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Original Article

Evaluation of the Efficiency of Various Organic Fertilizers on the Growth and Head Yield of Cabbage

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Abstract

Cabbage (*Brassica oleracea* var. capitata L.) is an important vegetable crop worldwide. In this study, response of Cabbage crop (cv. Korsina) to five different (animal, poultry, plant, plant + animal, poultry + animal) organic manure treatments as compared to the chemical fertilization (control) was evaluated under field conditions in two consecutive seasons of 2019/2020 and 2020/2021. The aim of the experiments was to determine the best organic fertilizer (manure) option (whether plant, animal, poultry) for better growth and head yield of cabbage, and to determine the best organic combination on cabbage growth. Various vegetative parameters were measured including head length with and without wrapper leaves, stem length, inner and outer stem diameters, and total head yield. The results of our study showed that some vegetative growth parameters such as stem length, and inner and outer stem diameters were significantly enhanced by the different manure treatments. Cabbage plants fertilized with plant manure had the highest mean values of total head yield. The second best treatment for enhancing total head yield of cabbage was the mixture of plant and animal manure fertilizer. *We conclude that* plant manure can be used either alone or in combination with animal manure for growing the studied cabbage cultivar.

Keywords: *Cabbage, Organic Fertilizers, Poultry Manure, Plant Manure, Animal Manure.*

Introduction

Cabbage (*Brassica oleracea* L.) is considered a major crop which belongs to the Brassiceae family (Hague, 2006 and Moyin-Jesu, 2015). It is low in fat, high in dietary fiber, foliate, water, vitamin A, B and C, processing a very high nutritional density which can help to protect a range of diseases. It is used as fresh in salads and pickles, and it can be boiled, cooked, or dehydrated. It neutralizes acidity, improves digestion and appetite, (Kumar, *et al*., 2017). The total area cultivated of cabbage was 24926 feddan in 2020, with an average yield of 13.344 ton/feddan, according to the Economic Affairs Sector 2020.

Organic or inorganic fertilizers provide plants with the essential minerals for better plant growth and maximal yield (Roba 2018). Organic fertilizers are

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environmentally friendly as they improve soil health, water-holding capacity, and result in better soil structure by increased cation exchange capacity and by lowering bulk density. They also promote a diverse population of beneficial soil microorganisms (Islam, *et al*., 2016; Mohammad, *et al*., 2013 and Bulluck, *et al*. 2002). Moreover, organic matter is a rich source of both macro and micro nutrients, which is required in large quantities for the healthy growth and development of the plant (Kumar, *et al*. 2017).

Organic wastes when decomposed, the resulting product is called vermicompost. The process is called 'vermicomposting' which is reported as a rapid, viable and cost effective procedure for managing solid wastes (Payal, *et al.*, 2006). Animal dung was found to be a pool of essential nutrients (N, P, K and S) for higher yield of cabbage (Asfaw, 2022, Batsai *et al.,* 1997). The content of organic matter in animal manure is also high and its addition to agricultural soils often improves soil structure and chemistry (Antonious, 2016).

Poultry manure is known to improve yields of many different crops. Poultry manure is particularly good for acid soils as it has a liming effect. This manure helps reduce the acidity of the soils which protects plants from aluminum toxicity. The organic poultry manure showed a positive effect on plant height, number of branches, and total yield of cabbage (Pujiastuti, *et al.,* 2018). Earlier reports suggest that a combined application of manures increase the yield and improve the quality of vegetable crops (Bahadur, *et al*., 2004 and Islam, *et al*., 2016).

Although chemical fertilizers are high in prices and are not always available, smallholder farmers are still using them for growing their crops (Wortmann, *et al.,* 2019). Now, there is more awareness of the residual effect of the chemical substances of the inorganic fertilizers used on the crops and soils. Besides, it is an established fact that the excess use of inorganic fertilizers might have negative impact on human health and on the environment because of the residual chemicals (Sharma, *et al.,* 2017), however organic fertilizers do not create such concerns (Tindall, 2000 and Hasan*, et al.,* 2012). On the other hand, the application of organic fertilizer can improve the yield besides keeping the environment sound (Hsieh, *et al.,* 1996).

Considering the above-mentioned factors, *the aim* of the present experiment is to determine the best organic fertilizer (manure) option (whether plant, animal, or poultry) for better growth and head yield of cabbage, and to determine the best organic combination on cabbage growth.

Material and Methods

Open field experiment setup and treatments

A field experiment was conducted at the Vegetable Crops Department Farm, Faculty of Agriculture, Assiut University (located at 27º-11 09′ N, long 31º 16′E and alt 53 m a.s.l.) during the two seasons of 2019/2020 (Season1) and 2020/2021 (Season 2).

The following treatments were assessed:

- T1: plant manure (vegetable compost) at the rate of 12 ton/fed.
- T2: mixture plant and animal manure at the rate of 12 ton/fed. (equally split to 6 ton/fed of plant and 6 ton/fed of animal manure in the plot).
- T3: mixture animal and poultry manure at the rate of 12 ton/fed. (equally split to 6 ton/fed. of animal and 6 ton/fed. of poultry manure).
- T4: animal manure at the rate of 12 ton/fed.
- T5: poultry manure at the rate of 12 ton/fed.
- T6: chemical fertilizers used as a control treatment as recommended by the agricultural ministry.

The vegetable compost was obtained from the agricultural research nursery at the Department of Ornamental Plants and Landscape Gardening, El-Azhar University. The animal compost was from the farm of Animal Production Department, while the poultry compost was from the Farm of the Poultry Production Department", Assiut University in the two following seasons.

Control treatment of chemical fertilization application was equal to 150 kg N/fed. and 45 kg P_2O_5/fed., as recommended by the Agricultural Ministry. Organic fertilization was blended with soil in each row on the 20th of October in S1 and on 25th of October in S2. Soil was subsequently irrigated and the seedlings were planted on the following day of each season. Ten seedlings of cabbage plantlets 'Korsina' cultivar (*Brassica oleracea* var. capitata L) were planted in each row and the distance between plants was 25 cm. The seedlings were obtained from El-Salam nurery, Assiut governorate.

The experiment was designed as a randomized complete block. There were 6 treatments in 6 plots and each plot consisted of 6 rows. The row length was 3.5 m while the distance between each row was 0.70 m. Therefore, the plot size area was 4.2 m^2. The experiment had three replications (two rows/replicate) for a total of 6 rows/plot. Harvest of cabbage plants was started on the 25th of February.

Soil samples collection and analysis

Random soil samples were gathered from each plot of the examination at 25 cm depth, before and after planting to measure some physicochemical properties of the soil (Table 1). Analysis was conducted at the Soils Lab for Analytics and Technical Consultations at the Soils and Water Department, Faculty of Agriculture, Assiut University, Assiut, Egypt.

Chemical analysis of manures

Table 2 shows the chemical analysis of the animal, poultry, and plant manure samples. Analysis was conducted at the Soils Lab for Analytics and Technical Consultations at the Soils and Water Department, Faculty of Agriculture, Assiut University, Assiut, Egypt.

Table 1. Some physical and chemical properties of soils

Soil properties	2019 and 2020
1- Physical properties	
Sand %	57.52
Silt %	12.00
Clay %	30.48
Soil Text grade	Sandy clay loam
2- Chemical properties	
pH (1:2.5) suspension	7.72
N %	0.06
P %	0.01
K%	0.34
Total $CaCO_3$ %	2.40
EC e calculated moles/cm	3.87
Hyper capacity %	63.20
EC Mill moles/cm 1:2.5	0.0979

N% = Nitrogen percentage, P% =phosphorus percentage, K% =potassium percentage, CaCO3% = Calcium Carbonate percentage, and EC e = Calculated electrical conductivity

Table 2. Analysis of poultry, vegetable, and animal compost samples in the two seasons of 2019/2020 -2020/2021

	Season 1			Season 2		
	Poultry compost	**Vegetable compost**	**Animal compost**	**Poultry compost**	**Vegetable compost**	**Animal compost**
pH (1: 2.5 H_2O)	7.22	7.71	7.96	7.00	7.75	7.78
EC Mill moles/cm (1: 2.5)	14.60	7.51	17.21	9.90	12.18	9.30
N%	2.97	0.92	1.62	3.91	1.26	1.32
P%	0.02	0.01	0.01	1.52	1.21	1.04
K%	2.00	1.15	1.70	2.65	2.35	1.75
Organic matter	5.26	3.51	3.51	43.60	6.00	35.20

EC: electrical conductivity, N% = Nitrogen percentage, P% =phosphorus percentage, K% =potassium percentage,

Plant growth traits and head yield of cabbage

Plant growth traits were measured at harvest time. Three cabbage heads were randomly selected from each row to measure head length with and without wrapper leaves (cm), wrapper leaves number, stem length (cm), and stem inner and outer diameters (cm). After cutting the head from the soil surface, it was weighed on a digital scale (g). Measurement of the diameters of inner and outer stem (cm) was done using Vernier caliper, while length of the head was measured using a ruler from the beginning of the stem till the top of the head of cabbage (cm). Cabbage head yield was calculated in ton/feddan.

Statistical analysis

The experimental data were statistically analyzed using analysis of variance (ANOVA) and the experimental data were statistically analyzed using 1998-2004 CoHort Software, CoStat Software, version 6.303 (798 Lighthouse Ave. PMB 320, Monterey, CA, 93940, USA). Means of the studied traits were compared using L.S.D at 5% probability level according to (Steel and Torrie, 1981).

Table 3. Effect of different fertilizers on the growth and head yield of cabbage

Treatment	Head length with wrapper leaves (cm)	Wrapper leaves number	Head length without wrapper leaves (cm)	stem length (cm)
		Season 1		
T1	36.000 ab	8.000 a	13.733 a	8.733 a
T2	37.333 ab	8.333 a	12.133 ab	7.833 ab
T3	38.667 a	7.333 a	11.633 ab	7.800 ab
T4	34.467 b	8.000 a	11.533 ab	6.867 b
T5	27.767 c	7.333 a	7.500 c	3.567 c
T6	19.933 d	8.000 a	11.000 b	6.333 b
		Season 2		
T1	31.300 a	8.333 bc	18.733 a	10.867 a
T2	30.667 a	10.667 a	18.533 a	10.700 a
T3	30.567 a	9.667 ab	16.633 a	9.467 a
T4	29.200 a	10.333 a	17.500 a	9.400 a
T5	30.467 a	9.333 abc	17.233 a	9.500 a
T6	19.133 b	8.000 c	11.000 b	6.467 b
L.S.D $_{0.05}$				
Season 1	3.130	1.151	2.336	1.822
Season 2	3.905	1.546	3.296	2.111

Means with the same letter are not significant at 5% level according to LSD multiple range test.
T1= Plant manure, T2= Plant and animal manure, T3= Animal and poultry manure, T4= Animal manure, T5=Poultry manure and T6=Chemical fertilizers

Results and Discussion

The effect of different manures and their combinations on the vegetative growth and head yield of cabbage (ton/feddan) is presented in (Table 3). Head length with wrapper leaves were significantly higher in all treatments, compared to the control in the two seasons of the study (Table 3). Only T1 plants that had significantly higher head length without wrapper leaves and stem length than the

control in S1, however, all treatments had significantly higher head length with wrapper leaves and stem length than the control in S2 (Table 3).

Outer stem diameter was significantly higher in plants of all treatments as compared to the control in the two seasons (Table 3). Inner stem diameter was consistently significantly higher in plants treated with T1, T2, T3, and T4 than the control in the two seasons (Table 3). Regarding the total head yield (ton/feddan), only T1 and T2 were consistently significantly higher than the control in the two seasons (Table 3).

Table 3. Continued

Treatment	Outer stem diameter (cm)	Inner stem diameter (cm)	Total head yield (ton/fed)
		Season 1	
T1	3.10 a	3.967 a	34.30 a
T2	2.93 ab	4.067 a	25.96 bc
T3	3.00 ab	3.700 ab	30.58 ab
T4	2.87 b	3.467 b	21.51 cd
T5	2.33 c	2.267 c	16.87 d
T6	2.07 d	2.067 c	14.31 d
		Season 2	
T1	2.53 b	3.900 a	32.63 a
T2	2.63 ab	3.900 a	31.72 a
T3	2.90 a	2.967 c	15.09 b
T4	2.40 b	3.267 bc	15.93 b
T5	2.50 b	3.667 ab	17.11 b
T6	2.07 c	2.067 d	12.48 b
L.S.D $_{0.05}$			
Season 1	0.19	0.390	7.79
Season 2	0.285	0.512	7.97

Means with the same letter are not significant at 5% level according to LSD multiple range test.
T1= Plant manure, T2= Plant and animal manure, T3= Animal and poultry manure, T4= Animal manure, T5=Poultry manure and T6=Chemical fertilizers.

The results of our study proved that plant manure was the best treatment for improving cabbage vegetative growth, and consequently for increasing total head yield (ton/feddan) as compared to the control and all other manure treatments. The second best treatment of the study was the mix of plant + animal manure.

Findings of our study are in harmony with those obtained by Chaudhary *et al.* (2018) who observed that application of organic manure increased head diameter of cabbage. Also, Wanderley *et al*. (2004) and Laczi *et al*. (2016) found that cultivation of Chinese cabbage under the influence of organic manure produced the highest mean value of heads characteristics such as length, diameter,

and weight, and on the number of leaves and yield, when compared with the control.

Application of manures might have improved soil porosity, structure, aggregation, water holding capacity, and supplied plants with growth promoting substances, improved availability of nutrients, as well as encouraged plants to have good root development by improving the aeration in the soil Awad *et al*. (2021). All the mentioned factors might have significantly increased vegetative growth of the studied cabbage cultivar of our experiment. Similar finding was observed by Teshome *et al*. (2018). Obidola *et al*. (2019) reported that the introduction of organic farmyard manure to soils enhanced the microbial activity and thereby increased the fertility of the soil, hence the productivity.

Cabbage is a vegetative crop which requires large amount of essential nutrients for the growth and for the production of high head yields. Lešić *et al*. (2003) and Debrah *et al*. (2021) recorded that cabbage had high requirements for all nutrients, especially nitrogen (130 to 310 kg N/ha) for achieving high yields. Also, Bahadur *et al*. (2004) and Debrah *et al*. (2021) stated that proper fertilization is needed to increase the yield and to improve the quality of cabbage. As organic fertilizers store plant nutrients and decrease loss of elements by leaching, they are considered good source of nutrients, which are necessary for the growth of the cabbage crop. They also activate beneficial soil organisms such as earthworms. Moreover, organic fertilizers are exposed to mineralization which releases substantial quantities of nitrogen, phosphorus, Sulphur, and small amount of micronutrients (Prabhakar, 2020 *et al*., and Debrah *et al*., 2021).

In conclusion, our data revealed that the tested fertilizers treatments had a significant effect on the total head yield trait of the cabbage cultivar (cv. Korsina) in the two growing seasons. Cabbage plants fertilized by plant manure gained the highest mean values of total head yield (34.30 ton/feddan in S1 and 32.63 ton/feddan in S2.). The second best treatment for enhancing total head yield of cabbage was the plant+ animal manure fertilizer. We conclude that plant manure can be used either alone or in combination with animal manure for growing the cabbage cultivar (cv. Korsina).

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تقييم تأثير الأسمده العضويه المختلفه على نمو ومحصول الكرنب

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قسم الخضر – كلية الزراعة – جامعة أسيوط

الملخص

الكرنب من اهم محاصيل الخضر فى جميع انحاء العالم، فى هذه الدراسة، تم دراسة استجابه محصول الكرنب صنف كورسينا لخمس انواع مختلفة من السماد العضوي (سماد حيوانى – دواجن - نباتى - نباتى + حيوانى - دواجن + حيوانى) مقارنه بالسماد الكيماوى (الكنترول) تحت الظروف الحقل فى كلا الموسمين (٢٠١٩/٢٠٢٠ ، ٢٠٢٠/٢٠٢١).

الهدف من التجربة لتحديد افضل سماد عضوى (سواء كان سماد نباتى - حيوانى او دواجن) لتحقيق افضل نمو ومحصول للرأس ولتحديد افضل خليط من السماد لنمو محصول الكرنب.

القياسات الخضرية المختلفة تشمل طول الرأس بالأوراق الخارجية، عدد الاوراق الخارجية، طول الرأس بدون الاوراق الخارجية، طول الساق، قطر الساق الداخلية والخارجية، محصول الرأس الكلى.

اوضحت النتائج فى دراسة بعض من القياسات النمو الخضرية مثل طول الساق- قطر الساق الداخلية والخارجية تم تحسينها بشكل واضح باستخدام معاملات الاسمده المختلفه.

نباتات الكرنب التى تم تسميدها بالسماد النباتى شكلت اعلى القيم فى المحصول الكلى للرأس. ثم يليه افضل معامله فى تحسين محصول الرأس الكلى وهى الخليط بين النباتى والحيوانى. نستنتج من ذلك ان السماد النباتى يمكن ان يستخدم بمفرده او مع خليط مع السماد الحيوانى لنمو صنف الكرنب المدروس.