Academic Journal of Nawroz University (AJNU), Vol.12, No.4, 2023
This is an open access article distributed under the Creative Commons Attribution License
Copyright ©2017. e-ISSN: 2520-789X
https://doi.org/10.25007/ajnu.v12n4a1476

Effect of Foliar Application Nano NPK Fertilizers and Bio Stimulants on Growth, Yield, and Quality of Two Red Cabbage Cultivars *(Brassica oleracea L. var. capitata rubra)*

Dunya S. Saeed [1] and Sanaa M.S. Rasheed [2]

1 Department of Horticulture, Technical College of Akre, Duhok polytechnic University, Kurdistan Region –Iraq
2 Department of Horticulture, College of agriculture engineering science, University of Duhok, Kurdistan Region _Iraq

ABSTRACT: The experiment was done during growing seasons 2021-2022 in field condition at Protected cultivation Department/ in Zakho technical institute/Dohuk polytechnic university, to investigate the effect of Nano NPK fertilizers(0 and 2 g.l^{-1}) and Bio stimulants (0, fulvic acid 0.5 g.l^{-1}, amino acid 1g.l^{-1} and F+A g.l^{-1}) on growth, yield, and quality of two red Cabbage Cultivars (*Brassica oleracea* L. var. *capitata rubra*) .The treatments will be arranged in split-split plot system. The fertilizers spray was done one month after transplanting and repeated three time interval 10 days between them. The result showed that the Nano NPK had no significant difference on the all parameters. fulvic acid (0.5 g.l^{-1}) significantly increases head length (cm), head weight (kg) , and total yield (ton. ha^{-1}). Number of leaves per plant increase with Amino acid (1 g.l^{-1}). While (F+A g.l^{-1}) increased ascorbic acid (%), but bio stimulants no affected to anthocyanin (mg/100g) and carbohydrate (%) .The FIREBALL F1 cultivar significant increased No. of leaves per plant (leaf.plant^{-1}), head weight (kg), total yield (ton. ha^{-1}) and carbohydrate (%). While ZEINA F1 only increased ascorbic acid (%), but cultivars were not affected on head length (cm) and anthocyanin (mg/100g).The binary and triple interaction revealed that the combination between FIREBALL F1, fulvic acid (0.5 g.l^{-1}) significantly increased almost all characteristics.

Keywords: Red Cabbage, Nano fertilizers, Bio Stimulants, and cultivars.

1. Introduction

Red cabbage (*Brassica oleracea L .var. capitata L. f. rubra*) is a cool season leafy vegetable belong to the group of Cole crops (Brassicaceae family) (Sarkar and Rakshit, 2017). Cabbage is a high-protein, high-biological-value, and high-digestibility vegetable, its leaves are high in vitamin A, B1, B2, and minerals, and they are very high in vitamin C. Cabbage has also been shown to have anti-cancer properties (Beecher, 1994). Due to the presence of anthocyanin pigment, it produces red or purple colored heads (Sarkar and Rakshit, 2017).

One of the scientific revolutions in agriculture is the use of the recently introduced Nano-system to achieve the highest production in vegetable crops at a cheaper cost, which can decrease some of the essential stresses that impact vegetable crops and beneficial soil and plant microorganisms, as they are employed to convert hazardous and dangerous gases into safe gases, nanoparticles have a strong chemical activity, which is reflected in the reduced vital stresses they are exposed to soil and plants. (Ibraheem, 2020).

NPK is one of the most critical elements that agricultural crops require, and a loss of these elements during plant growth has a detrimental impact on plant reproduction, production, and growth. The addition of Nano fertilizer to the plant increases the solubility of nutrients as well as their distribution throughout a large area of the soil, allowing for rapid and easy absorption as well as long-term effectiveness(Naderi and Danesh-Shahraki, 2013).

(Abdulhameed et al., 2021) investigate a study aboutthe influenceo of NPK nano fertilizers on yield of cabbage plant. researcher used NPK nano fertilizers (30g, 48g, 100g), indicated that the two types of nano fertilization treatments were superior to the chemical fertilization treatment in head weight, and total plant yield. (Merghany et al., 2019) Consider a study about the effects of Nano fertilizer on cucumber growth. (3, 4.5, 6 and 9 ml), results showed that the Nano fertilizer significantly improved the growth compared with control treatment. All treatments of Nano fertilizer led to increase plant height, number of leaves / plant.

Bio stimulants are natural remedies that help plants increase their overall health, vitality, and growth while also protecting them from infections(Drobek et al., 2019). The role of bio stimulant in increasing crop production, makes available food at cheap rates and development in value of food (Kumar and Aloke, 2020). (Shehata et al., 2016) using spraying amino acid in cucumber enhance early total yield in the initial season and regular fruit weight in the alternate season compared with other stimulant. (Wang et al., 2019) Investigate a study about effect of foliar application of liquid fertilizer of amino acid on cowpea, the result showed that amino acid fertilizer increase yield of cowpea. (Kamel et al., 2014) showed in study by using fulvic acid on cucumber plants that the yield and carbohydrates content, fruit weight, fruit number of cucumber plant increased by useing fulvic acid.

The cultivar has a significant impact on the crop's production. With the introduction of new acceptable hybrid cultivars from overseas, there is a lot of scope to increase cabbage production. Many hybrid cabbage cultivars have been imported by various seed firms and are available on the market. Varietal performance must be established prior to making a recommendation to farmers (Moniruzzaman, 2011). (Olaniyi and Ojetayo, 2011) Carried out study about two cabbage varieties (Copenhagen market and F1 milor), result showed that the Copenhagen market had higher mean number of leaves, and taller plant height over F1 milor, also gave the highest head length in both varieties. (Voća et al., 2018) carried out study of four white cabbage ('Bravo F1', 'Bronco F1', 'Slava', 'Farao F1') and two red ('Maestro F1', 'Primero F1'), Result showed the significant difference between the cultivars, Red cultivars had significantly higher values of vitamin C, and higher antioxidant 3.9 times compared to white cabbage cultivars. (Pokluda, 2008) Carried out study about four cultivars of cabbage (Bilko, Nozaki, Optiko Parkin), Results showed significant effect of cultivar on the content of all observed substances in cabbage heads also cv. Parkin showed a higher content of vitamin C than the cv. Optika Parkin.

Due to the limited studies on the aforementioned issues in Iraq in general and the Kurdistan area in particular, this study was carried out to investigate the effect of Nano NPK fertilizers, Bio stimulants (Fulvic and Amino acid) and two cultivars on the growth and productivity of red Cabbage crop. Also to Protection of environment from pollution by using natural fertilizers, and increasing the productivity of organic red Cabbage.

2. Material and Methods

The experiment was done during growing seasons 2021-2022 to investigate the effect of Nano NPK fertilizers and Bio stimulants on growth, yield, and quality of two red Cabbage Cultivars grown in field condition at Protected cultivation Department/ in Zakho technical institute/Dohuk polytechnic university. The seeds of cabbage cultivars were planted in plate pods on 15thSeptember. The seedlings were planted on (12thOctober) in holes provided with peat moss mix. Seedling were transferred to the permanent place and planted at distance of 40 cm between the plant and 60 cm between row. The experiment comprised of the effect of 2 cultivars (FIREBALL F1) and (ZIANA F1), 4 levels of Bio stimulates (0, fulvic acid 0.5 g.l^{-1}, amino acid 1 g.l^{-1} and F+A g.l^{-1}) and 2 levels of Nano NPK (0 and 2 g.l^{-1}).The treatments were arranged in split-split plot system. The main-plot (2 cultivar) and the sub-plots 4 levels of bio stimulates and in sub-sub-plot will be the 2 level of Nano NPK fertilizers, going to randomly arrange in a Randomized Complete Block Design (RCBD), 16 treatments were involved in this trail (2×4×2=16) with three replication (48 experimental units), each experimental unit consist of 10 plants .The fertilizers spray was done one month after transplanting and repeated three time interval 10 days between them. The results will analyze statistically by using Duncan multiple range test at 0.05**(SAS, 2007)**. Experimental Measurements were: No. of leaves per plant, Head weight (kg), Head length (cm), Total yield (ton. ha^{-1}), Anthocyanin (mg/100g), Carbohydrate (%) and Ascorbic acid (%).

3. Results

3.1 No. of leaves per plant (leaf.plant^{-1})

Data presented in table (1) shows that a highly significant differences between cultivars in number of leaves per plant, FIREBALL F1 cultivar overcome ZEINA F1 cultivar which record (57.53 leaf.plant^{-1}) ,when sprayed with Amino acid (1 g.l^{-1}). Also the Bio stimulants significantly affected and the highest results was (58.28 leaf.plant^{-1}) .But Nano NPK recorded no significant differences on number of leaves per plant. The interaction between cultivars and bio stimulants showed significant variation among them superior interaction is FIREBALL cultivars with fulvic acid (0.5 g.l^{-1}) recorded (59.89 leaf.plant^{-1}). The interaction between cultivars and Nano NPK showed significant different among them, superior

interaction which FIREBALL cultivar with Nano NPK(2 g.l^{-1}) recorded (58.50). Interaction between bio stimulants and Nano NPK showed significant differences between them and the highest record (58.72 leaf.plant^{-1}). where amino acid (1 g.l^{-1}) with Nano NPK (2 g.l^{-1}).Interaction among three factors resulted in a significant differences the maximum number of leaves was determine among FIREBALL cultivars ,fulvic acid (0.5 g.l^{-1}) and Nano NPK (2 g.l^{-1}) which was (62.33 leaf.plant^{-1}),when compared to others.

Table 1: Effect of Cultivars, Bio stimulants, Nano NPK and their interaction on No. of leaves per plant (leaf.plant-1)

Cultivars	Bio stimulants	Nano NPK		Cultivars + Bio stimulants	Cultivars
		0	2 g.l^{-1}		
ZEINA F1	0	49.11 h	51.67 f-h	50.39 c	53.72 b
	Amino acid 1 g.l^{-1}	59.11 a-c	57.33 a-e	58.22 ab	
	Fulvic acid 0.5 g.l^{-1}	54.56 c-g	50.11 gh	52.33 c	
	F+A g.l-1	55.78 b-f	52.11 e-h	53.94 bc	
FIREBALL F1	0	52.22 d-h	55.44 c-f	53.83 bc	57.53 a
	Amino acid 1 g.l^{-1}	56.56 b-f	60.11 ab	58.33 bb	
	Fulvic Acid 0.5 g.l^{-1}	57.44 a-d	62.33 a	59.89 a	
	F+A g.l^{-1}	60.00 ab	56.11 b-f	58.06 ab	
Nano NPK		55.60 a	55.65 a		
Cultivars + Nano NPK	ZEINA F1	54.64 bc	52.81 c	Bio stimulants	
	FIREBALL F1	56.56 ab	58.50 a		
Bio simulants + Nano NPK	0	50.67 c	53.56 bc	0	52.11 b
	Amino acid 1 g.l^{-1}	57.83 a	58.72 a	Amino acid 1 g.l^{-1}	58.28 a
	Fulvic Acid 0.5 g.l^{-1}	56.00 ab	56.22 ab	Fulvic acid 0.5 g.l^{-1}	56.11 a
	F+A g.l^{-1}	57.89 a	54.11 b	F+A g.l^{-1}	56.00 a

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range test at 5% level.

3.2 Head length (cm)

Result in the table (2) showed that the cultivars did not effect on head length .The bio stimulants significantly affected to head length the maximum result was achieved by applying fulvic acid (0.5 g.l^{-1}) which was (13.65 cm). But Nano NPK recorded no significant differences on head length. In case of the interaction between cultivars and bio stimulants, there were a significant variation between them, superior interaction was (14.26 cm) between FIREBALL and fulvic acid (0.5 g.l^{-1}) . interaction between cultivars and Nano NPK gave a significant impact, the best data was obtained (13.50 cm) from interaction of FIREBALL and zero Nano NPK. the interaction between bio stimulants and Nano NPK there were a significant between them the highest result was in fulvic acid (0.5 g.l^{-1}) with zero Nano NPK which was (13.67 cm). triple interaction among the factors showed a significant variation, the superiority was found

in the interaction among FIREBALL , fulvic acid (0.5 g.l^{-1}) and zero Nano NPK which was (14.28 cm) when compared to others .

Table 2: Effect of cultivars, Bio stimulants, Nano NPK and their interaction on Head length (cm)

Cultivars	Bio stimulants	Nano NPK		Cultivars + Bio stimulants	Cultivars
		0	2 g.l^{-1}		
ZEINA F1	0	11.28 e	12.61 cd	11.94 c	12.60 a
	Amino acid 1 g.l^{-1}	12.56 cd	12.39 cd	12.47 bc	
	Fulvic acid 0.5 g.l^{-1}	13.06 cd	13.05 cd	13.05 bc	
	F+A g.l-1	12.56 cd	13.34 a-d	12.95 bc	
FIREBALL F1	0	13.44 a-c	12.28 d	12.86 bc	13.34 a
	Amino acid 1 g.l^{-1}	12.94 cd	13.06 cd	13.00 bc	
	Fulvic Acid 0.5 g.l^{-1}	14.28 a	14.23 ab	14.26 a	
	F+A g.l^{-1}	13.33 a-d	13.17 b-d	13.25 b	
Nano NPK		12.93 a	13.02 a		
Cultivars + Nano NPK	ZEINA F1	12.36 c	12.85 bc	Bio stimulants	
	FIREBALL F1	13.50 a	13.18 ab		
Bio simulants + Nano NPK	0	12.36 c	12.44 c	0	12.40 b
	Amino acid 1 g.l^{-1}	12.75 bc	12.72 bc	Amino acid 1 g.l^{-1}	12.74 b
	Fulvic Acid 0.5 g.l^{-1}	13.67 a	13.64 a	Fulvic acid 0.5 g.l^{-1}	13.65 a
	F+A g.l^{-1}	12.94 a-c	13.26 ab	F+A g.l^{-1}	13.10 ab

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range test at 5% level.

3.3 Head weight (kg)

Data in table (3) indicated that there was a difference between the two cultivars on head weight , the best value was obtained in FIREBALL cultivar (1.55 kg) as compared to ZEINA F1. The bio stimulants significantly influenced in head weight, the highest number recorded in fulvic acid (0.5 g.l-1) which was (1.55 kg) as compared to others. Spraying with Nano NPK showed a significant effect on head weight, the best result was (1.43 kg) with zero Nano NPK .Interaction between cultivars and bio stimulants showed significant differences between them best result recorded in FIREBALL cultivar with fulvic acid (0.5 g.l-1) which was (1.76 kg).interaction with cultivars and Nano NPK recorded significant influences on head weight the FIREBALL cultivar with zero Nano NPK had the highest value (1.59 kg). The interaction between bio stimulant and Nano NPK resulted in a significant impact between them best result when combination between fulvic acid (0.5 g.l-1) with zero Nano NPK which was (1.69 kg). In the interaction between the three factor there was a significant difference between them in head weight best result were recorded in combination of FIREBALL, fulvic acid (0.5 g.l-1) and Nano NPK zero which recorded (1.92kg) as compared to others interactions.

Table 3: Effect of cultivars, Bio stimulants, Nano NPK and their interaction on Head Weight (kg)

Cultivars	Bio stimulants	Nano NPK		Cultivars + Bio stimulants	Cultivars
		0	2 g.l^{-1}		
ZEINA F1	0	1.10 g	1.17 h-j	1.14 d	1.25 b
	Amino acid 1 g.l^{-1}	1.23 g-j	1.16 ij	1.20 d	
	Fulvic acid 0.5 g.l^{-1}	1.45 de	1.24 g-i	1.35 c	
	F+A g.l-1	1.27 g-i	1.40 d-f	1.34 c	
FIREBALL F1	0	1.30 f-h	1.41 d-f	1.36 c	1.55 a
	Amino acid 1 g.l^{-1}	1.63 bc	1.66 b	1.65 b	
	Fulvic Acid 0.5 g.l^{-1}	1.92 a	1.60 bc	1.76 a	
	F+A g.l^{-1}	1.52 cd	1.33 e-g	1.42 c	
Nano NPK		1.43 a	1.37 b		
Cultivars + Nano NPK	ZEINA F1	1.26 c	1.24 c	**Bio stimulants**	
	FIREBALL F1	1.59 a	1.50 b		
Bio simulants + Nano NPK	0	1.20 d	1.29 c	0	1.25 c
	Amino acid 1 g.l^{-1}	1.43 b	1.41 b	Amino acid 1 g.l^{-1}	1.42 b
	Fulvic Acid 0.5 g.l^{-1}	1.69 a	1.42 b	Fulvic acid 0.5 g.l^{-1}	1.55 a
	F+A g.l^{-1}	1.39 b	1.37 bc	F+A g.l^{-1}	1.38 b

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range test at 5% level.

3.4 Total yield (ton. ha-1)

Data presented in table (4) shows highly significant differences between cultivars in total yield, FIREBALL F1 cultivar overcome ZEINA F1 cultivar in yield which record (56.69 ton. ha^{-1}). Also the Bio stimulants significantly affected in plant yield, the highest was fulvic acid (0.5 g.l^{-1}) recorded (56.88 ton. ha^{-1}). Nano NPK resulted in significant differences on plant yield, zero Nano NPK recorded (52.35 ton. ha^{-1}). The interaction between cultivars and bio stimulants showed significant variation among them superior interaction is FIREBALL cultivars with fulvic acid (0.5 g.l^{-1}) recorded (64.43 ton. ha^{-1}). The interaction between cultivars and Nano NPK showed significant different among them, superior interaction which FIREBALL cultivar with zero Nano NPK recorded (58.39 ton. ha^{-1}).Interaction between bio stimulants and Nano NPK showed significant differences between them and the highest record (61.80 ton. ha^{-1}) where fulvic acid (0.5 g.l^{-1}) with zero Nano NPK used. Interaction among three factors resulted in a significant difference on plant yield the maximum number was determine among FIREBALL cultivars ,fulvic acid (0.5 g.l^{-1}) and zero Nano NPK which was (70.32 ton. ha^{-1}),when compared to others.

Table 4: Effect of cultivars , Bio stimulants, Nano NPK and their interaction on Total Yield (ton. ha-1)

Cultivars	Bio stimulants	Nano NPK		Cultivars + Bio stimulants	Cultivars
		0	2 g.l^{-1}		
ZEINA F1	0	40.33 k	42.98 i-k	41.66 d	45.96 b
	Amino acid 1 g.l^{-1}	44.94 h-k	42.70 jk	43.82 d	
	Fulvic acid 0.5 g.l^{-1}	53.29 de	45.39 h-j	49.34 c	
	F+A g.l-1	46.65 g-j	51.41 d-g	49.03 c	
FIREBALL F1	0	47.83 f-i	51.78 d-f	49.81 c	56.69 a
	Amino acid 1 g.l^{-1}	59.81 bc	60.83 b	60.32 b	
	Fulvic Acid 0.5 g.l^{-1}	70.32 a	58.54 bc	64.43 a	
	F+A g.l^{-1}	55.61 cd	48.77 e-h	52.19 c	
Nano NPK		52.35 a	50.30 b		
Cultivars + Nano NPK	ZEINA F1	46.30 c	45.62 c	Bio stimulants	
	FIREBALL F1	58.39 a	54.98 b		
Bio simulants + Nano NPK	0	44.08 d	47.38 c	0	45.73 c
	Amino acid 1 g.l^{-1}	52.37 b	51.76 b	Amino acid 1 g.l^{-1}	52.07 b
	Fulvic Acid 0.5 g.l^{-1}	61.80 a	51.96 b	Fulvic acid 0.5 g.l^{-1}	56.88 a
	F+A g.l^{-1}	51.13 b	50.09 bc	F+A g.l^{-1}	50.61 b

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range test at 5% level.

3.5 Carbohydrate (%)

Result in the table (5) shows a highly significant differences between cultivars on carbohydrate, FIREBALL F1 cultivar overcome ZEINA F1 cultivar on carbohydrate which record (1.83%). But Bio stimulants and Nano NPK did not significantly effect on carbohydrate percent.

The interaction between cultivars and bio stimulants showed no significant affected on carbohydrate. Also the interaction between cultivars and Nano NPK showed no significant different among them. But Interaction between bio stimulants and Nano NPK showed significant differences between them and the highest record(1.94%) where sprayed fulvic acid (0.5 g.l-1) and Nano NPK (2 g.l-1). Triple interaction among three factors showed no significant differences on carbohydrate.

Table 5: Effect of cultivars , Bio stimulants, Nano NPK and their interaction on Carbohydrate (%)

Cultivars	Bio stimulants	Nano NPK		Cultivars + Bio stimulants	Cultivars
		0	2 g.l^{-1}		
ZEINA F1	0	1.58 a	1.78 a	1.68 a	1.75 b

	Amino acid 1 g.l^{-1}	1.74 a	1.71 a	1.73 a	
	Fulvic acid 0.5 g.l^{-1}	1.71 a	1.91 a	1.81 a	
	F+A g.l-1	1.91 a	1.62 a	1.77 a	
FIREBALL F1	0	1.59 a	1.94 a	1.76 a	1.83 a
	Amino acid 1 g.l^{-1}	1.86 a	2.02 a	1.94 a	
	Fulvic Acid 0.5 g.l^{-1}	1.71 a	1.96 a	1.83 a	
	F+A g.l^{-1}	1.76 a	1.82 a	1.79 a	
Nano NPK		1.73 a	1.85 a	**Bio stimulants**	
Cultivars + Nano NPK	ZEINA F1	1.73 a	1.76 a		
	FIREBALL F1	1.73 a	1.93 a		
Bio simulants + Nano NPK	0	1.58 b	1.86 ab	0	1.72 a
	Amino acid 1 g.l^{-1}	1.80 ab	1.87 ab	Amino acid 1 g.l^{-1}	1.83 a
	Fulvic Acid 0.5 g.l^{-1}	1.71 ab	1.94 a	Fulvic acid 0.5 g.l^{-1}	1.82 a
	F+A g.l^{-1}	1.84 ab	1.72 ab	F+A g.l^{-1}	1.78 a

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range test at 5% level.

3.6 Ascorbic acid (%)

Data in table (6) indicated that there was a difference between the two cultivars on Ascorbic acid ,the best value was obtained in ZEINA F1 cultivar (42.08%) compared to FIREBALL F1 (39.72%).The bio stimulants significantly influenced in Ascorbic acid, the highest number recorded in (F+A g.l^{-1}) which was (42.66%).spraying with Nano NPK showed no significant effect on ascorbic acid .

Interaction between cultivars and bio stimulants showed significant differences between them best result recorded in ZEINA F1 cultivar with (F+A g.l^{-1}) which was (45.09%).Interaction with cultivars and Nano NPK recorded significant influences on Ascorbic acid the ZEINA F1 cultivar with zero Nano NPK had the highest value (42.49%).Interaction between bio stimulant and Nano NPK resulted significant impact between them best result when combination between (F+A g.l^{-1}) with zero Nano NPK which was (44.31%). In the interaction between the three factors there was a significant difference between them in Ascorbic acid best result were recorded in combination of ZEINA F1, (F+A g.l^{-1}) and Nano NPK zero which recorded (49.45%).

Table 6: Effect of cultivars , Bio stimulants, Nano NPK and their interaction on Ascorbic acid (%)

Cultivars	**Bio stimulants**	**Nano NPK**		**Cultivars + Bio stimulants**	**Cultivars**
		0	2 g.l^{-1}		
ZEINA F1	0	33.94 d	42.87 bc	38.41 d	42.08 a
	Amino acid 1 g.l^{-1}	44.47 b	40.72 bc	42.59 b	

	Fulvic acid 0.5 g.l^{-1}	42.11 bc	42.32 bc	42.22 bc	
	F+A g.l-1	49.45 a	40.74 bc	45.09 a	
FIREBALL F1	0	40.71 bc	40.25 bc	40.48 b-d	39.72 b
	Amino acid 1 g.l^{-1}	37.77 cd	39.00 c	38.39 d	
	Fulvic Acid 0.5 g.l^{-1}	40.29 bc	39.29 c	39.79 d	
	F+A g.l^{-1}	39.17 c	41.29 bc	40.23 cd	
Nano NPK		40.99 a	40.81 a	**Bio stimulants**	
Cultivars + Nano NPK	ZEINA F1	42.49 a	41.66 ab		
	FIREBALL F1	39.49 b	39.96 b		
Bio simulants + Nano NPK	0	37.32 c	41.56 ab	0	39.44 b
	Amino acid 1 g.l^{-1}	41.12 ab	39.86 bc	Amino acid 1 g.l^{-1}	40.49 b
	Fulvic Acid 0.5 g.l^{-1}	41.20 ab	40.81 ab	Fulvic acid 0.5 g.l^{-1}	41.00 b
	F+A g.l^{-1}	44.31 a	41.01 ab	F+A g.l^{-1}	42.66 a

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range test at 5% level.

3.7 Anthocyanin (mg/100g)

Result in the table (7) shows no significant differences between cultivars on Anthocyanin. Also Bio stimulants and Nano NPK resulted there are no significant effects on Anthocyanin in leaves.

The interaction between cultivars and bio stimulants showed no significant affect on Anthocyanin. Also the interaction between cultivars and Nano NPK showed no significant different among them. But Interaction between bio stimulants and Nano NPK showed significant differences between them and the highest record (115.46 mg/100g) where interaction zero bio stimulant with Nano NPK (2 g.l^{-1}). Triple interaction among three factors showed significant differences Anthocyanin , best result interaction ZEINA F1 ,zero bio stimulants and (2 g.l^{-1}) of Nano NPK which was (119.85 mg/100g).

Table 7: Effect of cultivars, Bio stimulants, Nano NPK and their interaction on Anthocyanin in Leaves mg/100g

Cultivars	**Bio stimulants**	**Nano NPK**		**Cultivars + Bio stimulants**	**Cultivars**
		0	2 g.l^{-1}		
ZEINA F1	0	104.16 bc	119.85 a	112.01 a	107.61 a
	Amino acid 1 g.l^{-1}	106.22 a-c	103.95 bc	105.08 a	
	Fulvic acid 0.5 g.l^{-1}	107.86 a-c	107.48 a-c	107.67 a	
	F+A g.l-1	115.38 ab	96.03 c	105.70 a	
FIREBALL F1	0	102.04 bc	111.08 ab	106.56 a	106.02 a
	Amino	105.88	103.82	104.85	

	acid 1 g.l^{-1}	a-c	bc	a	
	Fulvic Acid 0.5 g.l^{-1}	103.19 Bc	110.14 a-c	106.66 a	
	F+A g.l^{-1}	106.05 a-c	105.97 a-c	106.01 a	
Nano NPK		106.35 a	107.29 a		
Cultivars + Nano NPK	ZEINA F1	108.40 a	106.82 a	**Bio stimulants**	
	FIREBALL F1	104.29 a	107.75 a		
Bio simulants + Nano NPK	0	103.10 b	115.46 a	0	109.28 a
	Amino acid 1 g.l^{-1}	106.05 ab	103.88 b	Amino acid 1 g.l^{-1}	104.97 a
	Fulvic Acid 0.5 g.l^{-1}	105.52 b	108.81 ab	Fulvic acid 0.5 g.l^{-1}	107.16 a
	F+A g.l^{-1}	110.71 ab	101.00 b	F+A g.l^{-1}	105.86 a

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range test at 5% level.

4. Discussion

One of the most important uses of nanotechnology is Nano fertilizer, which improves the ability of plants to absorb nutrients(Merghany et al., 2019). But Nano NPK recorded no significant differences on almost all parameter. This depends mainly on the concentration, composition and size of modified nanoparticles in addition to their physical, chemical and plant species properties (Ma et al., 2010). The study showed In tables (1,2 ,3, 4, 5 and 6) that all factors individual and combination increase all study parameters significantly. This may be due to : The fact that the cultivar differ in their potential growth and productivity, and this depends mainly on the physiological processes controlled by the interaction of both genetic and environmental variance, The reason for this diversification can be attributed to the adaptability of genes and to morphological characteristics, and physiological factors during the growth period of the crop (Olaniyi et al., 2010). And also plays a great role for higher yield of the crop. (Kalisz et al., 2013) showed that Tatsoi cultivar had significantly more leaves than Misome, when study the effect of cultivars on cabbages growth. (Ezzo et al., 2008) carry out a study of two cabbage cultivars (Glob Master and Ruby Perfection), Result showed that Glob Master plants recorded higher head weight, and yield than those of Ruby Perfection. Fulvic acid (0.5 g.l^{-1}) showed best result on all parameter tables (2.3.4), because Fulvic acid has a highest effect on chemical reaction that increases the permeability of membrane because of the appearance of electronegative oxygen atoms more than other humate molecules, enhance enzyme activity, enhance yield and crop growth and stimulation of plant metabolism (BNV et al., 2014). Improve a study about yield of tomato affected by spray application of fulvic acid that enhance yield of tomato (Husein et al., 2015). (Shafeek et al., 2018) Investigate a study about amino acid on growth of onion plant The best results using (2 cm/L) concentration of amino increases number of leaves/plant. the role of bio stimulant in increasing crop production, making available food at cheap rates and improvement in quality of food (Kumar and Aloke, 2020). The use of Nano fertilizer leads to an increase in the efficiency of micro and macro elements and a reduction in soil toxicity compared to the addition of traditional fertilizer, as some studies have proven the importance of Nano fertilizer, which includes some beneficial effects, an increase in the efficiency of nutrient use and a reduction in soil pollution and thus a better outcome (Naderi and Danesh-Shahraki, 2013). But Nano NPK did not affect what is shown in all tables.

5. Conclusion and recommendation

According to the previous results, cultivars and bio stimulants have a positive effect on plant growth and yield. The FIREBALL F1 cultivar has superiority over the ZEINA F1 cultivar in almost all parameters.

Fulvic acid (0.5 g.l-1) from bio stimulants has a positive effect on plant growth and yield characteristics. Nano NPK not affected because of few concentrations.

I recommend all researchers to work at different cities in Kurdistan and use different cultivars and different concentrations to know how a red cabbage adaptation from different environmental circumstances also to increase the best organic product of red cabbage in Kurdistan.

References

Abdulhameed, M.F., Taha, A.A., Ismail, R.A., 2021. Influence of cerium oxide nanoparticles and NPK Nano Fertilizers on growth and yeild of cabbage plant. Plant Arch. 21, 1326–1331.

Beecher, C., 1994. Cancer preventive properties of varieties of Brassica oleracea: a review. Am. J. Clin. Nutr. 59, 1166S-1170S.

BNV, P., DS, G., Upadhyay, A.P., Sharma, N.K., 2014. Fulvic acid (FA) for enhanced nutrient uptake and growth: insights from biochemical and genomic studies. J. Crop Improv. 28, 740–757.

Drobek, M., Frąc, M., Cybulska, J., 2019. Plant biostimulants: Importance of the quality and yield of horticultural crops and the improvement of plant tolerance to abiotic stress—A review. Agronomy 9, 335.

Ezzo, M., Glala, A., Singer, S., 2008. Influence of some alternative nitrogen sources and regimes on two salad cabbage cultivars. Aust. J. Basic Appl. Sci. 2, 733–737.

Husein, M., El-Hassan, S., Shahein, M., 2015. Effect of humic, fulvic acid and calcium foliar application on growth and yield of tomato plants. Int. J. Biosci. 7, 132–140.

Ibraheem, F.F., 2020. The possibility of using Nano fertilizers to raise the efficiency of vegetable crops productivity, improve the quality and reduce the damage of biological stresses. Mesop. J. Agric. 48, 1–10.

Kalisz, A., SĘKARA, A., Joanna, G., Grabowska, A., CEBULA, S., 2013. Effect of Growing Period and Cultivar on the Yield and Biological Value of Brassica rapa var. narinosa. Not. Bot. Horti Agrobot. Cluj-Napoca 41, 546–552.

Kamel, S.M., Afifi, M.M., El-shoraky, F.S., El-Sawy, M.M., 2014. Fulvic acid: a tool for controlling powdery and downy mildews in cucumber plants. Int. J. Phytopathol. 3, 101–108.

Kumar, H.D., Aloke, P., 2020. Role of biostimulant formulations in crop production: An overview. Int J Appl Res Vet M 8, 38–46.

Ma, X., Geiser-Lee, J., Deng, Y., Kolmakov, A., 2010. Interactions between engineered nanoparticles (ENPs) and plants: phytotoxicity, uptake and accumulation. Sci. Total Environ. 408, 3053–3061.

Merghany, M., Shahein, M., Sliem, M.A., Abdelgawad, K., Radwan, A.F., 2019. Effect of nano-fertilizers on cucumber plant growth, fruit yield and it's quality. Plant Arch. 19, 165–172.

Moniruzzaman, M., 2011. Effect of plant spacings on the performance of hybrid cabbage (Brassica oleracea var. capitata) varieties. Bangladesh J. Agric. Res. 36, 495–506.

Naderi, M., Danesh-Shahraki, A., 2013. Nanofertilizers and their roles in sustainable agriculture. Int. J. Agric. Crop Sci. IJACS 5, 2229–2232.

Olaniyi, J., Akanbi, W., Adejumo, T., Ak, O., 2010. Growth, fruit yield and nutritional quality of tomato varieties. Afr. J. Food Sci. 4, 398–402.

Olaniyi, J., Ojetayo, A., 2011. Effect of fertilizer types on the growth and yield of two cabbage varieties. J. Anim. Plant Sci. 12, 1573–1582.

Pokluda, R., 2008. Nutritional quality of Chinese cabbage from integrated culture. Hortic. Sci. 35, 145–150.

SAS Institute, Inc (2007). Statistical analysis system. SAS institute Inc., Cary, NC. USA.

Sarkar, D., Rakshit, A., 2017. Red cabbage as potential functional food in the present perspective. Int. J. Bioresour. Sci. 4, 7–8.

Shafeek, M., Ali, A.H., Mahmoud, A.R., Helmy, Y., Omar, N.M., 2018. Effects of Foliar Application of Amino acid and bio fertilizer on growth and yield of onion plant under newly reclaimed land conditions. Sciences 8, 1197–1206.

Shehata, S., Hassan, H., Tawfik, A., Farag, M.F., 2016. Improving the productivity and quality of the cucumber crop grown under greenhouse conditions using some stimulants and spraying amino acids. J. Plant Prod. 7, 385–392.

Voća, S., Šic Žlabur, J., Dobričević, N., Benko, B., Pliestić, S., Filipović, M., Galić, A., 2018. Bioactive compounds, pigment content and antioxidant capacity of selected cabbage cultivars. J. Cent. Eur. Agric. 19, 593–606.

Wang, D., Deng, X., Wang, B., Zhang, N., Zhu, C., Jiao, Z., Li, R., Shen, Q., 2019. Effects of foliar application of amino acid liquid fertilizers, with or without Bacillus amyloliquefaciens SQR9, on cowpea yield and leaf microbiota. PLoS One 14, e0222048.