BIBLIOGRAPHY

FLORES, MARICAR F. APRIL 2007. Effect of Lesion Nematode (*Pratylenchus penetrans* Filipjev and Shuurmans Stekhoven) on the Growth and Yield of Six Strawberry Cultivars (*Fragaria x ananassa* Duch). Benguet State University, La Trinidad, Benguet.

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ABSTRACT

The study was conducted at BIOCON Laboratory and Greenhouse, Horticultural Research and Training Institute (HORTI), Benguet State University, La Trinidad, Benguet to determine the effect of *Pratylenchus penetrans* on the growth and yield of six strawberry cultivars.

Inoculation of 500 nematodes/pot did not significantly affect the fresh top weight, fresh root weight, weight of fruits of Strawberry cultivars: Festival, Sweet Charlie, Whitney, Winterdawn, Earlibrite and Camarosa. However, the number of fruits was significantly reduced by the nematode inoculation in cultivar Sweet Charlie. The nematode multiplication was significantly faster in cultivar Camarosa, however, it did not significantly differ with Whitney and Wintedawn. The lowest nematode count in the roots was obtained from Sweet Charlie, nevertheless, it was comparable to Earlibrite.

Based on the results it could be inferred that Sweet Charlie is more susceptible to the *P. Penetrans*. On the other hand, Camarosa and Festival seem to be more tolerant to nematodes.

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INTRODUCTION

The lesion nematode, *Pratylenchus penetrans* (Cobb) Filipjev and Schuurmans Stekhoven has been found to infest and be pathogenic on the cultivated strawberry, *Fragaria x ananassa* Duch (Potter and Dale, 1991). Several studies have observed that lesion nematode reproduction varies on different cultivars. In West Virginia, Midway strawberry appeared to be a better host than Surecrop (Adams and Hickman, 1970). In Price Edward Island, significantly more *Pratylenchus sp.* were found in the cultivar Cavalier than in Veestar, Redcoat, or Vibrant, and redcoat harbored more than Micmac (Kimpinski, 1985). In the Pacific Northwest, no useful resistance was found in 14 cultivars, although the nematode multiplied more rapidly on some cultivars than on others.

In the Philippines, *P. penetrans* was one of the plant parasitic nematodes found associated with strawberry in Benguet and Baguio City (Villanueva, 1994). It occurred in high population densities in all the fields surveyed and considered to be an active parasite of strawberry in the area (Kiat-ong, 2005). Based on the above and below ground symptoms, most of the strawberry cultivars grown are susceptible to the nematode. Lesion nematodes reduce or inhibit root development by forming local lesions on young roots, which may then rot with the entry of secondary fungi and bacteria. As a result of the root damage, affected plants grow poorly, produce low yields, and may finally die (Agrios, 1997).

The strawberry can both resist and tolerate the lesion nematode (Potter and Dale, 1994). Here we use the terminology of Boerma and Hussey (1992) to describe resistance and tolerance. Resistance describes the ability of a host to suppress nematode development and reproduction, and tolerance describe the sensitivity of a host to parasitism or the amount of damage sustained.

The study was conducted at the BIOCON Laboratory and Greenhouse, Horticultural Research and Training Institute, Benguet State University, La Trinidad, Benguet from November, 2006 to March, 2007 to determine the effect of *Pratylenchus penetrans on* growth and yield of six strawberry cultivars imported from California, USA.

REVIEW OF LITERATURE

The strawberry, a perennial herb of the genus *Fragaria* of the Rose family is a strange plant to many Filipinos particularly among the lowlanders. It is a semi-temperate and photoperiodic crop. Its sweet juicy fruit is one of the highly priced commodities in Baguio despite its abundance during the months of December to April. The crop is only produced in Baguio-Benguet area of the Northern Philippines where the climate is unique

Recently, five strawberry cultivars were imported from California, USA. They are Camarosa, Strawberry Festival, Earlibrite, Whitney and Winter Dawn. Camarosa, is an early short day variety. The vigorous plants produce large fruit throughout the most fruiting cycle. The interior color of Camarosa is a brilliant red and fruit colors uniformly. Yield potential is high to excellent in University of California performance tests. Strawberry Festival is also a short day cultivar. The fruits are mostly conic in shape. The external color of mature fruit is deep red and glossy while the internal color is bright red. The fruits of Strawberry Festival have very firm texture and excellent flavor. Strawberry Festival has a fruiting pattern and yield similar to that of Camarosa. Sweet Charlie is an early maturing sweet cultivar. The plant is medium in size making harvesting easy. Sweet Charlie has also anthracnose tolerance. On the other hand, Earlibrite originated from 1993 cross between Rosalinda and FL 90-38. It is an early producer. Usually in December it produces bright red fruits (Anonymous, 2002).

The lesion nematode, *Pratylenchus penetrans* (Cobb) Filipjev and Schuurmans Stekhoven has been found to infest and be pathogenic on the cultivated strawberry, *Fragaria x ananassa* Dutch (Potter and Dale, 1991). Several studies have observed that lesion nematode reproduction varies on different cultivars. In West Virginia, Midway strawberry appeared to be a better host than Surecrop (Adams and Hickman, 1970). In Price Edward Island, significantly more *Pratylenchus sp.* were found in the cultivar Cavalier than in Veestar, Redcoat, or Vibrant, and Redcoat harbored more nematodes than Micmac (Kimpinski, 1985). In the Pacific Northwest, no useful resistance was found in 14 cultivars, although the nematode multiplied more rapidly on some cultivars than on others. For instance, they were able to reproduce readily on the cultivars Olympus, Shuksan and Tyee, and less on Rainier (Vrain, 1985).

In Poland, Szczygiel (1981) evaluated 28 strawberry cultivars in pots for *P. penetrans* susceptibility in terms of nematode numbers per gram of root and tolerance on the bases of degree of root necrosis and reduction of plant growth. Also European and North American cultivars were compared. While no strawberry was completely resistant to *P. penetrans*, Guardian, Redchief and Sengana supported lower numbers of nematodes, whereas Midway, Vesper and Grenadier supported large numbers. The latter three cultivars also ranked among the highest in root necrosis, along with Cambridge Favourite, whereas Guardian and Senga sengana were almost equally low on root necrosis index. However, Midway and to a lesser extent, Vesper and Grenadier, did not show reduced growth commensurate with the root necrosis index or large numbers of nematodes. Szczygiel (1981) concluded that both root necrosis and reduced growth should be evaluated to indicate nematode-induced damage to a cultivar.

The strawberry can both resist and tolerate the northern lesion nematode (Potter and Dale, 1994). Here we use the terminology of Boerma and Hussey (1992) to describe resistance and tolerance. Resistance describes the ability of a host to suppress nematode development and reproduction, and tolerance describes the sensitivity of a host to parasitism or the amount of damage sustained.

P. penetrans is a migratory endoparasite with all stages found in root cortex. Low soil population can be associated with high root population. The nematodes feed mainly on cortex and form cavities containing nests or colonies of nematode of all stages. Discoloration of affected tissues is usually pronounced. Above ground symptoms of attack include chlorosis and stunting (Bridge *et al.,* 2002). High populations of lesion nematodes cause areas of poor growth; plants are less vigorous, turn yellow and cease to grow. Direct feeding often causes damage and, usually, only cortical tissues are affected. Large nematode populations cause extensive lesion formation and cortex destruction of unsuberized feeder roots (Brodie *et al.,* 1981).

According to Anonymous (1999) the symptoms on infected roots are small, light to dark brown lesions. The lesions tend to expand and to merge as the growing season progresses, giving the roots a discolored appearance overall. Nematode feeding causes cortical tissue disintegration and girdling, resulting in the sloughing off of the epidermis and remaining cortex, root pruning, and the reduction in size of the root system. The roots of severely infected plants maybe almost complete. Lesion formation results from an interaction of plant glycosides with enzyme released by the nematode during feeding. The chemicals are toxic to invaded and adjacent host cells. The degree of host parasite interaction depends on the concentration and location of specific glycosides within the root tissue on the concentration of enzymes released during feeding. The wounds produce by the nematodes provide a means of entry for a wide variety of relatively and nonspecific soil microorganisms, including root infecting pathogens that may also contribute to lesion formation and may enhance the disease.

Pratylenchus penetrans, the main species pathogenic to strawberry, was also found to carry spores of *Gnomonia comari*, the cause of leaf blotch (Kurppa and Vrain, 1989). These nematodes prefer coarse-textured, sandy soils. In temperate climates, they over winter in roots or in soil as eggs, juveniles, or adults. During periods of drought, they are quiescent and susceptible to drying if the soil is plowed and fallowed through hot months. Where soil moisture is low some species can survive more than a year without a host crop. Species of *Pratylenchus* are unusual in reproducing in larger numbers in stressed plants. In all motile stages, this nematode can invade and leave roots, so there is no infective stage. To estimate the size of population of *Pratylenchus* species, both roots and soil should be sampled. Staining of roots suspected of harboring these nematodes or extraction from such roots may be necessary to confirm their presence (Averre III *et al.*, 2000).

All species of *Pratylenchus* are readily distributed with the infected planting material and, consequently, *P. penetrans* is widely distributed wherever strawberries are grown. Several other species have been associated with strawberry but not all are damaging. Damage by *P. penetrans* is greatest on light soils where a threshold of 50 nematodes 100g soil has been reported (Szczygiel, 1983).

Currently, nematode management considerations include crop rotation of less susceptible crops and resistant varieties, cultural and tillage practices, use of transplants and preplant nematicide treatments. These methods unlike other chemical methods tend to reduce nematode population gradually overtime. Lesion nematodes can be best controlled by overall or row treatment of the soil with the nematicides before the crop is planted. Such treatments give good control of these nematodes, but they usually fail to eradicate them completely. In hot and dry climates fairly good control of lesion nematode can be achieved by summer fallow, which requires the nematode population by exposing them to heat and drying by eliminating the host plants. Control through crop rotation is rather unsuccessful because of the wide host range of the lesion nematodes. Several fungi and bacteria that parasitize and kill lesion nematodes are known, but none are effective as biological control agents under field conditions (Agrios, 1997).

MATERIALS AND METHODS

The study was conducted at the BIOCON Laboratory and Greenhouse of Horticultural Research and Training Institute, Benguet State, University, La Trinidad, Benguet from November 2006 to March 2007. There were two treatments replicated four times with two sample plants per replicate. The treatments were arranged randomly in greenhouse using the Randomized Complete Block Design (RCBD) involving factorial arrangement. Six strawberry cultivars were used namely: Camarosa, Festival, Sweet Charlie, Earlibrite, Whitney and Winter Dawn (Figure1).

Fig. 1. Experimental lay-out (RCBD)

The soil used in the experiment was obtained from the Benguet State University Experimental Area located at Balili, La Trinidad, Benguet containing a mixture of rice hull and sand together with the soil. It was heat-sterilized prior to use to get rid of other soil-borne pathogens that will affect the development of nematodes.

Source of Nematode Inoculum

The nematodes were cultured in carrot discs. Healthy carrot roots were washed in running water to remove the adhering soil particles and blot dried in tissue paper. It was surfaced sterilized with 70% ethanol and peeled three times Carrots were cut into discs and placed in sterile Petri dishes.

The infected roots were washed thoroughly with tap water and cut into small pieces. These were macerated with a kitchen blender and passed through a 40-micrometer sieve. The mixture of blended roots and nematodes from the sieve were placed overnight in a Baerman funnel. This allowed the nematodes to pass through the sieve to the water and the blended root tissue to remain. The residue in the sieve was rinsed with tap water to eliminate bacteria, etc. The nematodes were collected from the sieve with distilled water.

Sterilization of Nematodes

In order to establish a culture with the least possible contamination, it is important to use clean nematode solution. The nematode suspension was transferred into a sterile test tube containing sterile distilled water using a sterile pipette. About .6 ml of 600-ppm streptomycin sulphate was added in 2 ml nematode suspension. The nematode suspension was left overnight in sealed test tube; the streptomycin sulphate solution was removed from above the nematodes and which was allowed to settle at the bottom of the test tube for an hour. The water was removed and fresh sterile water is added. The process was repeated three times.

Inoculation of the Lesion Nematode

Six strawberry cultivars were used namely: Camarosa, Festival, Sweet Charlie, Earlibrite, Whitney and Winter Dawn. The inoculum was introduced in 4 holes near the root zone and later covered again with soil. Uninoculated plants were provided to serve as control.

The different treatments were the following:

Factor A: Inoculum Levels

T_1-0

T_2-500 nematodes/plant

Factor B: Variety

V_1- Festival

V_2- Sweet Charlie

V_3- Whitney

V_4- Winter dawn

V_5- Earlibrite

V_6- Camarosa

All the cultural management practices in strawberry production such as watering, fertilization, removal of old leaves and control of pests except nematode was employed uniformly in all the treatments to ensure good growth and yield of the plant.

Data Gathered

1. Top weight (g). This refers to the weight of the upper part of the plant after harvest.
2. Root weight (g). This refers to the weight of the roots after harvest.
3. Number and weight of fruits/plant. This refers to number and weight of fruits harvested per sample plant.
4. Number of nematodes in the roots. This was obtained by collecting one gram of roots. The nematodes were extracted using a blender and nematodes were collected using the blue sieve method (Figure 2).
5. Number of nematodes in the soil. This was obtained by collecting 200 cc of soil and processed using the Modified Tray Method (Figure 3).

The data were analyzed statistically using Analysis of Variance (ANOVA) and treatment means were separated using the Duncan's Multiple Range Test (DMRT).

(a) Blender (b) Blue sieve

Fig. 2. Extraction of nematode from the roots using (a) blender and (b) blue sieve

Fig. 3. M0dified tray method of isolating nematodes from soil placed in mayonnaise bottle (A&B), collection opf nematode suspension (C&D)

RESULTS AND DISCUSSIONS

Fresh Top Weight

Inoculation of root-lesion nematode resulted in significant reduction in fresh top weight of strawberry cultivars. (Fig.4a). Regardless of whether the plants were inoculated or not, cultivar Camarosa had the highest fresh top weight. This was significantly different from other strawberry cultivars. The fresh top weight of strawberry cultivars Festival, Sweet Charlie and Whitney were comparable but significantly lower than Camarosa. However, they were significantly higher than Winterdawn and Earlibrite which gave the lowest fresh top weight (Figure 4b). No significant interaction was noted between nematode inoculation and strawberry cultivars tested (Figure 4c).

Fresh Root Weight

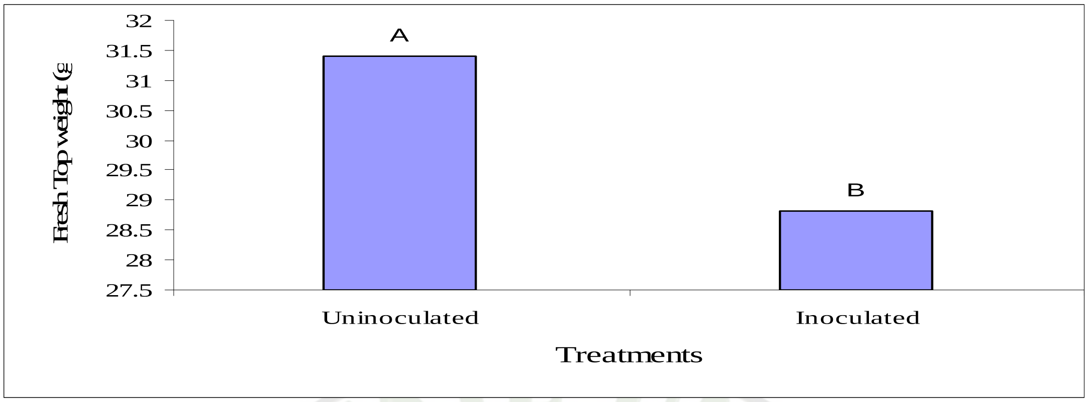
Plants inoculated with lesion nematode gave significantly lower fresh root weight than uninoculated plants (Figure 5a).Among the cultivars tested, Winterdawn gave significantly lower fresh root weight than cultivars Festival, Sweet Charlie, Whitney, Earlibrite and Camarosa (Figure 5b). Statistical analysis revealed no significant interaction between inoculation and strawberry cultivars in terms of fresh root weight (Figure 5c).

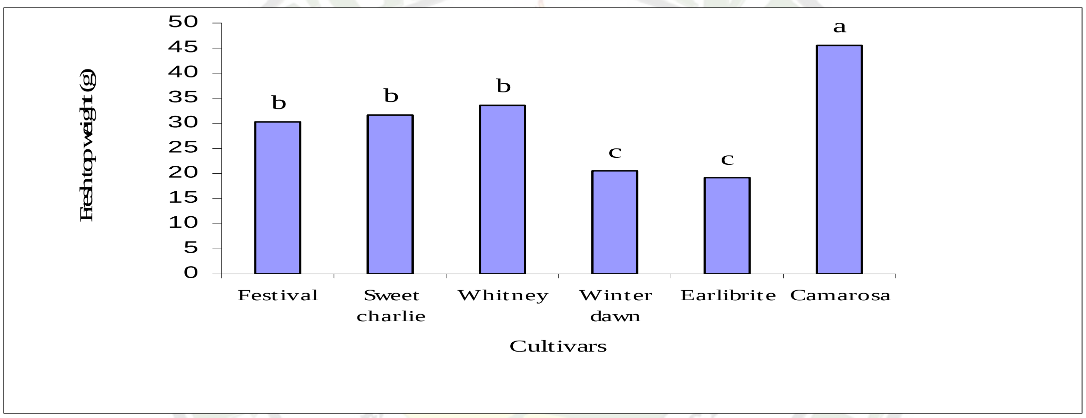
Plants inoculated with *P. penetrans* showed varying degrees of root necrosis (Figure 10). The most severe necrotic lesions were noted in cultivars Camarosa followed by Festival, Whitney, Winterdawn and Sweet Charlie. Because of severe infection the cultivar Earlibrite died prematurely. *P. penetrans* is a migratory endoparasite with all stage found in root cortex. The nematodes feed mainly on cortex and form cavities containing nests or colonies of nematode of all stages. Discoloration of affected tissue is usually pronounced. Above ground symptoms of attack include chlorosis and stunting (Bridge *et al.*, 2002). High population of lesion nematodes cause areas of poor growth, plants are less vigorous, turn yellow and cease to grow. Direct feeding often causes damage and usually only the cortical tissues are affected. Large nematode populations cause extensive lesion formation and cortex destruction of unsuberized feeder roots (Brodie *et al.*, 1981). According to Agrios (1997), the lesion nematodes reduce or inhibit root development by forming local lesions on young roots, which may then rot with the entry of secondary fungi and bacteria. As a result of the root damage, affected plants grow poorly, produce low yields and finally die.

Number of Fruits

Figure 6a, shows the difference between the inoculated and uninoculated strawberry cultivars. Apparently, inoculated strawberry cultivars gave significantly lower mean number of fruits than uninoculated ones. Among the strawberry cultivars, significantly more number of fruits was obtained from Sweet Charlie compared to Festival, Whitney, Winterdawn, Earlibrite and Camarosa which were comparable (Figure 7b).

Statistical analysis revealed significant interaction between inoculation and strawberry cultivars. Inoculation of 500 nematodes/pot significantly reduced the number of fruits of strawberry cultivar Sweet Charlie compared to the uninoculated plant. Although not significantly different, inoculated plants in cultivars Whitney and Winterdawn gave lower number of fruits than the uninoculated ones. On the other hand, in cultivars Earlibrite, Camarosa and Festival, the inoculated and uninoculated plants were comparable (Figure 7c).





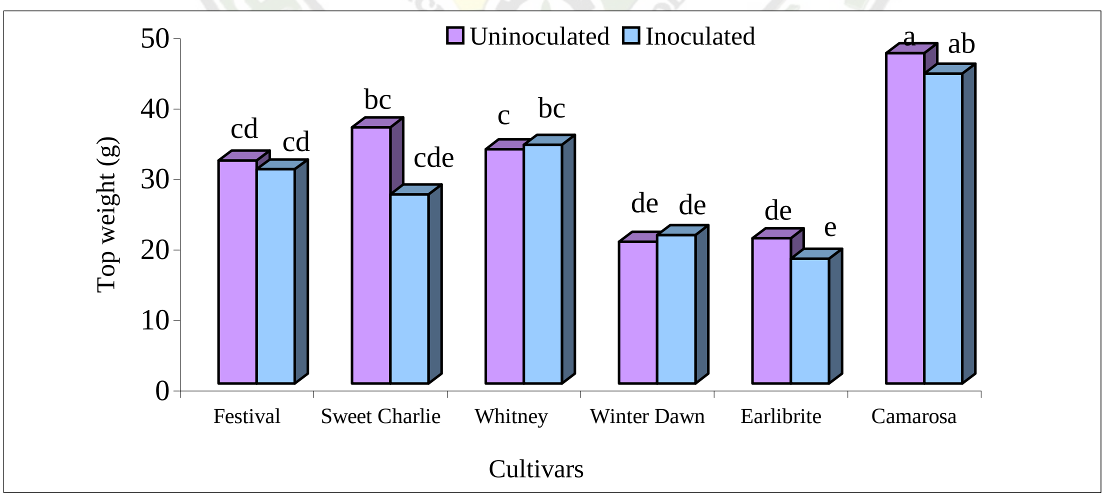
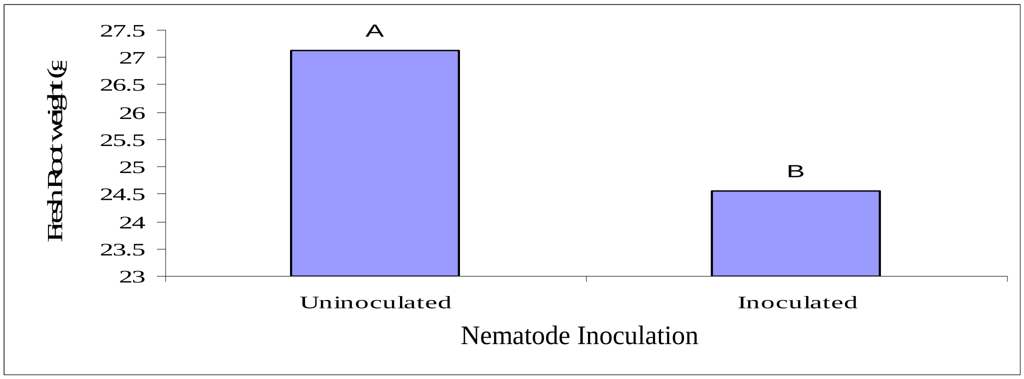
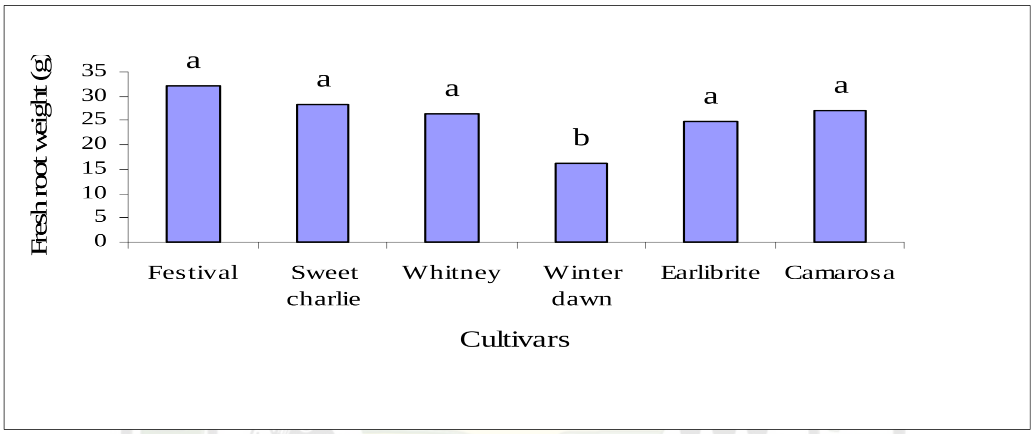


Fig. 4. Effect of inoculation and strawberry cultivars on fresh top weight; (A) nematode inoculation; (B) cultivars; (C) interaction of nematode inoculum and cultivars.





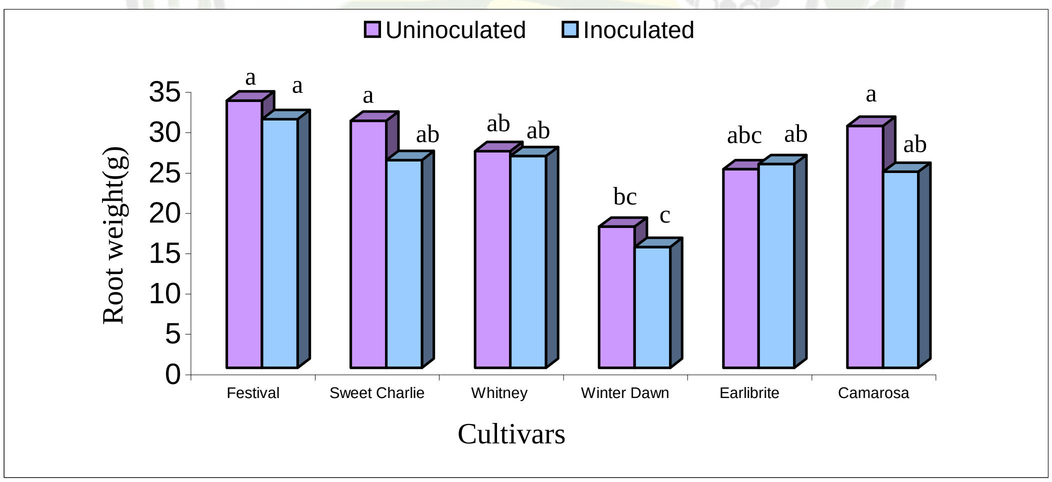


Figure 5. Effect of inoculation and strawberry cultivars on fresh root weight; (A) nematode inoculation; (B) cultivars; (C) interaction of nematode inoculum and cultivar

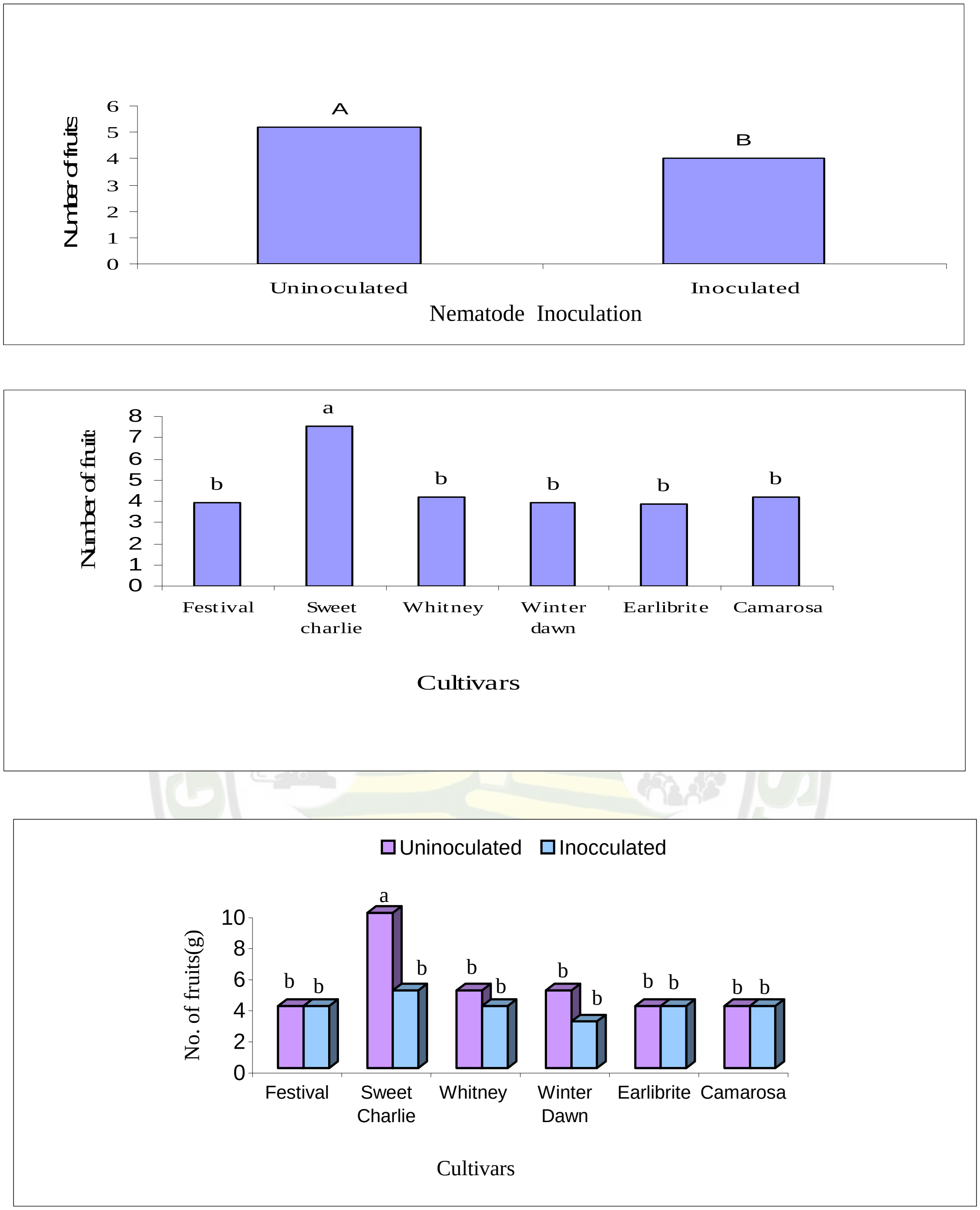


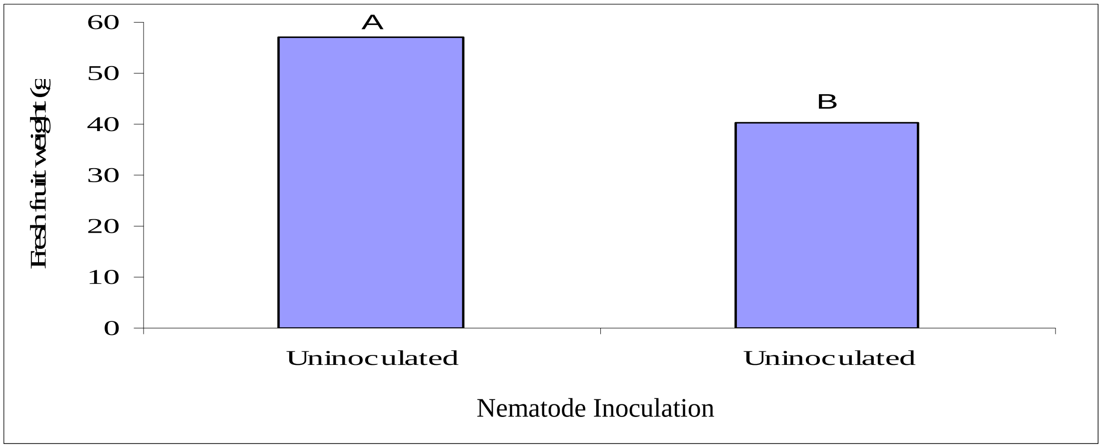
Figure 6. Effect of inoculation and strawberry cultivars on number of fruits; (A) nematode inoculation; (B) cultivars; (C) interaction of nematode inoculum and cultivar

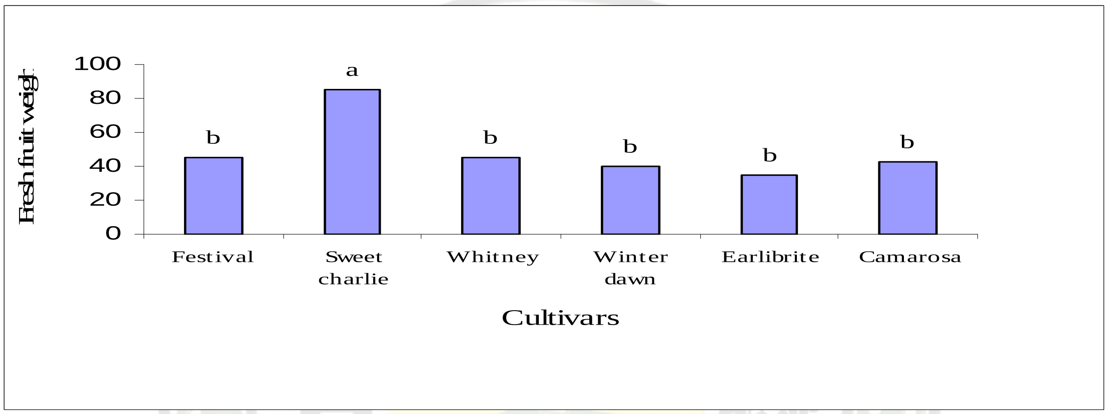
Fruit Weight

Inoculation of root-lesion nematodes significantly affected the weight of Strawberry fruits (Figure 7a). Likewise, highly significant difference was noted among the strawberry cultivars tested whether they were inoculated or not within the root-lesion nematode (Figure 7b). In cultivars Sweet Charlie, inoculated plants gave significantly lower fruits weight than the uninoculated one (Figure 7c).

Number of Nematodes in the Roots

Figure 8, shows the effect of strawberry cultivars on the number of nematodes in the roots. Apparently, the highest nematode population was noted in cultivars Camarosa (26,895), however, it did not significantly differ with the cultivars Festival (24,473), Whitney (17,058) and Winterdawn (12, 481). The lowest nematodes count was recorded in cultivars Sweet Charlie (5,956) however this is at par with cultivar Earlibrite (10,268).





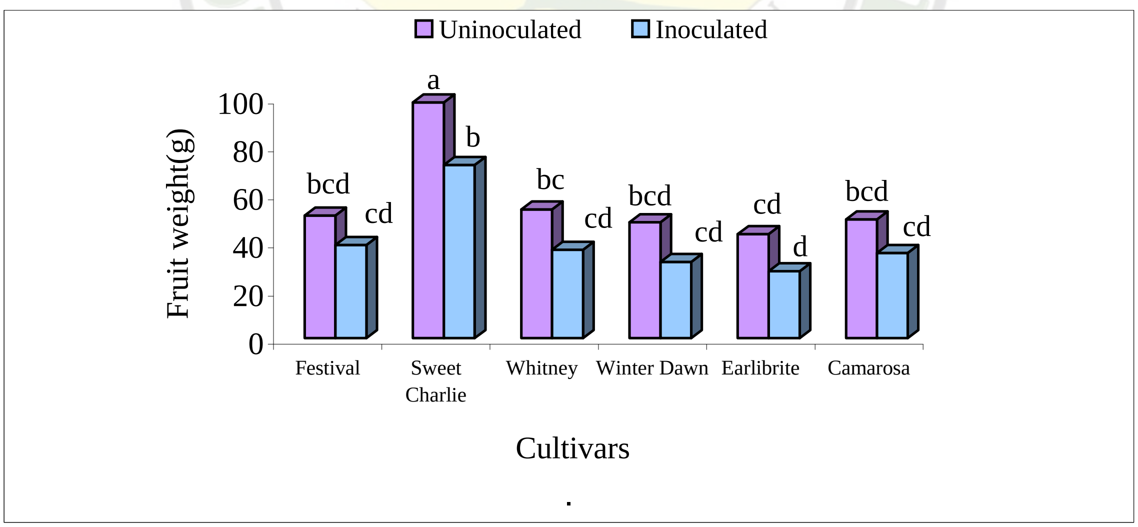


Figure 7. Effect of inoculation and strawberry cultivars on fruit weight; (A) nematode inoculation; (B) cultivars; (C) interaction of nematode inoculum and cultivar

<u>Number of Nematodes in the Soil</u>

The effect of strawberry cultivars on the total number of nematodes in the soil is shown in Figure 9. Highly significant difference was noted among the different treatments. The highest nematode counts were obtained from cultivars Whitney (855), this was followed closely with Sweet Charlie, Earlibrite, Festival and Camarosa with 668, 596, 447 and 255 nematodes/pot respectively. The lowest nematode population was noted on cultivar Winterdawn but this was comparable to Sweet Charlie, Earlibrite, Camarosa and Festival.

Strawberry cultivars Camarosa and Festival support a large number of nematodes in the roots. Inspite of this, there was no significant difference observed between inoculated and uninoculated plants in terms of yield. This could be aform of tolerance, According to Bernard and Laughlin (1976) a number of potato have been reported to possess some degree of tolerance to *P. penetrans.* The cultivar Russet Burbank is relatively tolerant to infestation by *P. penetrans* but it does not resist multiplication of the nematode.

On the other hand, Sweet Charlie supports only fewer nematodes compared to other cultivars, but its yield was significantly reduced by nematode inoculation. This shows that the above cultivar is susceptible to the root-lesion nematode.

Results of the present investigation revealed that the strawberry cultivars imported from California, USA have varying reaction to *P. penetrans*. Most of the cultivars evaluated support large number of nematodes in the roots but their yield was not significantly affected. This indicates tolerance to the root-lesion nematode. However, another trial is recommended using higher level of nematode inoculum in order to verify the above results.

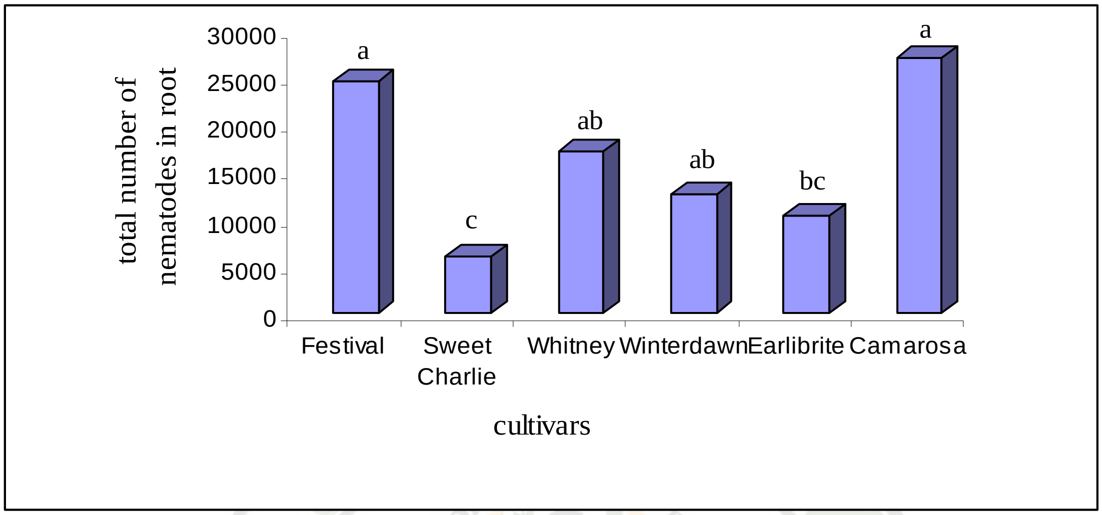


Fig.8. Effect of *P. penetrans* on final nematode population in roots of six strawberry cultivars.

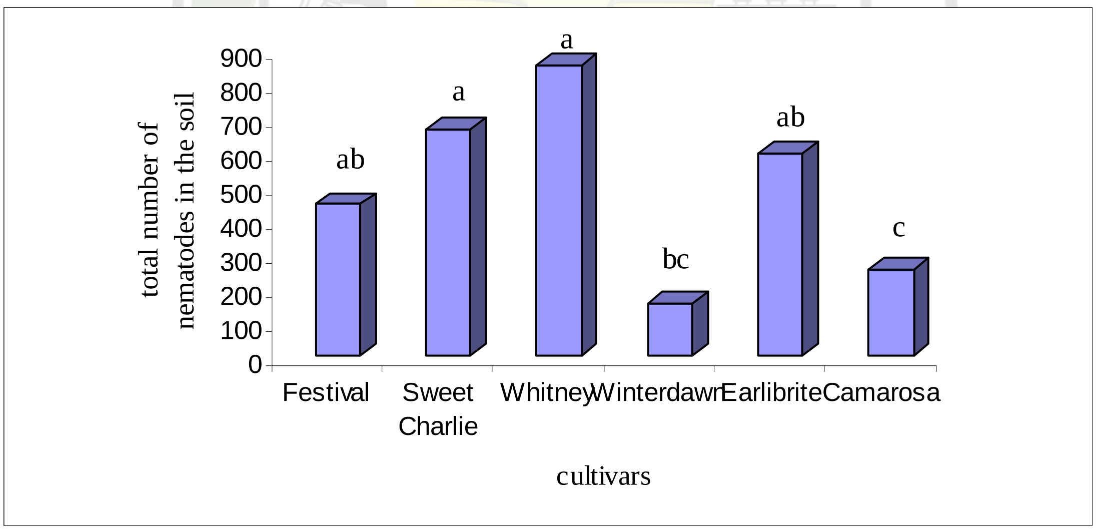


Fig. 9. Effect of *P. penetrans* on final nematode population in soil of six strawberry cultivars.

Figure 10. Root system of strawberry cultivars: (A) Sweet Charlie, (B) Whitney, (C) Festival, (D) Camarosa and (E) Winterdawn

Figure 11. Adult *P. penetrans* (A)male, (B)gravid female

SUMMARY, CONCLUSION AND RECOMMENDATION

Summary

A greenhouse experiment was conducted to determine the effect of *Pratylenchus penetrans* on the growth and yield of six strawberry cultivars. Inoculation of 500 nematodes/pot did not significantly affect the fresh top weight, fresh root weight and weight of fruits of Festival, Sweet Charlie, Whitney, Winterdawn, Earlibrite and Camarosa. However, the number of fruits was significantly reduced by the nematode inoculation in cultivar Sweet Charlie. On the other hand, the nematode multiplication was significantly faster in cultivars Camarosa, however, it did not significantly differ with the Whitney and Winterdawn. The lowest nematode count in the roots was obtained from Sweet Charlie, Nevertheless, it was comparable to Earlibrite.

Conclusion

Based on the results obtained, it can be inferred that Sweet Charlie is more susceptib le to the *P. penetrans*. On the other hand Camarosa and Festival seem to be more tolerant on the nematodes.

Recommendation

Another study is recommended using higher nematode inoculum in order to fully evaluate the true reaction of the strawberry cultivars to the root-lesion nematode.

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APPENDICES

Table 1. Effect of *P. penetrans* on fresh top weight (g) of six strawberry cultivars.

TREATMENT COMBINATION	REPLICATION I	II	III	IV	TOTAL	MEAN
T_1V_1	17.5	40.0	27.5	40.0	125.0	31.25
T_IV_2	27.5	45.5	32.5	40.0	145.5	36.38
T_1V_3	42.5	30.0	32.5	27.5	132.5	33.13
T_1V_4	20.0	18.0	20.0	22.5	80.5	20.13
T_1V_5	22.5	20.0	15.0.	25.0	82.5	20.63
$T1V_6$	50.0	47.5	47.5	42.5	187.5	46.88
Sub-Total	180.0	201.0	175.0	197.5	753.5	31.4
T_1V_1	25.0	35.25	35.85	25.5	121.6	30.4
T_IV_2	29.5	22.5	21.1	34.25	107.35	26.84
T_1V_3	31.5	40.0	34.0	30.0	135.5	33.88
T_1V_4	24.6	12.8	32.7	14.1	84.3	21.08
T_1V_5	18.9	25.0	18.2	8.75	70.8	17.7
$T1V_6$	32.7	44.2	53.4	45.5	175.9	43.98
Sub-Total	162.3	179.8	195.3	158.1	695.5	28.98

ANALYSIS OF VARIANCE

SOURCE OF VARIANCE	DF	SS	MS	F value	Pr > F
Model	14	3957.73	282.695	5.86	0.0001
Block	3	63.185	21.062	0.44	0.7281
INOC	1	80.213	80.213	1.66^{ns}	0.2061
TRT	5	3668.91	733.782	15.22**	0.0001
INOC*trt	5	145.422	29.084	0.60^{ns}	0.6978
Error	33	1591.03	48.213		
Corrected Total	47	5548.76			

ns-not significant

**-highly significant

Coefficient of variation- 23.07%

Table 2. Effect of *P. penetrans* on root weight (g) of six strawberry cultivars.

TREATMENT COMBINATION	REPLICATION I	II	III	IV	TOTAL	MEAN
T_1V_1	22.5	32.5	40.0	37.5	132.5	33.13
T_IV_2	30.0	32.5	27.5	32.5	122.5	30.63
T_1V_3	37.5	17.5	20.0	32.5	107.5	26.88
T_1V_4	20.0	17.5	20.0	12.5	70.0	17.5
T_1V_5	31.0	17.5	15.0	35	98.5	24.63
$T1V_6$	27.5	25.0	30.0	37.5	120.0	30.0
Sub-Total	168.5	142.5	152.5	187.5	651	27.13
T_1V_1	22.15	28.7	29	43.55	123.4	30.84
T_IV_2	26.55	24.2	25.9	26.4	103	25.75
T_1V_3	22.5	30.0	30	22.5	105	26.25
T_1V_4	15.9	8.3	23.5	12.3	60.0	14.99
T_1V_5	23.55	30.8	21.25	25.5.	101.1	25.26
$T1V_6$	20.5	29.0	26.5	21.25	97.3	24.31
Sub-Total	131.15	150.8	156.15	126	589.6	24.57

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SS	MS	F value	Pr > F
Model	14	1346.28	96.163	2.4	0.0192
Block	3	102.395	34.132	0.85	0.4755
INOC	1	78.541	78.541	1.96^{ns}	0.01708
TRT	5	1106.97	221.394	5.53**	0.0008
INOC*trt	5	58.37	11.674	0.29ns	0.913
Error	33	1321.78	40.054		
Corrected Total	47	2688.05			

ns-not significant

**- highly significant

Coefficient of variance-25.85%

Table 3. Effect of *P. penetrans* on weight of fruits (g) of six strawberry cultivars

TREATMENT COMBINATION	REPLICATION I	II	III	IV	TOTAL	MEAN
T_1V_1	72.8	47.7	26.15	57.2	203.85	50.96
T_IV_2	104.85	91.3	100.6	95.45	392.2	98.05
T_1V_3	46.55	72.4	51.4	43.7	214.05	53.51
T_1V_4	54.75	31.55	49.8	56.7	192.8	48.2
T_1V_5	44.25	35.6	68.35	22	173.2	43.3
T1V_6	39.6	38.25	60.3	59.3	197.45	49.36
Sub-Total	362.8	316.8	356.6	334.35	1373.55	57.23
T_1V_1	52.2	56.25	28.1	18.25	154.8	38.7
T_IV_2	73.05	88.3	76.65	50.05	288.05	72.01
T_1V_3	46	18.5	38.95	43.6	147.05	36.76
T_1V_4	12	51.2	42.35	21.65	127	31.75
T_1V_5	21.3	18.75	45.2	25.9	11.15	27.79
T1V_6	50.8	32.15	23.45	35.2	141.6	35.4
Sub-Total	255.35	265.15	254.7	194.65	869.65	40.4

ANALYSIS OF VARIANCE

SOURCE OF VARIANCE	DF	SS	MS	F value	Pr > F
Model	14	17163.9	1225.95	5.48	0.0001
Block	3	411.323	137.108	0.61	0.6113
INOC	1	3345.01	3345.01	14.96**	0.0005
TRT	5	13170.5	2634.1	11.78**	0.0001
INOC*trt	5	236.441	47.288	0.21^{ns}	0.9552
Error	33	7378.27	223.584		
Corrected Total	47	24541.5			

ns-not significant

**-highly significant

Coefficient of variation- 48.76%

Table 4. Effect of *P. penetrans* on number of fruits of six strawberry cultivars.

TREATMENT COMBINATION	REPLICATION I	II	III	IV	TOTAL	MEAN
T_1V_1	4.5	3.5	1.5	4.5	14	4
T_IV_2	12.5	10	10.5	7.5	40.5	10
T_1V_3	3.5	5.5	4	5.5	18.5	5
T_1V_4	4.5	3.5	4.5	6	18.5	5
T_1V_5	4.5	4	5.5	2	16	4
$T1V_6$	5	3.5	4	5	17.5	4
Sub-Total	34.5	30	30	30.5	125	5.33
T_1V_1	6	7	2	2.5	17.5	4
T_IV_2	8	3	2	7	20	5
T_1V_3	4.5	2	3.5	5	15	4
T_1V_4	1	5	4.5	2.5	13	3
T_1V_5	4.5	2.5	4.5	3.5	16	4
$T1V_6$	5	3.5	3.5	4	16	4
Sub-Total	29	23	20	24.5	97.5	4

ANALYSIS OF VARIANCE

SOURCE OF VARIANCE	DF	SS	MS	F value	Pr > F
Model	14	152.323	10.88	4.02	0.0005
Block	3	8.391	2.707	1.03	0.3904
INOC	1	16.922	16.922	6.25**	0.0175
TRT	5	84.151	16.83	6.22**	0.0004
INOC*trt	5	42.859	8.572	3.17*	0.0192
Error	33	85.297	2.706		
Corrected Total	47	241.619			

*-significant
**-highly significant

Coefficient of variation- 35.65%

Table 5. Effect of *P. penetrans* on final nematode population in roots

TREATMENT COMBINATION	REPLICATION I	II	III	IV	TOTAL	MEAN
Raw Data						
T2V1	4550	6115.88	8711.55	5096	24473.4	6118.36
T2V2	1829	1935	822.9	1370	5956.9	1489.23
T2V3	1354.5	7360	3094	5250	17058.5	4264.63
T2V4	2575.93	4806.4	3209.5	1889.4	12481.2	3120.31
T2V5	1748.25	3775	807.68	3937.5	10268.4	2567.11
T2V6	1735.75	1747.88	20158.5	3253.25	26895.4	6723.85
Sub-total	13793.4	25740.2	36804.1	20796.2	97133.9	4047.24
Transfomed Data						
T2V1	3.66	3.79	3.94	3.71	15.09	3.77
T2V2	3.26	3.29	2.92	3.14	12.6	3.15
T2V3	3.13	3.87	3.49	3.72	14.21	3.55
T2V4	3.41	3.68	3.51	3.28	13.88	3.47
T2V5	3.24	3.58	2.91	3.6	13.32	3.33
T2V6	3.24	3.24	4.3	3.51	14.3	3.57
Sub-total	19.95	21.44	21.06	20.95	83.4	20.85

ANALYSIS OF VARIANCE

SOURCE OF VARIANCE	DF	SS	MS	Computed F
Block	3	0.208	0.0609	0.7473
Trt	5	0.919	0.184	1.9810ns
Error	15	1.392	0.093	
Corrected Total	23	2.520		

ns- not signicant

Coeffecient of variation= 8.77%

Table 6. Effect of *P. penetrans* on final nematode population in soil.

TREATMENT COMBINATION	REPLICATION I	II	III	IV	TOTAL	MEAN
Raw Data						
T2V1	64.50	127.50	142.50	112.50	447.00	111.75
T2V2	123.75	393.75	101.25	48.75	667.50	166.88
T2V3	56.25	465.00	266.25	67.50	855.00	213.75
T2V4	56.25	33.75	33.75	30.00	153.75	38.44
T2V5	116.25	172.50	123.75	183.75	596.25	149.06
T2V6	56.25	116.25	67.15	15.00	254.65	63.66
Sub-total	473.25	1308.75	734.65	457.50	2974.15	123.92
Transfomed Data						
T2V1	1.81	2.11	2.15	2.05	2.650	2.030
T2V2	2.09	2.60	2.01	1.69	2.824	2.095
T2V3	1.75	2.67	2.43	1.83	2.932	2.168
T2V4	1.75	1.53	1.53	1.48	2.187	1.571
T2V5	2.07	2.24	2.09	2.26	2.775	2.165
T2V6	1.75	2.07	1.83	1.18	2.406	1.705

ANALYSIS OF VARIANCE

SOURCE OF VARIANCE	DF	SS	MS	Computed F
Block	3	1.97	0.22	0.5949
Trt	5	0.67	0.26	8.8936**
Error	15	1.3	0.62	
Corrected Total	23	2.91		

**-highly significant

Coeffecient of variation-21.58%