Journal of Experimental Agriculture International

41(5): 1-8, 2019; Article no.JEAI.51410
ISSN: 2457-0591
(Past name: American Journal of Experimental Agriculture, Past ISSN: 2231-0606)

Effects of Different Water Regimes and Spacing on Insect Pest Infestation and Efficacy of Control Measures in Cucumber (*Cucumis sativus*)

A. A. Oso[1*] and G. O. Awe[2]

[1]Department of Crop, Horticulture and Landscape Design, Ekiti State University, P.M.B 5363, Ado Ekiti, Nigeria.
[2]Department of Soil Resources and Environmental Management, Ekiti State University, P.M.B 5363, Ado Ekiti, Nigeria.

Authors' contributions

This work was carried out in collaboration between both authors. Author AAO designed the study, managed analyses of the study, wrote the protocol and wrote the first draft of the manuscript. Author GOA performed the statistical analysis. Authors AAO and GOA managed the literature searches. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JEAI/2019/v41i530415
Editor(s):
(1) Dr. Hab. Mariusz Cycoń, Department and Institute of Microbiology and Virology, School of Pharmacy with the Division of Laboratoty Medicine, Medical University of Silesia, Poland.
Reviewers:
(1) José Aires Ventura, Instituto Capixaba de Pesquisa Assistência Técnica e Extensão Rural, Brazil.
(2) Wisdom H. K. Hordzi, University of Education, Ghana.
(3) Suprakash Pal, Uttar Banga Krishi Viswavidyalaya, India.
Complete Peer review History: http://www.sdiarticle4.com/review-history/51410

Original Research Article

Received 07 July 2019
Accepted 20 September 2019
Published 23 November 2019

ABSTRACT

Aim: Information on the influence of water availability during different seasons of rainfed or irrigated agriculture as it relates to insect pest population build-up in crops could assist in the development of integrated pest management. A study was therefore conducted to investigate effects of spacing, pest infestation and control on cucumber under rainfed and irrigated conditions.
Place and Duration of Study: At the Teaching and Research Farm, Ekiti State University, Ado Ekiti, Nigeria during the 2016/2017 rainy and dry seasons.
Methodology: The experiment was laid out using randomized complete block design (RCBD) in a split-plot arrangement in five replications, with spacing (60 x 60 cm, 60 x 90 cm and 60 x 120 cm) as the main plot treatments and the sub-plot treatments were different pest control strategies. The

**Corresponding author: E-mail: adeola.oso@eksu.edu.ng;*

pest control strategies include synthetic insecticide (*Lambda-cyhalothrin*), botanical insecticide (*Anogeissus leiocarpus*) and control. Growth parameters and yield attributes were recorded. Insect pest occurrence, their build-up and percentage infestation on cucumber and the efficacy of the management strategies were monitored.
Results: The results showed that yield was enhanced in irrigated system with the widest spacing of 60 x 120 cm botanical treatment interaction. *Bemisia tabaci* was the most prominent insect pest attacking cucumber under irrigated system.
Conclusion: Other cultural control practices such as the use of trap crops with little or no financial implication should also be added to botanical pesticides as an integrated pest management tactic for effective management and control of the pest.

Keywords: Cucumber; irrigated system; Anogeissus leiocarpus; Lambda-cyhalothrin; insect pest.

1. INTRODUCTION

Cucumber (*Cucumis sativus* L.) alongside melon, squash, watermelon, and pumpkins are cultivated vegetables of global and local economic importance belonging to the gourd family *Cucurbitaceae* [1]. Although its place in the hierarchy of economically important vegetables in the African continent is yet to be determined, cucumber has become a sought after vegetable for improving the livelihood of many people in Nigeria.

The increased awareness of its nutritional and medicinal benefits is responsible for the high demand of cucumber as an important nutritious fruit. Cucumber is packed with high levels of vitamin K, vitamin C, cucurbitacins and their derivatives (triterpenoids), flavonoids, and antioxidants [2]. Cucumber contains about 95% water, and with the bonus of naturally-occurring nutrients and trace minerals. It could be a great supplement to drinking water or even serve as alternative to consuming sports drinks [3]). Cucumber leaves and seed-cake are sometimes used as cattle feed, and the leafy tops are grazed by stock and game. Major factors militating against production of cucumber in Nigeria include storage problems, scarcity of planting seed, lack of capital, water stress during dry season, infestation by insect and other disease-causing organisms, perishability nature of the fruit and lack of technical know-how by farmers in the handling of the crop [4] Due to its nature as a relatively shallow crop, cucumber farmers ensure all year supply of water by engaging in irrigated agriculture when the rains cease.

Irrigated agriculture, characterized by intensive land use and year-round production of crops particularly vegetables, has been reported to induce continuous presence and build-up of pests and diseases [5]. In Nigeria, information on the presence and build-up of pests in cucumber under rainfed or irrigated conditions, under different plant population densities as well as suitable control options are not well documented. This information is needed when considering and developing options for sustainable pest management strategy. We hypothesized that insect pest infestation differs under different water regimes and plant population and the cucumber has better yield and yield attributes during the dry season. This study therefore seeks to investigate the effect of different water regimes and plant spacing on pest infestation and the efficacy of two pest control measures in cucumber.

2. MATERIALS AND METHODS

2.1 Description of the Study Site

The study was carried out during the dry and rainy seasons of 2016/2017 at the Teaching and Research Farm of Ekiti State University, Ado Ekiti, southwest Nigeria, located on coordinates 7^{o} 31” N and 5^{o} 13” E and about 436 m above the mean sea level. The region is located in the tropical rain forest of Nigeria. The study site experiences a bimodal rainfall pattern between March and November, with peaks in June and October and dry season between late November and early March, with a total annual rainfall above 1900 mm. The average minimum and maximum temperature were 12 and 28^{o}C, respectively.

2.2 Experimental Design and Treatments

Randomized complete block design (RCBD) with split plot arrangement in three repetitions was used with spacing as the main plot and pest control strategies as the sub-plot. Spacing constituted the main plot treatments include 60 x 60 cm, 60 x 90 cm, 60 x 120 cm while the sub-plot was insect pest control measures comprising no insecticide application (control), synthetic insecticide (*Lambda-cyhalothrin*), and botanical insecticide (*Anogeissus leiocarpus*).

2.3 Field Procedure

The area of land selected was first cleared of bushes, ploughed, and harrowed thoroughly. The dimension of the total land area was 320 m^2 and it was divided into different experimental units of 1.8 x 3.6 m, with a spacing of 1.2 m between plots. After field layout, drip irrigation lines of discharge rate of 2 L/h and 30 cm spacing (*Maker: Netafim Incorporation®, Israel*) were laid at a spacing of 60 cm between drip lines. The drip lines were connected to 1" submains and the submains were connected to a 1" mainline with control valves and other accessories (T-joints, union etc). The mainline was connected to a 3000 L water supply tank placed on concrete support, about 1.5 m above the ground for proper supply of water to the field. Water was supplied to the tank from a borehole installed within the area. The cucumber variety planted was *cucumber market-more,* and it was sown at two seeds per hole which was later thinned to one. During the dry season, water was supplied for one (1) hour for the first twenty-one (21) days and two (2) hours for the next thirty-three (33) days at interval of two days either in the evening, giving a total irrigation amount of 414.8 mm. Routine manual weeding exercise was done at an interval of every two weeks from the first week after sowing. There was no irrigation during the rainy season.

2.4 Source and Preparation of Control Materials

The bark of *Anogeissus leiocarpus* was sourced from Ekiti State University campus, Ado Ekiti, Nigeria. The bark was taken to the laboratory for further dicing into smaller pieces to affect the easier soaking and extraction of liquid concentration. Five hundred grammes (500 g) of the bark *Anogeissus leiocarpus* was weighed and thereafter poured into a bowl of 1000 ml of water. The substrate from the *Anogeissus leiocarpus* was removed after 24 hours. From the stock solution of *A. leiocarpus,* 20 ml was diluted with 100 ml of distilled water to get 20% spraying volume. *Lambda-cyhalothrin* (Lara-force gold) purchased from a local chemical store was also applied at a sub-lethal dose of 0.5 ml per each treatment i.e. 0.5 ml per 60 x 60 cm, 0.5 ml per 60 x 90 cm and 0.5 ml or 60 x 120 cm.

2.5 Treatment Application and Pest Incidence

The synthetic and botanical extracts were sprayed on experimental plots once a week using manually hand-operated sprayer. Insect pest attack was monitored twice daily; early in the morning between 6 and 8 am and late in the evening between 5 and 7 pm. The number of plants attacked leaves attacked, and the population of insect pests were done once in a week.

2.6 Data Collection on Growth Parameters and Yield Attributes

Data were collected on vine length, stem girth, and number of leaves as well as fruit weights, fruit lengths and fruit diameters.

2.7 Calculation of Percentage Insect Infestation

Data collected on number of leaves attacked was used to calculate percentage infestation by insects, and the number of insects counted per week was transformed to determine the occurrence of insects. The percent of leaves infested was calculated using the relation:

$$\% \text{ Infestation} = \frac{\text{No. of infested leaves}}{\text{No. of sampled leaves}} \text{ x } 100$$

2.8 Statistical Analysis

Data were subjected to two way ANOVA and means were separated at 5% level of probability using Duncan multiple range test (DMRT). The interaction effect of plant spacing and control measures on the varieble s were obtained. All analysis were performed in SPSS (*IBM version 20*)

3. RESULTS AND DISCUSSION

Table 1 shows the identified insect pests and prevailing stage of attack on cucumber under irrigation system. Three distinct orders of insects including Coleoptera, Hemiptera and Lepidotera were observed infesting the plant. They include whitefly (*Bemisia tabaci*), cotton leaf roller (*Sylepta derogata*), aphids (*Aphis gossypii*), ladybird beetle (*Coccinella magnifica*), blister beetle (*Hycleus lugens*), and brown stinkbug (*Halymorpha halys*), stripped cucumber beetle (*Acalymma vittatum*) and spotted cucumber beetle (*Diabrotica undecimpunctata*). Among these insects, the aphids' and white flies pierced the plant tissues to suck the sap which resulted in yellowing, mottling and curling, of the leaves. The adult beetles also fed on the leaves creating holes and wilting of the leaves.

This corroborates the findings of Emeasor and Ndumele [6] who reported cucumber beetle (*Diabrotica undecimpunctata*), pumpkin beetle (*Aulacophora foveicollis*) and aphids (*Aphis gossypii*) as the three main insect pests associated with cucumber in Southeastern Nigeria. In this study, we observed that *Bemisia tabaci* was prominent as it attacked the plant by sucking the sap, introducing toxins into the plant's vascular system, coating the leaf with honeydew. This facilitated the growth of sooty mould fungi on the leaves and leaf physiological disorders(squash silver-leaf). High temperatures, water availability through irrigation as well as flush of new leaves could be likely indices for the prominent damage caused by whiteflies. This is because the weather is usually warm in the dry season and earlier reports had confirmed the abundance of this pest during warm season [7]. Other observed activities of the other insects included, rolling up of the leaves and leaf defoliation by *Sylepta derogata*. The predatory Lady bird beetles assisted in keeping the population of *Aphis gossypii* under check through their preying activities. Blister beetles defoliated the leaves. The adults of stripped and spotted cucumber beetles fedon leaves resulting into stunted plant growth. At low population densities, these beetles have been implicated with the spread of bacterial wilt disease in cucurbits even at low population densities [8].

Table 2 shows the calculated percentage infestation caused as a result of whitefly attack. Weather conditions such as temperature, sunshine and relative humidity contribute around 55% impact on population of *Bemisia tabaci* [9]. The high temperature, increased intensity of sunshine and low humidity usually associated with the dry season in Nigeria may have accounted for the high infestation of cucumber by *Bemisia tabaci*.

Table 3 shows the effects of spacing and management strategies on the growth of cucumber at 4, 5, 6 and 7 weeks after planting. There were no significant differences among the treatment combinations for all the growth parameters recorded. For the seven week period, the 60x60/xcal combination produced the longest vines (19.08 cm, 28.02 cm, 31.37 cm and 36.17 cm) while the shortest vines (15.47 cm, 23.08, 26.25 cm and 30.33 cm) were recorded at 60x120/ctrl combination. However, for vine length, there were no significant differences among the means of the different treatment combinations. The thickest girth (8.25 cm)

Table 1. Identified pests and prevalent stage on cucumber under irrigation and rainfed systems

Insect name	Scientific name	Order	Plant stage
Irrigated system			
White flies	*Bemisia tabaci*	Hemiptera	Vegetative/Flowering
Cotton leaf roller	*Sylepta derogata*	Lepidoptera	Vegetative
Aphids	*Aphis gossypii*	Hemiptera	Vegetative/Flowering
Rainfed system			
Lady bird beetle	*Coccinella magnifica*	Coleoptera	Vegetative
Blister beetle	*Hycleus lugens*	Coleoptera	Vegetative/Flowering/Fruiting
Brown stink bug	*Halymorpha halys*	Hemiptera	Vegetative/Flowering/Fruiting
Stripped cucumber beetle	*Acalymma vittatum*	Coleoptera	Vegetative/Flowering/Fruiting
Spotted cucumber beetle	*Diabrotica undecimpunctata*	Coleoptera	Vegetative/Flowering/Fruiting
Aphids	*Aphis gossypii*	Hemiptera	Vegetative/Flowering

Table 2. Assessment of the percentage infestation on cucumber by *Bemisia tabaci*

Insect name	Scientific name	Order	% Damage	Time/Stage
White flies	*Bemisia tabaci*	Hemiptera	77.8	4WAS/vegetative
White flies	*Bemisia tabaci*	Hemiptera	100	5WAS/vegetative
White flies	*Bemisia tabaci*	Hemiptera	40.7	6WAS/vegetative-flowering
White flies	*Bemisia tabaci*	Hemiptera	29.6	7WAS/vegetative-flowering

WAS: weeks after sowing

Table 3. The effects of spacing, pest control method and their interaction on growth components of cucumber under irrigation system

Treatments	Vine length(cm)				Stem girth (cm)				Number of Leaves			
	4WAP	**5WAP**	**6 WAP**	**7WAP**	**4WAP**	**5WAP**	**6WAP**	**7WAP**	**4WAP**	**5WAP**	**6WAP**	**7WAP**
60x60/xcal	18.52a	27.27a	30.18ab	34.13a	3.67a	3.83a	8.05a	8.10a	12.17a	15.33a	20.83a	31.00a
60x90/xcal	19.08a	28.02a	31.37a	36.17a	3.42a	4.07a	8.03a	8.25a	9.33a	14.67a	20.33a	29.33a
60x120/xcal	16.72a	24.95a	28.53a	31.72a	2.65a	3.72a	7.67a	7.95a	11.17a	13.33a	19.33a	25.17a
60x60/bot	18.60a	27.83a	29.43a	34.00a	3.50a	3.83a	8.01a	8.17a	12.50a	15.00a	19.83a	28.67a
60x90/bot	15.50a	23.02a	27.75a	31.85a	2.85a	3.62a	7.55a	7.80a	12.67a	11.67a	18.00a	27.17a
60x120/bot	16.05a	24.49ab	28.20a	31.82a	3.03a	3.37a	7.42a	7.57a	11.00a	13.17a	18.83a	25.67a
60x60/ctrl	17.04a	25.98a	28.67a	32.87a	3.00a	3.63a	7.63a	7.85a	9.83a	14.00a	16.50a	29.83a
60x90/ctrl	16.05a	24.83a	28.63a	32.87a	2.88a	3.76a	7.62a	7.77a	10.33a	12.33a	17.00a	25.66a
60x120/ctrl	15.47a	23.08a	26.25a	30.33a	2.42a	3.22a	7.30a	7.50a	10.33a	13.17a	18.00a	25.00a

Values with the same letters in the same column are not significantly different (P= 0.05) by Duncan Multiple Range Test (DMRT) and highest number of leaves (31) were recorded on 60x90/xcal and 60x60/xcal combinations respectively. Also, these parameters were not significant different from the other treatment combinations. This suggests that spacing may not necessarily impact plant growth. Our findings run contrary to the findings of Nweke et al. [10], who reported that closer plant spacing enhances the growth of cucumber. In another study where the effect of pruning and plant spacing on growth and yield of watermelon was investigated [11]. They reported that widest spacing significantly increased the number of leaves and was adequate for maximizing total yield of the crop.

Table 4 shows the effects of spacing and pest control on the yield of cucumber. For spacing as a treatment, 60x120 cm gave the highest mean fruit weights (270.4 g, 134.5 g), highest fruit lengths (19.5 cm, 12.6 cm) and widest fruit diameters (17.2 cm, 12.3 cm) in the irrigated and rain-fed systems respectively. These yield attributes were significantly different from those recorded for the 60x90 cm and 60x60 cm spacings. However, 60x60 cm produced the smallest mean weights (118.6 g,84.5 g), shortest fruit diameters (15.3 cm, 11.6 cm) and thinnest fruit diameters (14.2 cm, 12 cm) for the irrigated and rain-fed systems respectively. This finding corroborates the submissions of Jonathan and Todd [12], Phamthic [13], Hardy and Rowell [14] and Paulo et al. [15] who obtained highest yield at higher plant spacing. This is because competition and overcrowding are avoided, and the plant is well-positioned to trap light energy for effective photosynthetic activities, that will enhance fruit yield. The variations in the submissions of different co-operative research efforts on the relationship between crop spacing and crop performance is an indication that spacing may not be a reliable determinant for the performance of trellising crops but soil nutrient factors, edaphic factors and also climatic factors are likely indices responsible for growth and yield of crops in this category. It was also observed

Table 4. The effects of spacing, pest control method and their interaction on yield components of cucumber under irrigation and rain-fed systems

	Fruit weight, g		Fruit length, cm		Fruit diameter, cm	
	Irrigated	**Rainfed**	**Irrigated**	**Rainfed**	**Irrigated**	**Rainfed**
Spacing, cm						
60 x 60	118.6Ab	84.5Bb	15.3Ab	11.6Ba	14.2Ab	12.0Aa
60 x 90	208.5Aab	105.6Bb	16.7Ab	11.3Ba	14.7Ab	14.0Aa
60 x 120	270.4Aa	134.5Ba	19.5Aa	12.6Ba	17.2Aa	12.3Ba
Mean	199.17	108.21	17.18	11.83	15.35	12.74
SEM	44.06	14.49	1.23	0.38	0.94	0.62
Insecticide						
Synthetic insecticide	155.2Ab	81.4Bb	16.2Ab	11.4Bb	16.3Aa	11.3Ba
Botanical	214.4Aab	122.5Ba	16.5Aab	10.9Bb	14.3Ab	14.6Aa
Control	228.0Aa	120.7Ba	18.8Aa	13.2Ba	15.5Aa	12.4Bb
Mean	199.17	108.21	17.18	11.83	15.35	12.74
SEM	22.35	13.42	0.82	0.69	0.59	0.98
Interaction						
60x60/syn	89.63Ac	79.69Bb	14.90Aa	11.75Aa	15.60Aa	10.20Ba
60x90/syn	171.31Ab	80.87Bb	16.30Aa	11.15Ba	15.90Aa	11.30Ba
60x120/syn	204.55Ab	83.60Bb	17.40Aa	11.35Ba	17.36Aa	12.35Ba
60x60/bot	79.00Ac	81.20Ab	15.10Aa	11.35Ba	12.90Aa	14.70Aa
60x90/bot	240.00Aab	109.65Bab	15.50Aa	9.95Ba	13.65Ba	17.00Aa
60x120/bot	324.15Aa	176.69Ba	19.00Aa	11.40Ba	16.20Aa	12.10Ba
60x60/ctrl	187.25Ab	92.59Bb	16.00Aa	11.75Ba	13.95Aa	11.10Aa
60x90/ctrl	214.22Aab	126.40Ba	18.25Aa	12.85Ba	14.55Aa	13.60Aa
60x120/ctrl	282.45Aa	143.17Ba	22.15Aa	14.95Ba	18.06Aa	12.35Ba
Mean	199.17	108.21	17.18	11.83	15.35	12.74
SEM	26.83	11.42	0.78	0.46	0.58	0.69

syn: synthetic insecticide; bot: botanical insecticide, crtl: control

Values with different letters (lower case in the same column and upper case in the same row between irrigated and rainfed) differed significantly different (P= 0.05) by Duncan Multiple Range Test (DMRT)

SEM: standard error of the mean

that yield was better enhanced in the irrigated system than the rainfed system. This observation corroborates with the study of Tilahun et al. [16]. They compared the efficiency of the small-scale irrigation (SSI) and the large-scale irrigated agricultural schemes in different river basins against the rain fed system and reported that irrigated agriculture is more efficient both in terms of water use and economics regardless of the typology or the basins considered. On the efficacy of pest control measures, irrigated control treatment produced the highest fruit weight (228 g) which was not significantly higher than the weight produced by irrigated botanically treated plants (214.4 g). Rainfed botanically treated plants also produced the significantly highest fruit weight (122.5 g) which did not sisnificantly differ from the weight produced by rainfed control treated plants (120.7 g). Also irrigated system combined effectively with the pest control measures to produce significantly greater yield. In the spacing and pest control interactions, irrigated plots with the combination of 60 x 120/ botanical produced significantly higher fruit weight (324.15 g) when compared with all the other treatment interactions. In a similar vein, rainfed 60x120/botanical interaction also produced significantly higher fruit weight of (143.17 g) when compared with other interactions during the rainy season. Our study has shown that botanical pesticides have the potential to improve crop yield. In a study on eco-friendly pest control in cucumber (*Cucumis sativa* L.) field with botanical pesticides, Azad et al. [17] also reported that combined application of some plant extracts not only show good protection of cucumber plants from insect attack but also increased the cucumber production.

4. CONCLUSIONS

Results from this study showed that irrigated farming system produced higher yield of cucumber and *Bemisia tabaci* was the most prominent insect pest attacking cucumber under irrigated system. The different plant spacing of 60 x 60 cm, 60 x 90 cm and 60 x 120 cm did not significantly improve cucumber growth, but the interaction of widest spacing of 60 x 120 cm with the botanical treatment produced the highest fruit weight of cucumber. The result, therefore, suggests that cucumber farmers in Ekiti State who are interested in dry season farming should adopt the wider spacing in combination with botanical pesticides. However, due to the notorious feeding pattern of *Bemisia tabaci;* we suggest that other cultural practices such as the use of trap crops with little or no financial implication should also be added as an integrated pest management tactic for effective management and control of the pest.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Bello MO, Owoeye G, Abdulhammed M, Yekeen TA. Characterization of gourd fruit (*cucubitaceae*) for dietary values and anti-nutrition constituent. J Pharm Biol Chem Sci. 2014;6:7575-7585.
2. Mukherjee PK, Maity N, Nema NK, Sarkar BK. Phytochemical and therapeutic potential of cucumber. Fitoterapia. 2013; 84:227-236.
3. Murad H, Lange D. The murad method. New York: Macmillan; 2003.
4. Umeh OA, Ojiako FO. Limitations of cucumber (*Cucumis sativus* L.) production for nutrition security in Southeast Nigeria. Int'l Journal of agric. And Rural Dev. 2018;21(1):3437–3443.
5. Sithanantham S, Seif AA, Ssennyonga J, Matoka C, Mutero C. Integrated pest management issues in irrigated agriculture: Current initiatives and future needs to promote IPM adoption by smallholder farmers in Eastern Africa; 2002.
6. Emeasor KC, Ndumele PN. Comparative toxicity of aqueous extract of *Tephrosia vogelii* and some synthetic insecticides in the control of insect pests of cucumber (*Cucumis sativus* L.). Greener Trends in Plant Pathology and Entomology. 2019; 2(1):1-8.
7. Bellows TS, Kabashima JN, Robb K. Pest Notes: Giant Whitefly. Oakland: Univ. Calif. Agric. Nat. Res. Publ. 7400; 2006.
8. Buchanan AL, Bryant A, Morrison III WR, Werling B, Quinn N, Szendrei Z. Striped and spotted cucumber beetles as pests of cucurbits in Michigan; 2017. Available:http://vegetable.ent.msu.edu
9. Sudeepa Kumari Jha and Manoj Kumar (2017). Effect of weather parameters on incidence of whitefly, *Bemisia tabacii* (Gennadius) on tomato. 2017;5(6):304-306.
10. Nweke IA, Orji EC, Ijearu SI. The effect of staking and plant spacing on the growth and yield of cucumber (*Cucumis sativus*).

Journal of Environmental Science, Toxicology and Food Technology. 2013; 3(4):26-31.
11. Oga IO, Umekwe PN. Effects of pruning and plant spacing on the growth and yield of water melon (*Citrullus lanatus* L.) in Unwana- Afikpo. International Journal of Science and Research. 2016;5(4):110-115.
12. Jonathan R, Schlthesis, Todd, Wehner C Optimum density of determinate and normal pickling cucumbers harvested once over. Hort. Sci. 1996;10(3):151-155.
13. Phamthic Kin Thu (1991). Effect of spacing and pruning on the yield of cucumber. Hort. Sci. 1991;36(2):230-235.
14. Hardy C, Rowell, B. (2002). Trellising slicing cucumber in Western Kenturcky Hort bulletin. 2002;3:15-18.
15. Paulo S, Lima S, Jailton FR, Jaedson CAM, Jaeverson DAS. Plant density and fruit density of muskmelon. Rer. Bras frutic. 2003;25(2). Jaboticabal.
16. Tilahun H, Teklu E, Michael M, Fitsum H, Awulachew SB. Comparative Performance of Irrigated and Rainfed Agriculture in Ethiopia. World Applied Sciences Journal. 2011;14(2):235-244.
17. Azad AK, Sardar A, Yesmin N, Rahman M, Islam S. (2013). Eco-friendly pest control in cucumber (*Cucumis sativa* L.) field with botanical pesticides. Natural Resources. 2013;4:404-409.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/51410