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QUANTITATIVE AND QUALITATIVE EFFECTS OF SOME INORGANIC AND ORGANIC FERTILIZERS ON MAIZE (ZEA MAYSL.) UNDER ALLUVIAL SOIL

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ABSTRACT: Two field experiments were conducted at the Experimental Farm of Tag El- Ezz , Dakahlia governorate (30° 59\\ N latitude, E 31° 58\\ longitude) ,ARC, Egypt during the two growing summer seasons of 2020 and 2021 as sake of studying the possibility of partially substituting for the amount of inorganic NPK fertilizers required for maize plants using compost and/or vermicompost and their effects on growth, yield and nutrients uptake of maize plants (Single cross 10 variety) under the alluvial soil conditions. Experiments were laid out in split plot design with three replicates. However, main plots were affected for four rates of inorganic NPK fertilizers i.e.; without, 50%, 75% and 100% of the recommended dose (RD)) whereas, four organic fertilizers namely without, compost (C); (5 ton fed-1), vermicompost (VC); (0.5 ton fed-1) as well as half compost and half vermicompost (mix)) were randomly distributed in the sub plots. Results showed that:

1- **Application of inorganic NPK fertilizers at 100% RD recorded the highest values of growth parameters, yield and nutrients uptake by maize grains in the two investigated seasons**
2- **Using organic fertilizers i.e. compost and /or vermicompost caused a significant effect on all growth parameters, yield and nutrients uptake. In this respect, V.C. attained the superiority impacts followed by mix and lately C compared with control (without adding NPK fertilizers).**
3- **The addition of inorganic NPK fertilizers at 100% RD and organic V.C. had positive impacts on maize growth parameters, yield and nutrients uptake better than the application of inorganic NPK fertilizers at 100% RD singly under the two investigated seasons.**
4- **Dual application of inorganic NPK fertilizers at 100% RD and organic C treatment application achieved the highest values of available NPK in the soil post harvesting.**
5- **Economically using inorganic NPK fertilizers at 75%RD and C recorded the highest net return and benefit cost ratio (BCR). So, it could be a good alternative to other treatments, save 25% of inorganic NPK fertilizers and viable option for enhancing crop yield and farmers income.**

Key words: Inorganic, Organic, Compost, Vermicompost, Maize.

INTRODUCTION

Maize is one of the most important cereals in the world and the third one after wheat and rice (FAO, 2009). It is considered as a staple food for humans in the most developing countries especially Africa, also it used as an animal feed and a low price raw material for several industrial processes. (Adetiminrin et al., 2008). Increasing the national production of maize is one of the most important agricultural goals in Egypt to face the human and animal needs. Soil fertility is an important for achieving high crop yields over a period

of time. Fertilizer applications have usually been the major means of supplying plant nutrients (Fageria and Baligar, 2005).

The chemical (inorganic) fertilizers contain nitrogen, phosphorus and potassium in forms readily utilized by plants. Nitrogen is a major nutrient that responsible for protoplasm synthesis, rapid cell division and important for plant growth and yield production where it is a constituent of amino acids, nucleic acids and enzymes (Singh *et al*., 2003).

Phosphorous has a vital role in several physiological processes within plant such as releasing energy during cellular, photosynthesis, respiration and several other processes in living plants (Rai, 2006).

Potassium adjust osmotic potential and water uptake. Moreover, it has a responsible role in activating most of enzyme systems that regulate photosynthesis, water use efficiency, movement nitrogen uptake and protein production (Singh *et al*., 2003).

Excessive use of inorganic fertilizers has adverse effects in the soil i.e. soil physical degradation, imbalance of soil nutrient and declining soil fertility as well as food quality (Makinde and Ayoola, 2010). Alternate fertilizers were used such as organic fertilizers that more safety on healthy of human and have a positive effects on soil properties such as improving soil structure and increasing water-holding capacity of the soil (Edwards *et al.,* 2004).

Compost is a biologically decomposed organic material by thermophilic and mesophilic microorganisms (Bastida *et al*., 2010). Compost positively impact on improving soil properties, increasing soil organic matter, enhancing microbial activities and improving soil structure. (Gao *et al.,* 2010).

Vermicomposts are organic materials broken down in a mesophilic process by earthworms. Earthworms transform inorganic nutrients to forms more available, also provide organic material with auxins, cytokinins and gibberellins via their secretions and finally produced fully stabilized organic soil amendments with low C: N ratios (Ramasamy and Kathirvelu, 2011).

Vermicompost application improves the soil fertility, adjust the soil temperature and increases the availability of nutrients required by plants (Dignac *et al*., 2017).

Using inorganic and organic fertilizers simultaneously increased yield and crop productivity as well as improved soil properties. Yet, combination of organic fertilizers and inorganic ones increase maize yield via increasing soil productivity and raising the efficiency of the used fertilizer. (Abd El-Gawad and Morsy, 2017).

So, the present investigation aimed to raising the efficiency of the adding mineral fertilizers and saving their amounts required for maize plants via partial substituting by some organic fertilizers (compost and vermicompost) and integrated impacts of their combinations on growth, yield and nutritive contents of maize. Available nutrients in the soils after harvesting were also taken into consideration.

MATERIALS AND METHODS

Locations of study

The present study was established at Tag El-Ezz agricultural research station, Dakahlia governorate (30° 59\\ N latitude, E 31° 58\\ longitude), ARC; Egypt during the two summer seasons of 2020 and 2021 to study the impact of partially substituting the amount of integrated inorganic NPK fertilizers required for maize using compost, vermicompost and

mix of them on growth, yield and nutrients uptake of maize plants under alluvial soil conditions.

Each plot area was 19.2 m^2 included four rows 6.00 m long and 0.80 m apart between rows. The maize grains variety single cross 10 (SC10) were sown at a rate of 10 $kgfed^{-1}$ on 7th and 1st June on summer seasons of 2020 and 2021 respectively. The experiment was irrigated six times, the first one at 21 days after sowing and the others were every 15 days. The plants were thinned to one plant/ hill before the first irrigation.

Nitrogen fertilizer as urea (46.5 % N), was added in three equal doses before first, second and third irrigations. Potassium was added as potassium sulphate (48% K_2O) in one dose (after 45 days from sowing). Super phosphate (15% P_2O_5) was added to all plots as a single dose and well mixed with such surface layer. Compost and vermicompost were thoroughly mixed with 0-30 cm soil surface layer two weeks before sowing.

Soil samples from 0-30 cm soil surface layer were randomly collected before planting. Soil physical and chemical characteristics as well as nutrients status of the experimental sites were determined according to Page *et al*., (1982) and Klute (1986) as shown in Table (1). Samples from compost and vermicompost were analyzed according to methods described by Cottenie (1982) as shown in Table (2).

Table (1): Soil physical and chemical analyses under the two investigated seasons

Soil Characteristics		
I. Physical properties:	**1st season**	**2nd seasons**
Particle size distribution		
Sand	**19.31**	**19.33**
Silt	**37.92**	**38.02**
Clay	**42.77**	**42.65**
Soil Texture Class	**Clay**	**Clay**
II. Chemical properties:		
pH, [1:2.5 soil water suspension] *	**8.00**	**8.02**
EC, [soil extract, dS m^{-1}] **	**4.31**	**4.30**
Soluble cations, meq 100 g^{-1} soil)		
Ca^{2+}	**8.58**	**8.60**
Mg^{2+}	**7.30**	**7.28**
Na^{+}	**23.09**	**23.12**
K^{+}	**4.10**	**4.00**
Soluble anions, meq 100 g^{-1} soil)		
CO32-	**-**	**-**
HCO3-	**1.98**	**2.00**
Cl-	**19.61**	**19.50**
SO42-	**21.48**	**21.50**
III. Nutritional properties, mg kg^{-1}:		
N	**47.62**	**52.12**
P	**9.15**	**9.92**
K,	**200.25**	**204.38**

Table 2. Physical and chemical analyses of the used vermicompost (VC) and compost (C).

Properties	Vermicompost (VC)	Compost (C)
pH, 1:10	7.52	6.42
EC, (1:10), dS m^{-1}	2.70	3.75
O.M%	33.64	33.00
Organic carbon%	35.64	18.02
Total N%	2.35	1.42
C/N ratio	15.16	12.73
Total P%	2.14	0.44
Total K%	1.33	0.76
Fe mg kg^{-1}	61.42	64.25
Mn mg kg^{-1}	26.08	26.34

Experiment description:

Each experiment included the impact of sixteen treatments resulting from the combinations of four inorganic NPK fertilizers levels (without, 50, 75 and 100% of the recommended dose (RD) , 120 Kg N, 200Kg P_2O_5 and 50 Kg K_2O. fed^{-1}) as the main plots and four types of organic fertilizers (without, compost (C); (5 ton fed^{-1}), vermicompost (VC); (0.5 ton fed^{-1}) and half amount of compost+ half amount of vermicompost (mix)) as the sub plots on maize (Zea mays L.) var. SC10 plants growth, yield and nutrients uptake as well as available nutrients in the soil after maize harvesting. So, the experimental design was a split- plot in three replications.

Data recorded

1- Growth Stage measurements:

Plant samples were collected from each sub plot at maximum vegetative growth stage for measurement of some growth parameters (shoot height (cm), plant fresh weight (g $plant^{-1}$) and plant dry weight (g $plant^{-1}$)). Chlorophyll a and chlorophyll b (mg g^{-1} fresh weight of leaf) were also determined using a method described by Nayek *et al*., (2014). Total N, P and K concentration were determined according to the methods described by Buresh (1982) and Chapman and Pratt (1961), respectively.

2-Harvest stage measurements:

At harvest, the following characters, Plant height (cm) , ear length (cm), ear diameter (cm), ear weight (g), 100 kernel weight (g) and grain yield (ton fed^{-1}) were recorded at randomly ten guarded plants from each plot. The yielded seeds were cleaned, crushed and digested to determine total N, P and K percentages. Nutrients uptake was determined according to the following formula:

$$\text{Nutrients uptake } kg\ fed-1 = \frac{Nutrient\ concentration \times seed\ yield\ (kg\ fed-1)}{100}$$

3- Residual nutrients in soil:

Surface soil samples (0-30 cm) from each sub plot were collected after harvesting to determine the available N, P and K (mg kg^{-1}).

Economics

Total cost of cultivation and gross return were calculated on the basis of

prevailing market rates for different practices and produces. The total cost of cultivation per feddan was subtracted from the gross income for computing net return from each treatment.

Net return (£. fed^{-1}) = Gross return (£. fed^{-1}) - Cost of cultivation (£. fed^{-1})

Benefit cost ratio (BCR) was calculated treatment wise as below.

$$\text{Benefit Cost Ratio (BCR)} = \frac{\text{Gross return}}{\text{Cost of cultivation}}$$

Statistical analysis

All data were subjected to statistical analysis according to Snedecor and Cochran (1980) and the means were compared using least significant difference at 5% level. Appropriate analyses of variance were performed for the two experiments according to Steel and Torrie (1984).

RESULTS AND DISCUSSION

1- Integrated effect of inorganic and organic fertilizers on some plant growth measurements.

Data tabulated in Table 3 show that maize vegetative growth parameters as: shoot height (Cm); fresh weight (g plant^{-1}) and dry weight (g plant^{-1}) were significantly affected by all applied treatments during the two successive seasons.

It's clear that using inorganic NPK fertilizers at 100% RD gave the highest values of all previous studied parameters where the values were (256.77, 259.86) for shoot height, (203.35, 206.62) for fresh weight and (42.72, 49.85) for dry weight of maize plants comparing with the control (no addition) . These results are in matching with those found by (Khan *et al.,* 2011).

These results may be due to the positive impact of NPK nutrients on plant growth where they increase internodes numbers and length that increase shoot length as well as their role in promoting meristematic activities in plant (Hafez and Abdelaal, 2015).

Organic fertilizers sources enhancing values of shoot height, fresh weight and dry weight comparing with control treatment application. In this concern organic V.C. treatment recorded the highest values of shoot height (226.80, 230.78); fresh weight (174.12, 176.80) and dry weight (36.15, 41.61) comparing with other organic fertilizer sources in the two seasons, respectively. These results may be attributed to the enrichment of V.C. with organic matter which supply plant with essential nutrients for growth in available forms (Atiyeh *et al.*, 2002).

Sinha *et al*., (2010) also found that V.C. application enhances maize growth from 50 to 100% over compost and 30 to 40% over inorganic fertilizers.

Its clear that, addition of inorganic NPK at 75% or 100% in combination with either organic compost or vermicompost gave values higher than that recorded by inorganic NPK at 100%RD singly. Addition of inorganic NPK fertilizers at 100 % RD and organic V.C. recorded the highest values of maize shoot height by (268.20, 272.33), fresh weight by (218.45, 222.37) and dry weight by (47.30, 55.66) in the two investigated seasons comparing with those attained when application of NPK fertilizers at 100% RD singly.

These increments may be due to the fact that organic and inorganic fertilizers enhance plant growth, increase length and internode numbers that increase plant height (Laekmariam and Gidago, 2012). Yet, vermicomposts have vital roles in enhancing soils quality via increasing microbial activity and microbial biomass that are key components in nutrient cycling and plant growth regulators production. These results are in matching with that concluded by Adamu *et al.,* (2015).

Table 3. Integrated effect of inorganic and organic fertilizers on vegetative growth parameters of maize plants in the two successive seasons.

Treatments		(cm)		g plant $^{-1}$			
		Shoot height		Fresh weight		Dry weight	
		1st	2nd	1st	2nd	1st	2nd
Main : inorganic fertilizer rates							
0		155.07	158.56	108.55	110.03	21.22	22.63
50		205.16	208.97	154.18	156.73	30.82	33.34
75		243.74	246.40	183.47	185.36	36.96	43.04
100		256.77	259.86	203.35	206.62	42.72	49.85
F test		***	***	***	***	***	***
LSD at 0.05%		1.82	0.499	0.119	0.286	0.321	0.180
Sub main: organic fertilizer sources							
0		200.49	203.06	147.80	149.91	28.92	32.13
C		213.52	216.96	160.31	162.13	32.49	36.03
V.C		٢٢٦,٨٠	٢٣٠,٧٨	١٧٤,١٢	١٧٦,٨٠	٣٦,١٥	٤١,٦١
Mix		219.92	222.99	167.32	169.90	34.16	39.09
F test		***	***	***	***	***	***
LSD at 0.05%		1.33	0.942	0.0815	0.221	0.277	0.128
Interaction							
0 NPK	0	146.40	149.32	93.25	95.22	18.30	20.36
	C	152.33	156.26	103.52	102.14	19.87	18.65
	v.c	166.30	168.33	122.18	125.46	24.50	27.28
	Mix	155.26	160.33	115.27	117.33	22.24	24.28
50% NPK	0	186.26	188.14	145.33	146.28	27.92	27.92
	C	201.42	206.28	152.65	156.72	30.12	33.19
	v.c	220.24	226.15	163.50	165.22	33.74	37.22
	Mix	212.72	215.33	155.26	158.70	31.53	35.04
75% NPK	0	232.33	234.66	174.62	177.82	34.56	39.62
	C	242.70	244.50	180.46	182.56	36.48	42.12
	v.c	252.46	256.33	192.36	194.16	39.09	46.36
	Mix	247.50	250.12	186.44	186.92	37.74	44.08
100% NPK	0	237.00	240.13	178.00	180.33	34.92	40.62
	C	257.66	260.80	204.62	207.12	43.52	50.16
	v.c	268.20	272.33	218.45	222.37	47.30	55.66
	Mix	264.23	266.20	212.33	216.66	45.15	52.99
F test		***	***	***	***	**	***
LSD at 0.05%		2.66	1.88	0.163	0.442	0.554	0.256

2- Integrated effect of inorganic and organic fertilizers on leaves chlorophyll content.

Chlorophyll content of maize leaves i.e. chl. a, chl. b and chl. a+b values as affected by inorganic and organic fertilizers in the two successive summer seasons were shown in Table 4. Application of inorganic NPK fertilizers at 100% RD recorded the highest values of chl. a (0.275, 0.283); chl. b (0.100, 0.103) and chl. a+b (0.374, 0.386) in the two

investigated summer seasons of 2020 and 2021, respectively. These results are in agreement with those found by Hussain *et al.,* (2007).

Application of inorganic NPK fertilizers increase chlorophyll content where N fertilizer increases the availability of important nutrients as P, Ca and Mg for chlorophyll production (Khan *et al.,* 2011). Phosphorus has an effective role in chlorophyll synthesis and enhancement photosynthesis process in plant. In addition, potassium has important role in control stomotal guard cells of leaves and increasing photosynthesis (Hussain *et al*., 2007).

Table 4. Integrated effect of inorganic and organic fertilizers on chlorophyll content of maize leaves in the two successive seasons under investigation.

Treatments		Chlorophyll contents mg .g^{-1} FWt					
		Chl. A		Chl. B		Chl. a+b	
		1st	2nd	1st	2nd	1st	2nd
Main : inorganic fertilizer rates							
0		0.244	0.246	0.068	0.070	0.312	0.316
50		0.252	0.256	0.080	0.082	0.332	0.339
75		0.265	0.273	0.092	0.096	0..357	0.369
100		0.275	0.283	0.100	0.103	0.374	0.386
F test		***	***	***	***	***	***
LSD at 0.05%		0.004	0.004	0.002	0.004	0.004	0.003
Sub main: organic fertilizer sources							
0		0.251	0.257	0.078	0.081	0.329	0.339
C		0.257	0.263	0.084	0.086	0.342	0.349
V.C		0.264	0.271	0.090	0.093	0.355	0.365
Mix		0.262	0.267	0.087	0.090	0.349	0.357
F test		***	***	**	***	***	***
LSD at 0.05%		0.003	0.003	0.004	0.003	0.005	0.006
Interaction							
0 NPK	0	0.239	0.242	0.060	0.066	0.299	0.308
	C	0.242	0.244	0.068	0.070	0.310	0.314
	V.C	0.250	0.253	0.074	0.075	0.324	0.328
	Mix	0.247	0.246	0.070	0.070	0.317	0.316
50% NPK	0	0.245	0.250	0.076	0.078	0.321	0.328
	C	0.252	0.254	0.079	0.081	0.331	0.335
	V.C	0.258	0.263	0.084	0.086	0.342	0.349
	Mix	0.256	0.260	0.081	0.084	0.337	0.344
75% NPK	0	0.258	0.266	0.088	0.092	0.346	0.358
	C	0.263	0.270	0.090	0.094	0.353	0.364
	V.C	0.271	0.280	0.097	0.102	0.368	0.382
	Mix	0.268	0.277	0.094	0.098	0.362	0.375
100% NPK	0	0.265	0.280	0.088	0.090	0.353	0.362
	C	0.274	0.272	0.101	0.101	0.375	0.385
	V.C	0.280	0.290	0.107	0.112	0.387	0.402
	Mix	0.279	0.284	0.104	0.110	0.383	0.396
F test		**	**	**	**	**	**
LSD at 0.05%		0.009	0.007	0.009	0.008	0.010	0.012

Organic V.C. fertilizer application achieved the highest values of chlorophyll content comparing with other organic fertilizers treatments application where it recorded chl. (a+b) with values (0.355, 0.365), mix recorded values (0.349, 0.357) and C recorded values (0.342, 0.349) in the both tested seasons. Same results were found by Sigaye *et al.,* (2021).

Chlorophyll content values attained with vermicompost (V.C.) were higher than those recorded by compost (C.) where it contains macro and micronutrients more than those found in compost especially N which increases chlorophyll content and improves photosynthesis process (Sayfallah *et al*., 2015).

The combination of inorganic NPK fertilizers at 100% RD and organic V.C. fertilizer achieved the highest values of chl. a (0.280, 0.290), chl. b (0.107, 0.112) and chl. a+b (0.387, 0.402) in the two investigated successive seasons. Those results may be due to the positive effect of inorganic and organic fertilizers in supplying plants with nutrients which are responsible for chlorophyll production and promoting photosynthesis process (Abd El-Gawad and Morsy, 2017). Addition of inorganic NPK at 75% or 100% in combination with either organic compost or vermicompost gave values higher than that recorded by inorganic NPK at 100% RD.

3- Integrated effect of inorganic and organic fertilizers on yield and yield attributes.

Results recorded in Table 5 show influence of inorganic and organic fertilizers on grain yield (ton fed^{-1}) and some yield attributes such as plant height (cm); ear length (cm); ear diameter (cm); ear weight (g) and 100 kernel weight (g). All tested treatments had significant effects on grain yield and most of yield attributes of maize in the two seasons under investigation. Using inorganic NPK fertilizers at 100% RD gave the highest values of plant height (299.08, 302.91); ear length (20.10, 20.26); ear diameter (4.38, 4.25), ear weight (225.71, 229.29), 100 kernel weight (54.77, 58.22) and grain yield (3.32, 3.34) of maize in the two investigated seasons, respectively. The same result was found by El Fouly *et al.,* (2012). Increasing yield and yield attributes as the addition of inorganic NPK fertilizers may be due to the facts of their effective roles in increasing plant growth and enhancing plant photosynthesis. Moreover, K has a responsible role in activating some enzymes important for several physiological plant processes (Olowoboko *et al.,* 2017).

Organic fertilizers sources also positively affected on yield and yield attributes of maize in the two seasons. The highest values of plant height (270.49, 273.91); ear length (18.80, 19.01); ear diameter (4.22, 4.41); ear weight (201.11, 203.95); 100 kernel weight (47.24, 52.80) and grain yield (2.98, 3.01) in the two seasons, respectively were observed plants treated with organic V.C. fertilizers. The same findings were found by Deepak et al., (2018), Sifolo *et al.* (2019) and Jagwe *et al*. (2020) who concluded that the application of organic fertilizer improved soil fertility as well as the growth and yield characters. The increments recorded by organic fertilizers comparing with control were explained based on the effective roles of compost and vermicompost on improving soil properties and increasing availability of nutrients. Consequently, increasing plant growth, yield and yield attributes (Laekemariam and Gidago, 2012).

Table 5: Integrated effect of inorganic and organic fertilizers on yield and yield attributes of maize plant in the two successive seasons.

Treatments		(cm)				(g)				(ton fed^{-1})			
		Plant height		Ear length		Ear diameter		Ear weight		100 kernel weight		Grain yield	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Main: inorganic fertilizers rates													
0		195.08	200.91	16.03	16.49	3.79	4.04	151.15	153.49	30.69	31.73	2.05	2.09
50		258.32	262.66	17.97	18.08	4.10	4.15	173.70	176.67	39.43	42.98	2.69	2.83
75		280.41	283.99	18.76	18.95	4.24	4.20	200.61	204.29	47.87	50.95	3.11	3.22
100		299.08	302.91	20.10	20.26	4.38	4.25	225.71	229.29	54.77	58.22	3.32	3.34
F test		***	***	***	***	***	***	***	***	***	***	***	***
LSD at 0.05 %		1.38	0.576	0.499	0.499	0.009	0.017	0.050	0.125	0.251	3.03	0.047	0.050
Sub main : organic fertilizers sources													
0		243.07	247.41	17.33	17.55	4.00	3.82	171.48	174.62	37.92	39.06	2.43	2.54
C		255.58	261.33	18.29	18.49	4.12	4.14	186.13	189.16	42.51	44.24	2.85	2.88
V.C		270.49	273.91	18.80	19.01	4.22	4.41	201.11	203.95	47.24	52.80	2.98	3.01
Mix		263.74	267.82	18.44	18.72	4.17	4.27	192.46	196.01	45.09	47.78	2.91	3.04
F test		***	***	**	*	***	***	***	***	***	***	***	***
LSD at 0.05%		0.842	0.910	0.942	0.940	0.018	0.009	0.087	0.072	0.470	2.27	0.032	0.024
Interaction													
0 NPK	0	178.33	182.66	15.20	15.70	3.60	3.65	146.32	146.55	28.76	29.05	1.70	1.72
	C	191.33	202.33	16.10	16.50	3.80	3.82	150.12	152.23	29.98	30.48	2.10	2.12
	V.C	208.33	212.33	16.63	16.95	3.92	3.95	155.33	158.26	32.22	34.75	2.25	2.32
	Mix	202.33	206.33	16.22	16.83	3.85	3.88	152.84	156.92	31.82	32.65	2.16	2.20
50% NPK	0	245.99	252.33	17.10	17.24	4.02	4.06	164.25	166.42	36.58	37.08	2.30	2.35
	C	254.33	258.33	18.12	18.15	4.10	4.13	170.00	172.33	38.47	39.97	2.74	2.83
	V.C	270.66	274.33	18.46	18.62	4.18	4.20	184.43	188.42	43.26	52.76	2.92	3.04
	Mix	262.33	265.66	18.22	18.33	4.13	4.18	176.13	179.52	39.42	42.12	2.80	3.12
75% NPK	0	265.33	270.33	18.30	18.45	4.15	4.17	180.23	185.16	40.72	40.92	2.70	3.06
	C	278.33	282.33	18.80	19.01	4.24	4.27	198.22	201.42	47.37	50.33	3.19	3.22
	V.C	292.66	294.66	19.02	19.23	4.30	4.35	218.36	221.12	52.75	58.33	3.30	3.33
	Mix	285.33	288.66	18.92	19.10	4.28	4.32	205.65	209.48	50.66	54.22	3.26	3.30
100% NPK	0	282.33	284.33	18.72	18.84	4.25	4.28	195.14	200.36	45.63	49.22	3.04	3.06
	C	298.33	302.33	20.15	20.33	4.35	4.39	226.18	230.66	54.24	56.18	3.33	3.35
	V.C	310.33	314.33	21.10	21.24	4.50	4.52	246.33	248.00	60.74	65.36	3.47	3.50
	Mix	305.00	310.66	20.43	20.63	4.42	4.45	235.22	238.15	58.49	62.14	3.42	3.45
F test		***	***	Ns	Ns	***	***	***	***	***	**	**	***
LSD t 0.05%		1.68	1.82	1.87	1.88	0.037	0.035	0.175	0.145	0.940	4.54	0.064	0.048

Combination of inorganic NPK fertilizers at 100% RD and organic V.C. fertilizer recorded the highest values of maize grain yield and yield attributes in the both tested seasons followed by NPK at 100% RD and C , NPK at 75% RD and V.C and lately NPK at 75% RD and C treatments comparing with the application of inorganic NPK fertilizers at 100% RD singly, this result may be attributed to the positive effect of inorganic NPK fertilizers on vegetative growth parameters and chlorophyll content as mentioned before. V.C. also has a responsible role in improving the growth and crop development. Fanuel and Gifole, (2013) also found that application of compost at 5 t ha^{-1} with urea was better than application of 10 t ha^{-1} of compost plus urea. Also, Zeinab *et al.,* (2014) concluded that the combination of vermicompost with nitrogen fertilizers was better than the addition of nitrogen fertilizers alone. The same result was also concluded by Kandil *et al*., (2020).

4- Integrated effect of inorganic and organic fertilizers on NPK concentrations.

Results presented in Table 6, Figs (1 to 4) show the impact of inorganic and organic fertilizers treatments on NPK concentrations in maize leaves at maximum growth vegetative stage and grain under the two investigated successive seasons, respectively.

All treatments significantly affected on NPK concentrations in maize leaves and grains. Using inorganic NPK fertilizers at 100% RD gave the highest values of NPK concentrations where the values of N were (3.57, 3.61) in leaves and were (2.63, 2.75) in grains; values of P were (0.394, 0.396) in leaves and were (0.266, 0.271) in grains and values of K were (2.92, 2.97) in leaves and were (2.67, 2.71) in grains in the two tested seasons, respectively. These results were in accordance with that found by Olowoboko *et al.,* (2017).

Increasing the levels of inorganic NPK fertilizers applied increase N, p and K availability in the soil and consequently increase their concentrations within plant, on the other hand increasing N fertilizer dose increase P concentration (Nahidah *et al*., 2002). Potassium fertilizer application also impact on nitrate uptake and transport within the plant which may be the reason for increasing nitrogen concentration within plant (Bruns and Ebelhar, 2006).

Organic fertilizers application also increased NPK concentration in maize leaves and grains comparing with non-addition. In this concern organic V.C. treatment recorded the highest values of N (3.35, 3.42) in leaves and (2.47, 2.55) in grains; values of P (0.367, 0.371) in leaves and (0.243, 0.248) in grains and values of K (2.72, 2.75) in leaves and (2.45, 2.51) in grains in 2020 and 2021 seasons, respectively. These results are in matching with those observed by (Sigaye *et al.,* 2021). Vermicompost is faster decomposition, higher nutrients content, much finer structure than compost and also it releases nutrients faster and in more available forms for plant uptake (Erdal *et al.*, 2018). On the other hand, releasing of organic acids from vermicompost through organic matter decay solubilize fixed phosphorus from Fe and Al complexes in the soil (Yadvinder *et al.,* 2010).

Both compost and vermicompost are organic materials sources that improve the soil physical, chemical and biological properties. In addition, they supply the soil with high quantities of available nutrients. Consequently nutrient concentrations within the plant increase (Jagwe *et al*., 2020). Organic fertilizers supply the soil with more nutrients in available forms and produce organic and inorganic acids during decomposition which reduce the soil pH and promote the solubility and availability of N, P, and K (Erdal *et al*., 2018).

Table 6. Individual effect of inorganic and organic fertilizers on NPK concentrations of maize leaves and grains in the two successive seasons.

Treatments	Nutrients concentrations (%)											
	N				P				K			
	Leaves		Grains		Leaves		Grains		Leaves		Grains	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Main : inorganic fertilizers rates												
0	2.69	2.76	2.04	2.09	0.297	0.304	0.191	0.196	2.18	2.21	1.92	2.01
50	3.18	3.24	2.28	2.37	0.347	0.353	0.220	0.224	2.55	2.59	2.26	2.30
75	3.43	3.47	2.50	2.59	0.377	0.383	0.250	0.253	2.80	2.83	2.52	2.56
100	3.57	3.61	2.63	2.75	0.394	0.396	0.266	0.271	2.92	2.97	2.67	2.71
F test	***	***	***	***	***	***	***	***	***	***	***	***
LSD at 0.05%	0.047	0.024	0.046	0.047	0.004	0.005	0.004	0.002	0.047	0.024	0.044	0.025
Sub main : organic ferilizers sources												
0	3.02	3.06	2.22	2.32	0.337	0.343	0.217	0.221	2.46	2.52	2.19	2.25
C	3.22	3.28	2.35	2.44	0.351	0.356	0.232	0.235	2.60	2.64	2.34	2.38
v.c	3.35	3.42	2.47	2.55	0.367	0.371	0.243	0.248	2.72	2.75	2.45	2.51
Mix	3.28	3.33	2.41	2.49	0.361	0.365	0.236	0.240	2.66	2.69	2.38	2.43
F test	***	***	***	***	***	***	***	***	***	***	***	***
LSD at 0.05%	0.043	0.043	0.044	0.043	0.004	0.003	0.004	0.005	0.043	0.047	0.047	0.047

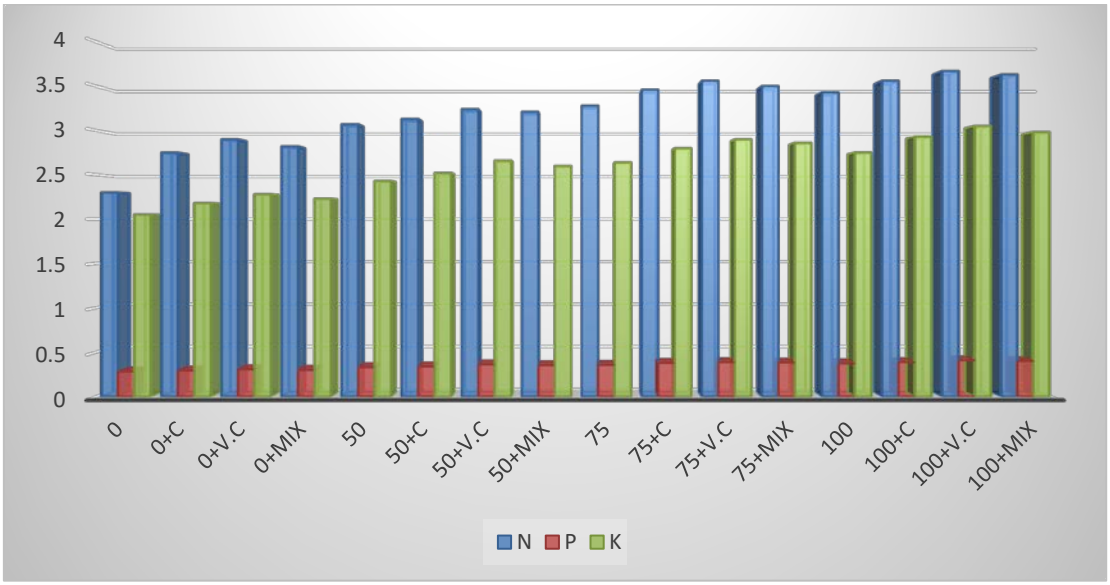

Fig 1: Interaction effect of inorganic and organic fertilizers on NPK concentrations in maize leaves at 2020 season.

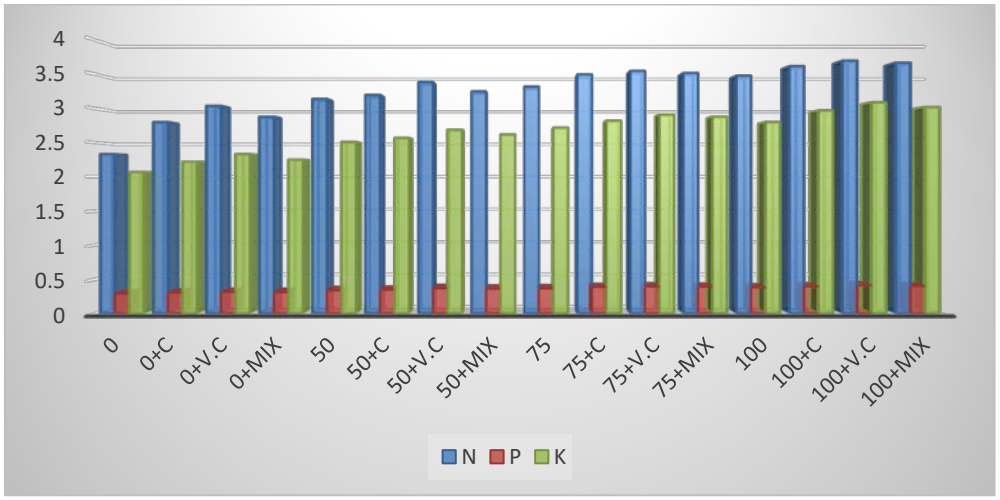

Fig 2: Interaction effect of inorganic and organic fertilizers on NPK concentrations in maize leaves at 2021 season.

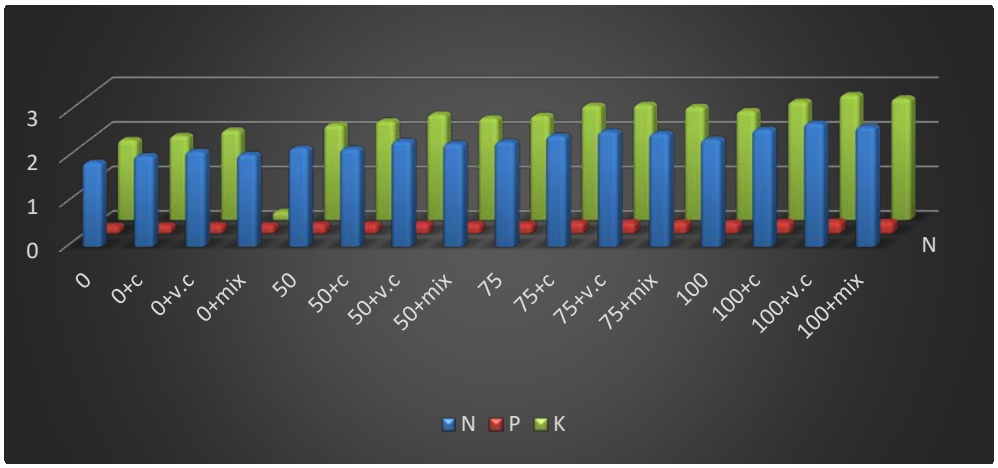

Fig 3: Interaction effect of inorganic and organic fertilizers on NPK concentrations in maize grains at 2020 season.

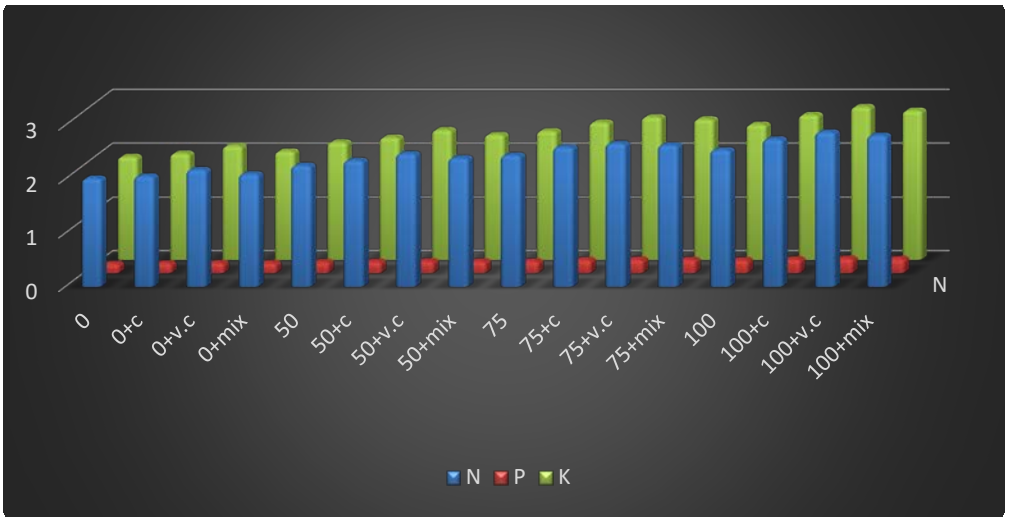

Fig 4: Interaction effect of inorganic and organic fertilizers on NPK concentrations in maize grains at 2021 season.

Application of inorganic NPK fertilizers at 100% RD together with organic V.C. fertilizer gave the highest values of NPK concentration in leaves and grains of maize during the two investigated seasons comparing with the addition of in organic NPK fertilizers at 100% RD only.

The interaction of inorganic and organic fertilizers improve soil properties, increase nutrients availability in the soil and cause balance between them. As a result, nutrients concentrations within plant increase (Djawu, 2017). The same results were concluded by (El Mantawy *et al*., 2021).

5- Integrated effect of inorganic and organic fertilizers on NPK uptake

Data in Table 7 show that the application of inorganic and organic fertilizers positively affected on N, P and K uptake by maize grains in the both seasons. In this respect, the addition of inorganic NPK fertilizer at 100% RD recorded the highest values of N, P and K uptake by maize grains in the two successive seasons namely (87.90,92.05) for N uptake , (8.88, 9.06) for P uptake and (89.14, 90.80) for K uptake comparing with the control treatment . These results were corresponding to those attained by (El Fouly *et al*., 2012).

Application of organic fertilizers i.e. compost (C), vermicompost (V.C.) and the mix also increased N, P and K uptake by maize grains in the two investigated seasons. These increments may be attributed to slow releasing of nutrients from organic fertilizer in available forms (Zaremanesh *et al.,* 2017).

Compost release nitrogen in ammonium ions form while vermicompost release the same mineral in nitrate form, in addition to releasing of bicarbonate ions from organic matter decomposition that increase P availability in the soil via displacement of phosphate by organic acids produced during organic manure decomposition (Joshi and Sharma, 2010).

The highest values of N (74.95, 78.94), P (7.38, 7.40) and K (74.65, 77.81) uptake by maize grains in the two seasons were achieved by organic V.C. fertilizer application. The same result was found by (Sigaye *et al.*, 2021).

The combination of inorganic NPK fertilizers at 100% RD and organic V.C. fertilizer treatment achieved the highest values of N, P and K uptake by maize grains during the two successive seasons comparing with their addition at 100% RD singly, these results are in matching with that recorded by El-Mantawy *et al.,* (2021).

6- Integrated effect of inorganic and organic fertilizers on available NPK in the soil after harvesting.

Data presented data in Table 8 show the impact of the inorganic and organic fertilizers on available N, P and K in the soil after maize harvesting in the both seasons. Soil fertility is the main controlling factor in agricultural production (El-Gamal, 2015). Using of inorganic NPK fertilizers at 100% RD achieved the highest values of available N (47.88, 49.59), P (10.25, 10.31) and K (221.13, 229.89) in the both seasons, respectively at the post harvesting maize. The same result was found by (Abd El-Gawad and Morsy, 2017).

Compost and vermicompost should be applied before planting to take a sufficient time for natural oxidation of organic material that enhances the soil available nutrients (Erdal *et al*., 2018). Application of organic fertilizers i.e. compost (C), vermicompost (V.C.) and mix of them increase the available nutrients N,P and K in the soil via improving soil properties, increasing soil

CEC through raising the exchange sites numbers for available nutrients, promoting soil quality via increasing microbial activity and improving soil fertility (Jagwe *et al.,* 2020). Application of organic compost fertilizer recorded the highest values of available N (46.23, 47.49); p (9.85, 10.03) and K (216.82, 224.83) in the soil after maize harvesting in 2020 and 2021, respectively. This result is in harmony with that found by Laekemariam and Gidago, (2012).

Table 7. Integrated effect of inorganic and organic fertilizers on NPK uptake by maize grains in the two successive seasons.

Treatments		Nutrients uptake (Kg fed^{-1})					
		N		P		K	
		1st	2nd	1st	2nd	1st	2nd
Main : inorganic fertilizer rates							
0		42.17	43.79	3.94	4.11	39.73	42.16
50		61.51	67.46	5.93	6.39	61.06	65.56
75		78.00	83.72	7.81	8.20	78.67	82.77
100		87.90	92.05	8.88	9.06	89.14	90.80
F test		***	***	***	***	***	***
LSD at 0.05%		1.42	1.87	0.224	0.277	1.91	1.45
Sub main: organic fertilizer sources							
0		55.16	60.20	5.40	5.76	54.55	58.76
C		68.14	71.50	6.76	6.92	68.40	69.82
V.C		74.95	78.94	7.38	7.40	74.65	77.81
Mix		71.33	76.38	7.02	7.67	71.00	74.89
F test		***	***	***	***	***	***
LSD at 0.05%		1.44	1.29	0.295	0.252	1.62	1.53
0 NPK	0	32.31	34.76	3.06	3.18	30.78	33.04
	C	43.06	43.65	3.96	4.06	39.91	41.95
	v.c	48.39	50.55	4.54	4.86	45.46	49.20
	Mix	44.91	46.21	4.20	4.35	42.75	44.45
50% NPK	0	51.04	53.09	4.87	5.04	49.23	51.44
	C	60.57	66.48	5.97	6.28	61.11	64.50
	v.c	69.47	75.37	6.71	7.11	69.47	73.58
	Mix	64.97	74.89	6.19	7.12	64.41	72.71
75% NPK	0	63.70	74.95	6.10	7.04	63.43	73.45
	C	79.73	83.73	8.13	8.30	82.31	82.41
	v.c	85.45	89.07	8.64	8.87	85.81	88.73
	Mix	83.11	87.13	8.38	8.57	83.11	86.47
100% NPK	0	73.58	78.01	7.59	7.79	74.76	77.12
	C	87.92	92.14	8.85	9.04	88.89	90.43
	v.c	96.48	100.78	9.64	9.86	97.83	99.73
	Mix	92.35	97.27	9.30	9.59	93.72	95.92
F test		***	***	**	*	**	**
LSD at 0.05%		2.88	2.59	0.591	0.505	3.25	3.06

Table 8. Integrated effect of inorganic and organic fertilizers on available NPK in the soil after maize harvesting in the two successive seasons.

Treatments		Available nutrients in the soil (mg Kg^{-1} soil)					
		N		P		K	
		1st	2nd	1st	2nd	1st	2nd
Main : inorganic fertilizer rates							
0		39.94	40.76	8.27	8.51	202.56	205.19
50		45.92	46.82	9.52	9.64	215.40	220.03
75		46.86	48.02	9.91	10.01	217.71	225.03
100		47.88	49.59	10.25	10.31	221.13	229.89
F test		***	***	***	***	***	***
LSD at 0.05%		0.149	0.442	0.070	0.040	0.028	212.23
Sub main: organic fertilizer sources							
0		43.25	43.96	8.82	8.90	209.35	212.23
C		46.23	47.49	9.85	10.03	216.82	224.83
V.C		45.68	47.03	9.71	9.84	215.65	222.10
Mix		45.45	46.71	9.58	9.71	214.97	220.97
F test		***	***	***	***	***	***
LSD at 0.05%		0.133	0.373	0.029	0.045	0.045	0.039
Interaction							
0 NPK	0	38.10	38.22	7.84	7.92	198.70	198.97
	C	41.16	42.15	8.54	8.94	205.36	209.46
	v.c	40.38	41.53	8.40	8.67	203.14	206.22
	Mix	40.15	41.16	8.33	8.53	203.05	206.12
50% NPK	0	44.24	44.62	9.02	9.12	209.40	211.50
	C	48.81	47.92	9.83	9.97	218.18	226.01
	v.c	46.48	47.56	9.70	9.84	217.48	222.18
	Mix	46.18	47.18	9.53	9.66	216.55	220.43
75% NPK	0	44.90	46.18	9.15	9.21	211.54	215.66
	C	47.86	48.94	10.34	10.47	220.59	229.63
	v.c	47.51	48.63	10.16	10.23	219.78	227.92
	Mix	47.19	48.36	10.02	10.16	218.94	226.94
100% NPK	0	45.76	46.82	9.27	9.36	217.79	222.82
	C	49.12	50.96	10.71	10.76	223.15	234.22
	v.c	48.36	50.43	10.59	10.63	222.23	232.11
	Mix	48.30	50.16	10.45	10.50	221.37	230.42
F test		**	*	***	***	***	***
LSD at 0.05%		0.266	0.746	0.059	0.090	0.091	0.078

The addition of inorganic NPK at 100% RD and organic compost fertilizers simultaneously gave the highest values of available N, P and K in the soil after harvesting in the two seasons comparing with application of inorganic NPK fertilizers at 100% RD only. The result is in matching with that concluded by Adamu *et al.*, (2015) and El Mantawy *et al.*, (2021).

7-Integrated effect of inorganic and organic fertilizers on benefit: cost ratio.

Economics of maize as affected by inorganic and organic fertilizers have been given in Table (9). The highest total

cost of cultivation (£. fed^{-1}) was noticed with all treatments of V.C. followed by mix treatments. The cost of cultivation for control (no fertilizer application) was 6500 £. fed^{-1} however, the cost of inorganic NPK fertilizers at RD was 8955 £. fed^{-1}. This clears that vermin compost treatments recorded more cost of cultivation than other treatments. The maximum gross incomes namely 17350 and 17500 £. fed^{-1} of maize crop in the two seasons under study, respectively were recorded when the application of V.C. and NPK at 100% RD simultaneously followed by the treatment of mix and NPK at 100% RD with gross incomes of 17100 and 17250 £. fed^{-1} in 2020 and 2021seasons, respectively. Yet, the gross incomes for the treatment of NPK at RD were 15200 and 15300 £. fed^{-1} in the two tested seasons. On the other hand, all treatments of organic fertilizers in combination with inorganic NPK fertilizers at 75%RD achieved gross income more than using NPK at 100% RD singly.

The highest net returns namely 6795 and 6895 £. fed^{-1} were obtained when the application of NPK at 100% RD and C. followed by the treatment of NPK at 75% RD and C with net returns 6584 and 67354 £.fed^{-1} in the two investigated seasons. The lowest net return 2000 and 2100 £. fed^{-1} noticed in control treatments (without NPK fertilizers addition). It noticed that V.C. treatments recorded the lowest net returns comparing with the other organic fertilizers applications.

The highest B: C ratios (1.70 and 1.7) were recorded from combination of NPK at 75% RD and compost followed by the application of NPK at 100% RD with 1.69 and 1.70 B:C ratio. The B: C ratios of control treatment were 1.30 and 1.32 for the two investigated seasons, respectively.

Table 9. Costs of cultivation, gross and net returns, and benefit: cost ratios of different treatments.

Treatments		Total cost of cultivation (£.fed^{-1})		Gross return (£.fed^{-1})		Net return (£.fed^{-1})		Benefit cost ratio (BCR)	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd
0 NPK	0	6500	6500	8500	8600	2000	2100	1.30	1.32
	C	7400	7400	10500	10600	3100	3200	1.41	1.43
	V.C	9000	9000	11250	11600	2250	2600	1.25	1.28
	Mix	8200	8200	10800	11000	2600	2800	1.31	1.34
50% NPK	0	7978	7978	11500	11750	3522	3772	1.44	1.47
	C	8878	8878	13700	14150	4822	5272	1.54	1.59
	V.C	10478	10478	14600	15200	4122	4722	1.39	1.45
	Mix	9678	9678	14000	15600	4322	5922	1.44	1.61
75% NPK	0	8466	8466	13500	15300	5034	6834	1.59	1.60
	C	9366	9366	15950	16100	6584	6734	1.70	1.71
	V.C	10966	10966	16500	16650	5534	5684	1.50	1.51
	Mix	10166	10166	16300	16500	6134	6334	1.60	1.62
100% NPK	0	8955	8955	15200	15300	6245	6345	1.69	1.70
	C	9855	9855	16650	16750	6795	6895	1.68	1.69
	V.C	11455	11455	17350	17500	5895	6045	1.51	1.52
	Mix	10655	10655	17100	17250	6445	6595	1.60	1.61

The costs of cultivation for all vermicompost treatments were higher than the other organic fertilizers treatments because of price of V.C. where 5000 £ ton^{-1}, while compost price is 180 £.ton^{-1}. On the other hand, compost enhanced seed yield and recorded the highest net return.

Among organic fertilizers treatments there were much differences in B: C ratio and organic compost treatment recorded the highest net return and B: C ratio. The combination of organic compost fertilizer and inorganic NPK at 75% RD could be the best alternative compared with the other treatments and viable option for enhancing crop yield and farmers income.

CONCLUSION

This study recommends the addition of nitrogenous, phosphate and potassium fertilizers to the corn crop at rates of 75% of the recommended in combination with organic compost fertilizer due to the highest economic return as well as the highest and best productivity of the corn crop, in addition to that this treatment is an alternative and effective solution to add duration The major nutrients (nitrogen, phosphorous and potassium) at 100% of the recommended rates. That is, it provides 25% of the added mineral fertilizer, increases the productivity of the corn crop and improves its quality.

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التأثير الكمى والكيفى لبعض الأسمدة الغير عضوية و العضوية على نبات الذرة تحت الأراضى الرسوبية

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الملخص العربي

أجريت تجربتان حقليتان بمحطة بحوث تاج العزالزراعية ، محافظة الدقهلية ، مركز البحوث الزراعية بمصر خلال موسمى الزراعة الصيفيين ٢٠٢٠ و ٢٠٢١ بغرض دراسة امكانية الاستبدال الجزئى لاسمدة NPK المعدنية بالسماد العضوى كمبوست أو فيرمى كمبوست او الخليط منهما وتأثير ذلك على نمو وانتاجية وجودة محصول الذرة تحت ظروف الاراضى الرسوبية .

لذلك صممت التجربة بنظام القطع المنشقة مره واحدة فى ثلاث مكررات حيث شغلت القطع الرئيسية باربعة معدلات من الاسمدة الغير عضوية النيتروجينيه ، الفوسفاتية والبوتاسية (٠و٥٠و٧٥ و ١٠٠٪ من المعدل الموصى به) أما مصادرالاسمدة العضوية فقد تم توزيعها عشوائيا فى أربعة مصادر (بدون و كمبوست و فيرمى كمبوست وخليط منهما مناصفة) فى القطع المنشقة وقد أشارت النتائج المتحصل عليها الى النقاط الهامة الآتية :

١- أدت اضافة الاسمدة المعدنية الثلاث بمعدلاتها الموصى بها الى الحصول على أعلى قيم للنمو والمحصول وامتصاص العناصر الغذائيه

٢- كان لاستخدام الاسمدة العضويه موضع الدراسة (الكمبوست او الفيرمى كمبوست او الخليط منهما) تأثير معنوى على جميع الصفات المدروسة وكان افضلهم الفيرمى كمبوست يليه الخليط ثم الكمبوست مقارنة بمعاملة الكنترول (عدم اضافة الاسمدة المعدنية)

٣- حققت اضافة الاسمدة الغير عضوية (المعدنية) بمعدلات ١٠٠٪ من الموصى بها مجتمعه مع السماد العضوى الفيرمى كمبوست اعلى نتائج النمو والمحصول وامتصاص العناصر الغذائيه مقارنة باضافة الاسمدة المعدنية بمفردها بمعدلات ١٠٠٪ من الموصى بها .

٤- أدت اضافة الاسمدة الغير عضوية بمعدلات ١٠٠٪ من الموصى بها مع سماد العضوى الكمبوست الى تحقيق أعلى قيم العناصر الميسرة النيتروجين والفوسفور والبوتاسيوم فى التربة بعد حصاد الذرة .

٥- حققت معاملات الكمبوست أعلى عوائد اقتصادية

ومن ثم فان هذه الدراسة توصى باضافة الاسمدة الازوتية والفوسفاتية والبوتاسية لمحصول الذرة بمعدلات ٧٥٪ من الموصى بها مع الاهتمام باضافة سماد الكمبوست العضوى نظرا لما تحققه هذه المعاملة من أعلى عائد اقتصادى وأعلى وأفضل انتاجية لمحصول الذرة فضلا عن أن هذه المعاملة تعتبر حلا بديلا وفعالا لاضافة أسمدة العناصر الغذائية الكبرى (النيتروجين والفوسفور والبوتاسيوم) بمعدلات ١٠٠٪ من الموصى بها . أى أنها توفر ٢٥٪ من السماد المعدنى المضاف وتزيد من إنتاجية محصول الذرة وتحسن من جودته .

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