Effect of Organic Fertilizer Instead of Chemical Fertilizer on Tomato Growth and Soil Properties in Sunlight Greenhouse

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Keywords: Organic fertilizer instead of chemical fertilizer; Tomato; Growth; Soil nutrients

Abstract: In order to explore the effect of organic fertilizer instead of chemical fertilizer on tomato growth and soil fertility in sunlight greenhouse, this experiment used four treatments in two greenhouses of Shui Gaozhuang village and Xiao Shawo village. The results showed that organic fertilizer instead of 30% and 20% of chemical fertilizer could increase soil total and available nitrogen, phosphorus and potassium levels, and reduce soil bulk density, pH and EC. The organic fertilizer instead of 30% and 20% of chemical fertilizer promote would conducive to the accumulation of chlorophyll and nitrogen in tomato leaves, promote tomato growth and increase yield tomato growth.

1. Introduction

With the development of vegetable facilities in China, in the production process excessive application of chemical fertilizer and partial application of nitrogen fertilizer is very common. It will result the accumulation of nitrogen, phosphorus and other nutrients in the soil. When the nutrient accumulation exceeds its environmental tolerance, it will bring stress to environment. Excessive nutrients will aggravation soil secondary salinization, causing soil degradation, agricultural non-point source pollution, and causing waste of resources[1]. According to law of the diminishing returns, excessive application of nutrients will cause vegetables enter the production plateau, which will reduce the quality of agricultural products[2].Excessive nitrogen will makes the chlorophyll content close to saturation state, so that the leaves will ageing in advance and vegetables quality will be reduced[3].With blind and excessive application of chemical fertilizers, the environmental problems becoming more and more significant. According to the first national census of pollution sources, the loss of nitrogen and phosphorus from agricultural non-point sources accounts for one-third of the total[4]. The National Agricultural Work Conference held at the end of 2014 clearly stated that agricultural non-point pollution control needs"One Control,Two Reductions and Three Basics". The two reductions mean to reduce chemical fertilizers and pesticide application. In February 2015, the Ministry of Agriculture formulated the"Zero-growth Action Plan on Fertilizer Use by 2020". The plan "strives to achieve zero growth in the use of chemical fertilizers for major crops in 2020.The National "13th Five-Year Plan" outlines "to control the amount of fertilizer application" also strives to achieve zero growth target of chemical fertilizer use in 2016.The 2018 Document No.1 of the Central Committee proposed to promote the replacement of chemical fertilizers by organic fertilizers and reduce investment in chemical agriculture. Organic fertilizer has a lot of advantages such as improving physical and chemical properties of soil, increasing organic matter content in soil, improving soil fertility, etc. Obviously it is accord with the requirements of Chinese Green Sustainable Development Agriculture. Some scholars have proved that the application of organic fertilizer combined with chemical fertilizer can make the quick and slow effects of fertilizer complementary, improve the soil, and improve the utilization rate of fertilizer[5].

  DOI: 10.25236/isafb.2019.022

The feasibility of replacing organic fertilizers with fertilizers has been confirmed in rice cultivation[6]. Replacing chemical fertilizer with organic fertilizer can not only achieve the purpose of reducing fertilizer, but also promote the growth of plants. Tomato is a kind of popular fruit and vegetable which is widely planted in the world. Because of its nutrition and taste, it is deeply loved by consumers. It has high economic benefits and can be planted in greenhouses in every seasons[7]. In recent years, the research on fertilization of tomato is concentrated on formula fertilization[8], and there is relatively little research on the growth of tomato in greenhouse with organic fertilizer instead of chemical fertilizer. This experiment explores the effects of organic fertilizers instead of chemical fertilizers on tomato growth quality and soil properties, provides theoretical support for Zero-growth Actions of Fertilizers, and provides a reference for farmers to rationally fertilize.

2. Materials and Methods

2.1 Research Location.

The experiment was carried out in the sunlight greenhouse of Shui Gaozhuang Village and Xiao Shawo Village, Xin Kou Town, Xi Qing District, Tianjin.

2.2 Test Materials.

Shui Gaozhuang Village: The test sunlight greenhouse was coded as A, the soil was fluvo-aquic, the experimental soil in 0-30 cm had organic matter 18.96 g/kg, total nitrogen 1.30 g/kg, nitrate nitrogen 28.64 mg/kg, total phosphorus (P) 0.87 g/kg, available phosphorus (P) 50.49 mg/kg, available potassium (K) 49.91 mg/kg, pH (H_2O) 8.46, EC 248.50 μm/cm. Experimental vegetables was tomato (Oukele).Organic fertilizer (N 1.52%, P_2O_5 0.97%, K_2O 2.84%) produced by Heng Run (Tianjin) Biotechnology Development Co.Ltd. and the chemical fertilizer was urea (N 46%),calcium phosphate (N 18%, P_2O_5 46%), potassium sulfate (K_2O 60%), top dressing was Ba Tian 15-10-23 compound fertilizer.

Xiao Shawo Village: The experimental sunlight greenhouse was coded as B, the soil was fluvo-aquic, the experimental soil in 0-30 cm had organic matter 56.35 g/kg, total nitrogen 1.55 g/kg, nitrate nitrogen 49.05 mg/kg, total phosphorus (P) 5.56 g/kg, available phosphorus (P) 208.58 mg/kg, available potassium (K) 118.52 mg/kg, pH (H_2O) 8.13, EC 279.50 μm/cm. Experimental vegetables was tomato (AK-19). Experimental organic fertilizer and chemical fertilizer used as above.

2.3 Experimental Design.

The A's area is 862 m^2, and we used plot experiment, the area of each plot was 71.8 m^2, and there were 4 kinds of base fertilizer treatment. The representative symbols was CK1 (conventional fertilization), DY1 (organic fertilizer instead of 10% fertilizer), MY1 (organic fertilizer replacement 20% fertilizer) and GY1 (organic fertilizer instead of 30% fertilizer), repeated 3 times per treatment, and the fertilization amount in test plot was shown in table 1. The base fertilizer was applied once before transplanting in the soil preparation. The top dressing was applied to the soil in 5 times during the growth of the tomato, and the per plot was 1.6 kg (18.41kg for 666.7 m^2). Seedlings began in mid-December 2017 and were transplanted on February 1, 2018. The cultivation method is the same as the traditional alfalfa planting method, with a row spacing of 50 cm and a plant spacing of 40 cm.

The B's area was 288 m^2, and the area of each plot was 24 m^2, and there are 4 kinds of base fertilizer treatment, the representative symbols were CK2 (conventional fertilization), DY2 (organic fertilizer instead of 10% fertilizer), ZY2 (organic fertilizer instead of 20 % fertilizer) and GY2 (organic fertilizer instead of 30% fertilizer), repeated 3 times per treatment, and the fertilization amount in the test plot was shown in Table 1. The base fertilizer was applied once before transplanting in the soil preparation. The top dressing was applied to the soil in 5 times during the growth of the tomato, and per plot was 0.55 kg (15.27 kg for 666.7 m^2). Seedlings began to be planted in mid-December 2017, transplanted and planted on February 9. The cultivation method is

the same as the traditional alfalfa planting method, with a row spacing of 50 cm and a plant spacing of 40 cm.

Table 1 Test fertilizer and organic fertilizer dosage

Processing number	Fertilizer dosage [kg/666.7m^2]			Organic fertilizer (dry basis) dosage and nutrient content[kg/666.7m^2]			
	N	P_2O_5	K_2O	Dosage	N	P_2O_5	K_2O
A							
CK1	24.00	20.00	15.00	350.00	5.32	3.40	9.94
DY1	22.56	19.08	12.30	445.00	6.76	4.32	12.64
MY1	20.50	17.77	8.47	580.00	8.82	5.63	16.47
GY1	18.84	16.71	5.14	690.00	10.48	6.69	19.80
B							
CK2	20.00	16.00	14.00	300	4.56	2.91	8.52
DY2	18.56	15.13	11.31	395	6.00	3.83	11.21
MY2	17.20	14.30	8.50	495	7.52	4.80	14.06
GY2	15.74	13.28	6.00	580	8.82	5.63	16.47

2.4 Sampling and Determination Methods.

During the growth of tomato, chlorophyll and nitrogen content of tomato leaves were determined by TYS-3N plant nutrition analyzer, and A's plant height of the tomato plants was measured with a tape measure on March 13 and April 7, B's plant height of the tomato plants was measured with a tape measure on March 13 and April 5. In each experiments, the soil physical and chemical properties of 0-30 cm in each plot were measured before the application of the base fertilizer and the tomato harvested (table 2). When the tomato is ripe for picking, the yield is calculated according to the plot, which is converted into the yield of 666.7 m^2.

Table 2 Method for determining soil physical and chemical properties

Soil properties	Test methods
Organic matter	Chulin method
Total nitrogen	Concentrated sulfuric acid, Semi-micro-Kelvin method
Total phosphorus	Sodium hydroxide melting, Molybdenum antimony, Spectrophotometer
Total potassium	Nitric acid and perchloric acid digestion, Flame photometer or atomic absorption spectrometry
Alkaline nitrogen	Alkaline solution diffusion method
Available phosphorus	Sodium carbonate extraction, Molybdenum antimony, Spectrophotometer
Available potassium	Sodium acetate extraction,Flame photometer
Bulk weight	Ring knife method
pH	Water extraction, Acidity meter
EC	Water extraction, Conductivity meter

2.5 Data Statistics Method.

Use Microsoft Excel (Office 2003) to make charts and use DPS software to process data.

3. Results and Analysis

3.1 Effects of Organic Fertilizer Instead of Chemical Fertilizeron Soil Physical and Chemical Properties. Effect of Organic Fertilizer Instead of Chemical Fertilizer on Total Nutrient in Soil.

As it was shown in table 3, that in the treatment of organic fertilizer instead of chemical fertilizer

after tomato harvested, the total nitrogen content in the soil were inconsistent with the A and the B' soils, and the order from high to low of different fertilization treatments in the A'soil was GY1>MY1>CK1>DY1, GY1 and MY1 were significantly higher than CK1 and DY1, the difference between GY1 and MY1, CK1 and DY1 was not significant.It indicated that the replacement of chemical fertilizer with organic fertilizer in the A had a significant effect on the accumulation of total nitrogen in soil. The difference of total nitrogen content between DY1 and CK1 was not significant. The order from high to low of different fertilization treatment in soil the B was CK1>GY1>MY1>DY1, and the difference between treatments was not significant. It was indicated that under the condition of the B, there was no significant difference between different fertilization treatment for soil nitrogen accumulation.

Table 3 Differences of total nutrient contents in different fertilization treatments soils [g/kg]

Treatment	Total N	Total P	Total K	OM
A				
CK1	1.93bA	1.51aA	0.70aA	31.21 bB
DY1	1.89bA	1.52aA	0.77aA	29.34 bB
MY1	2.23aA	1.57aA	0.75aA	35.68 abAB
GY1	2.45aA	1.59aA	0.80aA	43.11 aA
B				
CK1	2.53aA	5.30abAB	0.99aA	59.40 bB
DY1	2.29aA	5.13bB	1.06aA	63.89 bB
MY1	2.30aA	5.27abAB	1.06aA	71.96 aA
GY1	2.38aA	5.47aA	1.09aA	73.10 aA

Table 3 showed that there was difference in soil total phosphorus content between the A and the B.The total phosphorus in the B's soil was very high. The performance of different fertilization treatments of two sunlight greenhouses after tomato harvested was also inconsistent. The difference was not significant, and four treatment changes were between 1.51 and 1.59 g/kg. The highest content of total phosphorus in GY2, which was significantly higher than DY2, and difference between CK2 and MY2 was not significant. It indicated that the replacement of 30% chemical fertilizer by organic fertilizer promoted the accumulation of total phosphorus in soil, and under different soil conditions, the effect of organic fertilizer instead of chemical fertilizer was different.

There was no significant difference in the total potassium content of the soil after tomato harvested between the two sunlight greenhouses'soil(table 3). The variation of different fertilization treatments in soil of A was between 0.70 and 0.80 g/kg. The change of total potassium content in the soil of the B was small, and the variation of four treatments was between 0.99 and 1.09 g/kg. The lowest was CK2, and the highest was GY2, indicating that the application of organic fertilizer would increase the total potassium content in the soil.

In the treatment of organic fertilizer instead of chemical fertilizer after tomato harvested, soil organic matter content of the A and the B were inconsistent in order from high to low (table 3) in the A was GY1>MY1>CK1>DY1. The content of organic matter in GY1' soil was the highest, which was 43.11 g/kg, and the lowest was DY1, which was 29.34 g/kg. The difference between MY1 and GY1, CK1 and DY1 was significant, and the difference between MY1 and GY1 was significant. It indicated that replacement of 30% chemical fertilizer by organic fertilizer had a significant effect on the accumulation of soil organic matter. The content of organic matter of soil the B in difference treatment from high to low was GY2>MY2>DY2>CK2, and GY2 was the highest, which was 73.10 g/kg, and the lowest was CK2, which was 59.40 g/kg. The difference between MY2 and GY2, CK2 and DY2 was significant. It indicated that the replacement of chemical fertilizer with organic fertilizer had a significant effect on the accumulation of soil organic matter. It also indicated that organic fertilizer could increase the content of organic matter in soil.

3.2 Effects of Organic Fertilizer instead of Chemical Fertilizer on Soil Available Nutrient Contents.

From table 4 we can find that, the order of nitrate nitrogen content in soil of the A from high to low was GY1>MY1>CK1>DY1, and GY1 (49.06 mg/kg)was the highest, and DY1(30.96 mg/kg)was the lowest. The order of that in soil of the B was GY2>CK2>DY2>MY2, and GY2(48.23 mg/kg)was the highest, and MY2 (45.73 mg/kg)was the lowest. GY1 was significantly higher than DY1 and CK1, GY2 was significantly higher than MY2. It was indicated that the content of nitrate nitrogen in the treatment of 30% chemical fertilizer replaced by high organic fertilizer of the A and the B's soil were significantly higher than that in other treatments.The organic fertilizer could increase the soil nitrate nitrogen content.

Table 4 also showed that the difference of available phosphorus in soil of the two greenhouses were not significant between the different treatments, especially in B, the values were almost equal, and results were the same as the total phosphorus. The available phosphorus in different treatments of the A was ranked from high to low as GY1>MY1>CK1>DY1, indicating that the replacement of chemical fertilizer by organic fertilizer could increase the available phosphorus content of soil.

The order of available potassium in the A and the B's soil from high to low were MY1>GY1>CK1>DY1 and GY2>MY2>DY2>CK2 respectively, it showed that the available potassium content of replacing organic fertilizer treatments was higher than other treatments, especially in the A, GY1 and MY1 were significantly higher than CK1 and DY1, the difference between GY1 and MY1 was not significant. It showed that the replacement of chemical fertilizer with organic fertilizer could increase the content of available potassium in soil.

Table 4 Differences in soil available nutrient contents under different fertilization treatments [mg/kg]

Treatment	Nitrate N	AvailableP	AvailableP
A			
CK1	35.29 bAB	159.28 aA	80.04 bB
DY1	30.96 bB	158.88aA	69.65 cB
MY1	41.83 abAB	168.70 aA	93.89 aA
GY1	49.06 aA	174.81 aA	92.51 aA
B			
CK2	48.08aA	340.26aA	223.81 aA
DY2	47.30abAB	340.32aA	227.95 aA
MY2	45.73bB	340.32aA	229.36 aA
GY2	48.23aA	340.39aA	239.06 aA

3.3 Effects of Organic Fertilizer instead of Chemical Fertilizer on Soil Bulk Density, Etc.

From table 5 we could see that, the change of soil bulk density of different fertilization treatments in the A and the B after tomato harvested was similar. The soil bulk density of organic fertilizer substituting chemical fertilizer was decreased, which showed that the bulk density of control treatment was the highest, and the high organic fertilizer instead of the chemical fertilizer treatment was the lowest. The change of soil bulk density in the soil of the A was between 1.25 and 1.15 g/cm^2, and the soil of the B was between 1.14 and 1.26 g/cm^2. The suitable bulk density for plant growth was 1.14-1.26 g/cm^2, indicating that increasing the amount of organic fertilizer applied would improve the physical and chemical properties of the soil, makes soil more loose, more porous and more suitable for growing plant.

Table 5 also showed that in the treatment of organic fertilizer instead of chemical fertilizer, the pH values of the A and the B were similar, and the difference between treatments was 0.1 and 0.11 respectively. The MY1 and GY1 were significantly lower than MY2 and CK1 in the A, MY2 and GY2 were significantly lower than CK2 and DY2 in the B, between MY1 and GY1, CK1 and DY1, MY2 and GY2, CK2 and DY2 were obviously different. The reason was that organic acids were produced during the mineralization of organic fertilizers, which caused the decrease of pH value in alkaline soils, indicating that medium and high organic fertilizers replace chemical fertilizers could

improve alkaline soils [9].

It could be seen from table 5 that after tomato harvested, EC value was the highest in the A and the B with the traditional high-concentration chemical fertilizer, but the difference was not significant in each treatment. The EC value of GY1 was the lowest in the A,DY2 was the lowest in the B. It showed that the application of high concentration of chemical fertilizer in the soil would increase the soil salinity, it would cause environmental non-point pollution, and reduce soil quality and produces secondary salinization[10].

Table 5 Soil sulk density, pH and EC between different fertilization treatments

Treatment	Bulk weight[g/cm]	pH	EC
A			
CK1	1.25aA	8.43aA	273.33 aA
DY1	1.22bB	8.40abA	268.37 aA
MY1	1.18cC	8.35bA	268.33aA
GY1	1.15dC	8.33bA	262.17aA
B			
CK2	1.31aA	8.46aA	184.03aA
DY2	1.28bAB	8.49aA	171.27aA
MY2	1.27bB	8.37bB	179.37aA
GY2	1.26bB	8.35bB	177.32aA

3.4 Effects of Organic Fertilizer instead of Chemical Fertilizer on Tomato Growth.

3.4.1 Effect of organic fertilizer instead of chemical fertilizeron plant height of tomato.

It could be seen from figure 1 that the order of plant height of different fertilizer treatment from high to low on March 11 and April 7 were MY1>GY1>CK1> DY1 in the A, the results of 2 measurements were not significantly different between different fertilization treatments. The result of the B was the same as that of the A(figure 2), The results of different fertilization treatments from high to low on March 13 and April 5 were MY2>GY2>CK2=DY2, and the plant height between different fertilization treatments were not obviously different. The results of two greenhouses' experiments showed that the plant height after treatment with organic fertilizer instead of chemical fertilizer was higher than that of the other treatment, indicating that the treatment of organic fertilizer instead of chemical fertilizer had a certain promoting effect on the plant height of tomato.

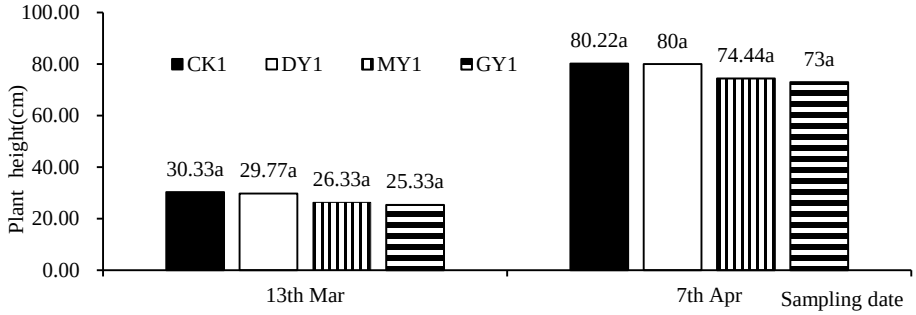

Fig. 1 Different fertilization treatment of tomato plant height in the A

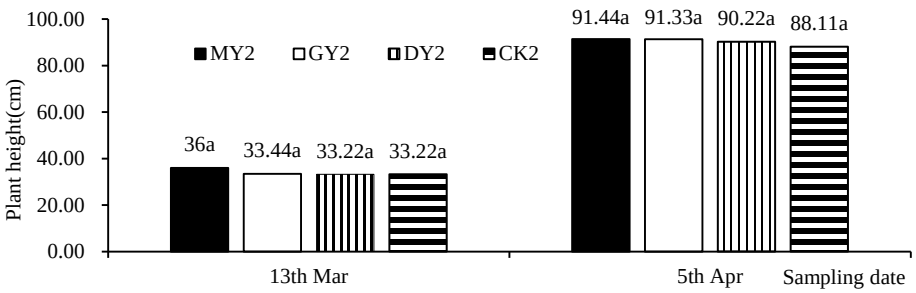

Fig. 2 Different fertilization treatment of tomato plant height in the B

3.4.2 Effect of organic fertilizer instead of chemical fertilizeron physiological indexes of tomato.

It could be seen from Fig.3 and Fig.4 that the nitrogen content and chlorophyll content of the leaves of the A's tomato were the same from high to low, the results of March 11 and April 7 were different between different fertilization treatments. Among them, on March 11 the order of different fertilization treatments was GY1>MY1>CK1>DY1, on April 7, it was GY1> MY1>DY1>CK1. The nitrogen content and chlorophyll content of tomato leaves in the B were tested on March 13 and April 5 (Fig.5 and 6), the order of different fertilization treatments both were MY2>GY2>CK2>DY2. The difference between treatments did not reach significant level. It indicated that the effect of organic fertilizer instead of chemical fertilizer on the content of nitrogen content and chlorophyll content in tomato leaves was not significant.

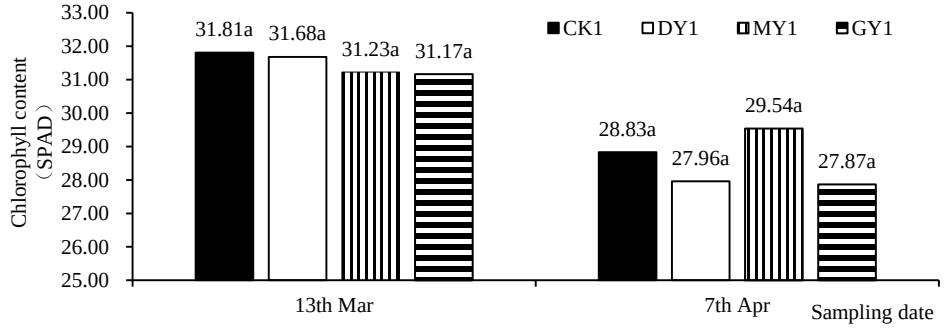

Fig. 3 Chlorophyll content of tomato leaves treated with different fertilization treatments of the A

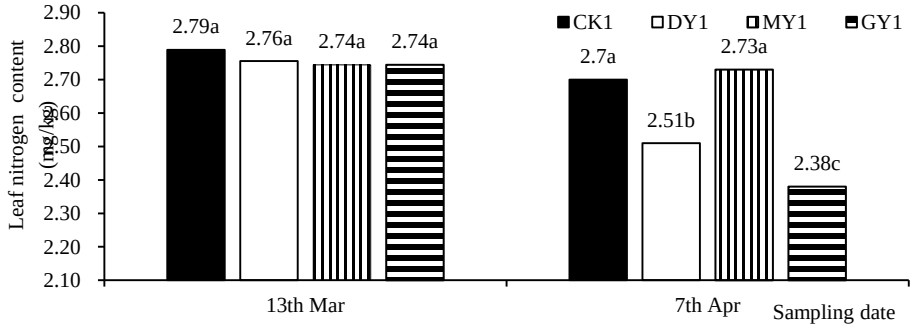

Fig. 4 Nitrogen content of tomato leaves in different fertilization treatments of the A

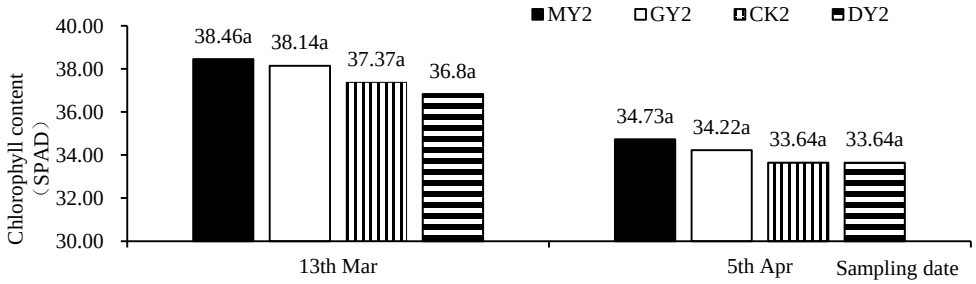

Fig. 5 Chlorophyll content of tomato leaves in different fertilization treatments of the B

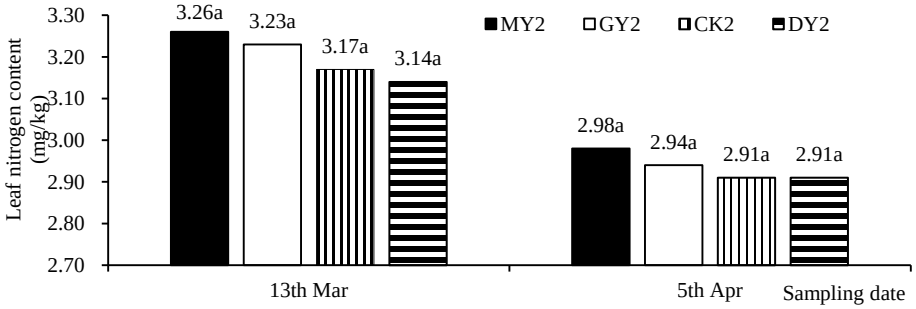

Fig. 6 Nitrogen content of tomato leaves in different fertilization treatments of the B

3.4.3 Effect of organic fertilizer instead of chemical fertilizer on tomato yield.

The yield of tomato in the A and the B(table 7) showed that the treatment of GY1, GY2 and MY1, MY2 significantly higher than CK1, CK2 and DY1, DY2. The difference between GY1, GY2 and MY1, MY2, CK1, CK2 and DY1, DY2 were not significant. It also showed that the replacement of chemical fertilizer with organic fertilizer could significantly increase tomato yield.

Table 6 Yield of tomato with different fertilization treatments in the A and the B

Treatment	Yield[kg/666.7m^2]	Treatment	Yield[kg/666.7m^2]
GY1	5930.97aA	GY2	5969.74aA
MY1	5874.18aA	MY2	5698.42abA
CK1	5569.84bAB	DY2	4930.80bA
DY1	5446.29bB	CK2	4874.31bA

4. Results

According to the experiment, from the perspective of soil nutrient, organic fertilizer could replace soil fertilizer to promote soil nutrient accumulation and conversion, it could promote the absorption of nutrients in soil and the transformation of soil nutrients. It provided the required nutrients for the growth of tomato, it could improve the physical and chemical properties of soil, improve the soil voids, alleviate the stress of alkaline soil on tomato, and make the soil more suitable for tomato growth. From the perspective of tomato growth physiology, the replacement of chemical fertilizer with organic fertilizer could promote the growth of tomato stems, promote the accumulation of chlorophyll and nitrogen of leaves, promote the photosynthesis of tomato leaves, and promote the accumulation of dry matter in tomato.

Acknowledgements

National key research and development plan project, Demonstration of Integrated Pollution Prevention Technology for Facility Vegetable Production (2018YFD0800405)

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