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Assessment of sampling units for sucking pests of okra

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Abstract
The present investigation was conducted during *kharif* season for the year 2015-16 and 2016-17 at Experimental Farm of Department of Entomology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, and Akola. An experiment was laid in Randomized block design. Sampling unit's *viz*., number of leaves according to strata i.e. top, middle and bottom canopy of selected plants were evaluated to determine best sampling unit for sucking pests. The results revealed that for counting of sucking pests, selection one each leaf from top, middle and bottom stratum of the plant gave highest population of sucking pests during both the season. Hence, this stratified sampling is appropriate and should be used for counting of sucking pests on okra.

Keywords: Stratified sampling, stratum, sampling units, canopy

Introduction
Okra or lady's finger also called as bhendi (*Abelmoschus esculentus* L, Moech) belongs to family malvaceae. Okra is one of the most popular vegetable crop grown extensively all over India besides India it is also grown in many tropical and subtropical parts of the world especially USA, Australia, Turkey, Africa, UK and other neighboring countries. Vegetable constitute an important item of our food supplying vitamins, carbohydrate and minerals needed for a balanced diet. Their value is important especially in under developed and developing countries like India, where malnutrition abound [8].

One of the limiting factors in the cultivation of okra is insect pest. In designing a pest management program, the methods for estimating population densities as well as sampling program including sampling unit, identification of the appropriate sampling time, determination of sampling pattern, and sample size have crucial role. By a comprehensive sampling program, a lot of information can be obtained which are used in ecological investigations such as study of population dynamics, detecting pest levels that lead to a justification of control measures and assessing crop loss [4]. When sampling, the objective may be to understand and predict the distribution, abundance, and possibly the interaction of a populations with the host crop. Or, the objective may be to apply the information gathered to aid in managing a crop.

Among several vegetable crops cultivated in India. Okra plants are attacked by a number of insect pests at different growth stages. Okra is ravaged by many insect pests right from germination to harvest [3]. These pests are major constraints in getting higher yields [5]. As many as 48 insect pest species which includes sap suckers, leaf suckers, leaf eaters, fruit borers, leaf rollers, flower feeders and leaf miners attack and damage okra crop [2]. The crop suffers from as many as 72 species of insect pests, which are responsible for low yield in crop [10] reported about 40.56 percent losses in okra due to leaf hopper. There is reduction of 49.8 and 45.1 per cent in height and number of leaves, respectively due to attack of leaf hopper [9]. Aphids and leaf hoppers are important pest in the early stage of the crop which desap the plant, make them weak and reduce the yield. Failure to control them in the initial stages was reported to cause a yield loss to the tune of 54.04 percent the spider mite, *Tetranychus cinnabarinus* has assumed the status of major pest and caused 17.46 per cent yield loss in okra.

Decision making is a key aspect of current integrated pest management (IPM) programs and will continue to play an important role as IPM programs mature. In an IPM context, decision making relies on protocols for deciding on the need for some management action based on an assessment of the state of a pest population. These protocols, which we refer to as control decision rules, consist of at least two components and may include a third a) a procedure for assessing the density of the pest population, b) an economic threshold and c) a phonological forecast, which is often necessary to determine the appropriate time to assess population densities. Assessment of pest density usually requires obtaining actual counts of the pest, and therefore, sampling is important. Because sampling is time consuming and expensive, one must know how to gather enough information about pest abundance to be able to make correct decisions without incurring excessive costs. Decision making in IPM is important for two reasons. First, decision making protocols can be used to reduce pesticide use. Ideally, IPM relies on being tactics such as biological control, plant resistance, and cultural practices to maintain fluctuating pest populations below economic injury levels.

Sampling is important for farmers and pest managers to understand insect activity in their crops and fields before they can make cost-effective and environmentally sound pest management decisions. Thus, the main objectives of insect sampling (pest and beneficial) are to: detect species that are present, determine their population density; determine how they are distributed in the field.

Insect's pests are responsible for enormous financial and production losses in agriculture and forestry. However, pest control can be expensive and often engenders concern over environmental impacts. A central goal of modern integrated pest management is to deploy pest-control interventions as efficiently as possible, in order to reduce crop damage at minimum cost and with minimum collateral damage to the environment. Perhaps the most basic requirement for any pest management program is the availability of a sampling method for assessing the level of infestation (either estimating mean pest density, or judging whether density exceeds a threshold beyond which intervention is deemed necessary). Estimating insect densities in the field is far from a simple task, and it involves decisions about when to sample during host or insect phenology, what to sample quadrant, whole plant, appropriate organ, or representative module; e.g., and which and how many plants, or other sampling units, to sample from the large number available at a site. Estimation is achieved by including more samples and selecting them in more sophisticated ways; but doing so requires more time, money and labour. Achieving the most accurate estimates from the smallest investment of effort can involve ingenuity in field technique,

Materials and Methods

The present investigation entitled "Assessment of sampling units for sucking pests of okra" conducted during *kharif* season for the year 2015-16 and 2016-17 at Experimental Farm of Department of Entomology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, and Akola. An experiment was laid in Randomized block design. The observations were recorded from five treatments and four replications at weekly interval at initiation of pests. Count of aphids, leafhoppers and white fly adults was recorded on leaves from various strata of selected plants. Leaves from various stratums i.e. top, middle and bottom canopy of selected plants was taken into accounts in order to determine appropriate sampling units. One each leaf from top, middle and bottom stratum of plant, Two leaves from top, one from middle, and one from bottom stratum of plant, Three leaves from top, one from middle, and one from bottom stratum of plant, Three leaves from top, two from middle, and two from bottom stratum of plant, Four leaves from top, one from middle, and one from stratum of plant. These sampling units were optimized by week wise counting of sucking pests. Then data were transformed into corresponding square root, square root of (x+0.5) values and was subjected to statistical analysis. It may not possible to consider entire population for the purpose of its measurement. The practical approach is to measure a part of it and then calculate the size of whole population. Life cycle of an insect pests determines the seasonal timing of sampling when only a single stage is being sampled that should be coincide with peak population.

Results and Discussion

Sucking pests population influenced by various sampling unit during kharif, 2015

The data given in Table 1 and Fig.1 presented sucking pests population (No/leaf) influenced by various sampling units during kharif, 2015. Aphid, leafhopper and whitefly population (No/leaf) when recorded in different canopy and in various sampling it was found that aphid population (No/leaf) in various sampling units on top and middle strata of plant was statistically significant. Treatment T_1 (i.e. counting of aphid nymph each one leaf from top, middle and bottom strata) was found significantly superior over rest of the treatments in recording maximum population (22.32) and (24.33) respectively. At bottom stratum, it was non-significant in various sampling unit.

Mean population data on aphid was found statistically significant and treatment T_1 i.e. counting of aphid nymph each one leaf from top, middle and bottom strata was found significantly superior over rest of the treatments in recording maximum population i.e. (21.04), it was followed by T_2 which was found at par to treatments T_4 and T_3.

Leafhopper population (No/leaf) in various sampling units on top, middle and bottom strata was statistically significant. Treatment T_1 (i.e. counting of leafhopper each one leaf from top, middle and bottom strata) was significantly superior over T_3, T_4 and T_5 and found at par to T_2. In middle and bottom stratum treatment T2(i.e. counting of leafhopper two leaf from top, one each leaf from middle and bottom strata of plant) was found significantly superior over T_4 and found at par to rest of the treatments and recording maximum population i.e.(18.10) and (17.48) respectively.

Mean population of leafhopper was found statistically significant Treatment T_1 (i.e. counting of leafhopper nymph each one leaf from top, middle and bottom strata) was found significantly superior in recording maximum population i.e. (12.74) followed by T_2 and T_3. And lowest population recorded at treatment T_5 i.e. (7.45) which was found at par to T_4.

Whitefly population (No/leaf) in various sampling units recorded on top stratum treatment T_1 (i.e. counting of whitefly nymph each one leaf from top, middle and bottom strata) was significantly superior over remaining treatments in recording maximum population i.e. (1.70). It was followed by treatment T_2 which was found at par to T_3, T4 and T_5. At middle stratum, treatment T_3 was found superior over T_4 and found at par to rest of the treatments. At bottom stratum, it was found that treatment T_5 (i.e. four leaves from top, one from middle and one from bottom stratum significantly superior over T_4- Three leaves from top, two from middle, and two from bottom stratum of plant and found at par over rest of the treatments.

Mean population of whitefly was found statistically significant Treatment T_1 (i.e. counting of whitefly each one leaf from top, middle and bottom stratum of plant) was significantly superior over remaining treatments in recording maximum population (7.88). It was followed by T_2 which was found at par to T_3.

Sucking pests population influenced by various sampling unit during kharif, 2016

The data presented in Table 2 and Fig.2 indicated sucking pests (No/leaf) population influenced by various sampling unit during crop season 2016. The data on aphid population (No/leaf) on top stratum according to different sampling units, strata was found statistically non-significant. Whereas, data on middle canopy of plant was statistically significant Treatment T_2 (i.e. counting of aphid two leaves from top, one from middle and one from bottom stratum of plant) was found significantly superior in recording maximum population i.e. (10.15). It was followed by treatment T_5 which found at par to T_1 and T_3. At bottom stratum, treatment T_5 was significantly superior over rest of the treatments and found at par to T_3. It was followed by treatment T_2 which was found at par to T_4 and T_1.

Table 1: Sucking pests population influenced by various sampling unit during kharif, 2015

Sampling unit	Sucking pest population in various stratum of plant (No/leaf)											
	Aphid /leaf				Leafhopper/leaf				Whitefly/leaf			
	Top	Middle	Bottom	Mean	Top	Middle	Bottom	Mean	Top	Middle	Bottom	Mean
T_1	22.32	24.33	16.61	21.04	4.24	16.57	16.83	12.74	1.70	9.75	11.35	7.88
	(4.72)*	(4.89)*	(4.05)*	(4.58)*	(2.06)*	(4.07)*	(4.10)*	(3.57)*	(1.30)*	(3.12)*	(3.37)*	(2.80)*
T_2	11.14	14.97	14.11	12.95	3.43	18.10	17.48	10.64	1.25	10.39	11.19	5.95
	(3.33)	(3.86)	(3.73)	(3.59)	(1.85)	(4.25)	(4.18)	(3.26)	(1.11)	(3.22)	(3.46)	(2.44)
T_3	6.87	17.92	15.56	10.51	2.59	17.84	17.37	9.00	1.05	11.15	12.30	5.26
	(2.62)	(4.23)	(3.73)	(3.24)	(1.60)	(4.22)	(4.16)	(3.00)	(1.02)	(3.33)	(3.50)	(2.29)
T_4	10.34	13.72	10.96	11.43	2.66	10.96	11.04	7.51	1.1	7.08	7.24	4.44
	(3.36)	(3.67)	(3.29)	(3.38)	(1.63)	(3.31)	(3.32)	(2.74)	(1.05)	(2.66)	(2.69)	(2.10)
T_5	6.04	17.90	14.47	9.49	2.68	17.12	16.70	7.45	1.18	10.54	12.42	4.56
	(2.45)	(4.22)	(3.70)	(3.08)	(1.64)	(4.14)	(4.08)	(2.72)	(1.08)	(3.25)	(3.52)	(2.13)
SE (m±)	0.21	0.21	0.42	0.12	0.07	0.06	0.08	0.05	0.05	0.10	0.06	0.05
CD at 5%	0.64	0.66	-	0.37	0.20	0.19	0.23	0.15	0.14	0.29	0.17	0.15
CV %	12.74	10.22	22.79	6.79	7.50	3.10	3.78	3.21	8.24	6.07	3.40	4.08

* Figure in parentheses indicates √x value

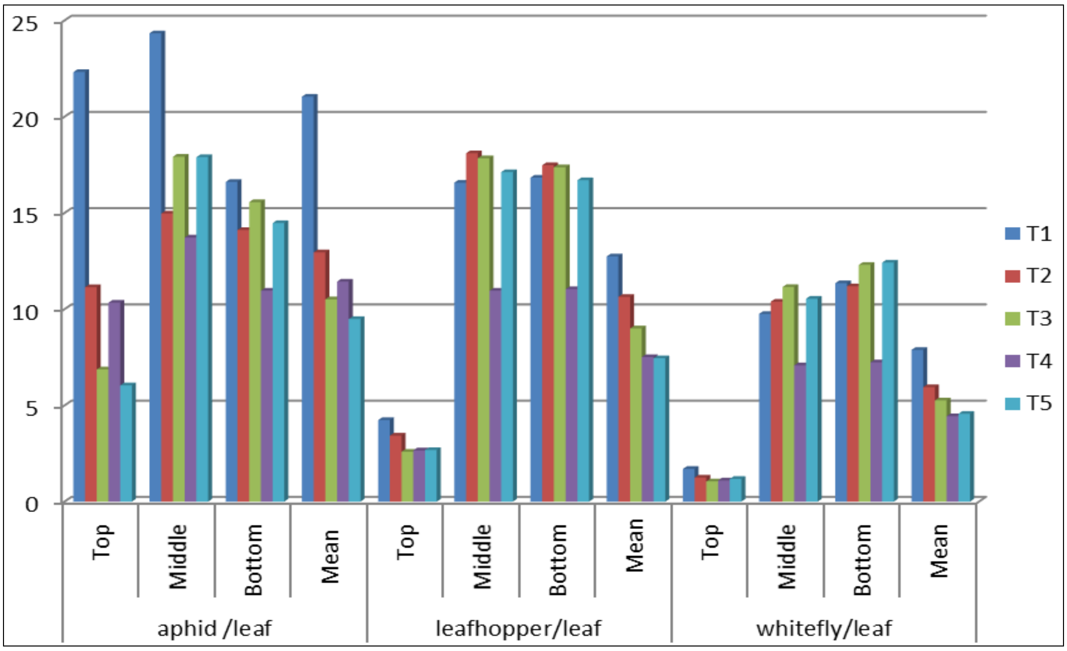

Fig 1: Sucking pests population influenced by various sampling unit during crop season 2015

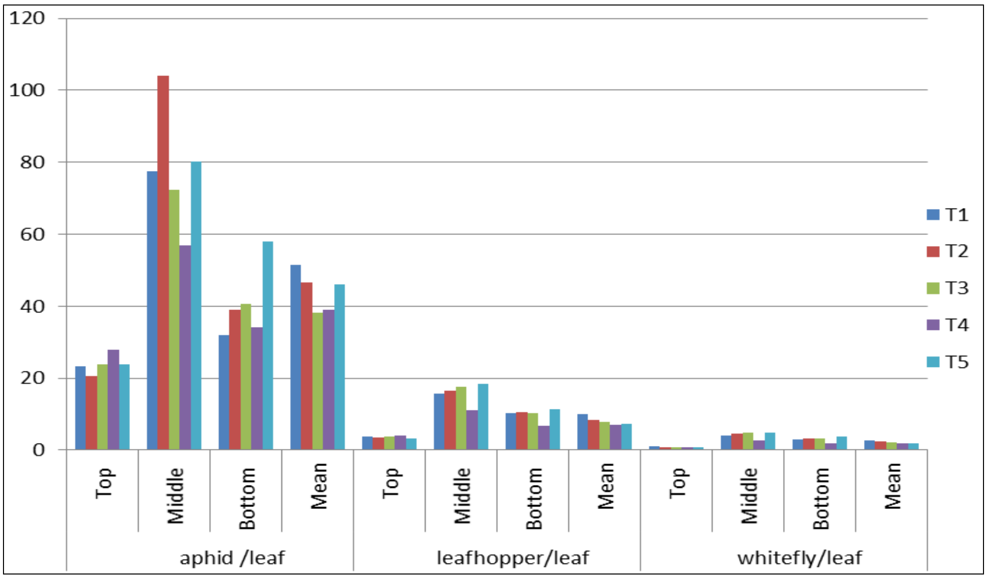

Fig 2: Sucking pests population influenced by various sampling unit during crop season 2016

Mean population of aphid was found statistically non-significant. However, numerically maximum population recorded at treatment T_1 i.e. (51.50).

The data on leafhopper population (No/leaf) on top canopy of plant in various sampling units was statistically non-significant. Whereas, population at middle stratum, of plant was statically significant treatment T_5 was found significantly superior recording highest population i.e. (18.33) which was found at par to T_1. It was followed by treatment T_3 which found at par to T_2. Lowest population recorded at treatment T_4. Highest mean population of leafhopper (9.96) was recorded in T_1 (i.e. counting of leafhopper each one leaf from top, middle and bottom strata of plant) it was followed by treatment T_2 which found at par to other treatments. The data on whitefly population (No/leaf) in different strata of plant (i.e. top, middle and bottom). At top stratum was found statistically non-significant. Whereas at middle and bottom stratum was found statistically significant treatment T_5 i.e. four leaves from top, one from middle and one from bottom stratum of plant found statistically at par to treatment T_3, T_2, T_1 and T_2, T_3 and T_1 respectively.

Mean population of whitefly was found statistically significant treatment T_1 i.e. one each leaf from top, middle and bottom canopy was found significantly superior and found at par to each other treatment.

Sucking pests population influenced by various sampling unit (pooled mean of kharif, 2015 and 2016)

The data presented in Table 3 and Fig. 3 indicated sucking pests (No/leaf) population influenced by various sampling unit (pooled mean of kharif, 2015 and 2016).

Table 2: Sucking pests population influenced by various sampling unit during kharif, 2016

Sampling units	sucking pest population in various stratum of plant (No/leaf)											
	Aphids /leaf				Leafhopper/leaf				Whitefly/leaf			
	Top	Middle	Bottom	Mean	Top	Middle	Bottom	Mean	Top	Middle	Bottom	Mean
T_1	23.21 (4.78)*	77.50 (8.78)*	31.98 (5.65)*	51.50 (7.16)*	3.90 (1.97)*	15.58 (3.94)*	10.17 (3.28)*	9.96 (3.15)*	0.98 (0.99)*	3.95 (1.97)*	3.05 (1.74)*	2.74 (1.65)*
T_2	20.54 (4.53)	103.93 (10.15)	39.12 (6.25)	46.64 (6.82)	3.59 (1.89)	16.50 (4.06)	10.56 (3.24)	8.52 (2.92)	0.90 (0.90)	4.72 (2.17)	3.33 (1.82)	2.48 (1.57)
T_3	23.76 (4.83)	72.36 (8.47)	40.77 (6.38)	38.33 (6.18)	3.87 (1.96)	17.63 (4.20)	10.29 (3.20)	7.77 (2.78)	0.76 (0.87)	4.79 (2.19)	3.26 (1.81)	2.09 (1.44)
T_4	27.98 (5.16)	56.84 (7.53)	34.15 (5.79)	39.12 (6.23)	4.02 (2.01)	11.09 (3.33)	6.76 (2.60)	6.93 (2.63)	0.92 (0.95)	2.70 (1.63)	2.02 (1.42)	1.83 (1.35
T_5	23.78 (4.85)	80.08 (8.91)	58.00 (7.47)	46.14 (6.69)	3.34 (1.82)	18.33 (4.28)	11.38 (3.37)	7.25 (2.69)	0.88 (0.94)	4.83 (2.20)	3.82 (1.95)	1.97 (1.40)
SE (m±)	0.23	0.32	0.38	0.37	0.07	0.09	0.03	0.05	0.12	0.08	0.07	0.04
CD at 5%	-	0.99	1.17	-	-	0.26	0.10	0.15	-	0.24	0.21	0.13
CV %	9.31	7.32	12.01	11.22	7.29	4.30	2.05	3.45	8.04	7.54	7.68	5.80

* Figure in parentheses indicates √x value

The data on aphid population (No/leaf) according to different strata i.e. (top and middle) and mean population in various sampling unit (treatments) was statistically significant. Whereas, data on bottom canopy of plant was found non-significant. At top stratum of plant, highest population of aphids (22.77) was recorded in treatment T_1 (i.e. counting of aphid nymphs each one leaf from top, middle and bottom stratum of plant) and it was significantly superior over rest of the sampling unit treatments. Whereas, at middle stratum plant, highest population (59.45) was recorded in treatment T_2 (i.e. sampling of population on two leaves from top and one each leaf from middle and bottom stratum of plant) and it was at par with $T_1$and T_5. Lowest population was noted in T_4 followed by T_3.

Highest mean population of aphid (36.27) was recorded in T_1 (i.e. counting of aphid nymphs each one leaf from top, middle and bottom stratum of plant) and it was at par with T_2. Lowest population was noticed in T_3 and it was at par with T_4 and T_5.

The data on leafhoppers (No/leaf) in different canopy of plant and mean in various sampling units was significant. At top canopy, highest leafhopper population (4.07) was recorded in T_1 (i.e. counting of leafhopper each one leaf from top, middle and bottom stratum of plant) and it was at par with T_2. Lowest population was noticed in T_5 and it was at par with T_3 and T_4. At middle canopy, highest population (17.76) was recorded in T_5 (i.e. four leaves from top, one from middle and one from bottom stratum of plant) and it was at par with T_3 and T_2. At bottom canopy, highest population (14.04) was registered in T_5 (i.e. Four leaves from top, one from middle and one from bottom stratum of plant) and it was at par with T_2, T_3 and T_1. Lowest population was recorded in T_4.

Highest mean leafhopper population was observed in T_1 (i.e. counting of leafhopper each one leaf from top, middle and bottom stratum of plant) followed by T_2 and T_3. Lowest population was noticed in T_4 and it was at par with T_5.

The data on whitefly adults (No/leaf) in different strata of plant and mean in various sampling units was significant. At top canopy, highest whitefly adults (1.34) was registered in T_1 (i.e. counting of leafhopper each one leaf from top, middle and bottom stratum of plant) and it was significantly superior over rest of the sampling treatments. Lowest population was noticed in T_3 and it was at pat with T_4, T5 andT_2. At middle canopy, the highest population (7.97) was recorded in T_3 (i.e. three leaves from top one from middle and one from bottom stratum of plant) and it was at par with T_5, T_2 and T_1. Lowest population was noted in T_4.At bottom canopy of plant, highest population (8.12) was recorded in T_5 (i.e. four leaves from top, one from middle and one from bottom stratum of plant) and it was at par with T_3. Population in T_2 and T_1 stood second in respect of noting higher population. Lowest population was observed in T_4.

Highest mean population of whiteflies (5.32) was registered in T_1 (i.e. counting of whitefly each one leaf from top, middle and bottom stratum of plant) followed by T_2 and T_3. Lowest population was recorded in T4 and it was at par with T_5.

The present finding supported by [7] reported that stratified sampling can improve sampling efficiency by reducing sample variation for a given sampling effort and ensuring that samples are collected from all areas of the habitat. The appropriate sampling method is stratified random sampling of cabbage aphids. [6] Reported that recommended sampling technique and appropriate sampling method is stratified random sampling and visual count of cotton leafhopper. Also [1] Reported sampling leafhopper nymphs and whitefly by visual counting and stratified random sampling method were the most suitable methods for local cotton growers among the various methods compared.

Table 3: Population of leafhoppers influenced by various sampling units (pooled mean of kharif 2015 and 2016)

Sampling units	sucking pest population in various stratum of plant (No /leaf)											
	Aphid/leaf				Leafhopper/leaf				Whitefly/leaf			
	Op	Iddle	Ottom	Ean	Op	Iddle	Ottom	Ean	OP	Iddle	Ottom	Ean
T_1	2.77	0.92	4.30	6.27	.07	6.07	3.51	1.33	1.34	.89	.20	.32
	4.74)*	7.13)*	4.93)*	6.02*)	2.01)*	4.00)*	3.67)*	3.36)*	1.16)*	2.62)*	2.68)*	2.30)*
T_2	5.84	9.45	6.61	9.79	.51	7.30	4.02	.58	.10	.56	.22	.22
	3.97)	7.68)	5.61)	5.46)	1.87)	4.16)	3.74)	3.09)	1.04)	2.74)	2.68)	2.05)
T_3	5.32	5.14	8.17	3.92	.27	7.74	3.83	.38	.91	.97	.79	.68
	3.89)	6.70)	5.29)	4.89)	1.80)	4.21)	3.72)	2.89)	0.95)	2.82)	2.79)	1.92)
T_4	9.15	5.28	2.56	5.28	.34	1.02	.89	.22	.02	.89	.63	.14
	4.34)	5.94)	4.72)	5.03)	1.83)	3.32)	2.98)	2.69)	1.01)	2.21)	2.15)	1.77)
T_5	4.92	8.99	6.24	7.82	.01	7.76	4.04	.42	.05	.91	.12	.27
	3.85)	6.98)	5.95)	5.27)	1.74)	4.21)	3.75)	2.72)	1.02)	2.81)	2.85)	1.81)
SE (m±)	.13	.23	.27	.24	.05	.05	.04	.04	.03	.07	.04	.03
CD at 5%	.41	.71	-	.73	.14	.14	.14	.13	.08	.20	.12	.08
CV %	.34	.64	0.53	.90	.99	.29	.47	.88	.22	.94	.90	.77

* Figure in parentheses indicates √x value

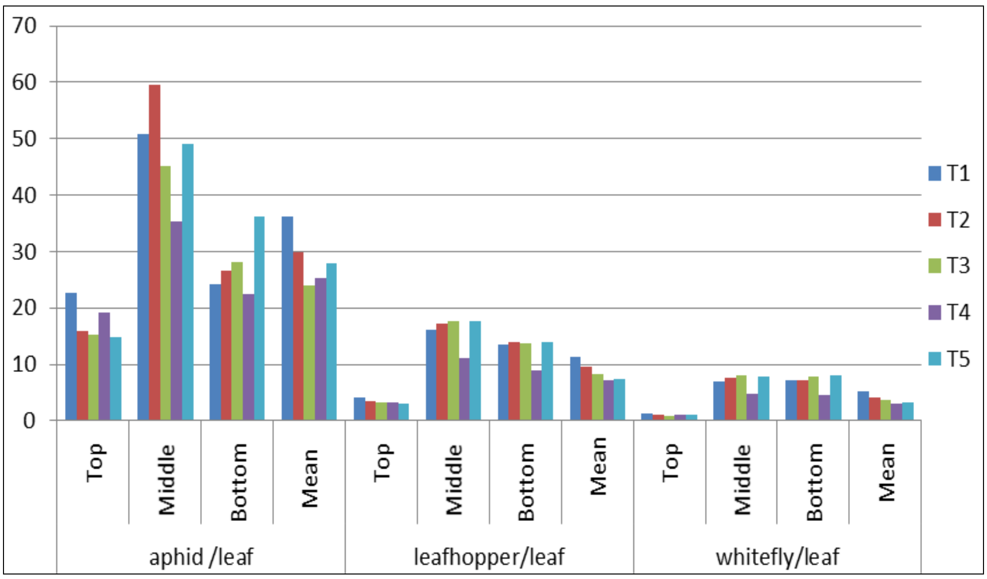

Fig 3: Population of sucking pest influenced by various sampling units (pooled mean of kharif 2015 and 2016

Conclusion
For counting of sucking pest's selection of one each leaf from top, middle and bottom stratum of the plant gave highest population of sucking pests during both the season. Hence, this stratified sampling is appropriate and should be used for counting of sucking pests on okra.

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