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Yield and fruit chemical constituents of squash as affected by organic, bio-, and N mineral fertilizer

Mohamed M.A Dawood[1], Alkharpotly, A. A.[1,2] K. G. Abdelrasheed[1] and Mona N. Shehata[1]

[1]Horticulture Department, Faculty of Agriculture and Natural Resources, Aswan University, Egypt.
[2]Horticulture Department, Faculty of Desert and Environmental Agriculture, Matrouh University, Egypt.

Abstract

A field experiment was carried out during the two successive winter seasons of 2019/2020 and 2020/2021 at the experimental farm of the Faculty of Agriculture and Natural Resources, Aswan University, Egypt, to study the effect of organic, bio- and mineral fertilizers on yield and fruit quality of summer squash *Cucurbita pepo L*" cultivar "Eskandrany". Four nitrogen fertilizer levels were used (0, 30, 45, 60 kg N/fed.) in the form of liquefied ammonium nitrate. Three types of organic fertilizer were used (control without organic manure, chicken manure at 9.5 tons/fed. and compost manure at a rate of 7.5 tons/fed). Microben and Halex are used as a source of bio-fertilizers. The data showed that the combined effects of organic manure, bio-fertilizers and chemical nitrogen rates had a significant impact on early yield, total yield per plant and per feddan in both seasons.

Among these interactions, the highest values of early yield per plant (g) were obtained from application of chicken manure + Microbien + 60 kg N/fed., for the first and second seasons, respectively. While the highest value of total yield per plant and per feddan (ton), were occur from plants treated with chicken manure + Microbien + 45 kg/N fed.

Key words: Squash, Chicken manure, Bio-fertilizers, Mineral fertilizers, Yield.

Introduction

Summer squash (*Cucurbita pepo* L.), is one of the most important crops of the Cucurbitaceae family, and a highly polymorphic vegetable grown during summer in tropical and subtropical conditions. Summer squash is eaten as a vegetable, either boiled, fried, or stuffed. Summer squash has a variety of health benefits for humans, including medicinal potential. [1]. Over and above, the use of organic amendments increases the soil quality and leads to enhancement of plant productivity [2,3]. Using organic materials as soil

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covers improves the soil's physical and chemical properties and increases the activity of soil microorganisms and enzymes. [4,5]. In arid and semi-arid areas, soil moisture content is a key factor affecting crop yield. [6]. In today's era, intensive use of chemical fertilizer has been found to obtain a better crop productivity and significantly enhance yield to various kinds of crop and efficient methods compared to organic manures [7,8]. However, the continuous application of chemical fertilizers has a negative impact on human health and several environment threats such as soil erosion, air and water pollution, water logging, and decrease in biodiversity [9–11].

The addition of high rates of chemical fertilizer adversely affects soil properties such as soil fertility, organic matter, biological activity, structure, water retention, salinity, and general soil quality [9–11].

Organic amendments have several beneficial effects such as improving the recovery of applied nutrients, water holding capacity, and minimizing ammonia volatilization [12,13] .

Nitrogen is an essential nutrient for crop production and important for plant growth. It constitutes about 1.5 - 6% of the dry weight of many crops [14]. It also plays a role in chlorophyll synthesis and hence the process of photosynthesis [15]. Nitrogen deficiencies exhibit stunted growth and small leaves, while excess nitrogen induces lush plants with soft tissues and lateness in maturity [16].

MATERIALS AND METHODS

The farm located at the University of Agriculture and Natural Resources in Aswan was the site of this experiment. The goal of this study was to determine the impact of chemical, organic and bio-fertilizers on the yield and yield components of summer squash "*Cucurbita pepo L*" cultivar "Eskandrany" over the successive winter seasons of 2019/2020 and 2020/2021. Before planting, random soil samples were obtained from the experiment field at a depth of 0–30 cm. **(Table 1**) shows the physical and chemical examination of soil according to [17].

Table 1: **Some physical and chemical properties of the experimental soil before planting summer squash during 2019/2020 and 2020/2021.**

Soil Constituents	Physical properties				E.C m.mhos /cm	Organic matter %	Available N%	Available p%(ppm)	Available k.mg/100g soil
	sand	silt	clay	texture					
Season 2019/2020	75.08	21.86	3.06	sand silt	15.2	1.5	1.02	1.54	3.01
Season 2020/2021	77.02	19.96	3.02	sand silt	20.1	2.9	3.03	3.05	1.40

The soil in the test field was ridged into rows of one meter width, separated into plots, and then plowed and ground into powder. Each plot had four rows, each measuring 3.5 meters long, and the size of the plot was 4.0 x 1.0 x 3.5 meters (1/300 fed.). On December 28th, seeds were sown in both seasons on one side of the row, 40 cm apart from one another. Plants were thinned after germination, leaving two plants per hill. Treatments consisted of three factors *i.e.*, chemical –N, organic manure and bio –fertilizers and conducted using split – spilt plot design with three replicates. Chemical N-fertilizer rates were assigned to the main plots and the subplots were set aside as a source of organic manure. The bio-fertilizer sources inhabited the sub-sub-plots. The following treatment methods were used: **Chemical N-fertilizer:-**

Four nitrogen fertilizer levels were used (0, 30, 45, 60 kg N/fed.) in the form of liquefied ammonium nitrate. Each N-level was divided to three equal doses (during field preparation, after 20 and 40 days from seed sowing), it applied with water irrigation. Liquefied ammonium nitrate obtained from Kima factory and composition of (NH_4NO_3) N=33.5%.

I. Organic manure: -

The following three types of organic fertilizer were used:

a. Control without organic manure.
b. Chicken manure at 9.5 tons per fed.
c. Compost manure at a rate of 7.5 tons per fed.

The soil was irrigated while the organic manures were added 40 days prior to planting at a depth of 30 cm. In (Table 2), the chemical analysis of the chicken and compost manures is displayed.

Table (2): The chemical analysis of chicken and compost manure was applied in 2019/2020 and 2020/2021 winter seasons.

Chemical analysis	Chicken manure		Compost	
	2019/2020	2020/2021	2019/2020	2020/2021
Total N%	2.5	3.4	1.92	3.2
Total p%	0.65	1.3	1.62	1.68
Total k%	2.16	2.45	2.35	2.00
E.C (mmoh/cm) *	6.2	6.6	14.6	11.5

*EC=Electric conductivity

II. Bio fertilizer treatments: -

1. Microben

This product was purchased from a certified place which is Agriculture Research Center prepare raw pollination by diluting with water and then the dry seeds were immersed in it and vegetable glue was placed to stabilize. The bio-fertilizer "Microbein" is a mixture of non- symbiotic N-fixing bacteria of the genera *Rhizobium*, *Azospirillum*, *Azotobacter* and *klebsiella* as well as the phosphate dissolving bacteria *Baccillus* was purchased from the General Organization for Agricultural Equalization Fund, Ministry of Agricultural, Egypt.

2. Halex

Another a vaccine was also used to install nitrogen which is Halex which was diluted with water then put the glue with the seeds to install at the time of planting. The biofertilizer Halex (a mixture of growth promoting of non-symbiotic N-fixing bacteria of genera *Azospirillum*, *Azotobacter* and *klebsiella*) was supplied by the Biofertilization Unit, Plant Pathology Department, Fac. of Agric., Alex. Univ., and used as a mixed biofertilizer in this investigation.

Recorded data

A. Yield and its components: -

1- Early yield (ton/fed) as the first three pickings (ton/fed.).
2- Total yield (kg/ plant).
3- Total yield (ton/fed).

B. Fruit chemical constituents: -

1- leaf N % and fruits were measured by micro kjeldah procedure.
2- Phosphorus (ppm) of leaves and fruits was determined calorimetrically by the ammonium molybdate stannous chloride method [18].
3- K % of leaves and fruits was measured by atomic absorption spectrophotometer [19].
4- pH leaves and fruits by using pH meter.
5- Total soluble solids (TSS) by using hand refractometer.

Statistical Analysis

As demonstrated by [20] the revised L.S.D. test at 0.05 level of probability was used to compare the differences among the means of the various treatment combinations. All data collected for the current study were statistically analyzed in accordance with the design used by the MSTAT-C computer software program [21].

RESULTS AND DISCUSSION

In both experiments that were carried out during the winter seasons of 2019/2020 and 2020/2021, the results typically indicated, more or less, identical responses to each of the three main examined treatments and their interactions. Under the following two primary headings: fruits chemical constituents, yield and its component, are the impacts of the numerous factors (organic, bio- and mineral fertilizers) utilized in this study and their interactions on the various characteristics of squash plants.

I. **Chemical fruit constituents** were enhanced by organic, bio-, and mineral N- fertilizers.

1. The main effects:

Data presented in Table (3) showed that individual treatments in organic, bio- and chemical N fertilizers rates showed significant superiority over the control treatment in terms of total soluble solids (TSS %), pH, and NPK % in fruits. There were no significant differences between the sources of organic fertilizers (Chicken manure and Compost), between the bio-inducing species Microbien and Halex, and chemical N levels 30, 45 and 60 kg fed^{-1}., for TSS, pH in fruits. On the contrary, the treatment of chicken manure was morally superior to the treatment of compost, and treatment of Microbien showed moral superiority over Halex and treatments at different levels of chemical N fertilizers showed a clear increase in NPK% in fruits, the best chemical N fertilizers were treatment by focusing 60 kg/fed. in both seasons respectively.

This result may be attributed to the synchronization of availability of the proper forms of nutritive elements via bio, organic or inorganic fertilization. In other words, organic manure mineralizes and uptakes slowly, compared to the inorganic fertilization N which releases readily to the plants. These findings could be accounted to the presence of nitrogen either in mineral or in combination with organic and biofertilization which could activate many enzymes having a direct effect on photosynthesis and might increase the dry matter and subsequently enhanced fruit sugars content or many enzymes involved in metabolism of sugars contents. Increasing fruits NPK may be due to that chicken manure contains major nutrient elements associated of photosynthetic activities as Mg^{+2}, N, P, K and thus cooperate with the other variables in promoting roots and vegetative growth, and the very close relationship between chlorophyll and nitrogen content especially in mineral (inorganic) forms [22,23]. Also, these results may be owned to the quick availability of N, P and K elements of N mineral fertilizer treatments and the slow release of organic manure of nutrient constituents during the crop growth cycle which reflect on vegetative and reproductive organs (fruits).

Table (3): Effect of organic, bio-, and mineral fertilizers on some fruit chemical characters of squash plants during 2019/2020 and 2020/2021 seasons.

Treatments	TSS %		PH		N %		P %		K%	
	2019/2020	2020/2021	2019/2020	2020/2021	2019/2020	2020/2021	2019/2020	2020/2021	2019/2020	2020/2021
Organic fertilizer (main effect)										
Control	3.71	3.59	6.43	6.29	1.20	1.31	0.12	0.17	1.12	1.23
Chicken manure	4.51	4.43	6.23	6.30	1.93	2.08	0.21	0.26	2.27	2.37
Compost	4.43	4.36	6.45	6.59	1.54	1.66	0.16	0.21	1.64	1.74
LSD(0.05)	0.29	0.09	0.34	0.091	0.02	0.02	0.002	0.001	0.02	0.02
Bio-Fertilizer (main effect)										
Control	4.03	3.64	6.31	6.19	1.47	1.58	0.15	0.20	1.55	1.64
Halex	4.30	4.22	6.39	6.44	1.59	1.73	0.17	0.22	1.71	1.82
Microbien	4.32	4.52	6.41	6.56	1.62	1.74	0.17	0.22	1.77	1.87
LSD(0.05)	0.29	0.09	0.34	0.091	0.02	0.02	0.02	0.001	0.02	0.02
Mineral fertilizer Kg.N/Fed. (main effect)										
30 kg.N/fed.	4.22	4.07	6.23	6.39	1.48	1.59	0.15	0.20	1.54	1.66
45 kg.N/fed.	4.3	4.16	6.53	6.57	1.56	1.67	0.16	0.21	1.67	1.77
60 kg.N/fed.	4.14	4.15	6.38	6.23	1.64	1.79	0.17	0.22	1.81	1.91
LSD(0.05)	0.29	0.09	0.34	0.091	0.02	0.02	0.02	0.001	0.02	0.02

Values having the same alphabetical letter (s) in common, within each column, do not significantly differ, using L.S.D. test at 0.05 level of probability.

2. Interactions effects: -

The results in Table (4) showed that the interactions of the three factors, significant effect was obtained, in both seasons. Among these interactions, the highest values of TSS% and pH were obtained from chicken manure + Microbien + chemical N at 45 kg N fed.$^{-1}$ *i.e*., TSS (5.07 and 5.4) and pH (7.47 and 7.13 %) for the first and second seasons, respectively. On the other hand, the results showed that the chicken manure + Halex + 60 kg N fed.,$^{-1}$ gave the highest concentration of NPK % in squash fruits. Again, the triple interactions were more effective in this character than that obtained from one sort of fertilizer. The obtain results may be due to that organic manure mineralizes and uptake slowly, compare to the inorganic fertilization N which release readily to the plants which may affect biofertilizers (Microbein and Halex) functions. These finding could be accounted to the presence of nitrogen either in mineral or in combination with the other two resources (organic and bio-fertilization) which could activate many enzymes having a direct effect on photosynthesis and might increase the dry matter and subsequently enhanced TSS content or many enzymes involved in metabolism of TSS content [24]. The increment of NPK fruit's content could be accounted for the enrichment of soil of the three major elements (N, P, K) in the soil by the combination between organic, bio and nitrogen fertilization.

Table (4): Effect of combination between organic, bio-, and mineral fertilizers on some chemical characters of summer squash plants during 2019/ 2020 and 2020/2021 growing seasons.

Treatments			TSS %		pH		N %		P %		K%	
Organic	Bio	Mineral	2019/2020	2020/2021	2019/2020	2020/2021	2019/2020	2020/2021	2019/2020	2020/2021	2019/2020	2020/2021
Control	Control	30	3.07	2.4	6.03	6.1	1.09	1.19	0.105	0.155	0.95	1.05
		45	3.23	3.2	6.4	6.53	1.13	1.23	0.109	0.161	0.97	1.07
		60	4.1	3.37	6.7	6.17	1.14	1.25	0.113	0.164	1.04	1.14
	Halex	30	3.07	3.37	6.43	6.4	1.16	1.28	0.114	0.165	1.07	1.19
		45	5.13	4.37	6.93	6.43	1.24	1.35	0.123	0.174	1.16	1.26
		60	3.17	4.23	6.07	6.07	1.27	1.39	0.13	0.18	1.26	1.37
	Microbien	30	4.07	3.9	6.23	6.4	1.21	1.31	0.118	0.159	1.14	1.24
		45	4.27	4.17	6.37	6.13	1.27	1.37	0.125	0.175	1.19	1.33
		60	3.27	3.3	6.7	6.4	1.33	1.45	0.135	0.185	1.31	1.44
Chicken manure	Control	30	4.23	4.2	6.27	6.2	1.74	1.86	0.18	0.24	1.96	2.06
		45	4.13	4.13	6.17	6.23	1.77	1.92	0.197	0.25	2.03	2.14
		60	4.07	3.63	5.97	5.87	1.84	1.97	0.204	0.253	2.27	2.31
	Halex	30	4.13	3.7	6.73	6.6	1.89	1.97	0.208	0.258	2.18	2.28
		45	4.27	4.2	6.07	6.17	1.97	2.09	0.217	0.267	2.34	2.45
		60	4.5	4.2	6.07	6.27	2.1	2.43	0.226	0.276	2.46	2.58
	Microbien	30	5.07	5.13	6.07	6.1	1.93	2.04	0.213	0.264	2.23	2.37
		45	5.07	5.4	7.47	7.13	2.03	2.16	0.222	0.273	2.42	2.53
		60	5.17	5.27	6.4	6.2	2.16	2.28	0.229	0.281	2.54	2.63
Compost	Control	30	3.1	4.33	6.3	6.13	1.38	1.49	0.137	0.189	1.41	1.51
		45	4.1	3.37	6.23	6.17	1.51	1.61	0.154	0.205	1.58	1.68
		60	4.3	4.17	6.77	6.3	1.61	1.74	0.173	0.224	1.74	1.87
	Halex	30	5.1	5.13	6.33	6.5	1.5	1.63	0.145	0.195	1.46	1.63
		45	4.27	4.3	6.8	7.13	1.53	1.65	0.162	0.212	1.63	1.74
		60	5.1	4.47	6.1	6.4	1.65	1.78	0.175	0.225	1.83	1.93
	Microbien	30	4.17	4.43	5.4	7.07	1.43	1.55	0.148	0.198	1.52	1.63
		45	4.23	4.77	6.33	7.2	1.58	1.67	0.165	0.215	1.71	1.71
		60	3.57	4.3	6.7	6.43	1.68	1.81	0.183	0.232	1.88	1.97
LSD(0.05)			0.89	0.26	1.01	0.27	0.05	0.08	0.005	0.005	0.07	0.07

Values having the same alphabetical letter (s) in common, within each column, do not significantly differ, using L.S.D. test at 0.05 level of probability.

II. Yield and Its Components were enhanced by organic, bio-, and mineral N- fertilizers.

1. Individual transactions

Data in Table (5) indicated that early yield (ton fed^{-1}.), total yield per plant and per feddan (ton), these characters, significantly, responded positively to the organic manures, bio-fertilizers or N fertilizer rates, in both seasons. Among the various Chicken manure surpassed composite in total yield per plant and per feddan (ton), but not significantly effect on early yield. The results obtained could be due to the enriched nutrient status of the plants which reflected on the yield production. Increased yield was correlated to balanced nutrition, better uptake of nutrients by plants which exerted such good yield. Chicken manure contains macro elements as N, P and K, in addition to these, it is, also, contains micronutrients. It is a good source of organic matter which acts as a store

house of all plant nutrients including trace elements might have released them gradually and steadily and this contributed towards the balanced nutrition of crop which resulted in extreme fruit yield. Meanwhile, Microbien resulted in higher early yield (ton fed^{-1}), total yield per plant and per feddan (ton) than Halex for the first and second seasons, respectively. Among the various chemical N-rates application of 60 kg N fed^{-1}., showed the most significant increase in yield and yield components during both seasons. Increasing early yield with increasing chemical N fertilizer rates agreed with that obtained on squash as reported by [25]**.** Increasing early yield with application of organic fertilizers agrees with that obtained on cucumber by [26]**,** and on melons by [27]**.** Increasing early yield with inoculation of biofertilizer agreed with that obtained on squash cv. "Eskandrany" [25]**.**

Table (5): Effect of organic, bio-, and mineral fertilizers on yield and its components characters squash plants during 2019/2020 and 2020/2021.

Treatments	Early yield (ton/fed.)		Total yield (g/plant)		Total yield (ton/Fed.)	
	2019/2020	2020/2021	2019/2020	2020/2021	2019/2020	2020/2021
Organic fertilizer (main effect)						
Control	**2.03**	**2.86**	**506.7**	**611.8**	**8.52**	**9.99**
Chicken manure	**4.47**	**4.55**	**1019.6**	**999.7**	**16.39**	**16.9**
Compost	**4.44**	**4.65**	**995.4**	**979.1**	**14.21**	**14.1**
LSD(0.05)	**0.18**	**0.19**	**15.9**	**19.4**	**0.36**	**0.35**
Bio-Fertilizer (main effect)						
Control	**2.85**	**2.25**	**705**	**735.9**	**11.7**	**11.9**
Halex	**3.60**	**3.95**	**825.5**	**844.6**	**13.7**	**13.7**
Microbien	**4.48**	**4.88**	**991.1**	**1022.0**	**15.7a**	**16.4**
LSD(0.05)	**0.18**	**0.19**	**15.9**	**19.4**	**0.35**	**0.35**
Mineral fertilizer Kg.N/Fed. (main effect)						
30 kg.N/fed.	**3.41**	**4.25**	**802.0**	**825.5**	**13.2**	**13.4**
45 kg.N/fed.	**359**	**4.04**	**845.2**	**872.9**	**13.9**	**13.9**
60 kg.N/fed.	**3.93**	**4.23**	**874.4**	**904.1**	**14.9**	**14.7**
LSD(0.05)	**0.18**	**24.2**	**15.9**	**19.4**	**0.35**	**0.35**

Values having the same alphabetical letter (s) in common, within each column, do not significantly differ, using L.S.D. test at 0.05 level of probability.

2. Interactions effects

Data in Table (6) showed that significant increase was obtained on early yield (ton/fed.), total yield per plant and per feddan (ton), with the triple interactions of organic manure, bio-fertilizers and chemical N rates, data obtained showed significant effect in both seasons.

Among these interactions, the highest values of early yield per plant (g) were obtained from application of Chicken manure + Microbien + 60 kg N fed^{-1}., for the first and second seasons, respectively. While the highest value of total yield per plant and per feddan (ton), were occur from plants treated with Chicken manure + Microbien + 45 kg N fed^{-1}. Increased yield was correlated to balanced nutrition, better uptake of nutrients by

plants which assisted for good fruit set and yield. More yield of squash in this investigation could be attributed to the impact of fertilizers, a mixture which encourages photosynthesis by more production of endogenous plant growth substances. The profound effect of both bio-and organic fertilizers on yield and quality of squash' s outcomes may be attribute to either the execute or pass off growth promoting substance such as cytokinins [28], the auxin Indole acetic acid[29], gibberellins like substances [30] and /or *via* releasing siderophores compounds [31] that function as chelating agents for iron elements acting its function to enhance the facilitating of iron for different biophysical and biochemical activities of squash plants.

Table (6): Effect of interaction of organic, bio-, and mineral fertilizers on yield and its components characters of squash plants during 2019/2020 and 2020/2021 seasons.

Treatments			Early yield (ton/fed.)		Total yield (g)/plant		Total yield (ton/fed.)	
Organic	Bio	Mineral	2019/2020	2020/2021	2019/2020	2020/2021	2019/2020	2020/2021
Control	Control	30	1.41	1.71	416.7	450.0	6.7	7.2
		45	1.61	2.03	426.7	470.0	6.7	7.5
		60	1.79	2.23	446.7	486.7	6.8	7.8
	Halex	30	1.84	2.67	518.3	541.7	8.4	8.7
		45	1.95	2.83	541.7	565.0	8.8	9.1
		60	2.19	3.04	551.7	685.0	8.7	12.6
	Microbien	30	2.35	3.68	543.3	756.7	8.8	12.1
		45	2.51	3.78	550.0	761.7	8.7	12.3
		60	2.67	3.81	565.0	790.2	12.6	12.6
Chicken manure	Control	30	2.91	3.57	790.0	843.3	12.6	13.6
		45	3.02	3.73	821.7	878.3	13.8	14
		60	3.73	4.24	860.0	900.0	15.4	14.5
	Halex	30	3.92	4.42	961.7	950.0	15.6	15.2
		45	4.59	4.72	975.0	960.0	15.9	15.3
		60	5.07	4.96	993.3	976.7	18.8	15.6
	Microbien	30	5.44	5.27	1140.0	1010.0	20.2	16.4
		45	5.44	5.61	1370.0	1221.7	21.9	19.4
		60	6.08	6.08	1265.0	1185	13.3	19
Compost	Control	30	3.57	5.55	833.30	850.0	13.8	14.6
		45	3.68	3.84	865.0	865.0	14.2	13.9
		60	3.97	3.89	885.0	880.3	14.8	14.2
	Halex	30	4.24	4.19	923.3	943.3	15.6	15.2
		45	4.27	4.34	973.3	986.7	15.9	15.8
		60	4.41	4.37	991.7	993.3	15.9	15.9
	Microbien	30	5.01	4.77	1091.7	1085	17.5	17.4
		45	5.33	5.47	1188.3	1185	19.0	18.9
		60	5.49	5.44	1206.0	1203	19.3	19.3
LSD(0.05)			0.55	72.8	47.8	58.2	245.6	1.06

Values having the same alphabetical letter (s) in common, within each column, do not significantly differ, using L.S.D. test at 0.05 level of probability.

CONCLUSION

In conclusion, the present study suggests positive impacts combined effects of organic manure, bio-fertilizers and chemical nitrogen rates had a significant impact on early yield, total yield per plant and per feddan in both seasons of squash plants under Aswan conditions.

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