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Production of Cabbage (Brassica Oleracea L.) As Affected by Humic Acid and Complex Fertilizer NPK

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Abstract:- **This study was conducted at the Agricultural Research Farm in Hada Al-Sham of King Abdulaziz University in Jeddah in 2018/2019 and 2019/2020 to evaluate the effect of humic acid fertilizer (0, 50, 100 liter / hectare) and NPK ferlitzer (0, 600, 900 kg/ha) and their interaction on the growth and yield components of the cabbage plant (Brassica oleracea L.). All the different treatments witnessed high significant increases (P≤0.01) in the morphological characteristics (stem length, stem diameter, head length, head diameter, head roundness coefficient), and in the properties of leaf area, leaf area index and in total yield. The percentages increased with increasing the rate of humic acid from 0 to 100 liters / hectare, and with increase of NPK from 0 to 900 kg/ha. The results of this study recommend fertilizing cabbage plants with HA at a rate of up to 100 litres / hectare, and with NPK fertilizer at rate up to 900 kg/ha, and also recommend application of mixture of HA and MPK fertilizers at rate of 50 L/ha HA with 900 kg/ha for optimum cabbage yield, and 100 liters /ha HA with 900 kg/ha NPK for other cabbage growth parameters.**

Keywords: Humic acid (HA), Cabbage (Brassica oleracea L.), NPK Fertilizer.

I. INTRODUCTION

The cabbage plant (Brassica oleracea var. Capitata L), which belongs to the Crusader family (Brassicaceae), is one of the families that have high economic importance, and is of high importance for the Saudi consumer, and it is one of the imported vegetables and its cultivation is badly needed in the Kingdom to improve its production conditions. Agriculture in the Kingdom of Saudi Arabia has become increasingly important, especially with the current limited water supply and the increasing global demand for food. Agriculture in the Kingdom mainly requires looking for factors that enable plants to obtain water and nutrients, hence the importance of using fertilizers and mineral and organic compounds to enhance growth and productivity. The use and application of compounds or bio-stimulants that promote growth are a promising tool for increasing the growth and productivity of plants in general, including vegetable crops, especially in light of harmful environmental and climatic conditions. Humic acid increases the growth and productivity of various crops, including vegetables, due to their effect on soil properties, soil water availability to plants, as well as nutrients (Atiyeh et al., 2002; Zandonadi, et al., 2007). One of the many properties of humic acid is its positive effect on nutrient uptake by vegetable crops (Cimrin & Yilmaz, 2005; Zandonadi et al., 2007). Humic acid is a promising natural resource to be used as a fertilizer alternative to increase crop yield (Nikbakht et al., 2008). Humic acid contains many elements that improve soil fertility, increase the abundance of nutrients, and thus increase plant growth and production through stimulation of cellular respiration, photosynthesis, water and nutrient uptake, and enzymatic activities (Piccolo, 1996; Chen et al., 2004). It also improves soil physical properties, controlling hormone levels , thus promoting plant growth, (Serenella et al., 2002). And many researchers have proven the positive effects of humus (HA) on the growth and productivity of many plants (Atiyeh et al., 2002; Dursun et al., 2002; Turkmen et al., 2004). Plant growth, development and yield increase are directly affected by humus acid, it improves plant absorption of nutrients, leads to availability of minerals to the plant, improves plant growth and controls soil-borne diseases (Mauromicale et al. 2011). Fertilizing with chemical (NPK) or organic fertilizers increased the available total phosphorous content, making it, more available for plants (Huang et al., 2016; Shi, et al., 2014). Application of the chemical fertilization (NPK) enabled growing rice twice in the same land during one year (Ye, et al. 2015). Addition of the chemical fertilizer NPK to soil growing two species of Bellflower resulted in increase of plant length, leaf area, number of nodes and number of branches (Kwon, et al. 2019). The aim of this research is to study the effect of humic acid as an organic fertilizer and NPK as chemical fertilizer on stimulation of growth and yield components of cabbage (Brassica oleracea L.).

I. MATERIALS AND METHODS

The research was conducted at the Agricultural Research Station, King Abdulaziz University - Hoda Al-Sham during two agricultural seasons (2019/2020) and (2020/2021). Randomly split plot design with 3 replicates was used. The main plot treatments were three concentrations of Humic acid (0, 50 and 100 L / ha), and the sub-plots were three concentrations of NPK (0, 600, 900 kg/ha). Cabbage was grown in rows in plots of 3x3 square meters, the distance between the rows is 50 cm and the distance between the plants is 50 cm.

Agricultural operations:

Land preparation for planting:

The soil was plowed with a plow to a depth of 25 to 30 cm and then leveled.

The area was divided into plots of 3 x 3 meters distributed according to the design of the experiment.

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Planting Methods:

During the first season seeds were sawn in 26-11-2019, and seedlings were planted in the field in 25-12-2019, and harvest was conducted in 17-2-2020. During the second season seeds were sawn in 2-11-2020, and seedlings were planted in the field in 4-12-2020, and harvest was conducted in 3-3-2021.

Irrigation system and networks:

A drip irrigation system was used, containing a 6000L storage tank, disc filter, pump, control and solenoid valve was used to control the flow time. Irrigation was carried out daily based on the full water requirements of the cabbage crop. The site was plowed and leveled, and the drip lines were placed at a distance of 50 cm between the lines and the distance between the points was 50 cm. A 125 µm disk filter system was used. The required irrigation water was calculated based on the requirements for crop need (evapotranspiration) and the total available water in the soil.

Experimental Data

Five plants were randomly selected at harvest for each treatment unit and morphological characteristics were measured including (stem length, stem diameter, head length, head diameter, coefficient of roundness, leaf area, leaf area index) as well as the total yield weight of the crop in ton / ha.

Statistical analysis:

Analysis of Variance for complete block design was used. Significant differences between means of the different treatments were statistical determined using the LSD test at P <0.05 according to El- Nakhlawi (2010) with the use of the SAS program for statistical analysis SAS (200).

II. RESULTS AND DISCUSSION

The data will be presented by analyzing the contrast between the different treatments of humic acid and different treatments of NPK and discussing the averages of the different morphological characteristics and the components of growth and yield of the cabbage plant (Brassica oleracea var. Capitata L) resulting from these treatments.

The data will be presented by analyzing the contrast between the different treatments of humic acid and different treatments of NPK and discussing the averages of the different morphological characteristics and the components of growth and yield of the cabbage plant (Brassica oleracea var. Capitata L) resulting from these treatments.

Morphological Traits:

Analysis of variance:

There are high significant differences (P≤0.01) between the different treatments of humic acid and NPK on stem length, stem weight, head length and head diameter of cabbage plants during the first and second agricultural seasons (Table 1).

TABLE . (1) ANALYSIS OF VARIANCE OF THE MORPHOLOGICAL CHARACTERISTICS OF THE CABBAGE PLANT PARTS (STEM LENGTH, STEM DIAMETER, HEAD LENGTH, HEAD DIAMETER AND ROUNDNESS COEFFICIENT (RC) UNDER THE INFLUENCE OF DIFFERENT RATES OF HUMIC ACID AND NPK FOR THE TWO SEASONS 2019/2020 AND 2020/2021

Source of variation	d.f	First season					Second season				
		Stem (cm)		Head (cm)			Stem (cm)		Head (cm)		
		Length	Dia	Leng.	Dia.	RC	Leng.	Dia.	Leng.	Dia.	RC
rep	2	0.45	3.00	27.5	90.2	0.018	0.41	2.8	24.8	85.2	0.02
HA	2	41.36**	18.38**	232.3**	891.9**	0.003	37.26**	17.3**	209.6**	736.4**	0.01
Error	4	0.76	0.53	3.0	19.7	0.036	0.69	0.5	2.7	17.6	0.03
NPK	1	13.61**	22.88**	**120.6	1377.4**	0.732**	12.26**	21.5**	108.7**	**1975.1	1.46**
HA+NPK	4	0.36	1.52	15.0	24.3	0.217*	0.33	1.4	13.5	9.3	0.21*
Error	12	0.37	0.70	8.55	36.4	0.04	0.33	0.66	7.72	32.9	0.04

*Indicates significant difference at (P≤0.01) level, ** significant difference at (P≤0.05) level, NS indicates no significant difference

Averages:

Length and diameter of stem and head, and head roundness:

Table (2) indicates significant average increases in stem length and diameter, head length and diameter, and head roundness of cabbage plant under HA application by (23.85, 13.90, 29.12, 26.42%) respectively under 50 L/ha, and by (48.63, 14.15, 58.89, 53.40%) respectively at 100 L/ha HA fertilizer during the first season with no significant difference in head roundness. Under NPK fertilizer the parameters increased by (13.85, 14.12, 1.49, 52.39, 2.16%) respectively at 600 kg/ha, and at percentages of (25.43, 29.17. 39.36, 71.85, 2.77%) respectively at 900 kg/ha during the first season. Also the averages of the studied parameters were significantly different under both HA and NPK fertilizer rates during the second season (Table 2).

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TABLE . (2) AVERAGES OF THE MORPHOLOGICAL CHARACTERISTICS OF THE CABBAGE PLANT PARTS (STEM LENGTH, STEM DIAMETER, HEAD LENGTH, HEAD DIAMETER AND ROUNDNESS COEFFICIENT UNDER THE INFLUENCE OF DIFFERENT RATES OF HUMIC ACID AND NPK FOR THE TWO SEASONS 2019/2020 AND 2020/2021.

	First season					Second season				
	Stem (cm)		Head (cm)			Stem (cm)		Head (cm)		
Humic acid	Length	Dia	Length.	Dia.	RC	Leng.	Dia.	Leng.	Dia.	RC
0	8.82 c	11.01 c	17.17 c	37.28 c	2.14 a	8.3 c	10.6 c	16.3 c	34.7 c	2.09 a
50	10.88 b	12.54 b	22.15 b	47.13 b	2.11 a	10.3 b	12.1 b	21.0 b	44.0 b	2.07 a
100	13.11 a	13.87 a	27.33 a	57.19 a	2.10 a	12.4 a	13.4 a	25.9 a	52.8 a	2.01 a
LSD	1.14	0.96	2.28	5.81	0.25	1.08	0.93	2.16	5.5	0.25
NPK										
0	9.67 c	10.90 c	18.574 c	33.4 c	1.78 b	9.1 c	10.5 c	17.6 c	32.0 c	1.8 b
600	11.01 b	12.44 b	22.194 b	50.9 b	2.29 a	10.4 b	12.0 b	21.0 b	39.09 b	1.85 b
900	12.13 a	14.08 a	25.895 a	57.3 a	2.27 a	11.5 a	13.6 a	24.5 a	60.5 a	2.52 a
LSD	0.63	0.86	3.0	6.1	0.214	0.59	0.83	2.55	5.89	0.212

The averages followed by the same letters did not differ significantly from each other according to the Lsd test at 0.05 significance level

The effect of interaction between humic acid and NPK fertilizer rates on the morphological characteristics of the cabbage plant:

The results of the averages (Table 3) indicate significant effects of the interaction of HA and NPK at all their different rates resulted in differences in the averages of stem length, stem diameter, head length, head diameter and rotation coefficient. The combination 100 L/ha HA with 900 kg/ha NPK resulted in the maximum percentage increases in stem and head characters, stem attained the highest percentage increase 27.27% in length, 38.30% in diameter, and head attained 48.16% in length, and 71.45% in diameter. While the combination 50 L/ha HA with 900 kg/ha NPK gave the highest percentage increase in head roundness (52.77%).

TABLE (3): AVERAGES OF CABBAGE PLANT (STEM LENGTH, STEM DIAMETER, HEAD LENGTH, HEAD DIAMETER AND ROTATION COEFFICIENT) UNDER THE INFLUENCE OF THE INTERACTION BETWEEN DIFFERENT RATES OF HUMIC ACID AND NPK DURING TWO SEASONS 2019/2020 AND 2020/2021

		First season					Second season				
Humic acid	NPK	Stem (cm)		Head (cm)			Stem (cm)		Head (cm)		
		Length	Dia	Length.	Dia.	RC	Leng.	Dia.	Leng.	Dia.	RC
0	0	7.58	10.10	13.60	24.1	1.7	7.20	9.79	12.92	23.15	1.79
	600	9.07	11.15	18.37	39.9	2.2	8.62	10.81	17.45	30.65	1.78
	900	9.82	11.79	19.53	47.8	2.4	9.33	11.44	18.56	50.50	2.71
50	0	9.84	10.92	19.27	34.2	1.7	9.35	10.59	18.31	32.90	1.78
	600	10.99	12.39	22.93	48.2	2.1	10.44	12.01	21.78	37.04	1.70
	900	11.82	14.31	24.26	58.8	2.4	11.23	13.88	23.04	62.18	2.73
100	0	11.61	11.68	22.84	41.8	1.8	11.03	11.33	21.69	40.15	1.84
	600	12.97	13.78	25.27	64.5	2.5	12.32	13.36	24.01	49.58	2.06
	900	14.75	16.15	33.89	65.1	1.9	14.01	15.67	32.19	68.84	2.14
Lsd		NS	NS	NS	NS	0.35	NS	NS	NS	NS	0.35

Each type of fertilizer has its own effect on crop growth and crop production due to the different nature and characteristics of these fertilizers in releasing inorganic and organic nutrients. The humic acid and NPK fertilizers led to significant increases in the morphological characteristics of the cabbage plant (length and diameter of the stem, the length and diameter of the head, and head roundness coefficient). These results correspond to many of the results reached by a number of researchers. Baldotto et al ., (2009) and Chen et al. (2004) obtained significant increases in plant growth and the growth of their roots and stems with the addition of humic acid fertilizer. Soare, et al. (2018) also found significant increases in the height and diameter of the head of the cabbage plant when fertilizing the plants with humic acid fertilizer. Al-Dabbagh, et al. (2020) found a significant increase in the length of the stem of the grapevine when fertilizing with humic acid fertilizer. Also (Sani, et al. 2015) found a significant increase in the height of canola When HA and NPK fertilizers were combined this interaction led to significant increases in cabbage plant characteristics compared to their individual effects. These positive effects plants when fertilized with humic acid fertilizer. Fan, et al. (2014) found a significant increase in stem diameter and head diameter of Chrysanthemums when fertilized with humic acid fertilizer. (Hope, et al. 2016) found a significant increase in head circumference and diameter of grapevine after fertilization with NPK fertilizer. (Laksono and Sugiono, 2019) obtained significant increases in plant height, stem diameter and root width of grapevine when fertilized with NPK fertilizer. (Fan, et al. 2014) found a significant increase in stem diameter and head diameter of chrysanthemums when fertilized with humic acid fertilizer, as well as with NPK fertilizer. Patel (2010) fertilized the cabbage plant with NPK fertilizer with an average (75-100-150) and obtained a significant increase in plant height, head length and head diameter. Moyin-Jesu (2015) added NPK (15-15-15) fertilizer at a rate of 300 kg / ha to the grapevine plant and found a significant increase in plant height, stem diameter, number of leaves, head length and head diameter.
of the combined interaction of humus fertilizer and the chemical NPK, on cabbage morphological characteristics are consistent with many previous studies. Verma, et al. (2014)

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found a significant increase in the height of the grapevine when fertilized with a mixture of humic acid and NPK. When (Islam, et al. 2017) fertilized the grapevine with organic fertilizer mixed with chemical fertilizer, they obtained a significant increase in plant length, head length and stem length.

Analysis of Variance:

There are high significant differences (P≤0.01) between the different treatments of humic acid, and different treatments of NPK on leaf area, leaf area index, and yield (ton / hectare) during the first and second agricultural seasons (Table 4).

TABLE . (4) ANALYSIS OF VARIANCE FOR LEAF AREA CHARACTERISTICS AND YIELD (TON / HECTARE) FOR CABBAGE PLANTS UNDER INFLUENCE OF DIFFERENT RATES OF HUMIC ACID AND CHEMICAL FERTILIZER NPK (20.20.20) DURING THE TWO SEASONS 2019/2020 AND 2020/2021

Source of variation	df	First season			Second season		
		Leaf area (m2)	Leaf area index(m2/m 2)	Total yield (ton/hectar)	Leaf area (m2)	Leaf area index(m2/m2)	Total yield (ton/hectar)(
rep	2	0.10	5.84	656.3	0.09	5.5	596.5
Humic acid	2	3.19 **	126.30 **	2757.9 **	2.96 **	126.8 **	2776.4 **
Error (a)	4	0.05	2.84	146.5	0.04	2.6	123.9
NPK	2	1.45 **	76.11 **	2767.5 **	1.29 **	72.0 **	2253.1 **
Humic acid * NPK	4	0.17 *	7.48	198.3 *	0.16 *	7.4	214.5 *
Error	12	0.047	2.46	37.15	0.04	2.31	45.45

**Indicates significant difference at (P≤0.01) level, *Indicates significant difference at (P≤0.05) level, NS indicates no significant

Averages:

averages: ton / ha) (, leaf area index and cabbage yield Leaf area

The means of leaf area, leaf area index and cabbage yield were significantly increased by the addition of humic acid and NPK fertilizers (Table 5). The increases reached (106.66, 76.00, 79.18%) under 50 L/ha HA fertilizer, and by (198.33, 150.00, 163.02%) at a rate of 100 liters / hectare respectively during the first season. Also the means of leaf area, leaf area index and cabbage yield were significantly increased by the addition of the chemical fertilizer NPK, up to (46.91, 45.34, 65.47%) respectively under addition of 600 kg/ha, and by (100.00, 98.30, 156.5%) respectively under application of 900 kg/ha during the first season. These studied parameters were also significantly increased with application of both HA and NPK fertilizers.

Leaf Area Index:

TABLE . (5) AVERAGES OF LEAF AREA, LEAF AREA INDEX AND TOTAL YIELD (TON / HECTARE) FOR CABBAGE PLANTS UNDER THE INFLUENCE OF DIFFERENT RATES OF HUMIC ACID AND NPK DURING THE SEASONS 2019/2020 AND 2020/2021

	First season			Second season		
Humic acid	**Leaf area (m2)**	**Leaf area index(m2/m2)**	**Total yield ((ton/hectar)**	**Leaf area (m2)**	**Leaf area index(m2/m2)**	**(Total yield (ton/hectar)**
0	0.60 c	5.01c	21.47 c	0.57 c	4.8 c	18.82 c
50	1.24 b	8.81 b	38.46 b	1.12 b	8.4 b	35.47 b
100	1.79 a	12.50a	56.48 a	1.72 a	12.3 a	53.93 a
LSD	0.29	2.20	15.84	0.28	2.14	14.57
NPK						
0	0.81c	5.91c	22.30 c	0.76 c	5.7 c	20.88 c
600	1.19b	8.69b	36.90 b	1.12 b	8.4 b	34.87 b
900	1.62a	11.72a	57.21 a	1.52 a	11.4 a	52.46 a
LSD	0.22	1.61	6.26	0.21	1.56	6.92

The averages followed by the same letters do not differ significantly from each other according to the Lsd test at 0.05 significance level

Interaction effects of HA and NPK rates on leaf area, leaf area index and yield:

The results of the of the interaction of HA and NPK (Table 6) showed increases in averages of leaf area, leaf area index and cabbage yield with significant differences in these parameters. The optimum combination that gave the highest percentage increases in leaf area and leaf area index was combination 100 L/ha HA with 900 kg/ha NPK resulted in the maximum percentage increases in leaf area (105.78%) during the first year season. While the combination 50 L/ha HA with 900 kg/ha NPK was the optimum combination for cabbage total yield giving the highest percentage increase (195.00%) during the first season. It is evident from these results that the joint interaction between the different rates of humus acid (50 and 100 liters / hectare) and the rates of NPK fertilizer 600 and 900 kg / ha) led to significant increases in leaf area, leaf area index and yield of cabbage plant, and the percentages increased with the increase in the rates of HA and NPK.

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TABLE (6) AVERAGES OF LEAF AREA, LEAF AREA INDEX AND YIELD (TON / HECTARE) FOR CABBAGE PLANTS UNDER THE INFLUENCE OF THE INTERACTION BETWEEN DIFFERENT RATES OF HUMIC ACID AND NPK DURING TWO SEASONS 2019/2020 AND 2020/2021

		First season			First season		
Humic acid	**NPK**	**LA(m2/plant)**	**LAI**	**Yield(t/ha)**	**LA(m2/plant)**	**LAI**	**Yield(t/ha)**
0	0	0.36	2.99	13.27	0.34	2.87	9.69
	600	0.69	5.73	20.71	0.66	5.50	19.61
	900	0.75	6.31	30.44	0.72	6.06	27.16
50	0	0.88	6.22	19.94	0.79	5.97	19.19
	600	1.23	8.74	36.64	1.11	8.39	37.71
	900	1.61	11.46	58.81	1.45	11.00	49.51
100	0	1.21	8.51	33.69	1.17	8.38	33.77
	600	1.66	11.61	53.35	1.60	11.43	47.31
	900	2.49	17.40	82.39	2.40	17.14	80.71
Lsd		0.38	NS	10.84	0.35	NS	11.99

The results of this study demonstrated the significant effect of humic acid and NPK fertilizers on the characteristics of cabbage leaf area, leaf area index and yield. The application of these fertilizers led to significant increases in averages of these characteristics during the two planting seasons compared to control. These fertilizers effects on cabbage characteristics are consistent with many previous studies. Ertani et al., (2013) found a significant increase in leaf area and biomass of maize leaves when adding humic acid. Abou-El-Hassan and El-Shinawy, (2015) found a significant increase in the components of red grape production when fertilized with humic acid and NPK. Ahmad, et al. (2013) fertilized Gladiolus grandiflorus with humic acid and obtained increases in foliage growth per plant, leaf area, stem diameter and length. Bettoni et al., (2016) added three rates of humic acid fertilizer and found a significant increase in the production and quality of onions with the increase in the acid rate. Li, et al. (2019) found that the use of humic acid over three years improved the yield and quality of the peanut crop. The increase in crop productivity due to the addition of humic acid was observed in many crops, including tomatoes and potatoes (Grady and Tina, 1999), onions (Erik et al., 2000) and maize (Ertani et al., 2013). Soare, et al. (2018) found a significant increase in cabbage production and yield quality when fertilized with humic acid fertilizer. Also (Al-Dabbagh, et al. 2020) found a significant increase in cabbage yield after fertilizing with humic acid fertilizer. Al-Ubaidy, et al. (2019) treated red cabbage plants by humic acid fertilizer at a rate of 0.5.10 mL / liter and obtained significant increase in the growth and yield components compared to the control treatment. Chen , et al. (2017) obtained significant increase (29.56%) in the yield of sweet potato under fertilization with HA plus N.

Patel (2010) fertilized Tacrambe with NPK fertilizer (75-100-150) and found a significant increase in the production of plant heads. In a study carried out by (Meage et al., 2011), the fruit and yield of Solanum melongena reached twice the weight when fertilized with NPK fertilizer, and NPK fertilizer at the rate of 200kg/ha improved pod production, weight of 100seeds, pod weight and final grain yield per hectare in cowpea (Kareem, et al., 2013), and there was a significant increase in wheat production (Jing, et al. 2015). Adediran and Banjoko (2003) found significant increase in onion production with NPK fertilizer.. Moyin-Jesu (2015) added NPK fertilizer (15-15-15) at a rate of 300 kg / ha to the grapevine and found a significant increase in leaf area and production components.

Humic acid provides nutrients to plants because it controls the exchange of carbon and oxygen between the soil and the atmosphere, which stimulates and increases plant growth (Barancikova and Makovnikova, 2003; Calvo et al., 2014). Turkmen, et al. (2004) assumed that humic acid influences plant yield through its effect on respiration and photosynthesis. Mauromicale et al., (2011) says that humic acid is an organic substance whose role lies in resisting diseases in the soil, improving soil properties and absorbing nutrients, and thus significantly affects plant growth. It was shown by (Mart, 2007; Sarir et al., 2005) that humic acid improves soil properties, increases enzyme activity, and increases crop productivity. Also, many studies have proven that adding humic acid to the soil helps to improve the absorption of elements by plants (Mackowiak et al., 2001; Sharif et al., 2004). Li, et al. (2019) found that adding humic acid to the soil over a period of three years improved the physico-chemical properties, enzymatic activities, and microbial diversity of the soil, which helped alleviate the obstacles to continuous peanut cultivation. Humic acid acts as a pH regulator (Campitelli et al., 2008). It also has the benefits of holding ions and works like chelating materials (Pinheiro et al., 2007: Manzoor et al., 2014). NPK enhances plant growth because it is quickly absorbed by plant roots (Xiaoyuan Yan (2010). Stefano et al., (2004) reported that chemical fertilizers have a strong effect on crop growth, development and yield. Also (Fashina et al., 2002) indicated that providing adequate nutrients from chemical fertilizer leads to improved cell activities, reproduction and growth.

II. CONCLUSION

This study was conducted to evaluate the effect of humic acid and NPK fertilizer on the growth and yield components of cabbage (Brassica oleracea L.) in 2018/2019 and 2019/2020. All the different treatments witnessed high significant increases ($P \leq 0.01$) in the morphological characteristics (stem length, stem diameter, head length, head diameter, head roundness coefficient), and in the characteristics of leaf area, leaf area index and in yield production. The percentages of the increases increased with increasing the humic acid rate from 0 to 100 litres / hectare,

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and increase in NPK from 0 to 900 kg/ha, and also in the interaction treatments of HA with NPK. The results of this study recommend adding humic acid to the soil on which cabbage plants are grown at a rate of up to 100 litres / hectare, and applying NPK fertilizer at rate up to 900 kg/ha because these amounts lead to significant increases in cabbage plant growth components and significant increases in cabbage plant yield production components. It also recommends application of mixture of HA and MPK fertilizers at rate of 50 L/ha HA with 900 kg/ha for optimum cabbage yield, and 100 litres/ha HA with 900 kg/ha NPK for other cabbage growth parameters.

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