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EFFECT OF SOLID AND LIQUID ORGANIC FERTILIZER AND SPRAY WITH HUMIC ACID AND NUTRIENT UPTAKE OF NITROGEN, PHOSPHORUS AND POTASSIUM ON GROWTH, YIELD OF CAULIFLOWER

Yousif A. Mahmood[1], Firas W. Ahmed*, Sinan Samir Juma[2] and Ahmed A.A. Al-Arazah[1]

[1]Soil sciences and water resources Department, College of Agricultural engineering sciences, University of Baghdad

[2]Combating Desertification Department, College of Agricultural engineering sciences, University of Baghdad

Abstract

A field experiment was conducted to study the effect of different levels of solid, liquid organic fertilizer and spray with humic acid and their interaction on growth, yield of cauliflower and nutrient uptake of nitrogen, phosphorus and potassium in the field of agricultural engineering sciences university of Baghdad for autumn season 2015 in Silty Loam texture soil classified to sub under great group Typic-Torriflovent. A randomized complete block design RCBD was used with three replicates including three levels of organic fertilizers (0, 15 and 30) $Mg.ha^{-1}$, and two levels of liquid humic acid (0, 10) $ml.L^{-1}$ add after 30 days of the transplantation, and three levels of foliar application of humic acid 0, 5 and 10 $ml.L^{-1}$ on plant after 40, 50 and 60 days after transplantation. Results showed significant effect of adding of solid and liquid organic fertilizer and spray with humic acid on plants and their interactions in the dry weight of the plant, weight yield, chlorophyll content and nutrient uptake of nitrogen, phosphorus and potassium absorbed in leaves. However, the highest plant yield was at 30 $Mg.ha^{-1}$ of organic fertilizers and liquid humic acid 10 $ml.L^{1}$ and sprayed 10 $ml.L^{-1}$ of humic acid reached 2490 $g.Plants^{-1}$ with an increase of 192.94% compared to control treatment. And the interactions treatment gave higher of nitrogen, phosphorus and potassium uptake reached 259 kg $N.ha^{-1}$, 69kg $P.ha^{-1}$ and 243 kg $K.ha^{-1}$ with an increase of 125.21%, 146.42 % and 73.57 % respectively.

Keyword: Solid organic; Liquid organic; Humic acid; nutrient uptake; Cauliflower.

Introduction

Most Iraqi soils suffer from a decrease in their organic matter content, which does is about 0.5-1.5 %, due to the low rainfall of 150 mm per year and high temperatures of 45-50^{o}C in the summer, in addition to the increase of carbonates in most of these soils. Several studies have confirmed the importance of using organic fertilizers to reduce the use of chemical fertilizers and improve the chemical, physical and fertility properties of soil, increase the availability of many nutrients and increase their productivity by increasing soil organic matter (Hanafy *et al*., 2002, Hassanein and Kandil, 2004).

The addition of organic fertilizer to the soil led to higher efficiency of nutrient utilization. Mader *et al*., 2003 found that the addition of organic fertilizer to soil has increased nitrogen, phosphorus, potassium, activity of microorganisms, soil physical and chemical properties and the absorption of elements by the plant. Tajalden *et al*., 2014 found that the addition of organic fertilizer to the soil led to increased content of nitrogen, phosphorus and potassium of the plant Cauliflower.

Humic acid is one of the forms of organic matter, which is the final product of organic matter. Studies have shown that humic acid increases the permeability of cellular membranes and enhances nutrient uptake. It also improves the absorption of nitrogen, phosphorus, potassium, calcium and magnesium and makes it available to the root system of the plant and increases production and quality (Pascual *et al*., 1999; Kaya *et al*., 2005).

Cauliflower (*Brassica oleracea* L.) is one of the most important winter vegetable crops with a relatively high economic yield, belonging to the family Cruciferae. It is cultivated in most of the country's governorates. It is contains 91.7% water, 4.9 g carbohydrate, 2.4 g protein,78 mg ascorbic acid, 25 mg of calcium, 56 mg phosphorus and some important vitamins and minerals such as iron, calcium and others (Hassan,1994). The Statistics of the Central Statistical Organization for 2008 and 2010, which is one of the latest available statistics, indicate a decrease in cropland crops in Iraq from 2360 ha for 2008 to 1770 ha in 2010 but the decline in the cultivated area was accompanied by an increase in the rate of productivity per hectare reached 52.28 $Mg.ha^{-1}$ to 58.28 $Mg.ha^{-1}$ last for the same years, while the average global production of crop cauliflowers reached 71.60 $Mg.ha^{-1}$.

Materials and Methods

A field experiment was conducted in one of the fields of Agricultural Engineering Sciences / University of Baghdad for season 2015-2016 in Silty Loam texture soil classified according to (Soil Survey staff, 2006).. The experiment was designed under a randomized complete block design RCBD with three replicates to study the effect of solid and liquid organic fertilizer and spray with humic acid and their interaction on growth, yield of cauliflower and nutrient uptake of nitrogen, phosphorus and potassium. Random soil samples were collected from the surface layer of 0-30 cm from different locations of the field to measuring some physical and chemical properties before transplantation (Table 1).

Field was prepared by tilling, Experimental includes four rows (3m length and 3m width and 1m separation between each experimental unit) and 2m between block, Cauliflower transplantation at 20/10/2015 on one side of the row, and planted with the spacing of 40 cm on each plot having 4 rows with 7 plants per row with 28 plants per experimental unit.

Solid organic fertilizer (sheep manure) were added at three levels 0,15,30 Mg.ha^{-1} symbolized as (O_0, O_1, O_2) respectively, residues properties are shown in table 2, after 10 days of transplantation, and two levels of liquid humic acid 0, 10 ml.L^{-1} symbolized as (M_0, M_1) respectively add to soil after 30 days of the transplantation, and three levels of foliar application of humic acid 0, 5 and 10 ml.L^{-1} water on plant symbolized as (H_0, H_1, H_2), respectively, after 40, 50 and 60 days after transplantation.

Nitrogen was added at 250 kg N.ha^{-1} using urea fertilizer 46% N, phosphorus was added at 120 kg P.ha^{-1} using superphosphate fertilizer 21% P, Potassium was added at 120 kg K.ha^{-1} using potassium sulphate fertilizer 41.5% K in two batches.

Table 1 : Chemical and physical properties of soil before planting

Textural class	pH (1:1)	ECe ds.m^{-1}	$CaCO_3$ %	O.M %	CEC c mol.c.kg^{-1}	Available (PPM)		
						N	P	K
Silty Loam	7.66	2.3	16.8	1.22	15	37	14	170

Table 2 : Characteristics of the Solid organic fertilizer

Properties	Value
pH	**7.1**
EC (ds.m^{-1})	**3.2**
O.M %	**66**
N %	**2.3**
P %	**0.82**
K %	**1.8**
C/N Ratio	**17**
Moisture ratio**%**	**30**
Ca %	**2.10**
Mg %	**0.82**
Na %	**0.50**
Fe (PPM)	**150**
Mn (PPM)	**400**
Zn (PPM)	**200**
Cu (PPM)	**100**

Table 3 : Characteristics of humic acid

Properties	Value
(Humic Acid + Fulvic Acid)%	**25**
N %	**3**
K %	**4**
O.M %	**40**
pH	**6**
Fulvic acid	**15**

Results and Discussion

Dry weight (leaves + stems) (g.plant^{-1})

Results in table 4 showed the significant effect of adding of solid organic fertilizer in dry weight, the application of organic fertilizer O_2 has recorded the highest dry weight at 172.7 g.Plants^{-1} with an increase of 31.83 % compared to control treatment O_0. The results of the same table indicate a significant increase in the dry weight due to the addition of liquid organic fertilizer to the soil, the treatment M_1 has recorded the highest dry weight at 158.0 g.Plants^{-1} with an increase of 9.63% compared to the treatment M_0, that could be related to the positive effect of solid and liquid organic fertilizer (Table 2, 3) as it improves the soil chemical and physical properties by improving the soil structure and improving soil pH, which is positively reflected on microorganisms in soil, in addition, organic fertilizer adds many nutrients to the soil and make them ready for absorption, these elements play an important role as they are involved in many physiological and biological processes related to the process of photosynthesis and food processing in the plant, as well as stimulate cell division and elongation, which is positively reflected in increased vegetative growth (Mader *et al*., 2003; Uzun *et al*., 2007).

The results of the same table indicate a significant increase in dry weight due to spraying of humic acid, the highest dry weight recorded in the treatment H_2 at 163.0 g.Plant^{-1} in an increase of 17.51 % compared to the treatment H_0, this increase could be related due to its role in increasing the growth parameters which will increase the absorption of plant nutrients, the efficiency of carbonation, the accumulated materials in the plant and chlorophyll content, this results are consistent with Rezazadeh *et al*., 2012; AL-Jumally and Jamilay, 2012 and Taj al-Deen *et al*., 2017.

There was a significant effect of the interaction between solid organic, liquid organic fertilizer and spraying with humic acid, the highest dry weight was recorded at 192.0 g.Plants^{-1} in the treatment $O_2M_1H_2$ with an increase of 69.91% compared to the control treatment $O_0M_0H_0$, due to the positive role of organic and liquid fertilizer by interfering with the spraying of humic acid in increasing the readiness of many nutrients in the soil and absorption by the plant, which has an effect in increasing the dry weight, these results agreed to Al-Bahranni, 2015.

Weight Yield

Results in table 5 showed the significant effect of adding of solid organic fertilizer in weight yield, the application of organic fertilizer O_2 has recorded the highest yield at 2044.6 g.Plants^{-1} with an increase of 73.89 % compared to control treatment O_0 without organic fertilization. The results of the same table indicate a significant increase in the yield due to the addition of liquid organic fertilizer to the soil, the treatment M_1 has recorded the highest yield at 1706.9 g.Plants^{-1} with an increase of 14.19 % compared to the treatment M_0, this may be due to the activity of microorganisms in organic fertilizer on the production of CO_2, which is the acid H_2CO_3 when dissolved in water decreases the pH of soil and increase the readiness of most elements to the plant, which was reflected in the improvement of vegetative growth and yield, the results agree with (Tajalden *et al*., 2014 , Mahmood and Al-Ziadi , 2011).

The results of the same table indicate a significant increase in the yield due to spraying of humic acid, the highest yield recorded in the treatment H_2 at 1825.0 g.Plant^{-1} in an increase of 36.74 % compared to the treatment H_0, the reason is that organic fertilizers lead to increased chlorophyll content, which increases the output of carbonate photosynthesis, carbohydrates and proteins and then increase the fresh weight yield, as well as the role of humic acid in increasing the permeability of the cellular membranes, thus facilitating and increasing the nutrient input speed, this effect is related to the function of the active groups of hydroxyl and carboxylic (Al-Zuhairy and Al-Hamdani, 2017).

There was a significant effect of the interaction between solid organic, liquid organic fertilizer and spraying with humic acid, the highest yield was recorded in the treatment $O_2M_1H_2$ at 2490.0 g.Plants^{-1} with an increase of 192.24 % compared to the control treatment $O_0M_0H_0$.

Chlorophyll Content

The results in table 6 showed the significant effect of adding of solid organic fertilizer in chlorophyll content, the application of organic fertilizer O_2 has recorded the highest chlorophyll content at 75.7 spad with an increase of 23.08 % compared to control treatment O_0 without organic fertilization. The results of the same table indicate a significant increase in chlorophyll content due to the addition of liquid organic fertilizer to the soil, the treatment M_1 has recorded the highest chlorophyll content at 71.8 spad with an increase of 5.74 % compared to the treatment M_0, this is due to the role of organic fertilization in improving soil physical and chemical properties because it contains a humic substance that may be nutritious to the plant and make the soil more fertile and increase the soil retention in water, thus increasing the plant content of the nutrients, especially nitrogen and magnesium that enter in chlorophyll (Abdl-rahman and Ramathan, 2015, AL-Hamdany and Hadie, 2017).

Results of the same table indicate a significant increase in chlorophyll content due to spraying of humic acid, the highest chlorophyll content recorded in the treatment H_2 at 74.0 spad in an increase of 12.63 % compared to the H_0, this may be due to the role of available nitrogen in the humic acid in the building of amino acids that stimulate the plant to produce oxydants that promote the process of cell division and elongation of cells, in addition the nitrogen absorbed through the vegetative provided the raw materials for the synthesis of the color of chlorophyll such as Polphyrins which increased the content of chlorophyll in the leaves, these results are consistent with Alali and Abdul Majid, 2013.

There was a significant effect of the interaction between solid organic, liquid organic fertilizer and spraying with humic acid, the highest chlorophyll content was recorded at 83.0 spad in the treatment $O_2M_1H_2$ with an increase of 50.90 % compared to the control treatment $O_0M_0H_0$.

Nitrogen Uptake

The results in table 7 showed the significant effect of adding of solid organic fertilizer in nitrogen uptake, the application of organic fertilizer O_2 has recorded the highest nitrogen uptake at 240.50 kg N.ha^{-1} with an increase of 77.93 % compared to control treatment O_0 without organic fertilization. The results of the same table indicate a significant increase in nitrogen uptake due to the addition of liquid organic fertilizer to the soil, the treatment M_1 has recorded the highest nitrogen uptake at 195.66 kg N.ha^{-1} with an increase of 9.38 % compared to the treatment M_0, this is due to the release of nitrogen from organic fertilizer and the low C/N ratio of organic matter and their containment of easily degradable compounds by microorganisms, resulting in increased soil availability and uptake by the plant (Saleh *et al*., 2003; Al-Salmani, 2005 and Al-Ziaidi, 2011).

Results of the same table indicate a significant increase in nitrogen uptake due to spraying of humic acid, the highest nitrogen uptake recorded in the treatment H_2 at 197.00 kg N.ha^{-1} in an increase of 11.40 % compared to the treatment H_0, the increase in nitrogen uptake in the leaves is due to the presence of many nutrients in the humic acid, including nitrogen and its direct absorption by the plant, as well as the role of the humic acid in the increase of the biological events, which leads to increased vegetative growth, this means increasing the plant's need for nutrients to achieve the state of nutritional balance, their absorption is increased from the soil and its concentration in the plant increases (Alali and Abdul Majid, 2013).

There was a significant effect of the interaction between solid organic, liquid organic fertilizer and spraying with humic acid, the highest nitrogen uptake was recorded at 259.00 kg N.ha^{-1} in the treatment $O_2M_1H_2$ with an increase of 125.21 % compared to the control treatment $O_0M_0H_0$.

Phosphorus Uptake

The results in table 8 showed the significant effect of adding of solid organic fertilizer in phosphorus uptake, the application of organic fertilizer O_2 has recorded the highest phosphorus uptake at 58.00 kg P.ha^{-1} with an increase of 56.75% compared to control treatment O_0 without organic fertilization. The results of the same table indicate a significant increase in phosphorus uptake due to the addition of liquid organic fertilizer to the soil, the treatment M_1 has recorded the highest nitrogen uptake at 49.89 kg P.ha^{-1} with an increase of 15.11 % compared to the treatment M_0, this increase may be due to the organic fertilizer content of phosphorus (Table 2), in addition, organic fertilizer decomposition produces carbonic acid with many organic acids that reduce soil pH, which dissolves some phosphorus compounds and releases them into soil solution and its

absorption by the plant, as well as the packaging of these compounds to the clay molluscs as well as their behavior which reduces the sedimentation reactions of phosphorus (Havlin *et al*., 2005; Tajalden *et al*., 2014, Naser and Ahmad, 2015).

The results of the same table indicate a significant increase in phosphorus uptake due to spraying of humic acid, the highest phosphorus uptake recorded in the treatment H_2 at 52.16 kg P.ha^{-1} in an increase of 29.88 % compared to the treatment H_0, this is due to the fact that the spraying of humic acid on the plants led to increase the growth of the plant and the activation of many of the biological processes and the subsequent increase in the absorption of phosphorus by the roots, as the acid molecule can enter the nutrient stream in the cell and make the membranes more permeable which allows for increased nutrient input and cell division, this effect is linked to the function of the hydroxyl and carboxylic active groups in humic acids, the results are consistent with Jones *et al*., 2007 and Al-Jumaily, 2016.

There was a significant effect of the interaction between solid organic, liquid organic fertilizer and spraying with humic acid, the highest phosphorus uptake was recorded at 69.00 kg P.ha^{-1} in the treatment $O_2M_1H_2$ with an increase of 146.42 % compared to the control treatment $O_0M_0H_0$.

Potassium Uptake

Results in table 9 showed the significant effect of adding of solid organic fertilizer in potassium uptake, the application of organic fertilizer O_2 has recorded the highest potassium uptake at 227.83 kg K.ha^{-1} with an increase of 37.94 % compared to control treatment O_0, and the results of the same table indicate a significant increase in potassium uptake due to the addition of liquid organic fertilizer to the soil, the treatment M_1 has recorded the highest potassium uptake at 203.88 kg K.ha^{-1} with an increase of 7.62 % compared to the treatment M_0, this may be due to the fact that organic fertilizer contributes to the dissolution of some potassium containing minerals through the formation of organic acids such as humic and fulvic acid which contribute to the release of potassium ions from these minerals to the soil solution and increase the uptake of potassium in soil, as well as the low C/N ratio of organic fertilizer added to the soil, which increases their ability to process this nutrient and thus increase its uptake by the plant (Havlin *et al*., 2005; Naser and Ahmed, 2015).

The results of the same table indicate a significant increase in potassium uptake due to spraying of humic acid, the highest potassium uptake recorded in the treatment H_2 at 206.00 kg K.ha^{-1} in an increase of 11.65 % compared to the treatment H_0, this is due to the fact that humic acid increases the absorption of some major elements, including potassium (Katkat *et al*., 2009).

There was a significant effect of the interaction between solid organic, liquid organic fertilizer and spraying with humic acid, the highest potassium uptake was recorded at 243.00 kg K.ha^{-1} in the treatment $O_2M_1H_2$ with an increase of 73.57 % compared to the control treatment $O_0M_0H_0$.

Table 4 : Effect of solid, liquid organic fertilizers and spray with humic acid in the dry weight (leaves + stems) (g. Plants^{-1})

Solid organic fertilizer Mg.ha^{-1}	liquid organic fertilizer ml.L^{-1}	Humic acid ml.L^{-1}			Mean
		H_0	H_1	H_2	O × M
O_0	M_0	**113.0**	**123.0**	**131.0**	122.0
	M_1	125.0	136.0	158.0	140.0
O_1	M_0	133.0	146.0	154.0	144.0
	M_1	143.0	155.0	166.0	155.0
O_2	M_0	151.0	169.0	177.0	166.0
	M_1	167.0	180.0	192.0	180.0
Mean		138.7	151.5	163.0	
L.S.D $_{(0.05)}$		**O**	**M**	**H**	**O×M×H**
		8.0	6.0	8.0	**16.0**

Table 5 : Effect of solid, liquid organic and spray with humic acid in fresh weight yield (g.Plants^{-1})

Solid organic fertilizer Mg.ha^{-1}	liquid organic fertilizer ml.L^{-1}	Humic acid ml.L^{-1}			Mean
		H_0	H_1	H_2	O × M
O_0	M_0	**850.0**	**1110.0**	**1215.0**	1058.3
	M_1	1040.0	1360.0	1480.0	1293.3
O_1	M_0	1220.0	1605.0	1700.0	1508.3
	M_1	1370.0	1733.0	1865.0	1656.0
O_2	M_0	1653.0	1900.0	2200.0	1917.6
	M_1	1875.0	2150.0	2490.0	2171.6
Mean		1334.6	1643.0	1825.0	
L.S.D $_{(0.05)}$		**O**	**M**	**H**	**O×M×H**
		30.0	26.0	30.0	**76.0**

Table 6 : Effect of solid, liquid organic and spray with humic acid in Chlorophyll content (SPAD)

Solid organic fertilizer Mg.ha^{-1}	Liquid organic fertilizer ml.L^{-1}	Humic acid ml.L^{-1}			Mean
		H_0	H_1	H_2	O × M
O_0	M_0	**55.0**	**60.0**	**63.0**	59.0
	M_1	62.0	64.0	65.0	64.0
O_1	M_0	66.0	70.0	76.0	71.0
	M_1	70.0	75.0	78.0	74.0
O_2	M_0	68.0	74.0	79.0	74.0
	M_1	73.0	77.0	83.0	78.0
Mean		**65.7**	**70.0**	**74.0**	
L.S.D (0.05)		**O**	**M**	**H**	**O×M×H**
		3.0	2.0	3.0	6.0

Table 7 : Effect of solid, liquid organic and spray with humic acid in nitrogen uptake (kg N.ha^{-1})

Solid organic fertilizer Mg.ha^{-1}	liquid organic fertilizer ml.L^{-1}	Humic acid ml.L^{-1}			Mean
		H_0	H_1	H_2	O × M
O_0	M_0	**115.00**	**130.00**	**135.00**	126.70
	M_1	140.00	144.00	147.00	143.66
O_1	M_0	167.00	176.00	186.00	176.33
	M_1	182.00	197.00	209.00	196.00
O_2	M_0	222.00	233.00	246.00	233.67
	M_1	235.00	248.00	259.00	247.32
Mean		**176.83**	**188.00**	**197.00**	
L.S.D (0.05)		**O**	**M**	**H**	**O×M×H**
		8.00	9.00	8.00	**12.00**

Table 8 : Effect of solid, liquid organic and spray with humic acid in phosphorus uptake (kg P.ha^{-1})

Solid organic fertilizer Mg.ha^{-1}	Liquid organic fertilizer ml.L^{-1}	Humic acid ml.L^{-1}			Mean
		H_0	H_1	H_2	O × M
O_0	M_0	**28.00**	**35.00**	**38.00**	33.67
	M_1	35.00	41.00	45.00	40.34
O_1	M_0	31.00	46.00	48.00	41.65
	M_1	43.00	48.00	53.00	48.00
O_2	M_0	49.00	55.00	60.00	54.68
	M_1	55.00	60.00	69.00	61.33
Mean		**40.16**	**47.50**	**52.16**	
L.S.D (0.05)		**O**	**M**	**H**	**O×M×H**
		2.00	3.00	3.00	**6.00**

Table 9 : Effect of solid, liquid organic and spray with humic acid in Potassium uptake (kg K.ha^{-1})

Solid organic fertilizer Mg.ha^{-1}	Liquid organic fertilizer ml.L^{-1}	Humic acid ml.L^{-1}			Mean
		H_0	H_1	H_2	O × M
O_0	M_0	**140.00**	**166.00**	**170.00**	158.64
	M_1	161.00	174.00	180.00	171.67
O_1	M_0	177.00	193.00	197.00	189.00
	M_1	193.00	207.00	215.00	205.01
O_2	M_0	209.00	222.00	231.00	220.63
	M_1	227.00	235.00	243.00	235.02
Mean		**184.51**	**199.52**	**206.00**	
L.S.D (0.05)		**O**	**M**	**H**	**O×M×H**
		3.00	4.00	4.00	**12.00**

Conclusion

Results of this research revealed that solid, liquid organic fertilizer and spray with humic acid and their interaction significantly increased in the dry weight of the plant, fresh weight yield, chlorophyll content and nutrient uptake of nitrogen, phosphorus and potassium absorbed in leaves of cauliflower, in conclusion, we can improve the yield of corn by application of organic fertilizers and humic acid.

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