Short Research Article

NEMATICIDAL ACTIVITY of *Aloe vera* EXTRACT/EXUDATES ON ROOT-KNOT NEMATODES (*M. incognita)* ASSOCIATED WITH TOMATO *(Lycopersicun esculentum*) PLANT GROWTH PARAMETERS.

ABSTRACT- Nematicidal activity of *Aloe vera* plant at different concentration treatments were evaluated to determine its effect on root-knot nematode. The study was conducted in the Federal College of Forestry Jos, Plateau State of Nigeria between March and May, 2017. Nematicidal activity of *Aloe vera* was tested on tomato associated with *M. incognita* using 80mg/ml, 70mg/ml, 60mg/ml, 50mg/ml and 40mg/ml. Three (3) blocks in area of about $300m^2$ partitioned into five (5) plots with 1m alley each in-between plots and blocks and each plot was about $50m^2$ for one (1) treatment between the tested nematicidal extract. Modified Baermann Funnel Method was used for nematode extractions and 70% ethanol was used for *Aloe vera* analysis. A complete randomized design (CRD) was used and data collected were analyzed using analysis of variances (ANOVA) to determine the significant differences. The results showed that there was a significant different at $p \leq 0.05$ level in nematode population and improved tomato growth and yield, the highest concentration in reducing the population numbers of the *M. incognita*, improving tomato plant growth parameters is the 80mg/ml and the order of performance are 80mg/ml > 70mg/ml > 60mg/ml > 50mg/ml > 40mg/ml respectively. 80mg/ml treatments on tomato

plant height in week one results in (18.00) which was higher in week three (26.00) when compared with 40mg/ml treatments in week one (8.00) and week three (13.00). Finally, the results obtained could be an outcome of the nematicidal contents of the extracts in inhibiting nematodes, *Meloidogyne incognita* proliferation and can be used as a bio-control agent.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study

Tomato *(Lycopersicun esculentum*) is an edible red fruit of *Solanum lycopersicum*, belongs to the nightshade family Solanaceae, one of the most important tropical vegetable crop widely used throughout the world. In recent years, root-knot nematodes *Meloidogyne* spp. problem has become a threat to tomato cultivations. Yield loss due to nematode cause diseases to nearly all plant crops of Economic importance with estimated losses of US $125 billion per year World-Wide (Chitwood, 2003). They can cause significant plant damage ranging from negligible injury to total destruction of plant materials. Nematodes had long been known to attack crops but had been studied less than the insects, this is because of their minute nature. Control of root-knot nematodes has been primarily accomplished through chemical nematicides. However, indiscriminate use of chemical pesticides causes great threat to human being, animals, vegetation and to the environment as a whole due to their non target effect, hazardous nature and besides they are expensive. So with the increasing awareness of possible deleterious effects of the chemicals, biological controls of plant pathogen have received considerable attention

(Gaima *et al*., 2005). Leaf of *Aloe vera* extracts apply directly to the soil will tend to offer a more nematode control, environmentally friendly and chemical-free possibilities as there is an urgent need to replace pesticides with alternative means of control that are less toxic and more environmentally friendly. Many investigators had managed root-knot nematodes by using some plant dried powder of certain ornamental plants (Mani *et al*., 1986; Akhtar and Alam, 1989; Montasser, 1991; Akhtar and Mohmood, 1993) studied the nematicidal effect chopped pine-apple (*Annanas cosmos*) leaves used as organic amendment against *Meloidogyne* spp. Some of the plant species and parts antagonistic to *Meloidogyne* spp. are the leaves and flowers of marigold (*Tagetes* sp).

In this research, activity of the leaf extracts of *Aloe vera* is study as nematicides for the control of root-knot nematodes, *Meloidogyne incognita* attacking tomato.

1.2 Statement of the Problem

Root-knot nematodes are very distinctive because of the galls or swelling produced on roots and underground portion of stems. These deformations can often completely ruin crops for sales and consumption. If infested when young, the following will be observed: stunted growth, more susceptible to draught, stress and show symptoms of nutrients deficient. Large and small roots may be affected with swelling varying from round shaped sphere-like galls to elongated spindle from large numbers of individual galls growing together. Nematode management is generally based upon chemical treatments (Soil fumigation) but environmental concern and Governmental regulations are now resulting in a strong interest on nematicides of natural origin.

1.3 Aim and Objectives of the Study

1.3.1 Aim of the study

The aim of this study is to evaluate the efficacy of nematicidal effect of *Aloe vera* on root-knot nematodes affecting tomatoes

1.3.2 Specific objectives

The specific objectives are;

i. To extract and identify parasitic nematodes associated with tomato
ii. To determine the nematicidal effect of *Aloe vera* extract on root-knot nematodes associated with tomato on plant height, root length, shoot weight, yield and nematode populations

1.4 Justification

More than 90% of nematodes including insects have at least one stage of their life-cycle in soil (Akhurst, 1993). It offers an opportunity for an effective management programme to be developed. Commonly used nematode control methods include: cultural methods such as crop rotations and along with chemical pesticide applications. The information to be generated from this study, if successful will go a long way in providing an alternative pest control measure that is environmentally friendly and safe. The huge losses caused by nematodes on tomato will be reduced with ease as peasant farmers can easily access the plants, it will give the public an opportunity of consuming clean vegetables free from contamination that will cause harm to health. Integration into already established soil amendment systems is a potential area for advances in this field, minimal labor costs, high moisture provisions and flexibility. Finally, this will encourage the need for growing

more of *Aloe vera* plants so as to have available plant materials that will be use continuously for the control of this pest

1.5 Scope of the Study

The study is limited to the use of *Aloe vera* plant extract in the control of nematode associated with tomato, adult form of the root-knot nematodes were extracted from suspected host plants particularly tomato cultivated in Faringada area of Jos-North.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

The study was carried out in the chemistry laboratory of Federal College of Forestry, Jos. Jos is a capital city of Plateau State of Nigeria. The Local Government lies in the Guinea Savannah Belt. The area now designated Jos-North Local Area came into being in September 1991 when the former Jos Local Government Area split to create Jos-North and South Local Government respectively. Former Jos-North that was carved covered an area of 1,695sq.km. The 1991 census indicated that Jos-North is populated by over 450,000 and 2006 census indicates that Jos-North is populated by about 1.000.000.00 people (Population Census, 2006).

3.2 Materials

- The materials that were used for this study are as follows:
- Tomato (infested), roots (galled), soil.

- *Aloe vera* (60g)
- Seedlings of tomato
- Funnel
- Cotton wool
- Masking tape
- Test tubes with connecting pipe
- Beakers
- Table with perforated holes for connecting pipe attached unto test-tubes
- Collecting beakers
- Centrifuge machines
- Microscope
- Microscopic slides
- Teasing pins
- Petri-dish
- Cover slips

3.3 Sample Collection

Suspected tomato plant was collected from farms around Farigada area of Jos, Plateau State. Seedlings of tomato grown at Faringada were transplanted and planted in the nursery.

The nematode were extracted and identified in Biology Laboratory, kept at a temperature suitable for their growth and leaves of *Aloe vera* plant of 60 grams were collected in the nursery all in Federal College of Forestry, Jos.

3.3.1 Laboratory extraction of nematodes

The infested young plant which showed sign of stunted growth and scanty leaves were used for the nematode extraction. Large and small roots showing swelling varying from round shaped sphere-like galls to elongated spindle from large numbers of individual galls were carefully up-rooted and washed gently to remove the soil directly attaching to the tomato. Suspected galls on the root were carefully transported to the laboratory where they were excised and teased with the use of forceps and teasing pins in other to expose and release the nematode from the root tissues. The extraction of the root-knot Nematodes from the host plant roots was done using the Modified Baermann Funnel Method (Southey, 1972). A regular funnel with a piece of rubber tube about 25-30cm long attached to its stem and in turn connected to the test-tube tightly held together with the aid of masking tape was constructed. The setup was kept in an upright position using a table stand with small regular holes and filled with distilled water to the brim of the funnel's stem. Cotton wools was placed in the funnel to assume the shape of the funnel so that the water slightly covered the wool before the teased root samples for the extraction to be place on the wool and then cover with water to prevent the samples from drying. The set-up was then allowed to stand for 24 hours. The juvenile Nematodes being very active readily passed through the cotton wool down the funnel stem and were collected at the bottom of the test-tube. Ten (10) sets of Modified Method were used so as to obtain enough quantities of the inoculums. The test-tubes were then carefully removed and their contents were centrifuged at 2000 RPM (Revolution per minute) for five (5) minutes in other to concentrate the nematode juveniles in the test-tubes which were then taken for

examinations, four hundred (400) total number of nematode were estimated in the test-tubes used.

3.3.2 Identification of nematodes

From the centrifuged content in each test-tube of extracted nematode, unto a grease-free microscopic glass slide, two (2) drops of the sample was added and covered with a cover slip, then viewed under the electron microscope at low power magnification (x10) and the presence of nematode was confirmed using the high power magnifying lens (x40).

3.3.3 Preparation of the plant material

The leaf extracts was prepare from fresh *Aloe vera* plant and line from healthy living plants, they were cut vertically. The plants then dried at room temperature and pulverized. The powdered leaves were soaked in 70% ethanol and was left to stand for 72 hours (3days) and then filtered using a sieve of minute mesh size suitable only to allow the flow of liquid through them and not the powdered solute reported by (Ogundare, 2007). Water was allowed to evaporate from the filtrate using hot plates at a temperature of 50°c suitable for even evaporation while still maintaining the active components within the filtrates especially the heat labile ones. The resultant powdered extracts were collected and then used for the nematicidal tests.

Different concentrations of the leave Extracts was prepared by dissolving variable concentration of the extracts in distilled water as follows:

i. 0.8g of *Aloe vera* to 10ml of distilled water

0.8g in 10ml = 0.08g/ml

=80mg/ml

ii. 0.7g of *Aloe vera* to 10ml of distilled water

0.7g in 10ml = 0.07g/ml

= 70mg/ml

iii. 0.6g of *Aloe vera* to 10ml of distilled water

0.6g in 10ml = 0.06g/ml

= 60mg/ml

iv. 0.5g of *Aloe vera* to 10ml of distilled water

0.5g in 10mI = 0.50mg/ml

=50mg/ml

v. 0.4g of *Aloe vera* to 10ml of distilled water

0.4g in 10ml = 0.04g/ml

= 40ml/ml

3.3.4 Planting of tomato and determination of nematicidal activity

The seedlings of tomato planted in Faringada, transplanted to nursery of Federal College of Forestry in six different pots, the soil used was tested using same procedures of Modified Baermann Funnel Method (Southey, 1972). There were three blocks in area of about $300m^2$ partitioned into five (5) plots with 1m alley each in-between plots and blocks, this is done to avoid treatments interaction. Each plot was $50m^2$ for one treatment between the tested nematicidal extract. This treatment was added at one rate of applications, each of the *Aloe vera* plants extract of varied concentrate 80mg/ml, 70mg/ml, 60mg/ml, 50mg/ml, 40mg/ml, control and four hundred (400) total numbers of the estimated nematode extract were thoroughly mixed with the soil to which the transplanted

tomatoes was planted on in the field and covering directly irrigation after three weeks of transplanting. The growing plant in each plots were then examined at intervals of two weeks in three replicates. After three months all plants were harvested and data for nematode population were counted and recorded. The plot to which no isolate of nematodes and extract was added serve as control.

3.4 Experimental Design Layout

The experiment was laid on a complete randomized design (CRD)

3.5 Data Measured

3.5.1 Plant height (cm)

The plant height were obtained by taking measurement (cm) using a measuring tape on the plant in each plot in the nursery after the introduction of nematode an treatment applications in the soil of the pot to in which the plant were planted. The data were recorded in an interval of two (2) weeks in three (3) replicates respectively.

3.5.2 Root length (cm)

The root length was obtained by taking measurement (cm) of the root plant using measuring tape on the plant in each plot in the field. The data obtained were recorded in an interval of two (2) weeks in three (3) replicates respectively.

3.5.3 Shoot weight (g)

The shoot weight was obtained using the weighing balance in which the shoot was un-plucked and weighed. The data obtained were recorded in an interval of two (2) weeks in three (3) replicates.

3.5.4 Yield of plant

The plant yield was obtained by viable counting the number of successful plant grown within each plots in the field. Data obtained were recorded in an interval of two (2) weeks in three (3) replicates.

3.5.5 Final nematode population

The final population of nematodes present was obtained and assessed by further extractions of nematodes in each plots, soil and ensuring viable counting to be certain on the estimated numbers of nematode present in each plots.

3.6 Data Analysis

Data collected were analyzed using analysis of variance, ANOVA to determine the significant difference between the concentrations of the *Aloe vera* plant extract and mean separation were made using Duncan multiple ratio test, DMRT.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Results

4.1.1 Identification of nematode

The results in Table 1 show the characteristics features for the identification of both the juvenile and adult (male and female) root-knot nematodes, *Meloidogyne incognita* when viewed under the electron microscope.

241 **Table 1: Identification of nematodes**

Nematode	Features of nematode seen on microscope
Juvenile	- Head not offset with truncated cone shape when viewed laterally. - Stylet knob is prominent and rounded.
Adult male nematode	- The head is not offset with a high truncate cone shape. - The head cap is clearly annulated. - The head cap is with stepped outline in lateral view. - Annule number behind head cap very variable usually 1-3 on sub-lateral head sector. - Conus of stylet longer than shaft. - Stylet knob is prominent usually of greater width than length with flat concave or toothed anterior.
female Adult nematode	- The body is spherical with projecting neck. - Head with 2 or 3 annule behind the head cap. - The cuticle thickening at base of relaxed stylet. - Stylet knobs are drawn out laterally. - Dorsal arch is high and rounded.

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4.1.2 Nematicidal effect of Aloe vera extract on tomato plant height for week 1 to 3

The results in Table 2 show the highest mean value with sample treated with 80mg/ml resulted in taller plant height and the observed difference was far more than the rest of the treatments. The performance was taller at week 1 (18.00) when compared to the rest and also resulted in taller plant height in week 3 (26.00). The order of performance on mean at week 3 for the treatments are: 80mg/ml (26.00) > 70mg/ml (24.00) > 60mg/ml (19.00) > 50mg/ml (17.00) > 40mg/ml (13.00) control (12.00).

Table 2: Nematicidal effect of Aloe vera extract on tomato plant height for week 1 to 3

Treatment (mg/ml)	Plant height (cm)		
	Week 1	**Week 2**	**Week 3**
80	18.00[a]	21.00[a]	26.00[a]
70	13.00[b]	20.00[a]	24.00[a]
60	12.00[b]	17.00[b]	19.00[b]
50	10.00[bc]	15.33[b]	17.00[bc]
40	8.00[c]	11.00[c]	13.00[cd]
Control	7.00[c]	10.00[c]	12.00[e]
SE±	**1.00**	**0.79**	**1.41**

Mean followed by the same superscript in a column are not significantly different from each other.

4.1.3 Nematicidal effect of Aloe vera extract on tomato root length for week 1 to 3

The results in Table 3 show the highest mean value with sample treated with 80mg/ml resulted in longer tomato root length. The performance was longer at week 1 (9.00) when compared to the rest and also resulted in longer root length in week 3 (12.00). The order of performance on mean at week 3 for the treatments are: 80mg/ml (12.00) > 70mg/ml (10.00) > 60mg/ml (8.00) > 50mg/ml (7.00) > 40mg/ml (5.00) control (4.00).

Table 3: Nematicidal effect of Aloe vera extract on tomato root length for week 1 to 3

Treatment (mg/ml)	Root length (cm)		
	Week 1	**Week 2**	**Week 3**
80	9.00^{a}	11.00^{a}	12.00^{a}
70	5.00^{b}	8.00^{b}	10.00^{ab}
60	4.00^{bc}	5.00^{c}	8.00^{bc}
50	2.00^{cd}	4.00^{cd}	7.00^{bcd}
40	2.00^{cd}	3.00^{cd}	5.00^{cd}
Control	1.27^{d}	2.00^{d}	4.00^{d}
SE±	**0.67**	**0.82**	**0.94**

Mean followed by the same superscript in a column are not significantly different from each other.

4.1.4 Nematicidal effect of Aloe vera extract on tomato shoot weight for week 1 to 3

The results in Table 4 show the highest mean value with sample treated with 80mg/ml resulted in higher tomato shoot weight. The performance was high at week 1 (0.40) when compared to the rest and also resulted in higher shoot weight in week 3 (0.80). The order

of performance on mean at week 3 for the treatments are: 80mg/ml (0.80) > 70mg/ml (0.60) > 60mg/ml (0.40) there was significant differences except in 50mg/ml (0.30) which did not differ from 40mg/ml (0.30) and control (0.30) in week 1,2 and 3, although at week 1, 60mg/ml did not differ from the others and at week 2, 50mg/ml (0.22) differs from 40mg/ml and control (0.11)

Table 4:Nematicidal effect of Aloe vera extract on tomato shoot weight for week 1 to 3

Treatment (mg/ml)	Shoot weight (g)		
	Week 1	**Week 2**	**Week 3**
80	0.40[a]	0.70[a]	0.80[a]
70	0.21[b]	0.50[b]	0.60[b]
60	0.11[c]	0.22[c]	0.40[c]
50	0.11[c]	0.21[c]	0.30[c]
40	0.11[c]	0.11[c]	0.30[c]
Control	0.11[c]	0.11[c]	0.30[c]
SE±	**0.02**	**0.34**	**0.06**

Mean followed by the same superscript in a column are not significantly different from each other.

4.1.5 Nematicidal effect of Aloe vera extract on tomato yield for week 1 to 3

The results in Table 5 show that there is a significant difference in yield for both weeks 1, 2 and 3. Although, there was no significant differences between concentration of 80mg/ml (6.00) when compared to control (6.00) and between concentration of 70mg/ml and 60mg/ml (4.00) and there was differences at 50mg/ml (3.00) and 40mg/ml (2.00).

Table 5: Nematicidal effect of Aloe vera extract on tomato yield for week 1 to 3

Treatment (mg/ml)	Yield		
	Week 1	**Week 2**	**Week 3**
80	6.00[a]	6.00[a]	6.00[a]
70	4.00[ab]	4.00[ab]	4.00[ab]
60	4.00[ab]	4.00[ab]	4.00[ab]
50	3.00[ab]	3.00[ab]	3.00[ab]
40	2.00[b]	2.00[b]	2.00[b]
Control	6.00[a]	6.00[a]	6.00[a]
SE±	**1.00**	**1.00**	**1.00**

Mean followed by the same superscript in a column are not significantly different from each other.

4.1.6 Nematicidal effect of Aloe vera extract on tomato nematode population for week 1 to 3

The results in Table 6 show the highest mean value of mortality rate of nematode population with sample treated with 80mg/ml, control and the observed difference was far more than the rest of the treatments. The order of performance on mean are: 80mg/ml, control (0.14) < 70mg/ml (40.00) < 60mg/ml (108.00) < 50mg/ml (150.00) < 40mg/ml (300.00).

Table 6: Nematicidal effect of Aloe vera extract on tomato nematode population for weeks 1 to 3

Treatment (mg/ml)	Treatment at weeks 1 to 3		
	Week 1	**Week 2**	**Week 3**
80	120.00[c]	60.00[e]	0.14[e]
70	150.00[c]	120.00[d]	40.00[d]
60	250.00[b]	150.00[c]	108.00[c]
50	300.00[b]	288.00[b]	150.00[b]
40	401.00[a]	350.00[a]	300.00[a]
Control	0.14[d]	0.14[f]	0.14[e]
SE±	**20.00**	**9.04**	**7.27**

Mean followed by the same superscript in a column are not significantly different from each other.

4.2 Discussion

Tomato plants are highly susceptible to *Meloidogyne incognita* as indicated by the final nematode population and plant growth, this results indicate that extracts of *Aloe vera* is effective in the reducing *Meloidogyne incognita* in the soil and improving plant growth. *Meloidogyne incognita* from this result having distinctive features such as head not offset with truncated cone shape, stylet knob prominent and round, conus of stylet longer than

shaft. Similar report been made by Orton Williams (1973). *M. incognita* identification that the body is spherical with projecting neck, in lateral view, stylet knob are drawn out, the head is clearly annulated, conus of stylet is longer than shaft. The extent of nematode population reduction was dependent on the rate of application of different concentration of the extracts and time of exposure, inhibition of of *M.incognita* reproduction resulted in significant improvement in the tomato growth parameters and yield, a similar report by (Alam, 1991; Ramesh *et al*., 2008) that plant powder treated plant showed increased plant growth parameters and yield and may be due to an additive effect of nutrients produced were increased soil fertility by the decomposed materials. Similar results have been reported by other research workers of different botanicals on different agricultural crops such as (Agbenin, 2004, Egunjobi and Onayemi, 1981, Agbenin *et al.,* 2002, Bello *et al.,* 2002, Rotimi and Mocu, 2002, Sukul, 1992, Sukul *et al.,* 1974, Fotoki and Oyedumale, 1996, Akhtar, 2008, Sasanelli and Addabbo, 1993, Akhtar and Malik, 2000). It was also earlier reported by Adegbite (2003), Adegbite and Adesiyan (2005), Ranjitsingh *et al.,*(2009) and Umar (2013) that botanical extract that contained alkaloids, saponins and flavonoids either singly or in combination inhibited of *Meloidogyne* spp. In a related work Ferreira *et al*., (2013) reported that aqueous extracts of *zinnia peruviana* and *Wedelia* species inhibited *Meloidogyne incognita* when compare to the control when compare to control by 92.72% and 97.48% respectively. Khan *et al*., (2008) reported that extracts of some plants such as onion, garlic, tobacco, cloves and chill were effective against *M. incognita* larvae and caused mortality of juveniles between 82-100%. The ready availability of the organic materials used in this study, its effects on nematode population,

plant growth and yield suggest the need for additional studies in the field to evaluate the efficacy and economics for it use in nematode management. The responses to pesticide treatment were not compared directly with the results attained from extract of *Aloe vera* plant tested, because this material were recorded promising, gave more attention to non-chemical methods for the control of nematode problems by safe economic and less dangerous method as well as environmentally safe.

CHAPTER FIVE

5.0 SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Summary

The effect of different concentrations of *Aloe vera* plants extract as alternative management method for the control of root-knot nematode *Meloidogyne incognita* on tomato, tomato being one of the most important tropical vegetable crop widely used throughout the world. In recent years, root-knot nematodes *Meloidogyne* spp. problem has become a threat to tomato cultivation. Yield loss due to nematode, cause diseases to nearly all plant crops of Economic importance with estimated losses of US $125 billion per year World-Wide. Control of root-knot nematodes has been primarily accomplished through chemical nematicides. However, indiscriminate use of chemical pesticides causes great threat to human being, animal, vegetation and to the environment. So with the increasing awareness of possible deleterious effects of the chemicals, biological controls of plant pathogen have received considerable attention. Some of the plant species and parts antagonistic to *Meloidogyne* spp. are the leaves and flowers of marigold (*Tagetes* sp). In this research, activity of the leaf extracts of *Aloe vera* is study as nematicides for the

control of root-knot nematodes. The results showed that, all the tested treatment led to a significantly ($p \leq 0.05$) reduction in nematode population and improved tomato growth and yield. Hence, having nematicidal activity on both the juvenile and adult root-knot nematode, the nematicidal increased with increase in concentration of the extracts and time of exposure to the extracts. Final death of nematode population recorded was highest when exposed to the highest concentration of *Aloe vera.* The highest concentration being 80mg/ml (0.14) followed by 70mg/ml (40.00) concentration and so on, this indicates that the higher the concentration of the extract, the higher the number of nematodes that would be killed

5.2 Conclusion

The results obtained could be an outcome of the nematicidal content of the extracts which killed nematodes, the effect of the different extracts of the botanical on the performance of tomato was significantly different at 5% level of probability. Tomato crop treated with different concentration recorded taller plant, longer root, higher shoot weight, high yield and higher mortality rate of nematode recovered from soil. The treated plant recorded better growth parameters and fewer nematodes due to the nematicidal or nemostatic effect of the different concentrations of extract. It was reported that extracts of plant containing tannins, alkaloids and flavonoids were effective against root-knot nematodes both *in-vivo* and *in-vitro* (Adegbite and Adesiyan, 2005, Anuja and Satyawati, 2007 and Umar, 2013. The result of the study indicated that 80mg/ml was more effective against *M. incognita* and hence improved tomato growth and yield. Although, others treatment were also able to reduced nematode population and were not as effective as the 80mg/ml.

5.3 Recommendation

As these results have demonstrated the nematicidal property of *Aloe vera* extract in reducing *Meloidogyne incognita* attacking tomato, it is recommended that:

1. Further investigations are necessary to evaluate economic aspects of this botanicals before recommendation to tomato farmers
2. To determine the most appropriate rate and concentrations of the extracts and it feasibility for use in the large field
3. Further study are to be carried out on the effectiveness of the powdered form of this botanical spray directly on the field against *M. incognita* and *M. javanica* and other *Meloidogyne* spp. attacking tomato before making final recommendation to tomato farmer as they may not know the effect of different nematode attacks on tomato.
4. For further work, the actual active ingredient should be identify and purify
5. Species of *Aloe* should also be assessed for their nematicidal or nematostatic effect of root-knot nematodes.

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640 **APPENDICES**
641 **Appendix i**
642
643 **TABLE 7: PLANT HEIGHT AT WEEK ONE**

Source	Sum of Squares	Df	Mean Square	F	Sig.	LSD
Treatment	238.000	5	47.600	15.867	0.000*	2.52
Error	36.000	12	3.000			
Total	274.000	17				

644 *** Significant**
645
646 **TABLE 8: PLANT HEIGHT AT WEEK TWO**

Source	Sum of Squares	Df	Mean Square	F	Sig.	LSD
Treatment	308.944	5	61.789	33.180	0.000*	1.99
Error	22.347	12	1.862			
Total	331.291	17				

647 *** Significant**
648
649 **TABLE 9: PLANT HEIGHT AT WEEK THREE**

Source	Sum of Squares	Df	Mean Square	F	Sig.	LSD
Treatment	484.500	5	96.900	16.150	0.000*	3.56
Error	72.000	12	6.000			
Total	556.500	17				

650 *** Significant**
651
652 **TABLE 10: ROOT LENGTH AT WEEK ONE**

Source	Sum of Squares	Df	Mean Square	F	Sig.	LSD

Treatment	124.144	5	24.829	18.475	0.000*	1.69
Error	16.127	12	1.344			
Total	140.271	17				

*** Significant**

TABLE 11: ROOT LENGTH AT WEEK TWO

Source	Sum of Squares	Df	Mean Square	F	Sig.	LSD
Treatment	172.500	5	34.500	17.250	0.000*	2.06
Error	24.000	12	2.000			
Total	196.500	17				

*** Significant**

TABLE 12: ROOT LENGTH AT WEEK THREE

Source	Sum of Squares	Df	Mean Square	F	Sig.	LSD
Treatment	136.000	5	27.200	10.200	0.001*	75.14
Error	32.000	12	2.667			
Total	168.000	17				

*** Significant**

TABLE 13: SHOOT WEIGHT AT WEEK ONE

Source	Sum of Squares	Df	Mean Square	F	Sig.	LSD
Treatment	0.208	5	0.042	23.731	0.000*	0.07
Error	0.021	12	0.002			
Total	0.229	17				

*** Significant**

TABLE 14: SHOOT WEIGHT AT WEEK TWO

Source	Sum of Squares	Df	Mean Square	F	Sig.	LSD
Treatment	0.855	5	0.171	47.931	0.000*	0.09
Error	0.043	12	0.004			
Corrected Total	0.898	17				

*** Significant**

TABLE 15: SHOOT WEIGHT AT WEEK THREE

Source	Sum of Squares	Df	Mean Square	F	Sig.	LSD

Treatment	0.645	5	0.129	12.900	0.000*	0.15
Error	0.120	12	0.010			
Total	0.765	17				

*** Significant**

TABLE 16: YIELD AT WEEK ONE

Source	Sum of Squares	Df	Mean Square	F	Sig.	LSD
Treatment	38.500	5	7.700	2.567	0.000*	0.12
Error	36.000	12	3.000			
Total	74.500	17				

*** Significant**

TABLE 17: YIELD AT WEEK TWO

Source	Sum of Squares	Df	Mean Square	F	Sig.	LSD
Treatment	38.500	5	7.700	2.567	0.000*	0.12
Error	36.000	12	3.000			
Total	74.500	17				

*** Significant**

TABLE 18: YIELD AT WEEK THREE

Source	Sum of Squares	Df	Mean Square	F	Sig.	LSD
Treatment	38.500	5	7.700	2.567	0.000*	0.12
Error	36.000	12	3.000			
Total	74.500	17				

*** Significant**

TABLE 19: NEMATODE POPULATION AT WEEK ONE

Source	Sum of Squares	Df	Mean Square	F	Sig.	LSD
Treatment	305015.677	5	61003.135	50.829	0.000*	50.41
Error	14402.006	12	1200.167			
Total	319417.683	17				

*** Significant**

TABLE 20: NEMATODE POPULATION AT WEEK TWO

Source	Sum of Squares	Df	Mean Square	F	Sig.	LSD
Treatment	269187.753	5	53837.551	219.446	0.000*	22.79
Error	2944.006	12	245.334			
Total	272131.759	17				

*** Significant**

TABLE 21: NEMATODE POPULATION AT WEEK THREE

Source	Sum of Squares	Df	Mean Square	F	Sig.	LSD
Treatment	198326.621	5	39665.324	249.990	0.000*	18.33
Error	1904.012	12	158.668			
Total	200230.634	17				

*** Significant**

Appendix ii

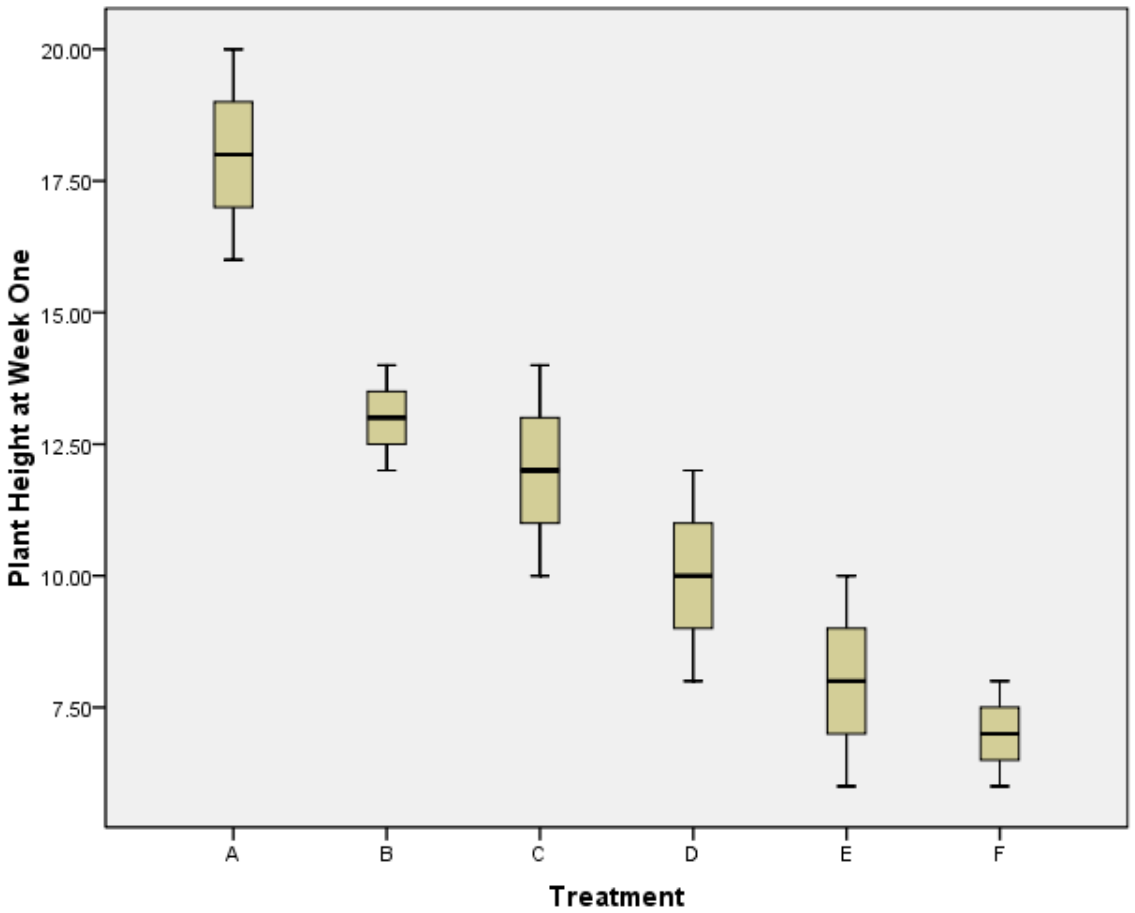


Fig 1: Effects of Treatment on Plant Height at Week One

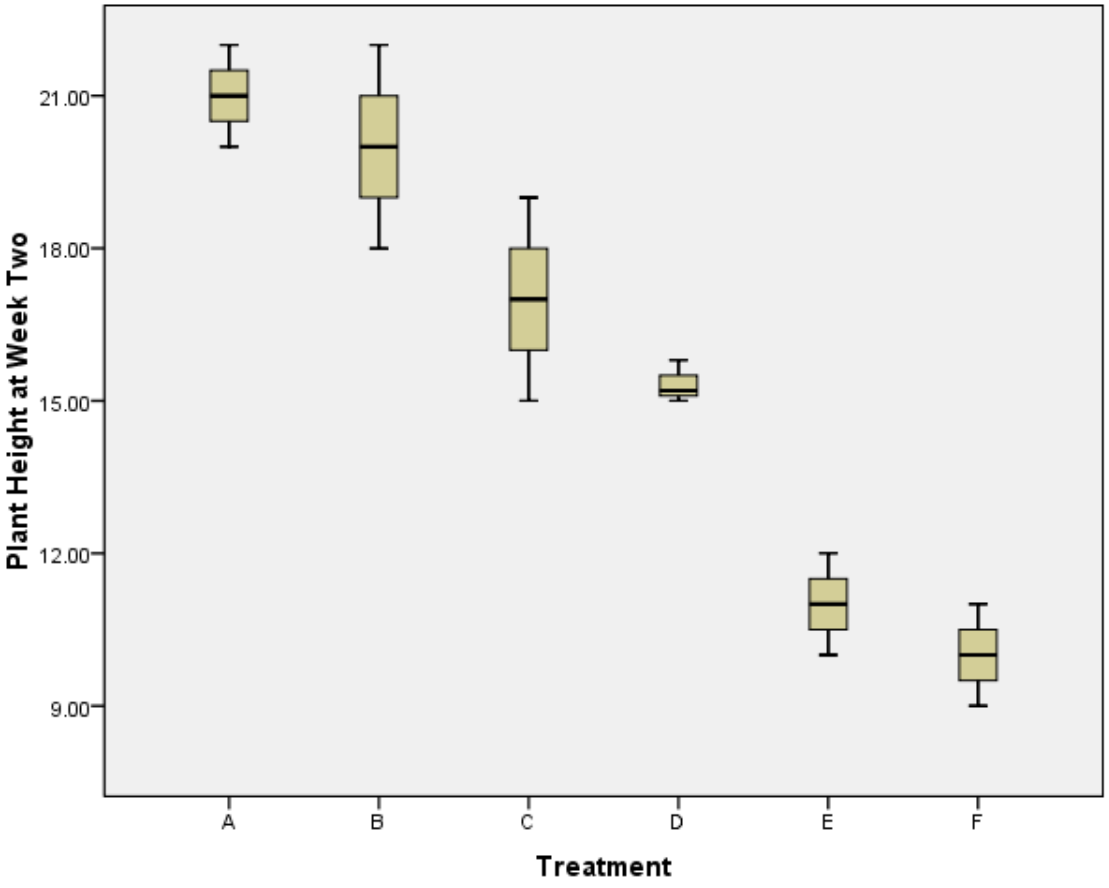


Fig 2: Effects of Treatment on Plant Height at Week Two

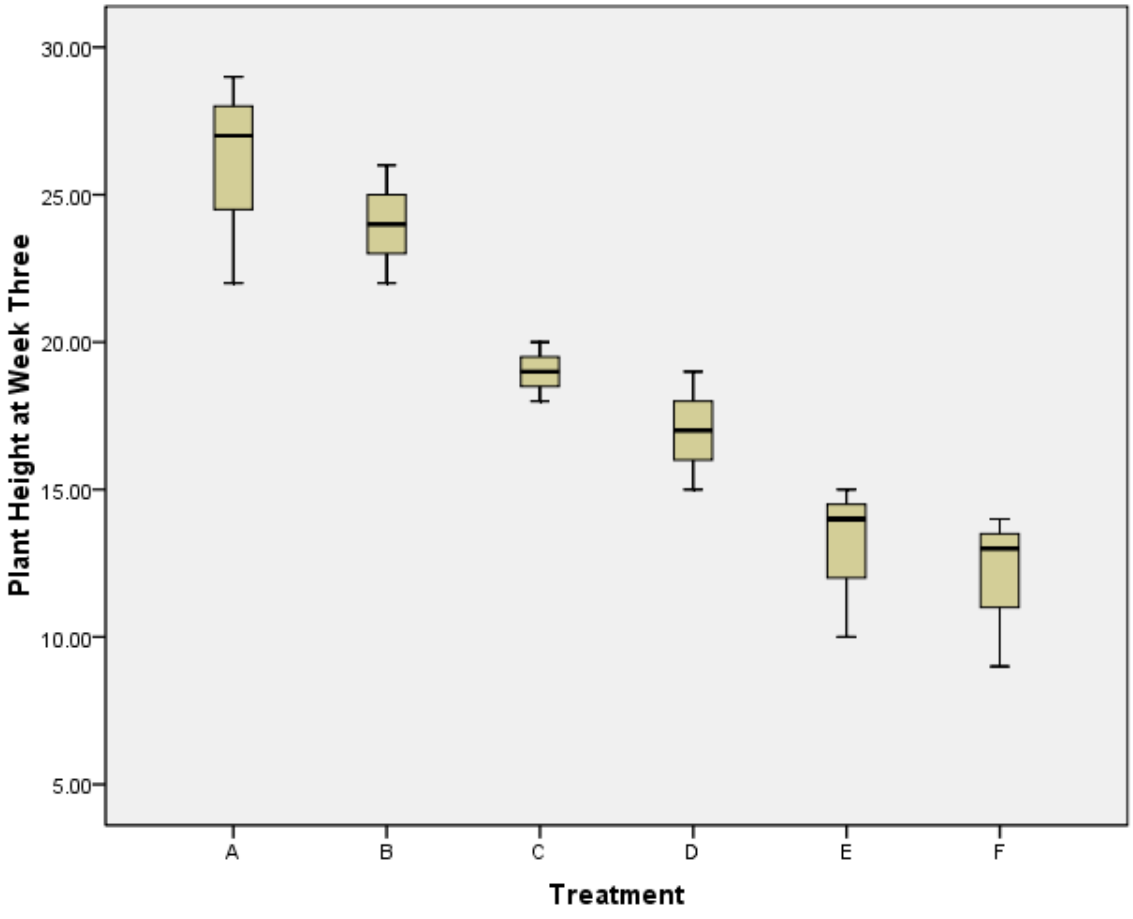


Fig 3: Effects of Treatment on Plant Height at Week Three

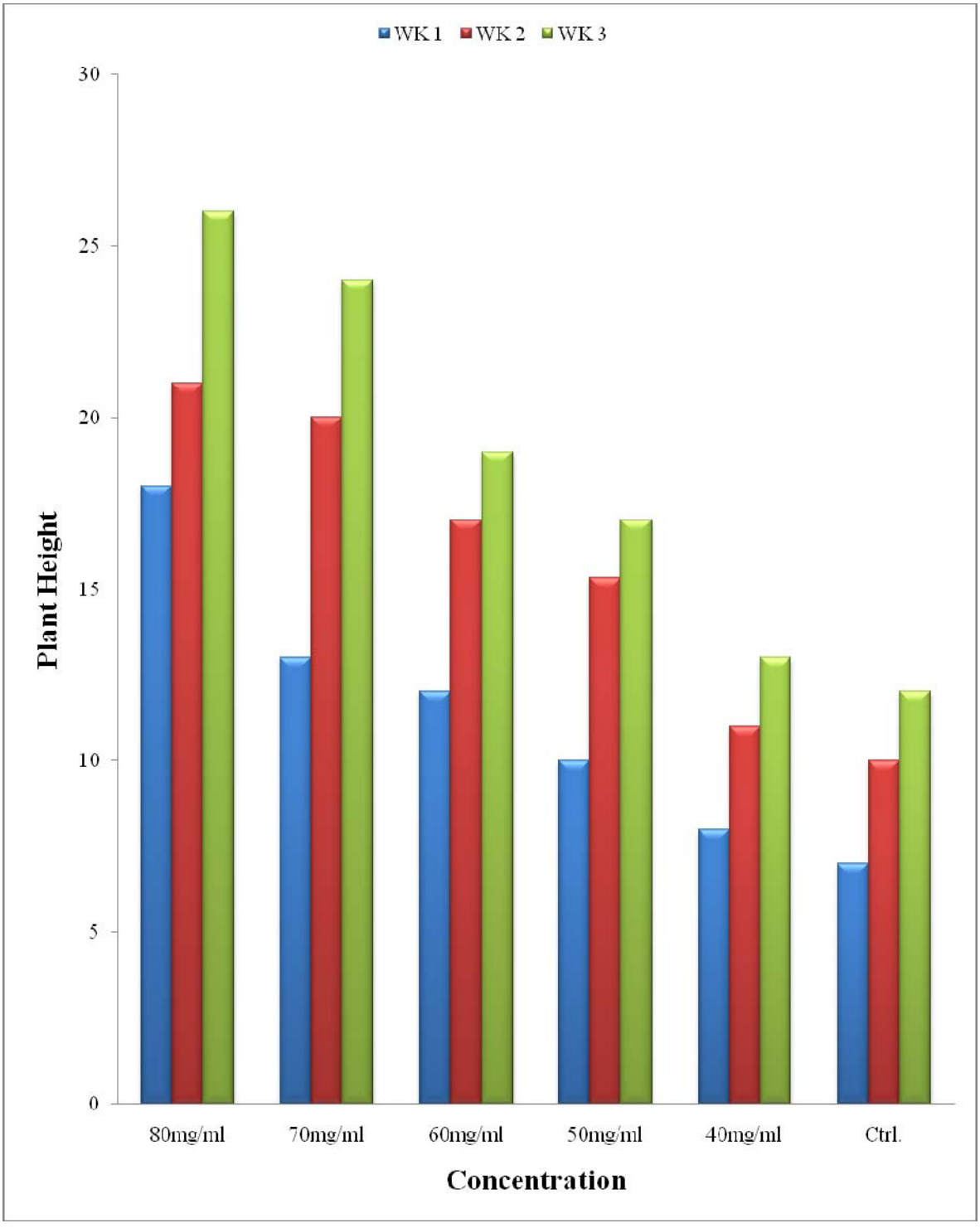

WK 1
WK 2
WK 3
30
25
20
15
10
5
0
Plant Height
80mg/ml
70mg/ml
60mg/ml
50mg/ml
40mg/ml
Ctrl.
Concentration

Fig 4: Effect of Treatment on Plant Height at Different Week Intervals

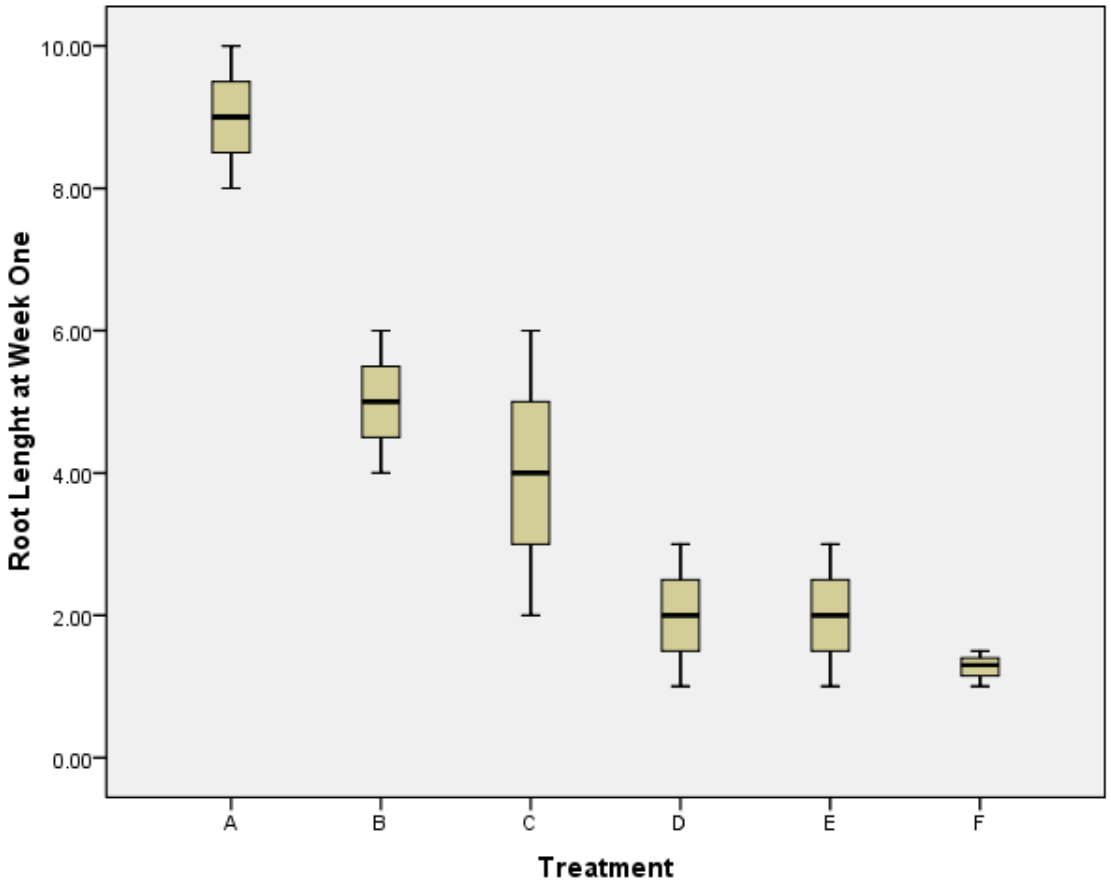


Fig 5: Effects of Treatment on Root Length at Week One

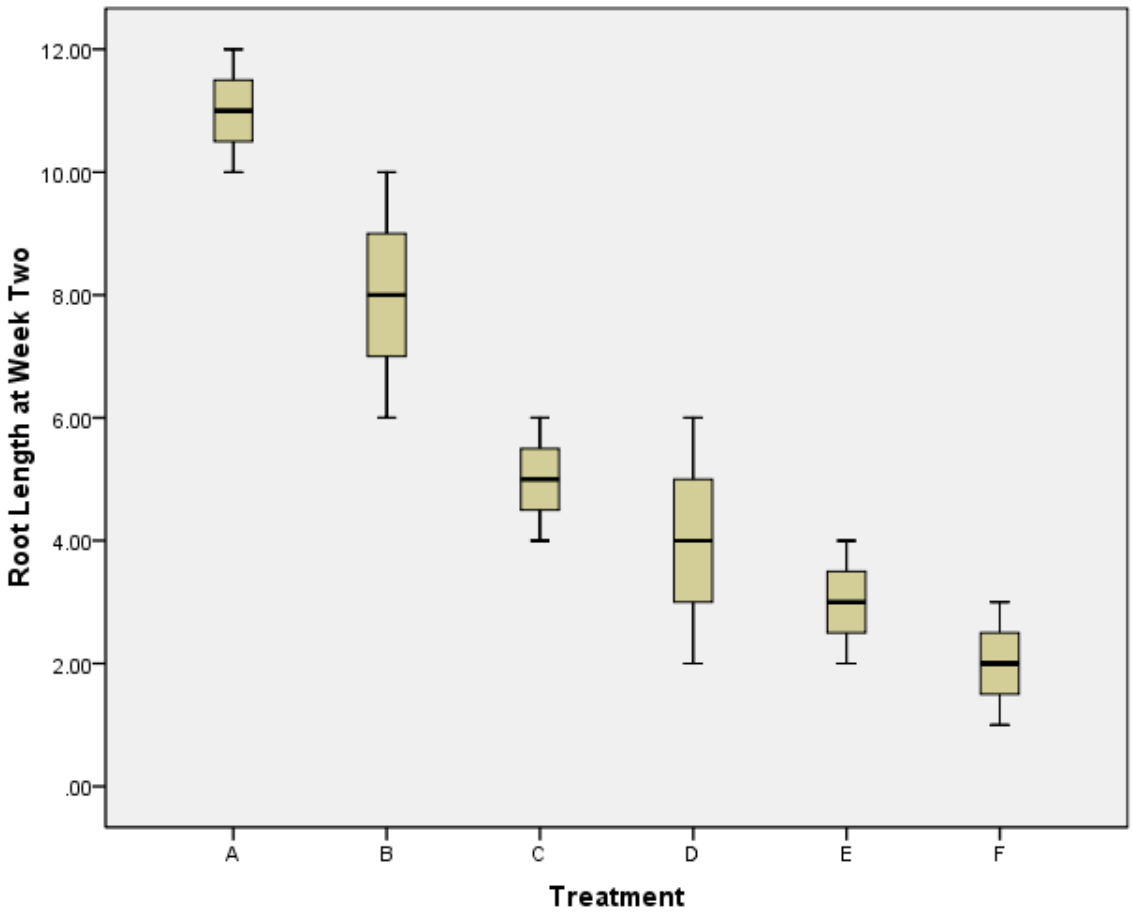
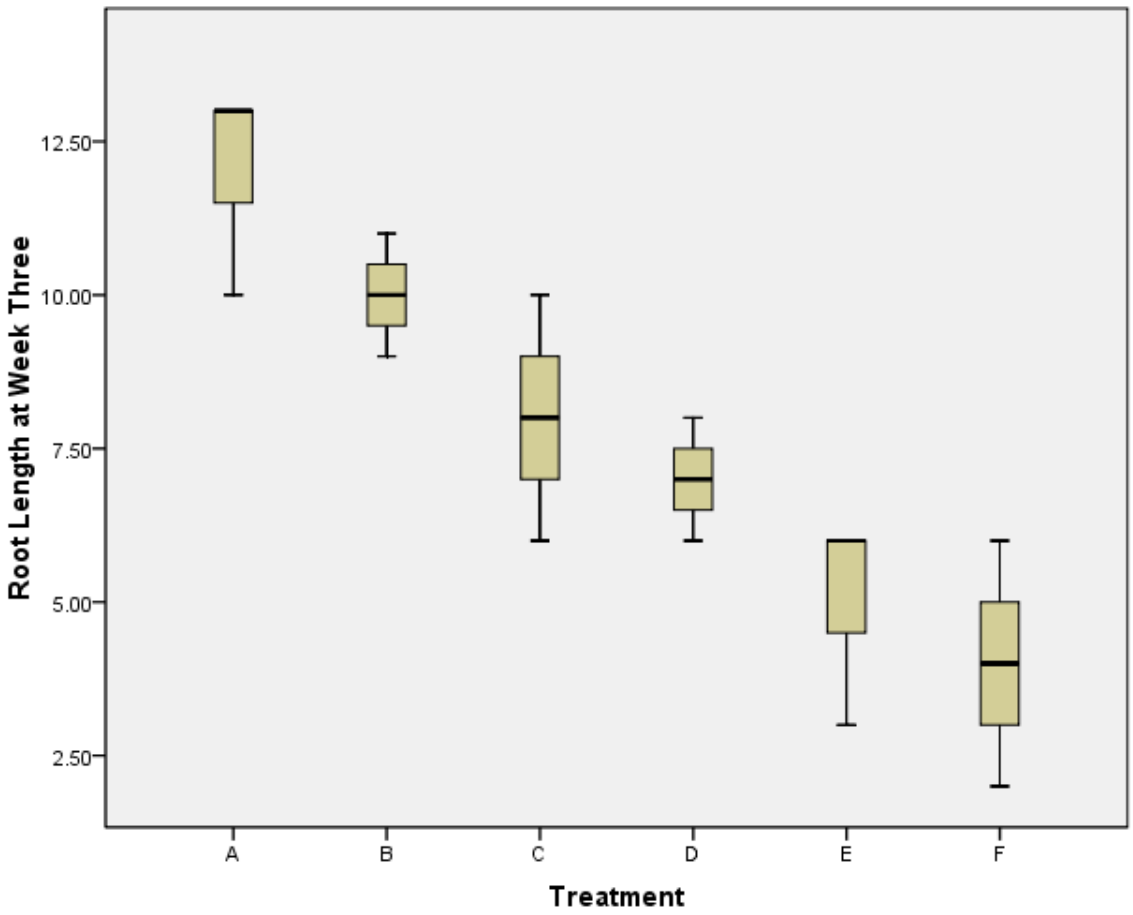


Fig 6: Effects of Treatment on Root Length at Week Two



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762 **Fig 7: Effects of Treatment on Root Length at Week Three**

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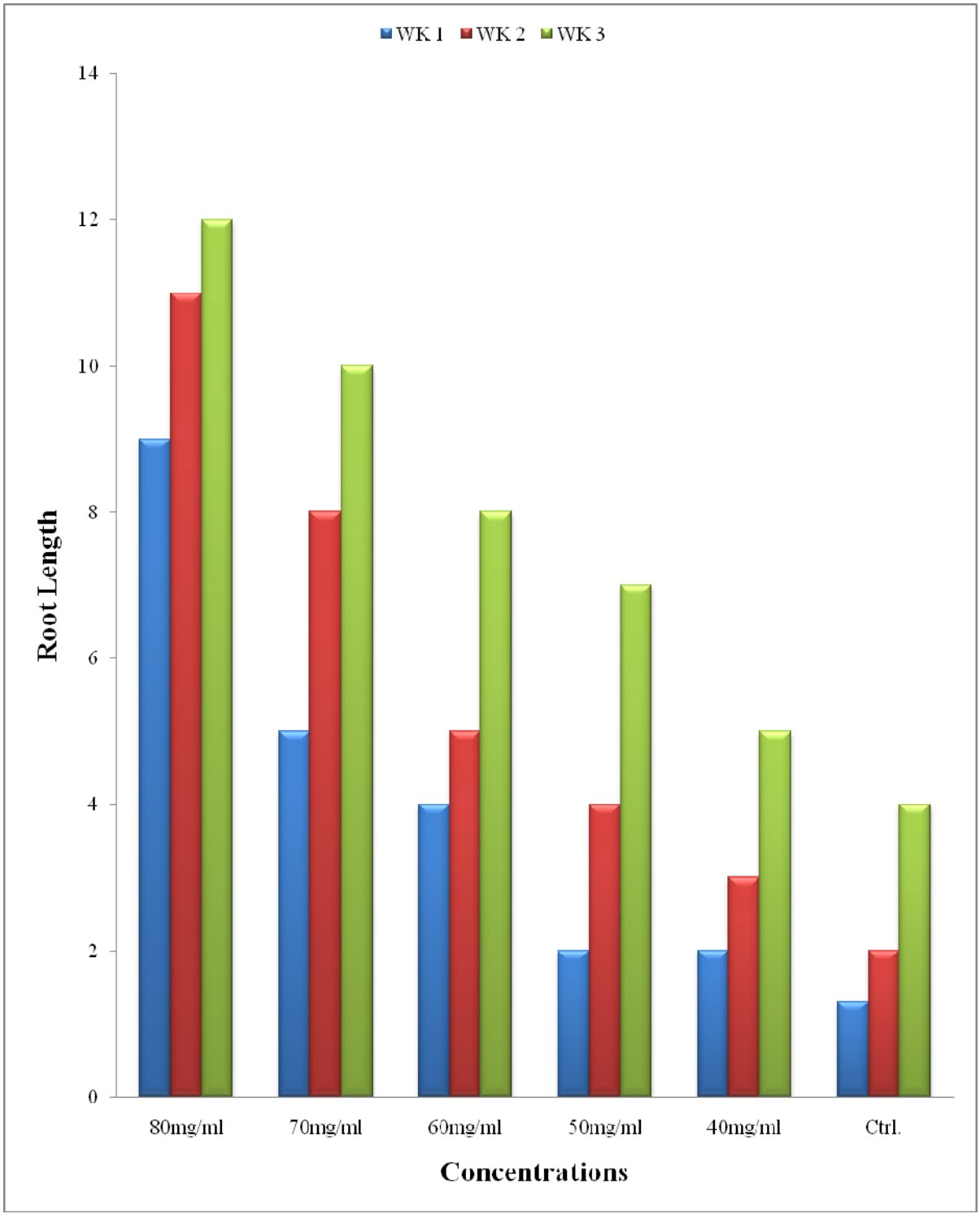
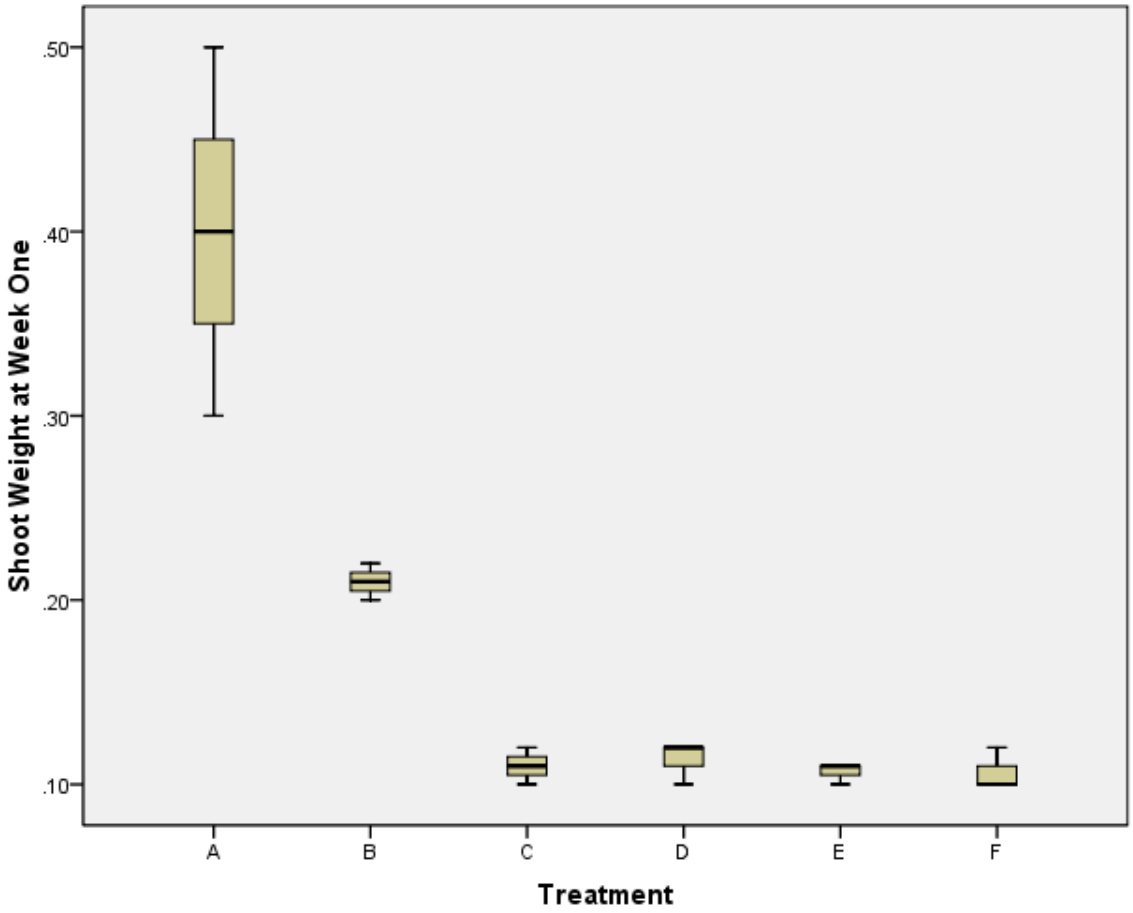


Fig 8: Effect of Treatment on Root Length at Different Week Intervals



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774 **Fig 9: Effects of Treatment on Shoot Weight at Week One**

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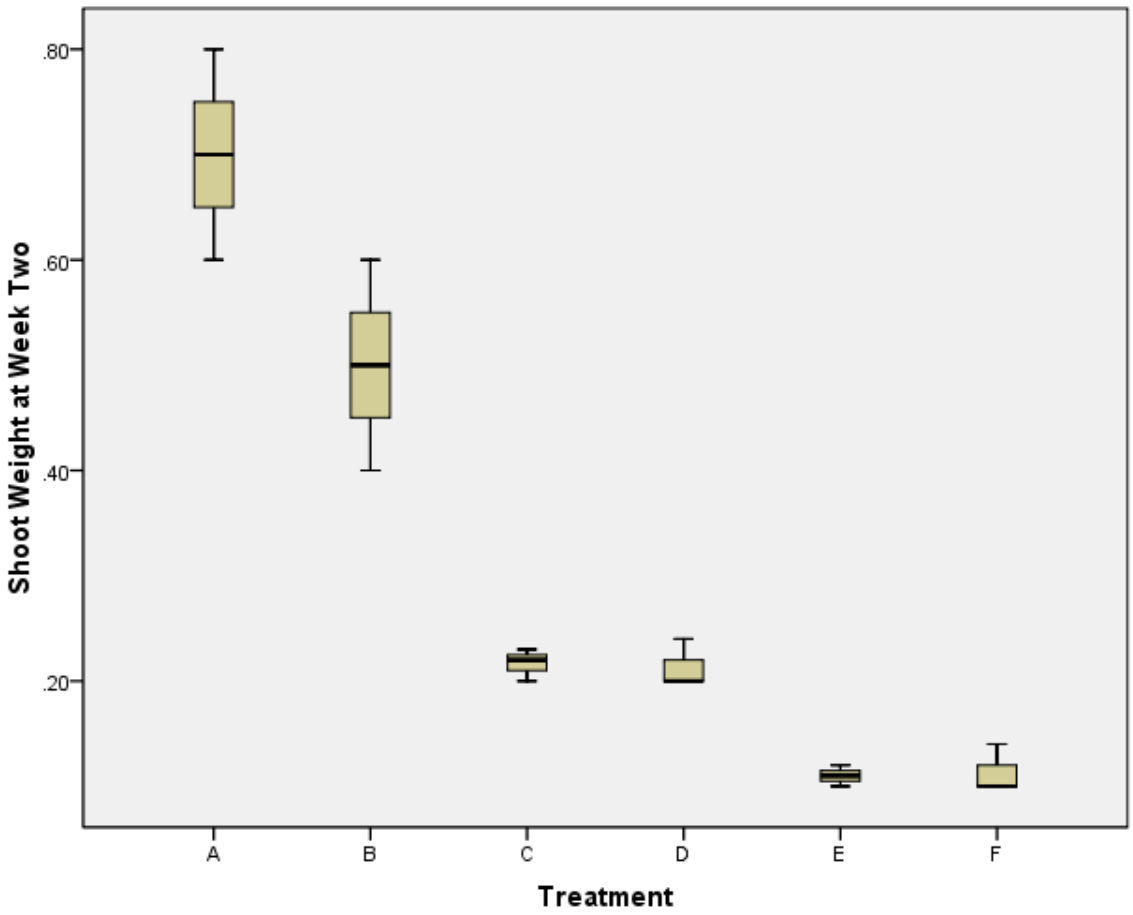

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777 **Fig 10: Effects of Treatment on Shoot Weight at Week Two**

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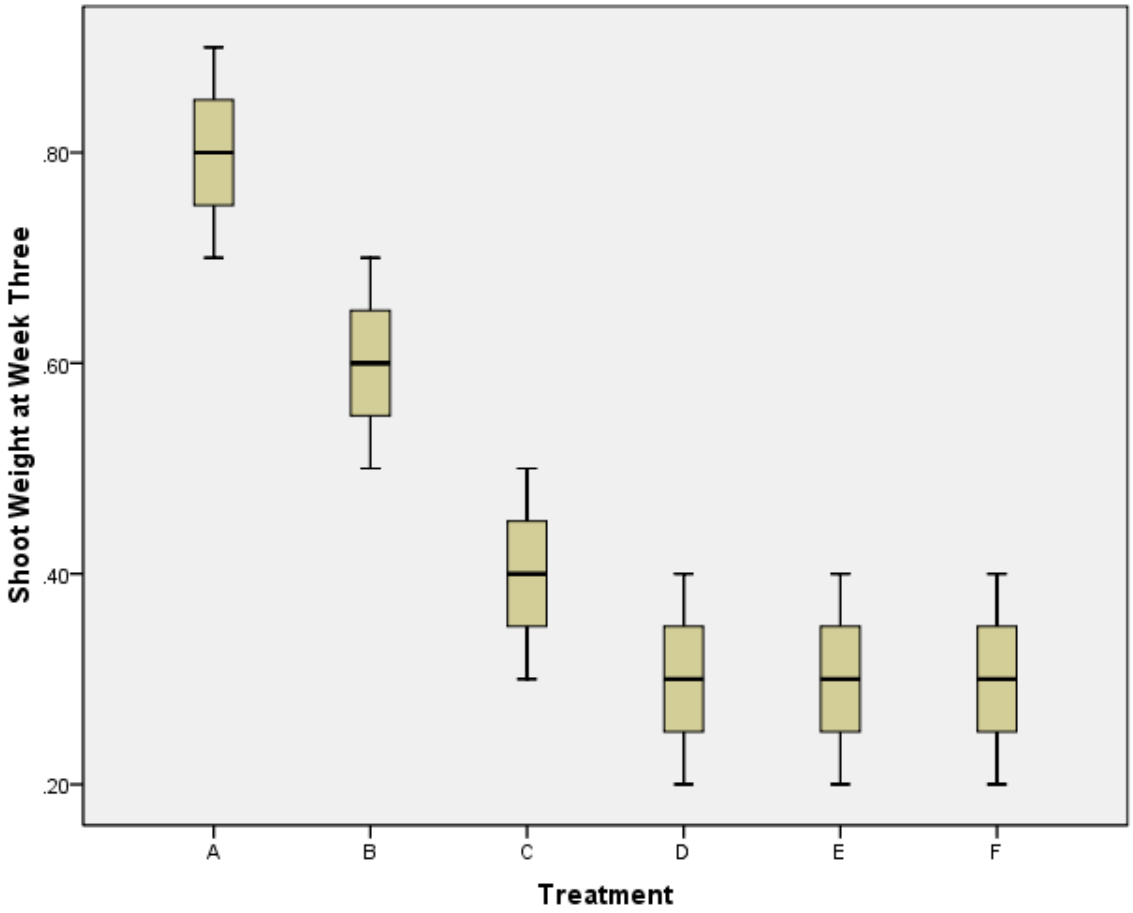


Fig 11: Effects of Treatment on Shoot Weight at Week Three

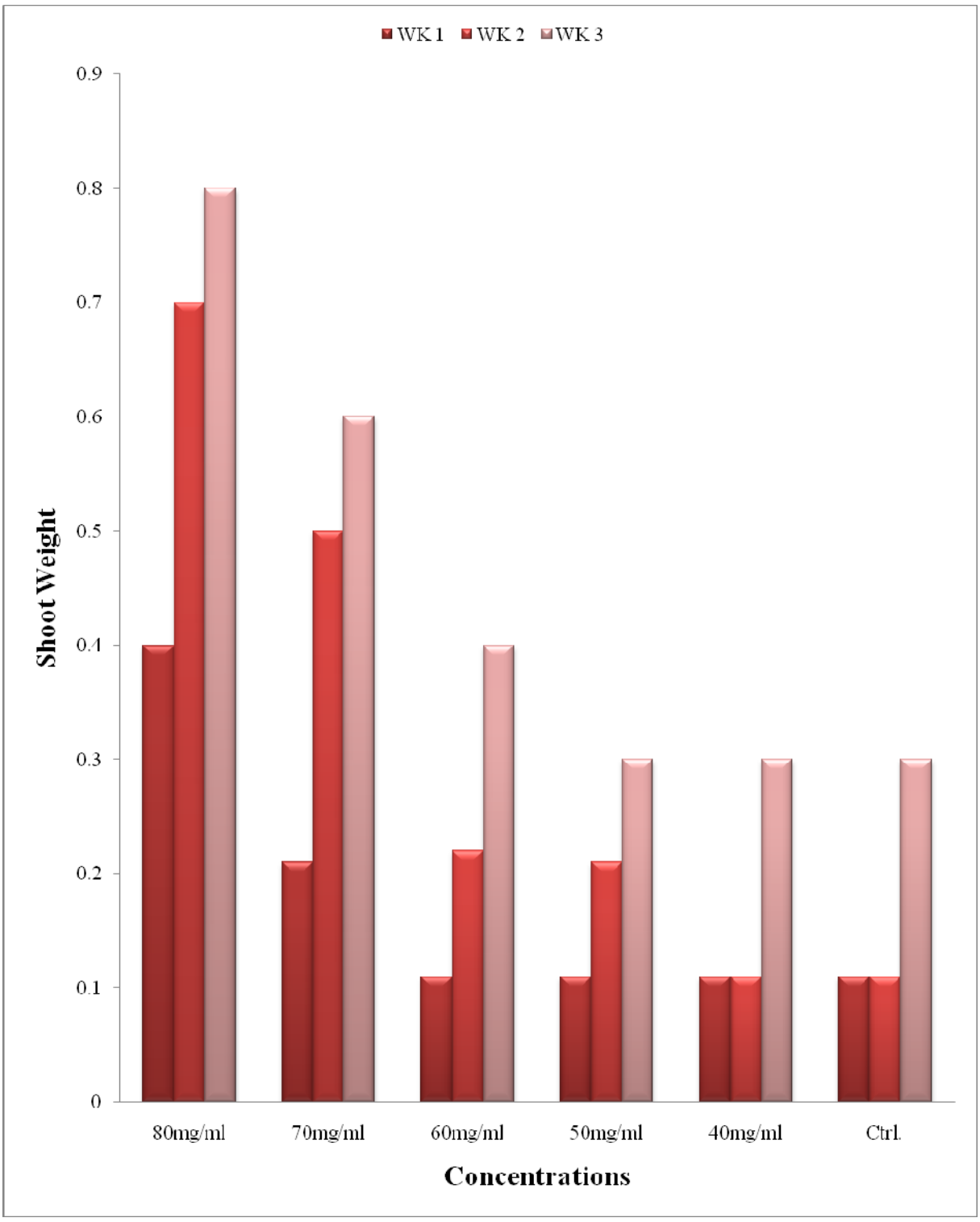


Fig 12: Effect of Treatment on Shoot Weight at Different Week Intervals

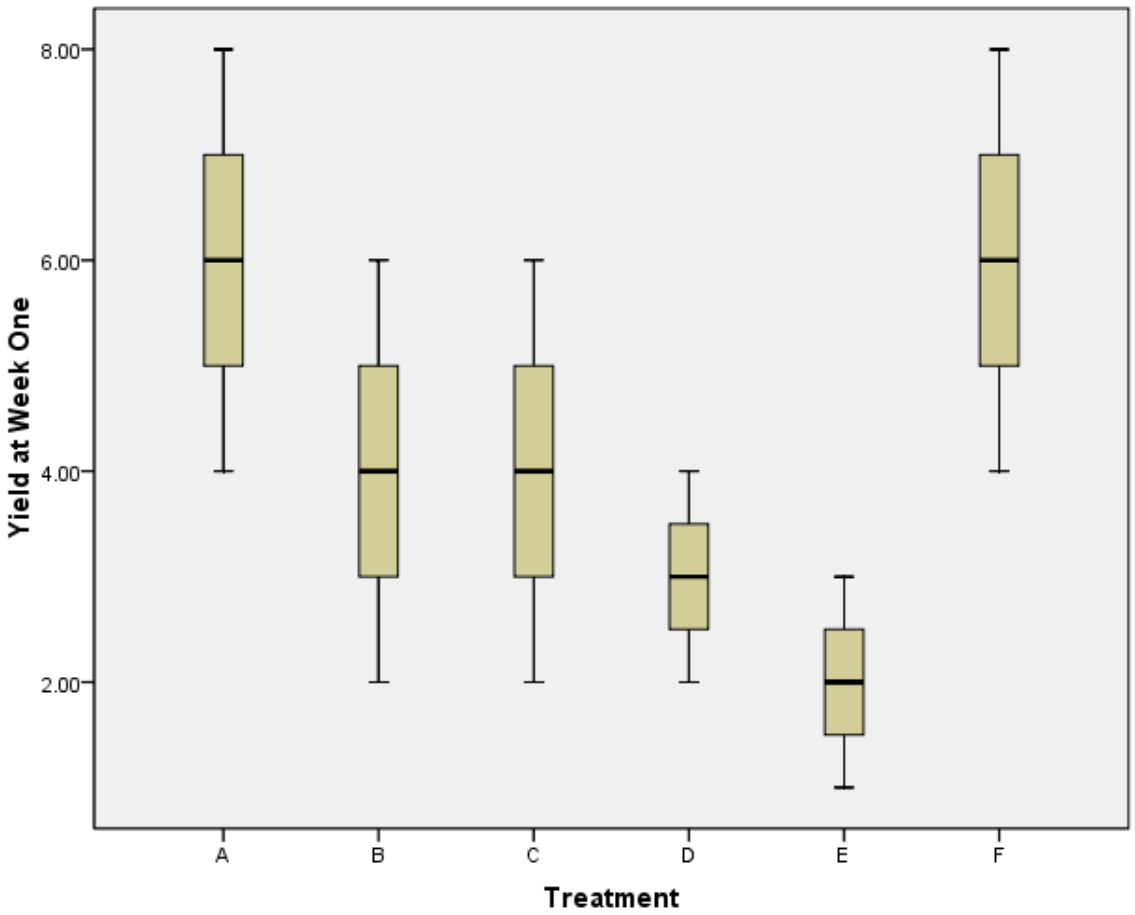


Fig 13: Effects of Treatment on Yield at Week One

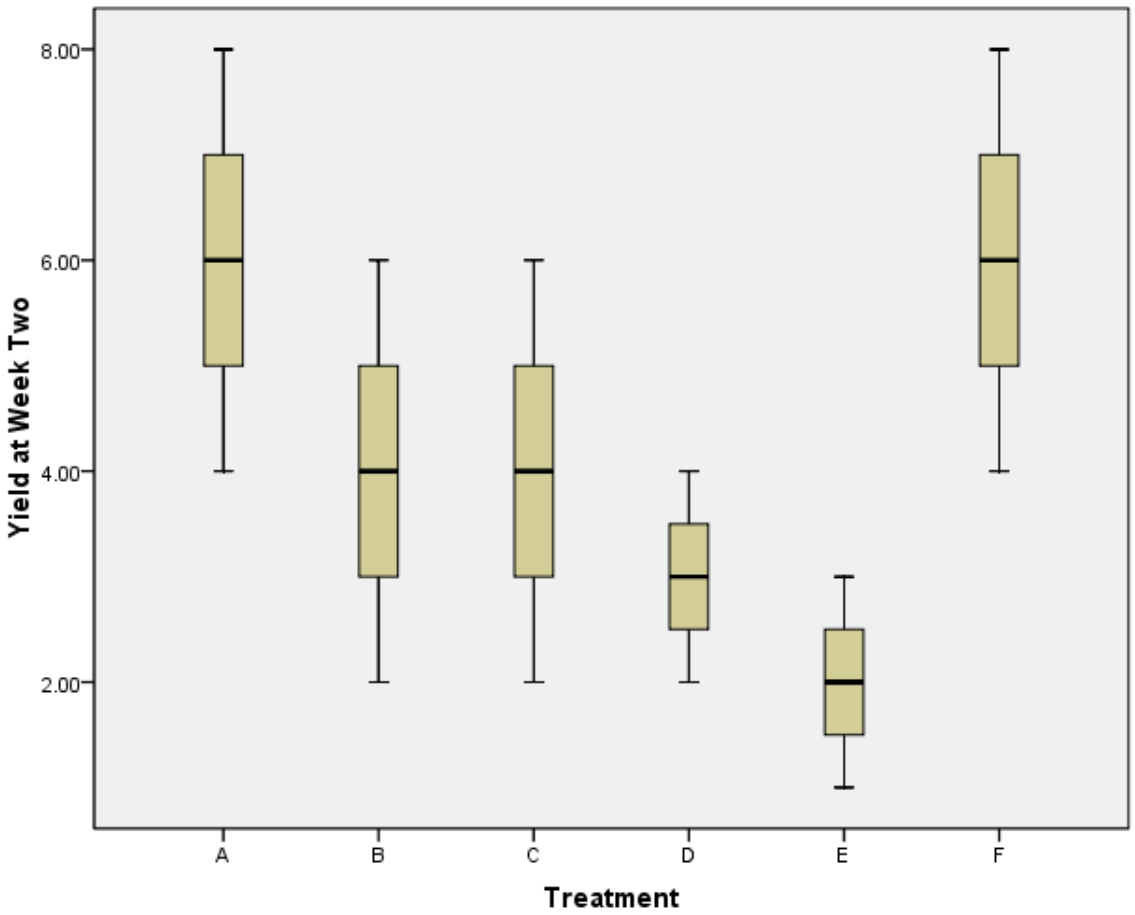


Fig 14: Effects of Treatment on Yield at Week Two

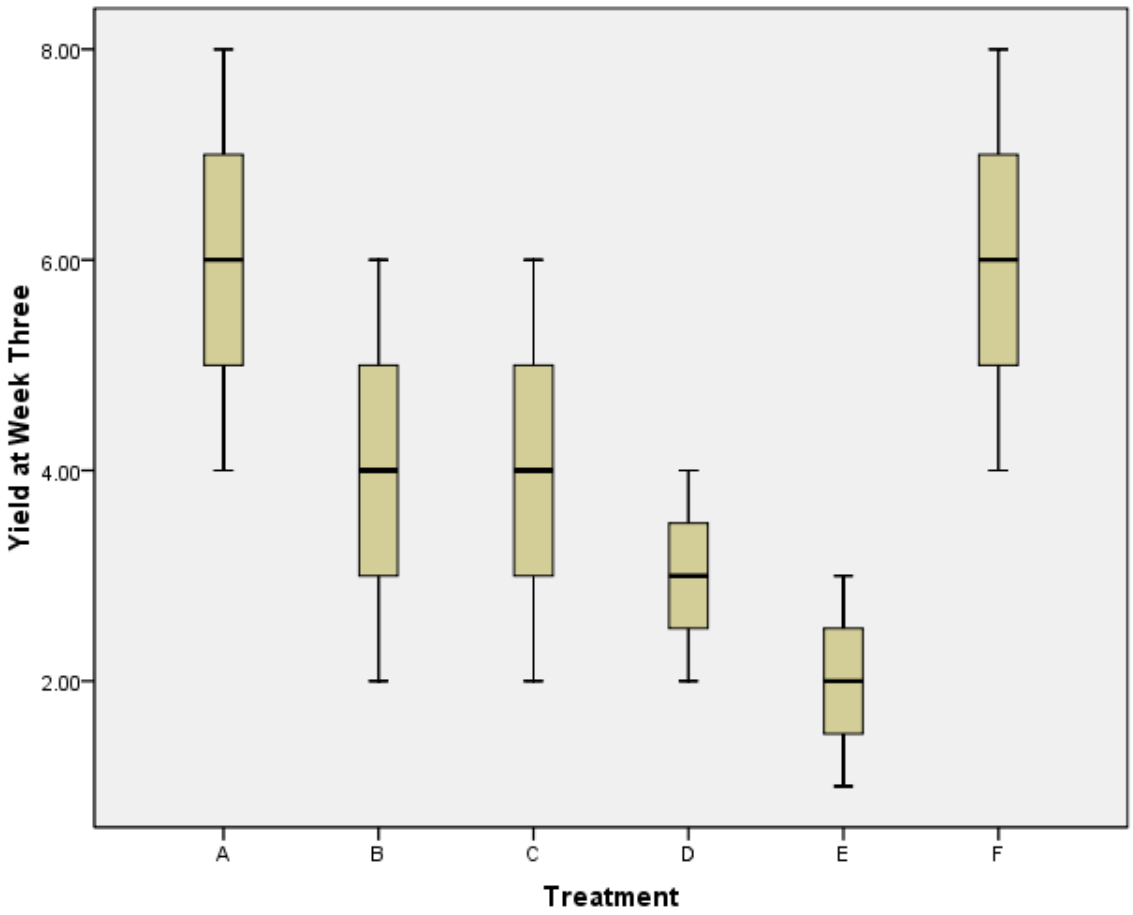


Fig 15: Effects of Treatment on Yield at Week Three

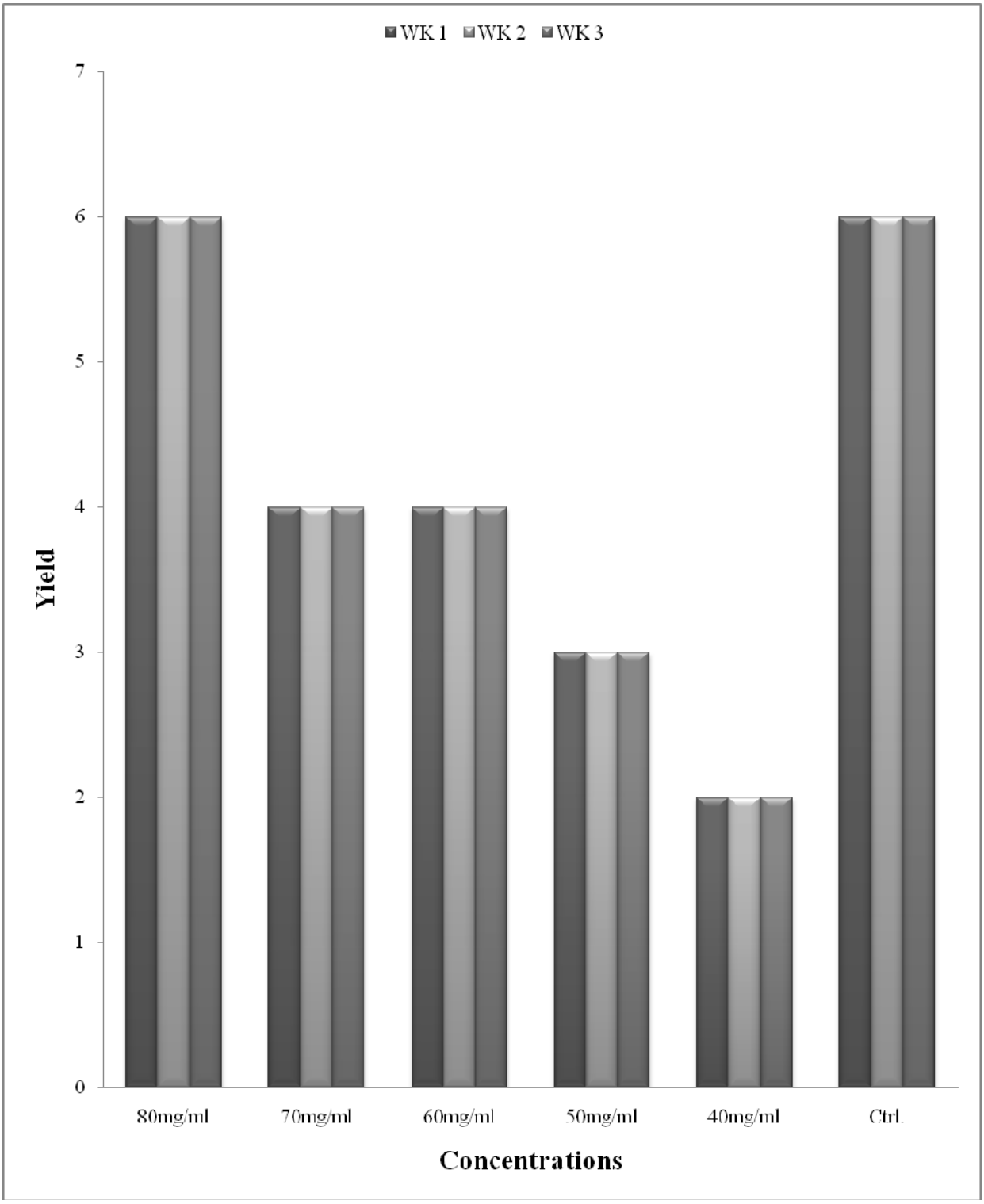
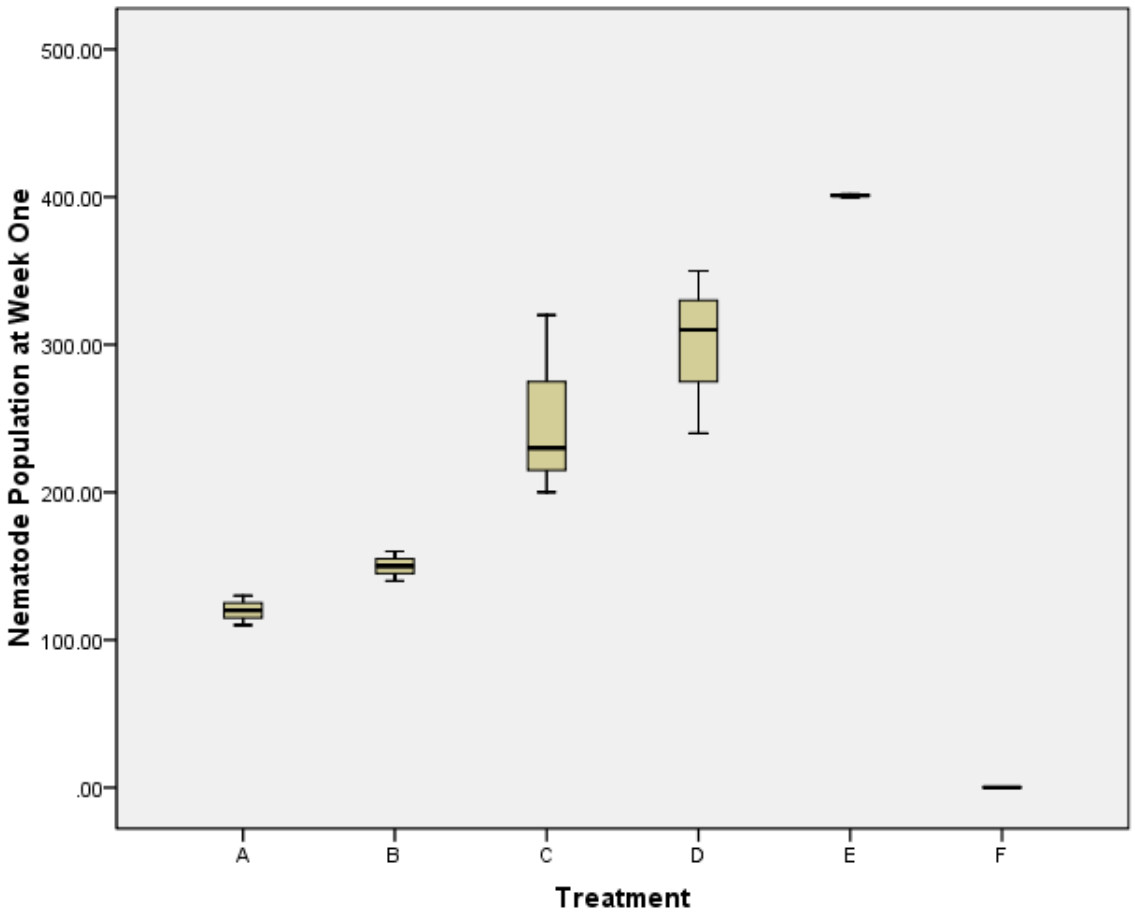


Fig 16: Effect of Treatment on Yield at Different Week Intervals



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836 **Fig 17: Effects of Treatment on Nematode Population at Week One**

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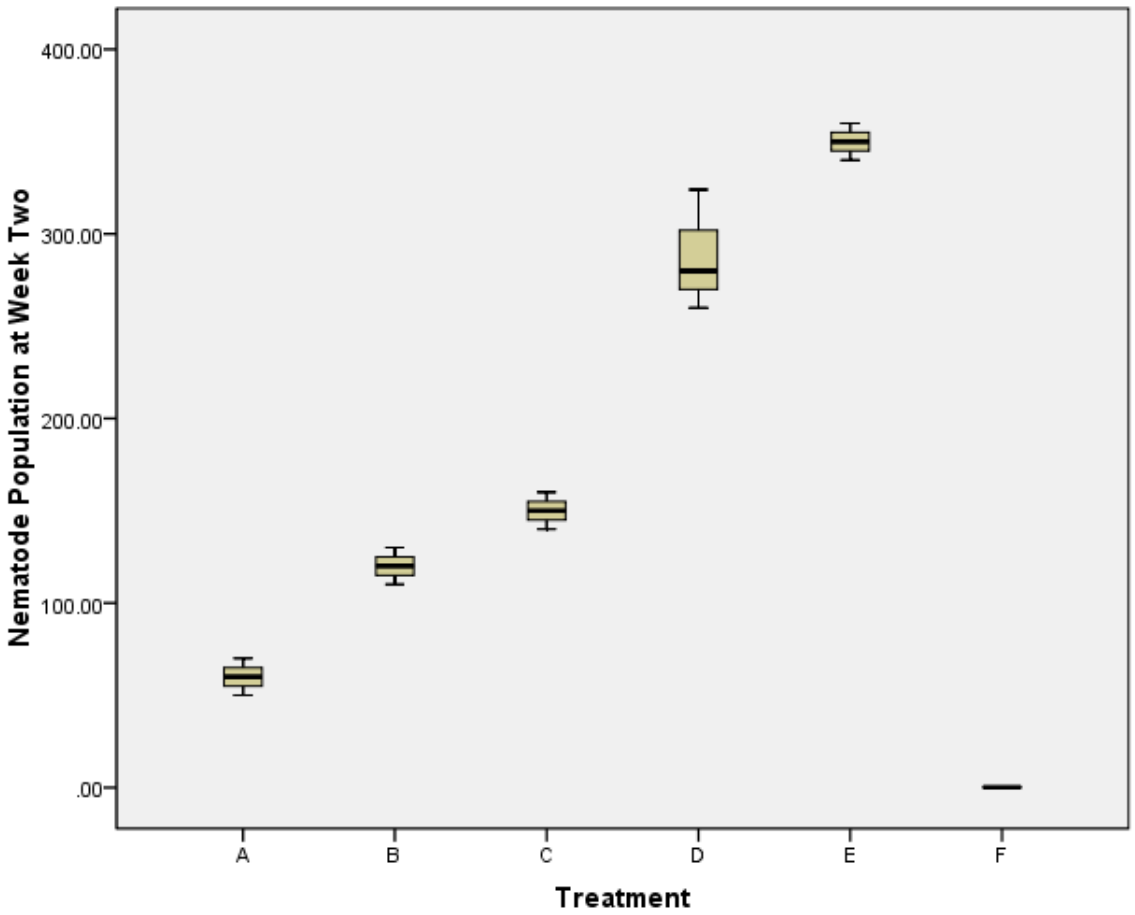

838

839 **Fig 18: Effects of Treatment on Nematode Population at Week Two**

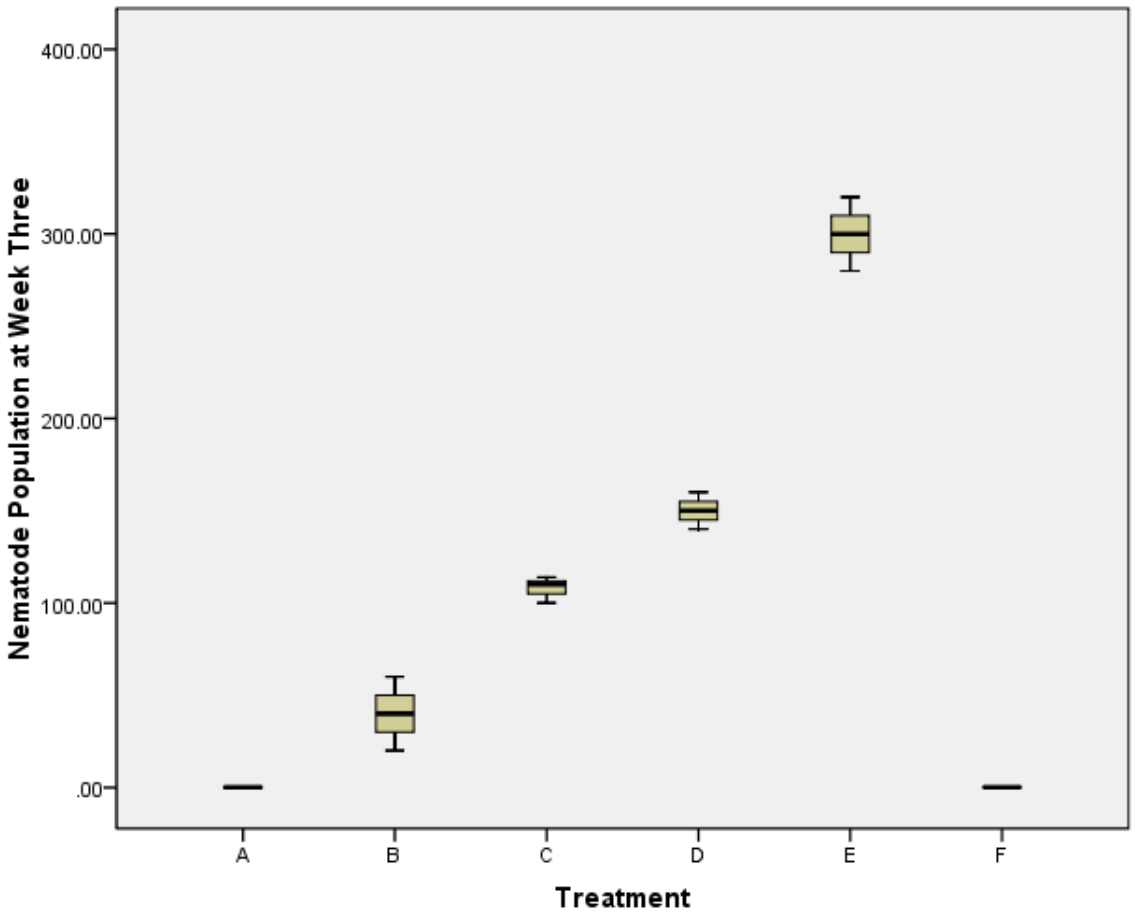

Fig 19: Effects of Treatment on Nematode Population at Week Three

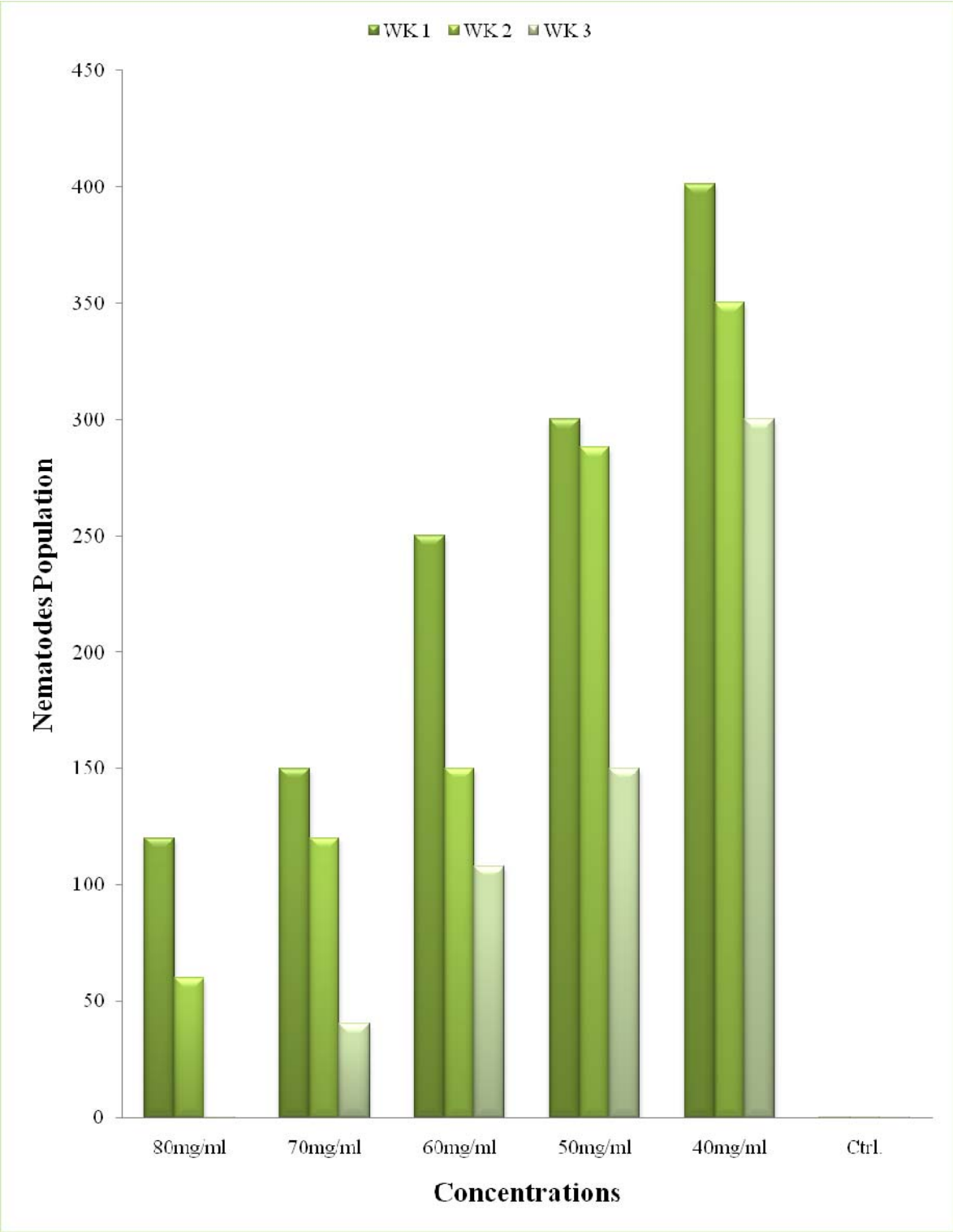

Fig 20: Effect of Treatment on Nematodes Population at Different Week Intervals