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Response of Cucumber (*Cucumis sativus* L.) Production to Different Doses of Nitrogen, Phosphorus and Potassium Fertilizers under cooled plastic Tunnels

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Abstract **Original Research Article**

The research work was conducted in a cooled plastic tunnel to Study the response of cucumber to different doses of soluble nitrogen, phosphorus and potassium (N, P and K) fertilizers at Shambat Research Station, Sudan, during the seasons, 2020 and 2021. The experiment was laid out in Randomized complete block design (RCBD) with four replications. The hybrid variety of cucumber "Mawasim" was used. Three combination doses of nitrogen, phosphorus and potassium fertilizers (20gm N + 13.3gm P + 23.3gm K), (40gm N + 26.7gm P + 46.7gm K) and (80gm N + 53.4gm P + 93.4gm K) per m^2 in addition to control (no fertilizer) were applied. The fertilizer doses were added twice weekly starting two weeks from sowing date. The data collected included plant growth parameters, the yield, yield and its components and fruit quality. The combined ANOVA was used for analysis. The results showed that application of fertilizers significantly increased all growth, yield and its components compared to control. The medium dose (40gm N + 26.7gm P + 46.7gm K/ m^2), gave significant positive effects on all parameters tested in both seasons. The growth and yield values were decreased with increased fertilizer dose. This indicates that the medium dose from N, P and K can be recommended for cucumber production under the cooled plastic tunnels.

Keywords: Cucumber**,** Cool plastic tunnel, Chemical fertilizer, Growth, Yield.

INTRODUCTION

The cucumber (*Cucumis sativus* L.) is one of the most popular vegetable crops grown throughout the world, and one of the oldest vegetables cultivated by early man and considered important due to its economic value (Soleimani et al., 2009 and Eifediyi and Remison, 2010). It is an annual monoecious, trailing, climbing and herbaceous plant. Cucumber is grown for its tender fruits, which are consumed either raw as salad, cooked as vegetable or pickled in its immature stage. It is a primary source of vitamins and minerals in the human diet, the fruits are good for people suffering from jaundice, constipation, and indigestion. The global production of cucumber is 71.36 million tons (FAOSTAT 2014).

Recently, cucumber production is gaining importance due to the increase of awareness among consumers regarding its nutritional properties leading to increased demand. Also the higher yield and high income in short period of time is attracting more farmers to produce.To achieve satisfactory yield cucumber needs to be produced under favorable climatic conditions relatively high soil moisture and optimum temperature (Yaghi 2013).

Cucumber production is gaining importance because of its characteristics, indeterminate vine growth, continually producing of fruit on new growth, and the response to training and pruning which makes it suitable for production under cooled plastic tunnels (El-Amir *et al*., 2001; Hochmuth, 2005 and Maragal *et al*., 2017). Management of cucumber production is very complicated and requires specialized knowledge (Yun *et al*., 2001) especially under greenhouse conditions.

In Sudan, production of cucumber under greenhouse conditions is facing serious challenges; commercial growers usually apply higher doses of fertilizers. The excessive use of fertilizers lead to increase production cost, harmful products which would affect human health (Singh and Ryan, 2015) and environment contamination. Therefore, application of fertilizers with sufficient nutrients and suitable levels of

fertilizers which leads to decrease production cost (Hochmuth, 2005; Elamin, 2007; Feleafel *et al*., 2014 and Ngwu and Edeh, 2018).

OBJECTIVES

The objectives of this study were to evaluate the effect of chemical fertilizers (N, P and K) on growth, yield and quality and to determine the optimum dose to be applied for cucumber production in cooled plastic tunnels.

MATERIALS AND METHODS

The experiment was carried out during two seasons (2020 and 2021) starting from the end of January to the end of May at Shambat Research Station, Agricultural Research Corporation (ARC), Sudan, (Lat.15°40′ N, Long.23° 32′ E, and of 380 meters above sea level). The soil is clay loamy type with high content of clay predominantly montemorillonite, slightly alkaline with pH range between 7.5 - 7.7

Pre-planting soil Analysis

Soil samples were collected from three locations inside the cooled plastic tunnel (0 – 30cm) and (30 – 60cm) deep with soil auger. They were analyzed for physical and chemical properties. Soil samples were also taken and analyzed after harvest (Table 1).

The plastic tunnel is well covered with polyethylene sheet (200 micron). The system of evaporative cooling is used to provide temperature range (25 – 30°C) and relative humidity of 65 - 77% at mid day. The cucumber hybrid variety namely "Mawasim" was selected from different hybrids already evaluated by (ARC) Sudan was used.

The soluble types N, P and K fertilizers used were urea (46% N), mono amino phosphate (61% P_2O_5) and potassium sulphate (42% K_2O). The different levels of N, P and K were selected according to the previous study and comparing the amount used by the growers.

Treatments

T_1: low dose 20.0g N + 13.3g P + 23.3g K / m^2
T_2: medium dose 40.0g N + 26.7g P + 46.7g K / m^2
T3: high dose 80.0g N + 53.4g P + 93.4 g K / m^2.
T_4: control (without fertilizer)

Statistical design and data analysis

The experimental units were arranged in randomized complete block design (RCBD) with four replications. Data was subjected to separate analysis of variance for traits using combined ANOVA across the two seasons. The statistical package Gen Stat edition 12th was used to run the analysis.

Husbandry

Sowing was done on both sides of the seed bed known as (Mustaba). The bed was 70 cm in width, 5 meters long and the spacing between plants was 40 cm. The fertilizers were added in equal doses twice weekly two weeks after planting the seeds. The amount of fertilizer dose is divided into 16 sub-doses and the sub-dose applied twice a week with the irrigation water during the growth period of the crop.

Irrigation was done using drip system every day for 10 – 15 minutes. Weeding was done manually; pests and diseases were controlled chemically when needed and pruning operation for the side branches and yellow leaves when required.

Harvesting

Crop harvest for the first pick was made about 35 days after planting. The harvesting season continued for almost two and half months. Picking interval was 2 - 3 days for the first month and half and then every 4 - 5 days interval for the rest of the growing period.

Data Collection

The data collected included the growth parameters mainly plant height and number of leaves/ plant. It also included the total yield and its components and fruit quality such as; number of flowers/plant, number of fruits set/plant, yield of cucumber (kg/m^2) number of fruits/m^2, average weight of fruit (g), fruit length (cm), and fruit diameter (cm).

Economic evaluation was conducted using partial budget techniques to calculate and compare the economic return and net benefits of the different treatments.

RESULTS AND DISCUSSION

Growth Parameters

The influence of fertilizers on plant growth (plant height and number of leaves) is presented in table (2). Significant differences in plant height and number of leaves was recorded across the two seasons between the different treatments. The medium dose recorded the highest values followed by the high dose, the low dose and the control respectively. The significant increase in growth may be due to the N/K level of fertilizers used was optimum, which promoted plant growth compared to other doses. Similar results were obtained by Marschner (1986) and Yaghi *et al*., (2013) who found that nitrogen is very important for cucumber growth. The growth of plant and hence fruit harvesting are totally dependent on availability of nitrogen, in adequate dose. The requirement of nitrogen is low at the beginning of growth cycle and increase gradually. The N, along with P and K are needed in relatively medium amounts and are often deficient in crops not receiving fertilizer application. This was in line with Abdel-Mawgoud *et al*., (2005) and Ahmed *et al*., (2007) who reported that increasing the level of N, P and K to a moderate amount resulted in a positive response in the vegetative growth. The high dose of nitrogen usually

leads to some disorders in plant growth specially burning in the edges of some of the leaves. The result reflected that the excess use of fertilizers by producers of cucumber in cool plastic tunnel is not useful.

Yield and yield components

Table (3) showed the effect of different N, P and K doses on the number flowers and number of fruits set per plant for cucumber during the two seasons. It is quite evident that the medium dose outnumbered the other treatments. For both, flowers and fruit set per plant this dose was significantly the highest; followed by high dose, low dose and control respectively in the two seasons.

The highest number of flowers and fruits set per plant (45 and 41) were recorded with the application of medium dose compared to (29 and 24) obtained by the control. The lower fertilizers dose than plant requirement leads to failure in flowering, fruit setting and continuation of fruit development. These results were in confirmatory with the results observed by Waseem *et al*., (2008) and Jilani *et al*., (2009) who found that proper nutrients promote vigorous growth of plant, which ultimately increases the number of flowers and fruits set per plant.

The fruits were harvested before reaching the fully ripe stage and before they become very hard. The statistical analysis of fruits harvested showed that different levels of N, P and K fertilizers had a positive effect on the fruits yield /m^2 (fruits weight and number). The medium fertilizer treatment increased the yield up to 38.9kg/m^2, followed by low dose with 23.9kg/m^2 and the high dose with 20.8kg/m^2 respectively. The lowest production was recorded by the control 12.4kg/m^2. Likewise the number of fruits per plant follows the same pattern of fruit weight for both seasons. Appropriate nutrients application increase up the growth of the plant which eventually increases the yield (number of fruits and fruit weight per square meter) accordingly. This result was in line with Abdel-Mawgoud *et al*., (2005), Waseem *et al*., (2008) and Arshad *et al*., (2014) who stated that proper nutrients promote vigorous growth of the plant, which ultimately increases the fruit weight and number of fruits per plant. Naeem *et al*., (2002) reported that different dozes of N, P and K showed significant difference for the number of fruits per plant and hence total yield. Likewise, Jilani *et al*., (2009) reported that an adequate N application significantly increased cucumber yield (Table 4).

Fruit Quality

In Table (5) it is noticed that due to the application of different N, P and K fertilizers levels there was significant increase in average fruit weight (127.0g) with the high dose, while the lowest fruit weight (99.5g) was found in the control. The observed results proved that by increasing N, P and K level the average fruit weight also started increasing gradually which shows the relation between N, P and K levels and fruit weight accordingly. Increasing N, P and K concentrations over the medium dose had a significant effect on fruit size. Our results are in agreement with the previous findings of Ahmed *et al*., (2007); Waseem *et al*., (2008) and Arshad *et al*., (2014), who stated that average fruit weight of cucumber increased with an increase in fertilizer nutrients to high level (N, P and K).The results were in conformity with Choudhari and More (2002) who stated that high dose of N, P and K produced biggest fruit weight (g) but also negatively affected the type of fruits. This is proved that excess use of fertilizers than the adequate limiting level affect the fruit weight and this is reflecting on the fruit quality besides adding more cost of production.

Table (5) shows the fruit length and fruit diameter. The fruit length and diameter (cm) were significantly affected by the application of fertilizers doses. Increasing N, P and K concentrations had significant effect on fruit quality. Big fruit length (22.2 cm) was observed with the high dose 80.0g N+53.4 P+93.4 g K/m^2 followed by the medium dose, and the low dose with (20.5cm) and (18.2cm) respectively. The lowest (16.2cm) fruit length was observed in the control, without fertilizer used. Likewise the fruit diameter follows the same pattern of fruit length. Increasing the N, P and K fertilizers application to a high level increased the fruit length and fruit diameter beyond which it started decreasing. This revealed that the excess fertilizer application ultimately affects the fruit length as compared to other doses and this is reflected on the type of fruit quality which is not preferred by the consumers. Similar results were quoted by Ahmed *et al*., (2007); Waseem *et al*., (2008); Jilani *et al*., (2009) and Arshad *et al*., (2014) who reported that an increase in N, P and K application to high level resulted in maximum fruit length and fruit diameter.

Table 1: Soil analysis before planting

Depth (cm)	$CaCo_3$ %	Mechanical analysis			Exchangeable Bases			O.C.	N	C/N
		Sand	Silt	Clay	Na	K	CEC			
0 - 30	5.0	29	36	20	1.1	0.3	20	0.330	0.032	10
30 – 60	5.1	28	33	24	1.0	0.5	23	0.460	0.034	11

Depth	Ava. P (ppm)	pH	EC ds/m	Soluble cations and anions					Bulk density		Available moisture capacity (%)	
				Na	Ca	Mg	cl	HCo_3	Dry	wet	Wt.	Vol.
0 - 30	3.8	7.4	0.7	6.2	1.0	0.2	1.7	2.7	1.05	1.87	19.2	21.3
30 – 60	3.7	7.2	0.9	6.1	1.1	0.3	1.8	3.0	1.01	1.83	17.3	19.1

Table 1 continue: Soil analysis after first harvest: (first season)

Depth (cm)	$CaCo_3$ %	Mechanical analysis			Exchangeable Bases			O.C.	N	C/N
		Sand	Silt	Clay	Na	K	CEC			
0 - 30	3.9	27	34	22	1.23	0.55	24	0.340	0.036	11
30 – 60	4.1	26	40	25	1.40	060	26	0.465	0.037	12

Depth	Ava. P (ppm)	pH	EC ds/m	Soluble cation and anions					Bulk density		Available moisture capacity (%)	
				Na	Ca	Mg	Cl	HCo_3	Dry	wet	Wt.	Vol.
0 - 30	4.0	7.3	0.71	6.4	1.4	0.4	1.9	2.6	1.60	1.30	19.1	21.2
30 – 60	4.0	7.1	1.0	6.3	1.7	0.5	2.0	2.9	1.27	1.56	17.0	19.0

Table 1 continue: Soil analysis after second harvest: (second season)

Depth (cm)	$CaCo_3$	Mechanical analysis			Exchangeable Bases			O.C.	N	C/N
		Sand	Silt	Clay	Na	K	CEC			
0 - 30	4.75	29	36	20	1.11	0.85	22	0.12	0.064	10
30– 60	4.61	32	33	28	1.50	0.51	25	0.18	0.069	9

Depth	Ava. P (ppm)	pH	EC ds/m	Soluble cation and anions					Bulk density		Available moisture capacity (%)	
				Na	Ca	Mg	cl	HCo_3	dry	Wet	Wt.	Vol.
0 - 30	3.6	7.5	0.46	1.9	5.2	1.2	0.4	2.5	-	0.0	13.20	19.35
30 – 60	2.8	7.6	0.80	1.7	1.5	5.1	0.2	2.7	-	2.0	19.60	26.00

Table 2: Effect of different N, P and K fertilizers doses on plant height (cm) and number of leaves / plant of cucumber hybrid

Treatments	Plant height (cm)			Number of leaves / plant		
	seasons			seasons		
	2020	2021	Mean	2020	2021	Mean
T_1 :20.0g N + 13.3g P + 23.3g K / m^2	257.7	252.1	254.9	29	31	30
T_2:40.0g N + 26.7g P + 46.7g K / m^2	296.5	305.4	300.9	35	39	37
T_3:80.0g N + 53.4 P + 93.4 g K m^2	288.4	282.6	285.2	33	36	35
T_4:control without fertilizer	209.3	218.6	213.9	26	26	26
Sig. level	***	***	***	**	***	***
SE±	4.96	4.48	9.71	1.29	0.83	1.37
CV%	3.80	3.40	10.40	8.50	5.10	12.30

** and *** significant at P= 0.01 and P = 0.001 respectively.

Table 3: Effect of different N, P and K fertilizers doses on number of flowers / plant and number of fruit set / plant of cucumber hybrid

Treatments	Number of flowers/ plant			Number of fruits set / plant		
	seasons			seasons		
	2020	2021	Mean	2020	2021	Mean
T_1 :20.0g N + 13.3g P + 23.3g K / m^2	36	37	36	31	30	31
T_2:40.0g N + 26.7g P + 46.7g K / m^2	44	46	45	39	42	41
T_3:80.0g N + 53.4 P + 93.4 g K m^2	33	37	35	26	30	28
T_4:control without fertilizer	29	29	29	25	22	24
Sig. level	***	***	***	***	***	***
SE±	0.58	1.30	1.16	1.17	1.13	1.19
CV%	3.30	7.00	9.10	8.10	7.30	11.10

*** Significant at P = 0.001

Table 4: Effect of different N, P and K fertilizers doses on cucumber yield (kg) / m^2 (number of fruits and fruits weight)

Treatments	Number of fruits / m^2			yield (kg) /m^2		
	seasons			seasons		
	2020	2021	Mean	2020	2021	Mean
T_1 :20.0g N + 13.3g P + 23.3g K / m^2	189	206	198	23.0	24.8	23.9
T_2:40.0g N + 26.7g P + 46.7g K / m^2	278	310	294	36.0	41.8	38.9
T_3:80.0g N + 53.4 P + 93.4 g K m^2	163	145	154	21.8	19.8	20.8
T_4:control without fertilizer	133	113	123	13.3	11.5	12.4
Sig. level	***	***	***	***	***	***
SE±	4.47	1.92	3.58	0.55	0.23	0.48
CV%	11.00	4.90	13.00	11.40	4.70	14.10

*** Significant at P = < 0.001

Table 5: Effect of different N, P and K fertilizers doses on fruit length, fruit diameter and average fruit weight of cucumber hybrid

Treatments	Fruit length (cm)			Fruit diameter (cm)			Average fruit weight(g)		
	seasons			seasons			seasons		
	2020	2021	Mean	2020	2021	Mean	2020	2021	Mean
T_1 :20.0g N + 13.3g P + 23.3g K / m^2	18.5	17.8	18.2	3.8	3.9	3.8	114.0	117.0	115.5
T_2:40.0g N + 26.7g P + 46.7g K / m^2	21.0	20.0	20.5	5.0	5.3	5.2	126.0	128.0	127.0
T_3:80.0g N + 53.4 P + 93.4 g K m^2	22.8	21.5	22.2	5.8	5.5	5.7	120.0	122.0	121.0
T_4:control without fertilizer	16.3	16.0	16.2	3.3	3.4	3.4	99.2	99.8	99.5
Sig. level	***	***	***	***	***	***	***	***	***
SE±	0.43	0.30	0.59	0.14	0.09	0.12	1.98	2.56	1.92
CV%	3.10	3.60	8.60	6.50	4.00	7.70	3.30	4.20	4.70

*** Significant at P = 0.001

Economic Analysis

Gross marginal and partial budget analysis for different rates of application was presented in Tables (6). Dominance and marginal analysis were used to show the most economically viable treatments. The marginal rate of return (MRR) estimated the return to investment. The marginal rate of return is equal to the marginal net benefit divided by the marginal cost times hundred. The medium dose (T_2) is profitable with the highest marginal rate of return (3713%).

Table 6: Partial budget analysis on the effect of different N, P and K fertilizers doses on cucumber yield (kg) /300 m^2

Treatment	Yield kg / m^2	Yield kg / 300 m^2	Cucumber price SDG /kg	Gross return SDG / 300 m^2	Variable cost SDG / 300m^2	Net return SDG / 300m^2
T_4: control without fertilizer	12.4	3720	200	744000	61000	683000
T_1: 20.0g N + 13.3g P + 23.3g K / m^2	23.9	7170	200	1434000	82440	1351560
T_2: 40.0g N + 26.7g P + 46.7g K / m^2	38.9	11670	200	2334000	103880	2230120
T_3: 80.0g N + 53.4 P + 93.4 g K / m^2	20.8	6240	200	1248000	146760	1101240

Table 6 (continue): Partial budget analysis on the effect of different N, P and K fertilizers doses on cucumber yield (kg/fed)

Treatment	Yield kg /m^2	Yield kg /fed	Cucumber price SDG/kg	Gross return SDG /fed	Variable cost SDG/fed	Net return SDG/fed
T_4:control without fertilizer	12.4	52080	200	10416000	854000	9562000
T_1: 20.0g N + 13.3g P + 23.3g K / m^2	23.9	100380	200	20076000	1154160	18921840
T_2: 40.0g N + 26.7g P + 46.7g K / m^2	38.9	163380	200	32676000	1454320	31221680
T_3: 80.0g N + 53.4 P + 93.4 g K / m^2	20.8	87360	200	17472000	2054640	15417360

Table 6 (continue): Marginal and dominance analysis on the effect of different N, P and K fertilizers doses on cucumber yield (kg/fed)

Treatment	Yield kg/fed	Cucumber price SDG/ kg	Gross return SDG / fed	Variable cost SDG / fed	Net return SDG / fed	Dominance
T_4: control without fertilizer	52080	200	10416000	854000	9562000	
T_1 : 20.0g N + 13.3g P + 23.3g K/ m^2	100380	200	20076000	1154160	18921840	
T_2: 40.0g N + 26.7g P + 46.7g K/ m^2	163380	200	32676000	1454320	31221680	
T_3: 80.0g N + 53.4 P + 93.4 g K/ m^2	87360	200	17472000	2054640	15417360	D

Table 6 (continue): Gross marginal analysis and marginal rate of return

Treatment	Yield kg/fed	Gross margin SDG/fed	Variable cost SDG/fed	MR SDG/fed	MC SDG/fed	MRR%
T_4: control without fertilizer	52080	9562000	854000	0	0	
T_1: 20.0g N + 13.3g P + 23.3g K/ m^2	100380	20076000	1154160	10514000	300160	3502
T_2: 40.0g N + 26.7g P + 46.7g K/ m^2	163380	31221680	1454320	11145680	300160	3713

Average cost of N, P and K fertilizer added in cool plastic tunnel:

* Low dose (T_1) = 21440 SDG/300m².
* Medium dose (T_2) = 42880 SDG/300m².
* High dose (T_3) = 85760 SDG/300m².
* Control (T_4) = 61000 SDG/300m^2
* Cost of adding N, P and K fertilizers and other variable cost in cool plastic tunnel (seeds, labour, planting, irrigation, weeding, pruning, training, pesticides and others)

= **61000SDG/300m².**
* Price of 1kg cucumber = 200 SDG/kg.

CONCLUSION

One of the most important challenges facing production of cucumber under cooled condition generally is the poor management of fertilization. The producers in Sudan usually apply chemical nutrients in level exceeding the plants requirements which leads to unnecessary costs.

The above results showed that the medium dose (40.0g N + 26.7g P + 46.7g K / m^2) significantly increased cucumber growth, yield and quality under cooled plastic tunnels, whereas no significant increase was obtained in most parameters (except for average fruits weight, fruit length and fruit diameter) at higher dose (80.0g N + 53.4 P + 93.4 g K m^2.) compared to control under cooled plastic tunnels.

REFERENCES

- Abdel-Mawgoud, A. M. R., EL-Desuki, M., Salman, S. R., & Hussein, S. D. A. (2005). Performance of some snap bean varieties as affected by different levels of mineral fertilizers. *J Agron*, 4, 242–247.
- Ahmed, N., Baloch, M. H., Haleem, A., Ejaz, M., & Ahmed, N. (2007). Effect of different levels of nitrogen on the growth and production of cucumber. *Life Sci Int J*, 1, 99–102.
- Arshad, I., Ali, W., & Khan, Z. A. (2014). Effect of different levels of npk fertilizers on the growth and yield of greenhouse cucumber (*cucumissativus*) by using drip irrigation technology. *International Journal of Research*, 1(8), 650-660.
- Choudhari, S. M., & More, T. A. (2002). Fertigation, fertilizer and spacing requirement of Tropical gynoeciouscucumber hybrids. ISHS. Tsukuba, Japan. *Acta Hortic*, 588, 233-240.
- Eifediyi, E. K., & Remison, S. U. (2010). Growth and yield of cucumber (*Cucumis sativum* L.) as influenced by farm yard manure and inorganic fertilizer. *Journal of Plant Breeding and Crop Science*, 2, 216-220.
- Elamin, M. H. (2007). Crop water Requirements of cucumber (*Cucumissativus* L.) Under cooled plastic tunnels (M. Sc. thesis). Agricultural Research council, Sudan Academy of Sciences (SAS), Sudan. PP. 52.
- El-Amir, M. R., Helal, M. M., Al-Shemi, A. H., & Mahmood, M. E. (2001). Economic feasibility of green house for some vegetable crops in Middle Egypt. *Assiut J Agric Sci*, 32, 377–388.
- FAOSTAT. (2014). Major crops – by countries/regions, rankings; choose cucumber and gherkins, world. Food and Agricultural Organization. www.fao.org.
- Feleafel, M. N., Mirdad, Z. M., & Hassan, A. S. (2014). Effecte of NPK fertigation rate and starter fertilizer on the growth and yield of cucumber grown in greenhouse. *Journal of Agricultural Science*, 6(9), 82-92. doi:10.5539/jas.v6n9p81.
- Hochmuth, R. C. (2005). *Greenhouse Cucumber Production*. In: Florida Greenhouse Vegetable Production Handbook. Vol 3. Horticultural Sciences Department, Florida Cooperative Extention Service, Institute of Food and Agricultural Sciences, University of Florida, USA.
- Jilani, M. S., Bakar, A., Waseem, K., & Kiran, M. (2009). Effect of different levels of NPK on the growth and yield of cucumber (*Cucumis sativus*) under the plastic tunnel. *J Agric Soc Sci*, 5, 99-101.
- Maragal, S. Y., Singh, A. K., Behera, T. K., Munshi, A. D., Dash, S. (2017). Effect of planting time and fertilizer dose on growth, yield and quality of parthenocarpic cucumber (*Cucumis sativus*) grown under poly house and net house conditions. ICAR-Indian Agricultural Research Institute, New Delhi
- Marschner, H. (1986). Mineral nutrition of higher plants. San Diego, California: Academic Press.
- Naeem, N., Irfan, M., Khan, J., Nabi, G., Muhammad, N., & Badshah, N. (2002). Influence of various levels of nitrogen and phosphorus ongrowth and yield of chilli (Capsicum annum L.). *Asian J Plant Sci*, 1, 599–601.
- Ngwu, O. E., & Edeh, V. N. (2018). Effect of varying rates of NPK 15:15:15 fertiliser on the physicochemical properties of the soil, growth and yield of cucumber, (*Cucumis sativus* L.). *Intel J Plant and Soil Sci*, 25(1), 1-7.
- Singh, B., & Ryan, J. (2015). Managing fertilizers to enhance soil health. *International Fertilizer Industry Association, Paris, France*, 1-24.
- Soleimani, A., Ahmadikhah, A., & Soleimani, S. (2009). Performance of different greenhouse cucumber cultivars (*Cucumis sativus* L.) in southern Iran. *Afr J Biotechnol*, 8, 4077-4083.
- Waseem, K., Kamran, Q. M., & Jilani, M. S. (2008). Effect of different levels of nitrogen on the growth and yield of Cucumber (*Cucumis sativus* L.). *J Agric Res*, 46, 259–266.
- Yaghi, T., Arslana, A., & Naoum, F. (2013). Cucumber (*Cucumis sativus* L.) water use efficiency (WUE) under plastic mulch and drip irrigation. *Agricultural Water Management*, 128, 149–157.
- Yun, C. Q., Chen, Q. T., & Li, H. (2001). Study on the expert system of cucumber culture management in greenhouse (Chinese). *Transactions of the Chinese-Society of Agricultural Engineering*, 17(6):142-146.