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Impact of NPK Fertigation on Indoor Productivity of Cucumber (*Cucumis sativus* L.) Under Dry Conditions of Kassala State, Sudan*

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Abstract: An experiment was carried out during March- August of two consecutive seasons (2017 and 2018) in a cooled plastic tunnel greenhouse (34m×9m). The objective of the study was to determine the effect of applying different rates of NPK (20:20:20) fertigation on the production of cucumber (*Cucumis sativus* L.) under greenhouse conditions at Kassala. The climate is semi desert with annual rainfall ranging between 100 and 250 mm, during July and October and temperature of 20 and 45 ^{o}C in winter and summer, respectively. Intra-row and inter-row seeding of the most popular cucumber hybrid (Fatin) was made at 40 cm and 50 cm spacing respectively on silt-loamy soil. Five levels of NPK were fertigated at the rate of 0, 25, 50, 75 and 100 g/m^2/week. Treatments were arranged in a randomized complete block design replicated thrice. The results showed the effect of treatments on cucumber growth parameters, namely, days to flowering, stem diameter and number of leaves per plant. The best growth parameters were recorded on the 50g/m^2/week. The highest values of water and economic productivities were obtained with 50g/m^2/week of NPK fertigation in both seasons. Hence, it is clear that the highest number of fruits per plant, fruit

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length, diameter and weight were obtained with NPK fertigation of 50g/m^2/week compared to control for the two seasons.

Keywords: Dry condition, indoor farming (greenhouse), cucumber, NPK fertigation.

INTRODUCTION

Greenhouses are the most important facilities for the production of off-season vegetables (Wang *et al.*, 2019). The technology of indoor (greenhouse) farming was first introduced in Sudan during 1994 for producing off-season horticultural crops (Egbal *et al.*, 2011).

Cucumber (*Cucumis sativus* L.) is one of the most important crops grown in greenhouses for early production to capture high prices and economic returns (El-Amir *et al.*, 2001). The crop needs high requirements and good fertilization and irrigation water to ensure high quality yield (Wang *et al.*, 2019). Moreover, Yan *et al.* (2009) observed that the yield and quality of cucumber increased with the increase in fertilization levels but decreased under excessive water and fertilizer applications.

The drip irrigation technology with small flow can lower deep downward migration rate of nitrogen into the soil, thus, reducing nutrient loss (Silber *et al.*, 2005). Integrated nutrient application not only ensures the supply of essential nutrients to plants but also has some positive interactions to increase nutrient use efficiency and reduces environmental hazards (Bewuket *et al.*, 2017). Application of all needed nutrients through fertilizers is also known to have deleterious effect on soil fertility leading to unsustainable yields, while integration of fertilizers can maintain the health, productivity and fertility of the soil (Yadav *et al.*, 2017).

The objective of this study was to determine the effect of NPK fertigation rate on the yield, yield components, water and economic water productivities of cucumber (*Cucumis sativus* L.) under the dry conditions of Kassala State.

MATERIALS AND METHODS

The experiment was conducted in greenhouses of the Horticulture Department of the Ministry of Production and Economic Resources, Kassala State, Kassala, during March to August of the two consecutive seasons 2017 and 2018. The site is located at latitude 15° 27´ N and longitude 36° 24´ E with average elevation of 500 m above mean sea level.

Each greenhouse was in the form of 34m×9m plastic tunnel laid in the North-South direction with ambient temperature 24-31°C and humidity 80-90%. Plants were drip irrigated with 2.5 liter/plant at an irrigation interval of 3 days, based on Mohamed and Ahmed (2009) recommendations.

Cucumber hybrid fatin was seeded on beds at intra-row and inter-row spacing of 40 cm and 50 cm, respectively (Khalifa *et al*., 2016) (Fig.1). Five levels of water soluble (20:20:20) NPK were fertigated at rates of 0, 25, 50, 75 and 100 g/m^2/week. Treatments were arranged in a randomized complete block experimental design (RCBD) replicated three times. 300cm×70cm plots (beds / mastabas) were seeded with one seed per hole on both sides (Fig.1). The first dose of fertilizer was applied after 2 weeks from sowing. Agricultural Research Corporation (ARC) standard cultural practices were strictly adhered to. The measured parameters were; days to flowering, stem diameter, number of leaves per plant, fruit length (cm), diameter (cm) and weight (g), number of fruits per plant and yield (t/ha).

Water productivity (WP) (in kg /ha) can be calculated as a ratio of crop yield to the total seasonal irrigation water (m^3/ha) according to Al-Jamal *et al*. (2001) using the following formula:

$$(1)\quad WP\ (kg/m^3) = \frac{\text{Yield (kg /ha)}}{\text{Total water applied } (m^3/ha)}$$

Economic water productivity (EWP) was calculated as the gross income in Sudanese Pounds (SDG) per gross water supplied in m^3 using the following relation:

(2) EWP = GI/GIWR……

where:

GI is the gross income from the sale of product (SDG/ha) and GIWR is the gross irrigation water applied (m^3/ha).

Crop Stat statistical package was used for data analysis and the least significant difference test was used for mean separation at 0.05level.

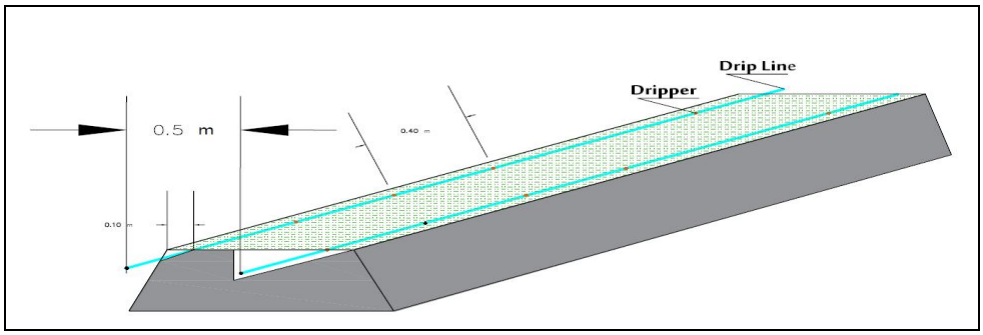

Figure 1. Layout of beds with drip lateral lines and cucumber seeded on both sides.

RESULTS AND DISCUSSION

Effect of NPK fertigation rates on growth parameters.

The effect of fertigation rate of NPK on cucumber showed highly significant differences on number of days from planting to flowering in both seasons. The shortest days from planting to flowering were recorded in 50g/m^2/week compared to control (Table 1). With regard to stem diameter, there were highly significant differences between control and other treatments. For the number of leaves per plant there were highly significant difference and the highest numbers of leaves per plant were obtained with 50g/m^2/week for the two seasons (Table 1). These results revealed that the best growth parameters were recorded in the

50g/m^2/week compared to other treatments (Table 1). The present results are in line with those obtained by Wang and Yingying (2016) who found that fertilizer treatment highly significantly influenced tomato stem diameter and the average stem diameter in F_3 (120-60-75 of NPK) which was significantly lower than that in the F_1 (240-120-150 of NPK) and F_2 (180-90-112.5 of NPK) treatments. Besides, Wang *et al*. (2019) found that the above ground biomass of cucumber first increased and then decreased with the increase in fertilizer application rates at the same irrigation level. Xiang *et al*. (2018) reported that different supplies of nitrogen had significant impacts on the growth parameters of sweet pepper under greenhouse conditions.

Table 1. Effect of NPK fertigation rates on days from planting to flowering, stem diameter and number of leaves per plant of cucumber under greenhouse conditions.

Rates of NPK fertigation	Days from planting to flowering		Stem diameter (cm)		Number of leaves/Plant	
	2017	2018	2017	2018	2017	2018
0 g/m^2/week	38.7 d	38.0c	1.0bc	1.1b	12.4b	10.6d
25 g/m^2/week	36.0bc	35.0b	1.2a	1.2a	14.3b	12.0bc
50 g/m^2/week	32.0a	31.7a	1.2a	1.2a	16.4a	13.1a
75 g/m^2/week	36.0bc	33.0a	1.2a	1.3a	13.1b	12.2bc
100g/m^2/week	37.3cd	35.0a	1.1ab	1.2a	12.7b	11.8c
Significance level	***	***	**	**	**	***
$SE^{\pm}$	0.67	0.49	0.35	0.25	0.60	0.15
CV%	3.2	2.5	5.3	3.6	7.5	2.2

***and ***: indicated significance at P≤0.01 and P≤0.001, respectively. Means within each column followed by the same letters are not significantly different according to LSD.*

Effect of different rates of NPK fertigation on yield parameters

Results showed highly significant differences in cucumber fruit length, diameter and weight in both seasons (Table 2). The highest values of fruit

length, diameter and weight were obtained with 50g/m^2/week compared to control. This may be attributed to the improved fruit quality by the fertilizer. Similar results were cited by Badr and Abou El-Yazied (2007) who showed that yield components of tomatoes registered significantly higher values at high rate of N. Moreover, Shedeed *et al*. (2009) found that higher numbers of fruits per plant and fruit weight of tomatoes were recorded with 75 and 100% NPK fertigation compared to 50% fertigation rate.

Table 2. Effect of NPK fertigation rates on cucumber fruit length, diameter and weight under greenhouse conditions.

Rates of NPK fertigation	Fruit length (cm)		Fruit diameter (cm)		Fruit weight (g)	
	2017	2018	2017	2018	2017	2018
0 g/m^2/week	15.4b	12.8d	3.2c	2.9d	97c	87.7c
25 g/m^2/week	16.3ab	14.6c	3.5b	3.1c	145.6b	136.3b
50 g/m^2/week	17.4a	16.0a	4.0a	3.5a	165.6a	151.0a
75 g/m^2/week	17.1ab	15.5ab	3.8a	3.3b	143.3b	138.0b
100g/m^2/week	16.8ab	15.1bc	3.6b	3.1c	141.1b	135.7b
Significance level	*	***	**	**	***	***
SE$^{\pm}$	0.41	0.27	0.34	0.55	5.3	2.4
CV%	4.3	3.1	1.7	3.0	6.6	3.2

, **and *: indicated significance at P≤0.05, P≤0.01, and P≤0.001, respectively. Means within each column followed by the same letters are not significantly different according to LSD.*

Effect of NPK fertigation rates on number of fruits per plant and yield

Different levels of Fertigation showed highly significant differences on the number of cucumber fruits per plant and yield (kg/m^2) in both seasons (Table 3). These results revealed that the highest number of fruits per plant and yield were obtained under 50 g/m^2/week compared to control (Table 3). This increase in yield might be attributed to the higher values

of growth parameters. These results are supported by those of Wang *et al*. (2019) who reported that the highest yield of cucumber obtained (360 kg/ha) compared to180kg/ha and 540 kg/ha rates of nitrogen application grown under greenhouse condition and irrigated at levels of 80% of ET_0. On the other hand, Xiang *et al*. (2018) found that an optimal window between 75% and 90% of ET_0 and between 50% and 75% of conventionally used nitrogen fertilizer, resulting in an increase of economic yields of sweet pepper of over 20%. Shedeed *et al*. (2009) reported that yield was significantly higher in 75 and 100% NPK fertigation than 50% Fertigation rate on tomatoes.

Table 3. Effect of NPK fertigation rates on number of cucumber fruit per plant and yield (kg/m^2) under greenhouse conditions

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Rates of NPK fertigation	Number of fruits per plant		Yield (kg/m^2)	
	2017	2018	2017	2018
0 g/m^2/week	19.7d	16.3c	9.1d	8.8d
25 g/m^2/week	24.7bc	18.3d	15.4bc	11.5c
50 g/m^2/week	29.0a	23.0a	20.2a	14.7a
75 g/m^2/week	25.3b	21.3b	15.6d	13.3b
100g/m^2/week	22.0cd	20.0c	13.4c	12.2c
Significance level	***	***	***	***
$SE^{\pm}$	0.89	0.34	0.66	0.34
CV%	6.4	3.0	7.7	4.8

****: indicated significance at P≤0.001. Means within each column followed by the same letters are not significantly different according to LSD.*

Effect of NPK fertigation rates on cucumber water and economic productivities.

50g/m^2/week of NPK fertigation recorded the highest values of water and economic productivities in both seasons (Figs.2 and 3). The productivity was increased with increasing rates of NPK fertigation up to the 50g/m^2/week level and then decreased. The increase in water and economic productivities might be attributed to the adequate supplies of

nutrients which resulted in triggering the production. These results are in close agreement with the findings of Wang and Yingying (2016) who reported that there was a positive correlation between the water use efficiency and fertilizer amount for tomato under greenhouse. Moreover, Wang *et al*. (2019) found that the highest values of water use efficiency for cucumber grown under greenhouse conditions was obtained with 360 kgN/ha compared to180kgN/ha and 540 kgN/ha

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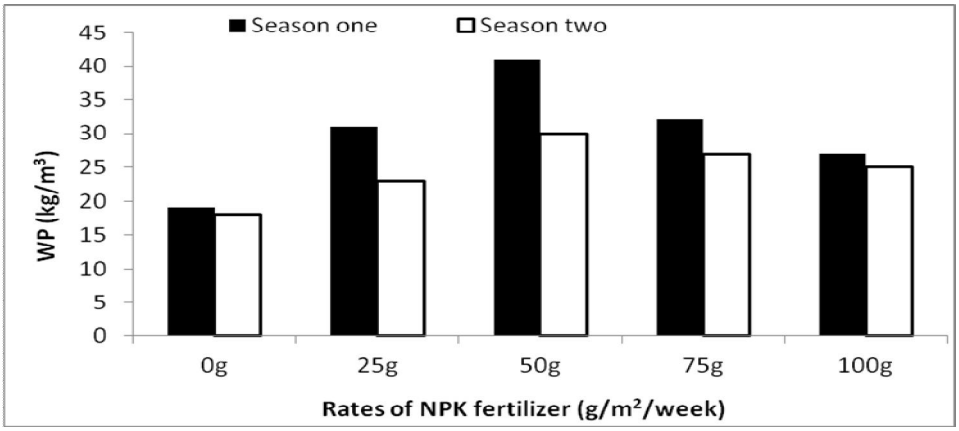

Figure 1. Effect of NPK fertigation rates on water productivity (WP) of cucumber grown under greenhouse conditions.

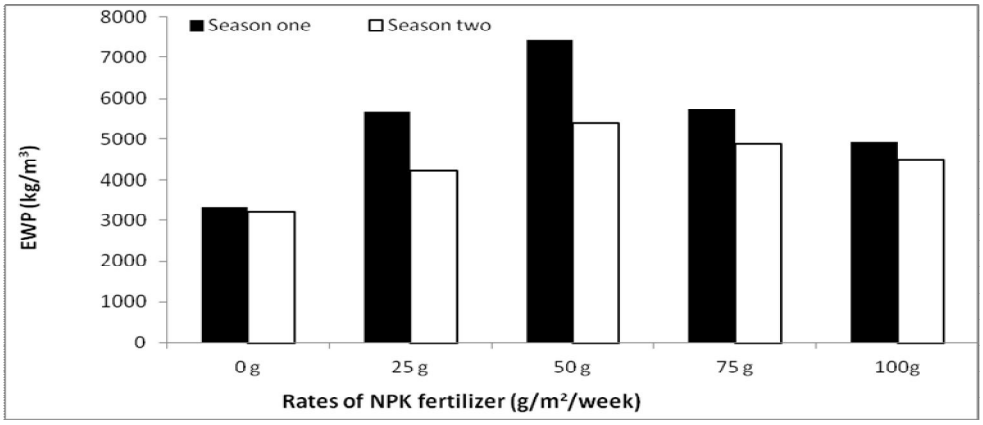

Figure 2. Effect of NPK fertigation rates on economic water productivity (EWP) of cucumber grown under greenhouse conditions.

SUMMARY

In summary, 50g/m^2/week of NPK fertigation (or15kg/single greenhouse/week) is the best treatment to enhance cucumber production in indoor under dry condition.

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اثر الرسمدة بالسماد المركب علي إنتاجية الخيار (*Cucumis sativus* L.) في الظروف الجافة بولاية كسلا ، السودان*

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مستخلص البحث: تم إجراء التجربة خلال الفترة من مارس إلى أغسطس من عامي 2016 و2017 في بيت بلاستيكي مبرد (34 × 9 م). وكان الهدف من هذه الدراسة هو تحديد اثر معدلات مختلفة من سماد NPK المركب عن طريق الرسمدة على انتاجية الخيار تحت ظروف البيت البلاستيكي المبرد في كسلا. المناخ في كسلا شبه جاف مع امطار تتراوح بين 100 الي 250 ملم خلال يوليو واكتوبر ودرجة حرارة بين 20 الي 45 درجة في الشتاء والصيف علي التوالي. زرعت بذور الخيار الهجين صنف فاتن علي مسافة 40 سم بين النباتات و 50 سم بين الصفوف علي التوالي في تربة سلتية لومية. خمس جرعات من سماد NPK المركب تمت اضافتها عن طريق الرسمدة بمعدل 0 و 25 و 50 و 75 و 100 جم/ م ^{2}/ أسبوع. تم تكرار المعاملات ثلاثة مرات في تصميم القطع كاملة العشوائية. أظهرت النتائج أن المعدلات المختلفة لسماد NPK أثرت علي مقاييس النمو خصوصا عدد ألايام حتي الإزهار وقطر الساق وعدد الأوراق في النبات الواحد. علاوة علي ذلك، أفضل النتائج في مقاييس النمو تم الحصول عليها عند اعطاء 50 جم/ م ^{2} /الأسبوع . اعلي قيمة لكفائتي المياه والاقتصادية تم الحصول عليها عند 50 جم/ م ^{2} /الأسبوع من سماد NPK المركب عن طريق الرسمدة في الموسمين. تم الحصول على أعلى طول وقطر ووزن للثمارعند المعاملة 50 جم/ م ^{2}/ الأسبوع مقارنةً بالشاهد. علاوة على ذلك، كشفت النتائج أنه قد تم الحصول على أكبر عدد من الثمار في النبات الواحد عند المعاملة 50 جم/ م ^{2}/ الأسبوع الأسبوع مقارنة بالشاهد. تم الحصول على أعلى انتاجية ومعدل ربح لعائد الخيار تحت ظروف البيت البلاستيكي في 50 جم/ م ^{2}/ الأسبوع. ومن ثم يتضح أنه تم الحصول على أكبر عدد من الثمار لكل نبات وطول وقطر ووزن الثمرة باستخدام التسميد NPK بواقع 50 جم / م ^{2} / أسبوع مقارنة بالشاهد في الموسمين.

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