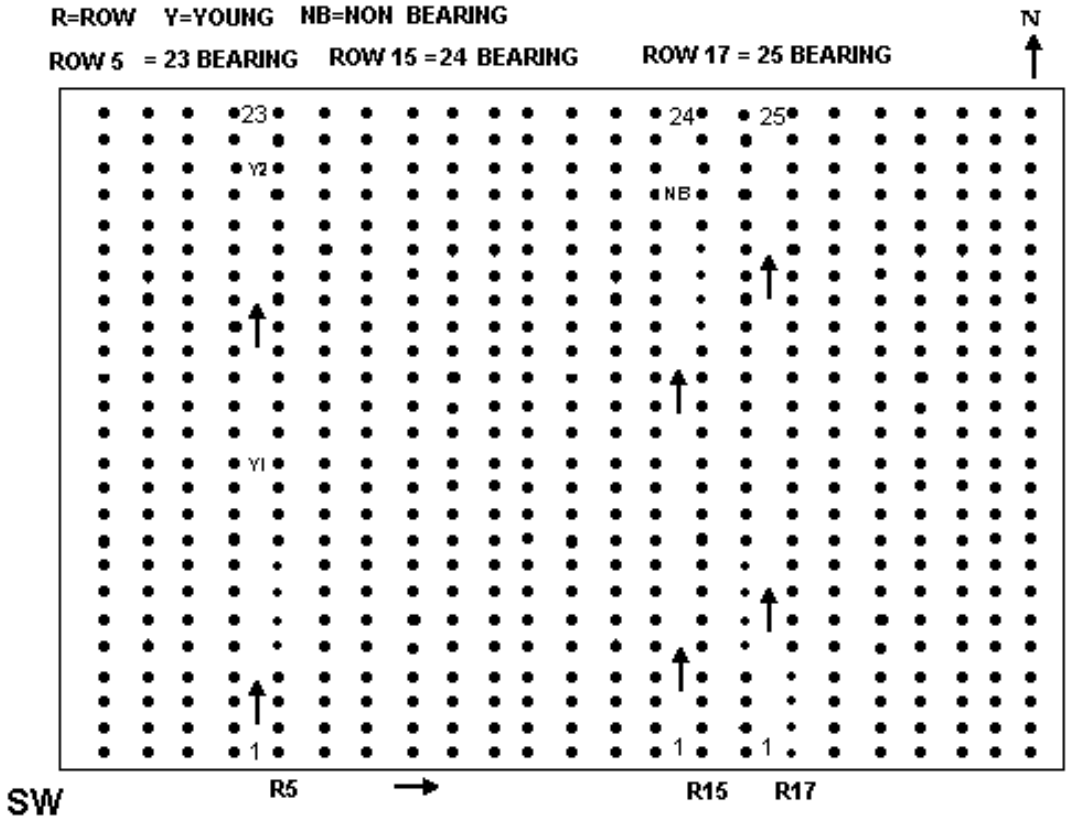
Selection of rows and enumeration of trees in selected rows:

Out of the total number of rows, select three rows randomly. Mark the selected rows, count the total number of trees in each selected row and give the number for each tree as per status of tree i.e. bearing, non-bearing and young (Fig.-4).

2.2.3 Selection of clusters:

Make the cluster of trees (cluster = four fruit bearing trees) in each selected row and select one cluster randomly from each selected row. Mark the trees of each selected cluster in each selected row and observe the trees for recording the yield per tree (Fig.-5).



Step 2-Enumeration of Trees in Selected Rows

Contd.

Example: There are 23 rows in the banana orchard. Referring to the column number two of two digit random number table, the selected rows are 5, 15 and 17. Numbering for each tree in each selected row should be done. In row number 5, 23 plants are fruit bearing and two are young. In row number 15, 23 plants are fruit bearing one is young and one is nonbearing. In row number 17, 22 plants are fruit bearing and one is nonbearing and two are young.

There are six clusters in each selected row. In rows 5, 15 and 17, last cluster has 3, 3 and 2 fruit bearing respectively. From each selected row one cluster has to be selected randomly using column number three of one digit random number table. Thus cluster number 2 of row number 5, cluster number 5 of row number 15 and cluster number one of row number 17 has been selected for recording the yield. The bunch of the banana has to be cut when it is fully matured. The weight of the bunch and number of fingers (banana) in bunch has to be recorded at appropriate place.

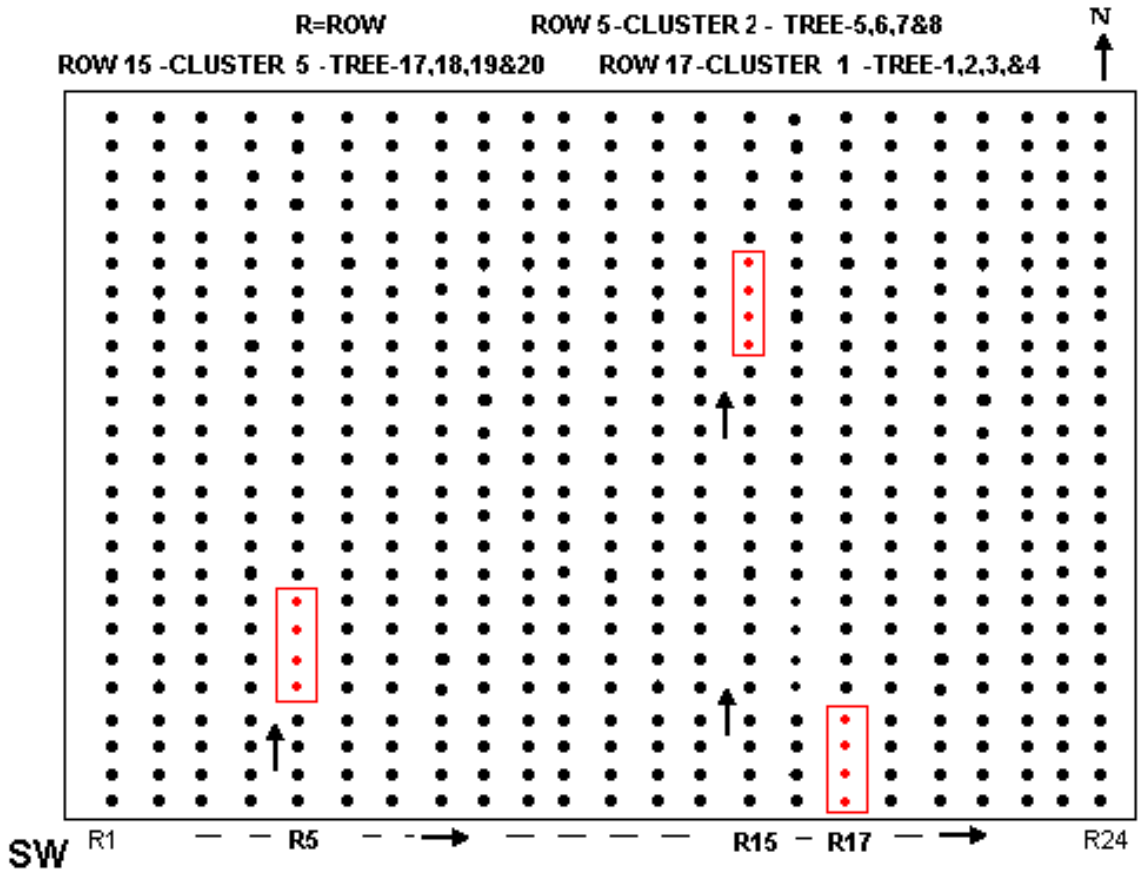
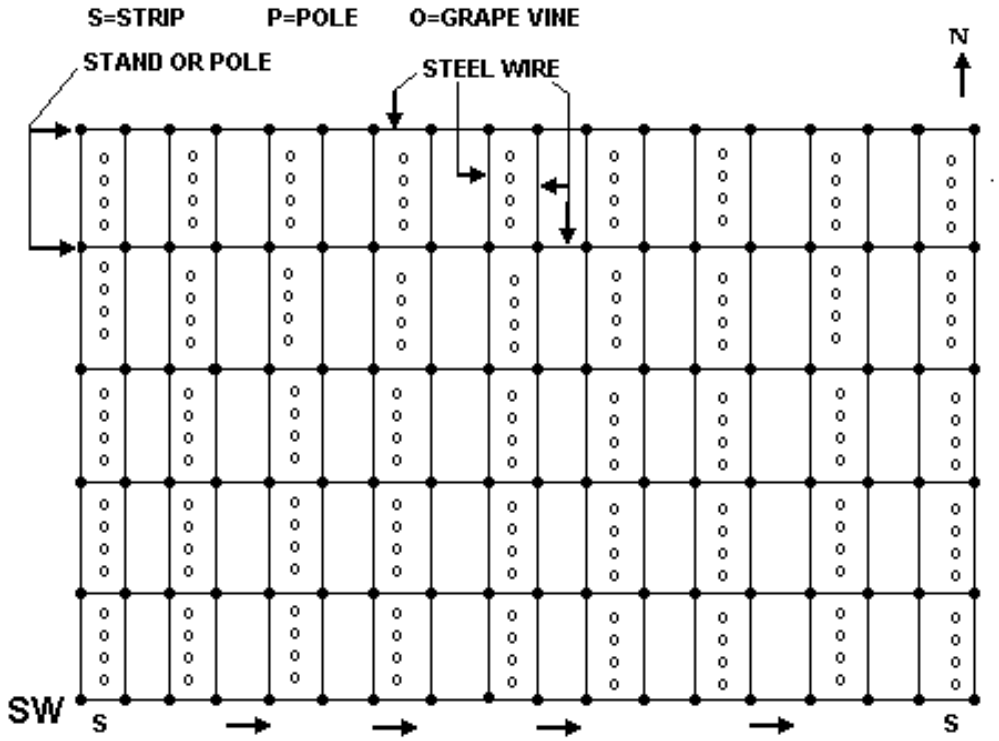


Figure- 5: Step 3- Selection of Cluster

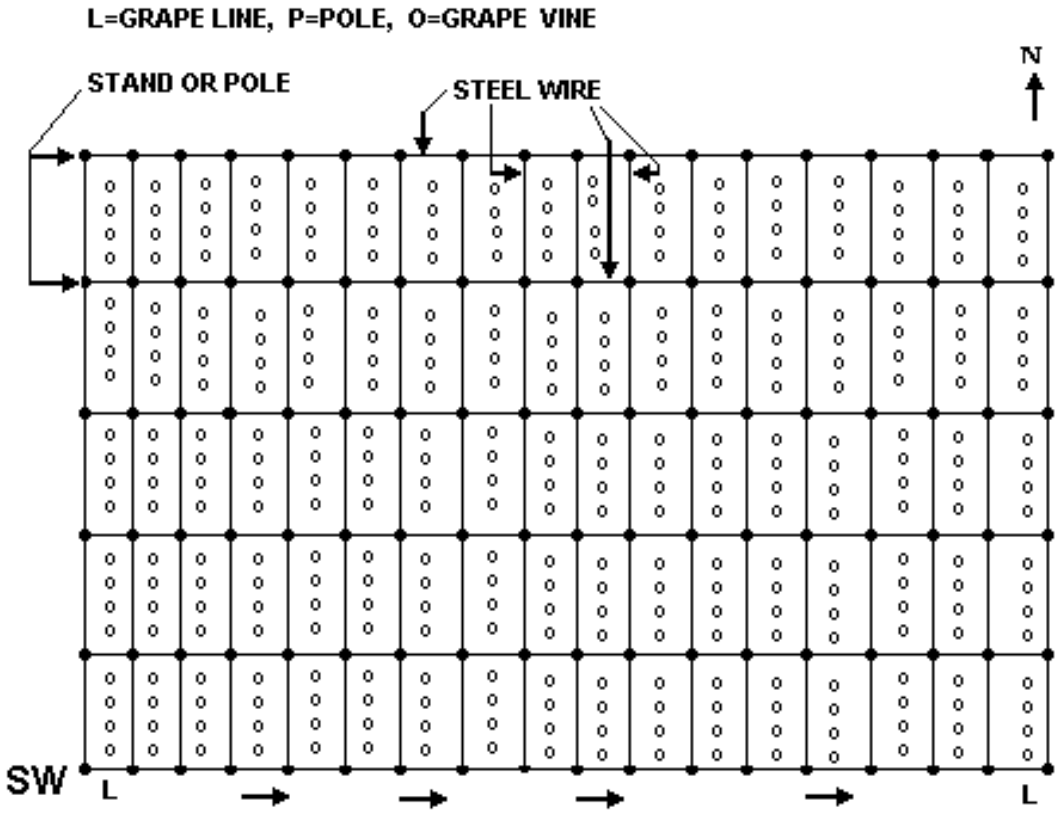
GRAPE:

Generally, grape vines are planted in the middle of the alternate row of stand/pole (Fig. 6).
The grape vines which are planted between two rows of stand/pole are called strip of grape vine.
The stands/poles are made of concrete or iron. The height of the pole varies between 6 to 7 feet from orchard to orchard.
The poles and steel wires tied on the top of the poles provide support to the grape vine.
The steel wire goes through the top of each pole in all the direction and makes a net type structure on which the grape vines hang (Fig. 6 and 7).
To avoid preventing the expenditure on pole, some farmers use every row for planting the grape vines (Fig. 7).



GRAPE ORCHARD

Figure – 6: Standard Planting Pattern



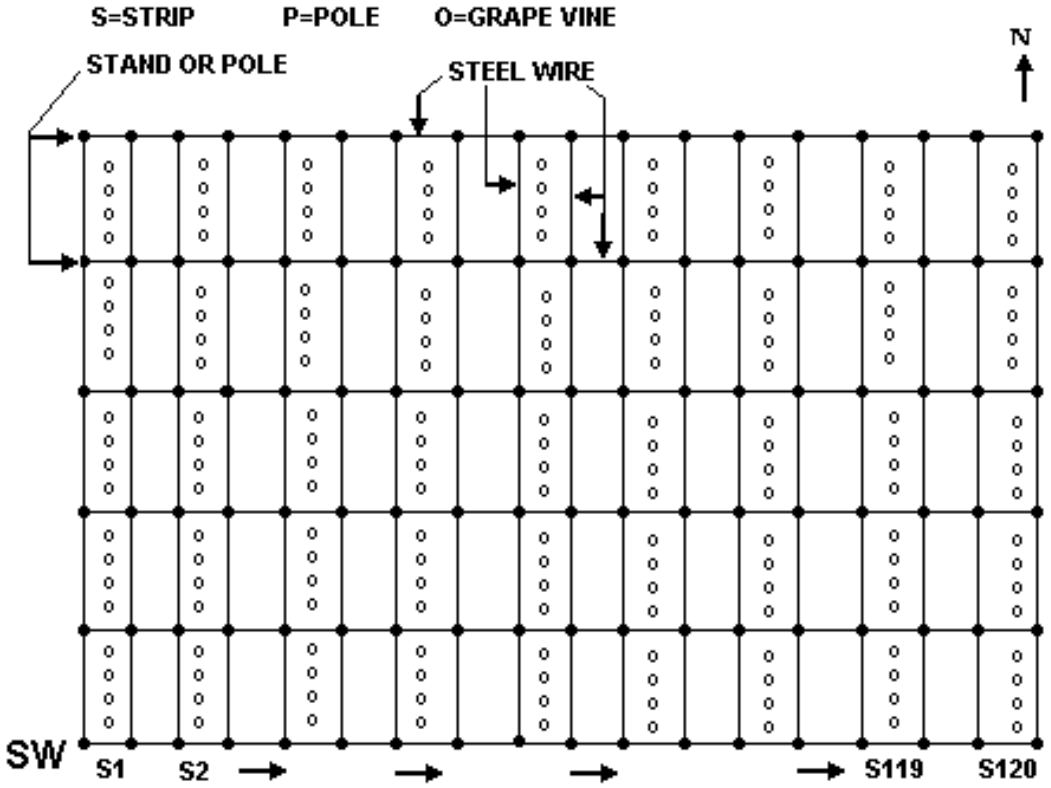
GRAPE ORCHARD

Figure - 7: Planting Pattern at farmers fields

Contd.

Enumeration of grape vine strip:

Moving from south west corner of the orchard towards the length, grape vine strips will have to be counted first (Fig. 8). For estimation of grape yield, two plots have to be selected randomly in each selected orchard. Therefore, out of the total number of grape vines strips, two strips will be selected at random. In each selected grape vine strip one random plot will be selected randomly. As shown in figure 8, there are 120 strips in the orchard. Using column number three of three digit random number table the random number which appears first is 99 followed by 92.



GRAPE ORCHARD (Standard Planting Pattern)

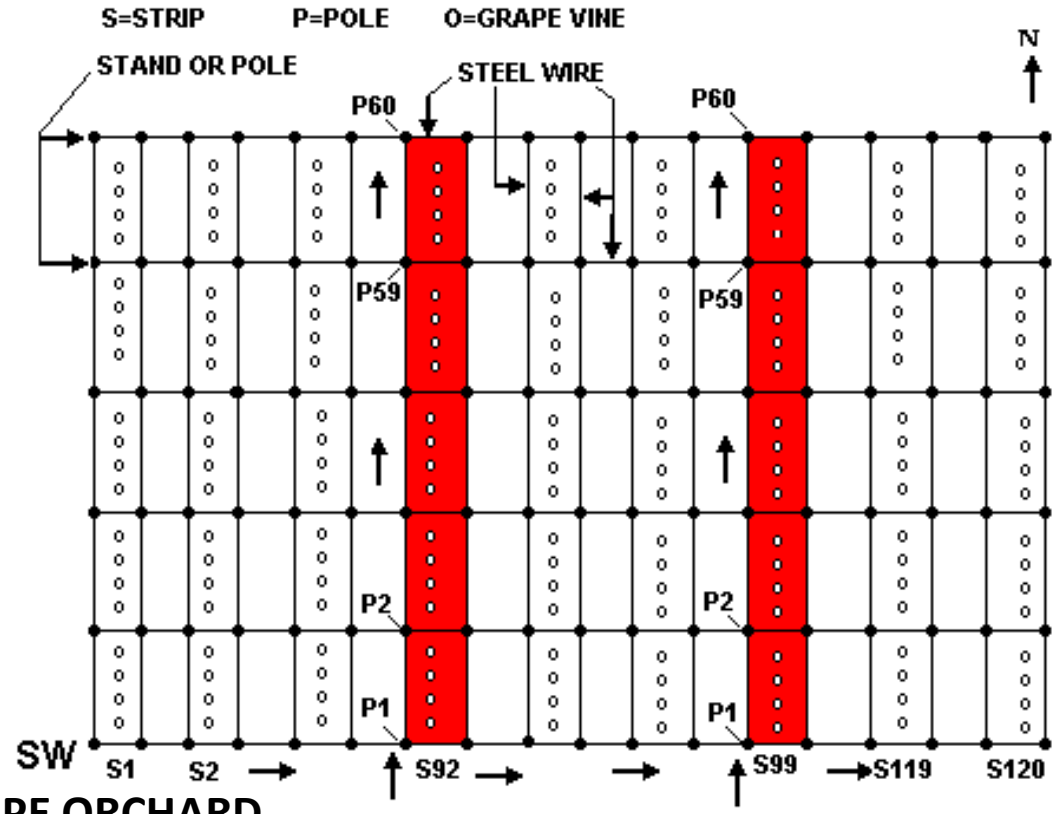
Figure - 8: Step-1 Enumeration of Grape Vine Strips

Contd.

Enumeration of stands/pole and selection of key stand:

The total number of stands/poles will be counted in preceding row of the stand/pole of the selected grape vine strip (row number 92 and 99; Fig.9). For demarcation of random plot within the orchard, one will be deducted from the total number of stands/poles. One random number which is equal to or less than the number obtained after deduction has to be selected randomly to locate the key stand/pole of the experimental plot.

The number of stand/pole corresponding to selected random number will be the key stand/pole and will be the first fixed corner of the plot on the land. As shown in figure 9, there are 60 stands/poles in each selected row. Using column number three of two digit random number table, the random number 20 appear first followed by 40. The random pair for identifying the key stand is (99, 20) and (92, 40). Pole number 20 is the key pole in row number 99 and pole number 40 is the key pole in row number 92. Key pole is denoted by “A”.



GRAPE ORCHARD

Figure - 9: Step-2 Enumeration of Stands/Poles in Selected Grape Vine Strip

Marking of experimental plot:

Experimental plot for picking of the grapes will be formed above the ground because the grape vine used to spread on the steel wire is tied along the top of the poles. Key pole is the first pole of the plot. The second pole is the nearest pole in the direction of length of the orchard. The third pole and fourth pole will be parallel to the first and second pole in the direction of breadth and inner side of the field in the same grape vine strip.

First, second, third and fourth pole is denoted by “A”, “B”, “C” and “D” respectively. For making the experimental plot half of the area (up to mid line) of both sides strip in which no grape vines is planted will be included. The size of the random plot will vary according to the distance between the stands. The area of the experimental plot must be recorded. The grape bunches within the area covered by the experimental plot has to be picked up regularly as per the practice till pickings are over.

Contd.

Example: As shown in the figure 10, “B”, “C” and “D” are the poles nearer to the key pole “A”. For including the half of the area of the adjoining strips of both side in the plot, the pole nearer to “A”, B”, “C” and “D” is denoted by a, b, c and d respectively. The mid point of the steel wire tied between first pole “A” and its nearest pole “a” in the left direction (preceding row) say “E”, the mid point of steel wire tied between fourth pole “D” and its nearest pole “d” in the left direction (Preceding row) say “H”, mid point of steel wire tied between second pole “B” and its nearest pole “b” in the right direction (Succeeding row) say “F” and mid point of steel wire tied between third pole “C” and its nearest pole “c” in the right direction (Succeeding row) say “G” has to be marked.

Rope should be tied between “E” and “H”, “F” and “G”. Steel wire is already tied between “E” and “F” & “G” and “H”. E, F, G and H are the four corners of a rectangular experimental plot of grape. The grape bunches within the area covered by the experimental plot E, F, G and H has to be picked up as per the practice. The same procedure may be followed to mark the second experimental plot in the orchards (Fig.11).

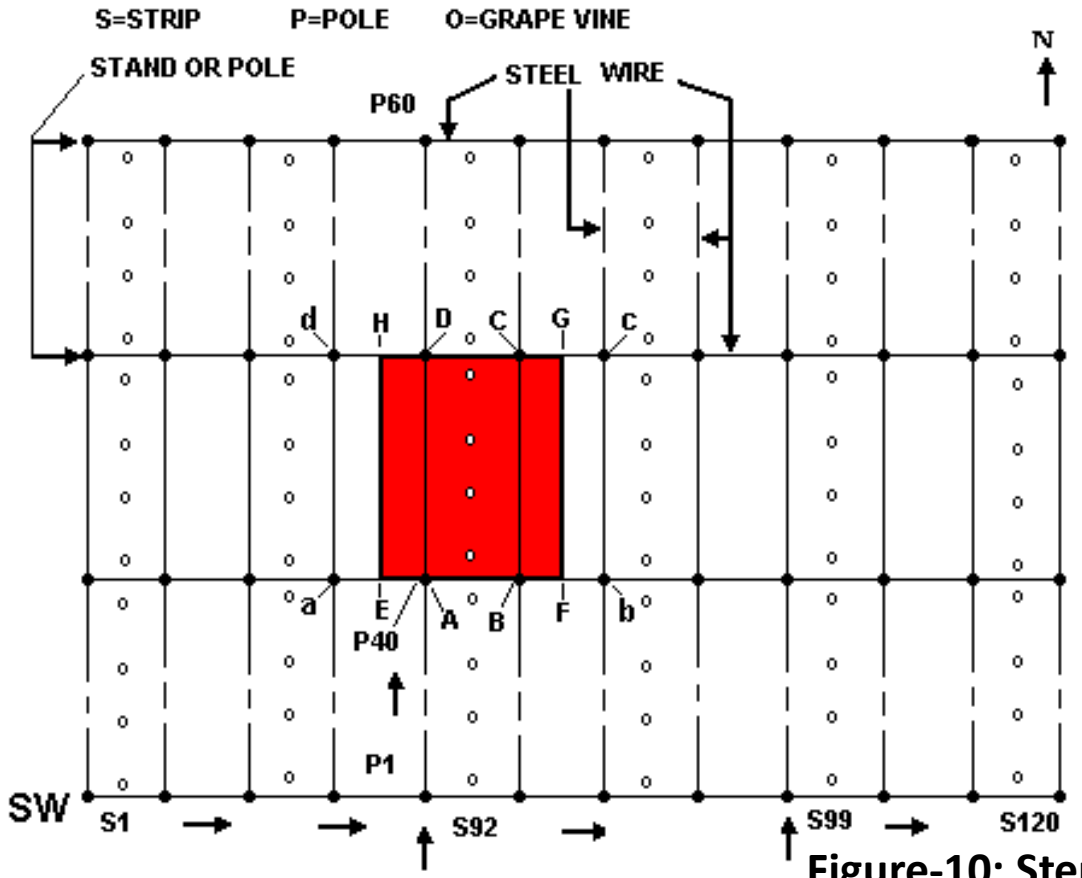
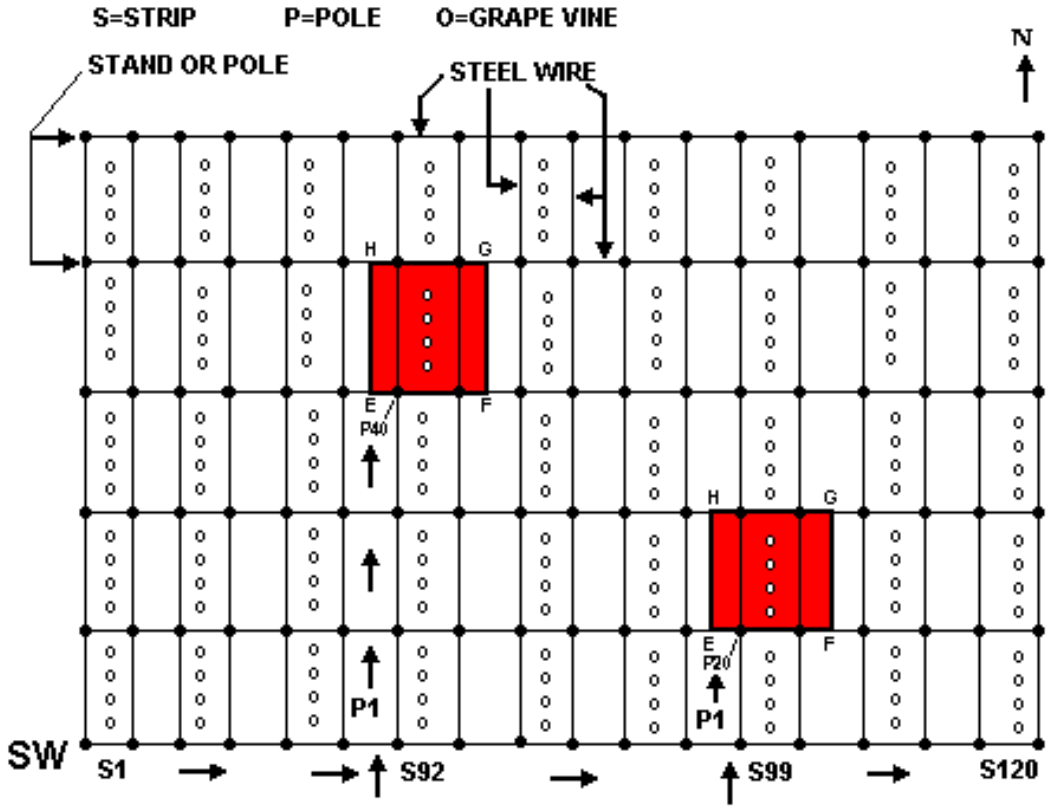


Figure-10: Step-3 Marking of Experimental Plot



GRAPE ORCHARD

Figure-11: Experimental Plot

Figure-1: Pure Orchard of Mango

36	37	38	39	40	41	42
35	Y-1	34	33	NB-4	32	31
26	27	28	NB-2	29	30	Y-3
25	24	23	22	21	20	19
13	14	NB-1	15	16	17	18
12	11	10	9	NB-3	8	Y -2
1	2	3	4	5	6	7

South West Corner
Y=Young, NB=Non-Bearing

Figure- 2: Mixed Orchard of Mango and Guava

7M	1G	13M	7G	17M	18M	29M
6M	Guava Y-1	12M	8G	Mango NB-4	19M	28M
5M	2G	11M	Guava Y-2	16M	20M	27M
4M	3G	10M	9G	15M	21M	26M
3M	4G	Mango NB-1	10G	14M	22M	25M
2M	5G	9M	Guava Y-3	Mango NB-3	23M	24M
1M	6G	8M	Guava NB-1	Mango NB-2	Mango NB-5	Mango Y -1

South West Corner

M=Mango, G=Guava, Y=Young, NB=Non-bearing

Contd.

In case of banana, papaya and grapes, write down the number for each row / strip in the sketch starting from the south west corner and numbering of trees/stands

will be done only for selected rows/strips. Suppose the selected rows are 1, 4 and 6, trees in these rows will be numbered as shown in figure 3 for Banana and Papaya.

In case of Grapes orchards, stands in the selected strips will be numbered.

Numbering of trees in a row should be done as per status of tree as bearing, non-bearing and young.