Application Effect of Sludge Extract in the Planting of *Zinnia elegans*

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Abstract [**Objectives**] The research aimed to study the effect of sludge extract on the growth of *Zinnia elegans*, and evaluate its possibility of application. [**Methods**] *Z. elegans* was taken as research object, and the effect of sludge extract on the growth indicators of *Z. elegans* was studied. [**Results**] The sludge extract can obviously promote the growth of *Z. elegans*, and the growth indicators were significantly improved when compared with the control group. The application effect was close to that of foliar fertilizer purchased in the market. In each treatment group, the low concentration of sludge extract did not significantly promote the growth of *Z. elegans*, while too high concentration could inhibit its growth, and the optimal dilution ratio was 600 times. [**Conclusions**] Further preparation of amino acid foliar fertilizer from sludge extract and its application in planting garden plants can realize the resource utilization of sludge and has a good development and application prospect.

Key words Sludge extract, *Zinnia elegans*, Plant growth

1 Introduction

With the rapid development of urbanization, the amount of sludge produced by urban sewage treatment in China has increased significantly[1]. It is reported that the amount of urban sludge in China can reach 7 500 tpd[2]. Incineration, composting and landfill are common solutions to surplus sludge, but there are many limitations[3]. From the perspective of environmental protection and sustainability, the best way of sludge disposal is resource utilization[4]. The sludge contains relatively abundant nutrients required for plant growth, and high protein content[5], which has the potential of resource utilization and is an excellent resource of amino acid foliar fertilizer. Therefore, the development of protein in sludge, the preparation of amino acid foliar fertilizer and the study of its application in agriculture and forestry[6] could not only broaden the raw materials of amino acid foliar fertilizer and reduce the production cost of amino acid foliar fertilizer, but also realize the resource utilization of sludge from sewage treatment plant[7].

Zhang Aifang *et al.*[8] carried out the research on the direct application of sludge as fertilizer in agriculture and forestry. Yang Yang *et al.*[9-10] carried out the research on sludge composting. Deng Jinfang *et al.*[11-12] carried out the research on the preparation of cultivation substrate for agriculture and forestry by sludge and other materials. At present, the research on sludge mainly focuses on direct application, composting and cultivation substrate[13]. Foliar fertilizer has the advantages of fast fertilizer efficiency, high nutrient utilization rate and low environmental pollution, and has become an important part of modern agricultural fertilizer[14]. In the research on the development of surplus sludge into foliar fertilizer, only Shi Zhoufang *et al.*[15] carried out the research on the preparation of amino acid foliar fertilizer by using surplus activated sludge, and there is no report on the preparation of amino acid foliar fertilizer by sludge and its application in gardens. Plant treatment and agricultural utilization is a new field of urban sludge treatment technology at present. It has the advantages of low cost and no secondary pollution, and has gradually become a hotspot of international research and development[16].

Zinnia elegans belongs to *Zinnia* L. of Asteraceae, is annual plant, and is widely used in landscaping[17]. Therefore, the research on the application effect of sludge extract in the planting of *Z. elegans*, the effect of sludge extract on the growth of *Z. elegans*, and the possibility of its application could provide a theoretical basis for the preparation of amino acid foliar fertilizer from the surplus sludge of sewage treatment plant and its application in the garden, and a reference for the resource utilization of surplus sludge in the sewage treatment plant.

2 Materials and methods

2.1 Test materials Test plant was *Z. elegans*. The test soil was taken from the abandoned land soil of a village in Dangwu Township, Huaxi District, Guiyang City, Guizhou Province and the natural forest land soil in the new campus of Guizhou Minzu University. The soil was mixed evenly according to the mass ratio of 2∶3 and sieved for future use. Basic physical and chemical properties of the tested soil were: pH 6.78, organic matter 12.25%, total nitrogen 0.78 g/kg, total phosphorus 1.35 g/kg, total potassium 9.29 g/kg, and available phosphorus 15.87 mg/kg. The test sludge was collected from the surplus sludge of a sewage treatment plant in Guiyang, Guizhou Province, and its physical and chemical properties were as below: moisture content 58%,

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pH 6.85, organic matter 28.6%, total nitrogen 19.31 g/kg, total phosphorus 10.95 g/kg, total potassium 4.58 g/kg, and available phosphorus 397.79 mg/kg. In the pot experiment, 4 kg of sieved soil was put into each pot, and the pot was made of polyethylene plastic, with the specification of 25 cm height and 28 cm caliber. The test sludge extract was prepared by the laboratory. By referring to the optimum extraction conditions of Cui Jing *et al.* [17-18], and considering that the potassium content of sludge is generally low[19], KOH solution was taken as extractant. According to the solid-to-liquid ratio of 1∶8 (sludge∶extractant), it was extracted for 10 h under 100 ℃. After filtration, the sludge extract used in the experiment was obtained[20].

2.2 Experimental methods The pot experiment was conducted from May to August 2019, with 6 treatment groups and 1 control group. They were sludge extract diluted 800 times (S1), 700 times (S2), 600 times (S3), 500 times (S4), 400 times (S5), commercial foliar fertilizer (SS), and clear water as control (CK), respectively. Three replicates were set for each process. 10 seeds of *Z. elegans* were planted in each pot. When the plants grew well, intercropping treatment was carried out, and 3 seedlings of *Z. elegans* were kept in each pot. According to the set treatment groups, the sludge extract was diluted and then sprayed, 250 mL each time, once a week. It was sprayed for 10 times in the whole growth period. Moreover, it should do a good job in weeding, watering and other daily management, and observe and record the growth status of *Z. elegans*.

2.3 Indicator determination Plant height, flower diameter, stem diameter, flower yield, dry weight and plant mass of *Z. elegans* in each pot were measured respectively. Plant height indicates length from stem base to growth point; flower diameter indicates the maximum value of petal extension in horizontal direction; stem diameter indicates width of plant stem; flower yield indicates fresh weight of flowers after picking; dry weight indicates the weight after flowers are put into the oven and dried at 75 ℃; plant mass indicates the weight of the whole plant after cleaning and drying[7].

2.4 Statistical analysis Excel software was used for data statistics and processing, and Origin 9.0 software was used for drawing map, and SPSS 18.0 was used for difference analysis.

3 Results and analysis

3.1 Plant height Plant height is one of the indicators to measure the growth status of plants, and can prove the growth speed[21]. Seen from Fig. 1, plant height of *Z. elegans* in SS processing group in whole growth period was the best, and it increased by 15.66% than CK when harvesting. Plant height in S1, S2 and S3 processing groups increased by 8.57%, 10.97%, and 10.97% than CK. Plant height in S4 and S5 processing groups was all lower than CK at later period, and it may also be because that too high application concentration inhibited the growth of plants. The results showed that the application of sludge extract with proper concentration could promote the growth of *Z. elegans*. Among them, S3 treatment group applied the best dilution concentration, while S4 or S5 treatment group caused greater damage to plants and inhibited their growth due to excessive concentration.

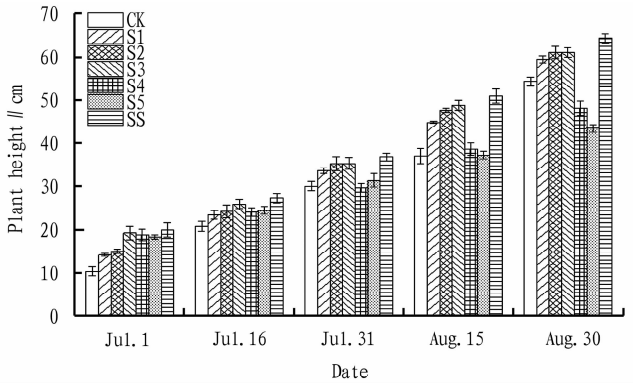

Fig. 1 Effects of sludge extract application on plant height of *Zinnia elegans*

3.2 Stem diameter Seen from Fig. 2, stem diameter of *Z. elegans* sprayed by sludge extract was all higher than CK. Under the same spraying amount, stem diameter in S3 processing group was the best. When harvesting, stem diameter in S1, S2, S3, S4, S5 and SS processing groups was 0.35, 0.37, 0.41, 0.37, 0.34, and 0.39 cm, respectively, while stem diameter in CK was 0.34 cm. It was clear that sludge extract could promote the growth of *Z. elegans* stem diameter. With the increase of the spraying concentration of sludge extract, the stem diameter of *Z. elegans* showed a trend of first increasing and then decreasing, and it respectively increased by 2.94%, 8.82%, 20.58%, 8.82%, 0, and 14.70% than CK. It showed that the effect of S3 processing group in each period was the best. It was clear that the sludge extract could make the stems of flowers strong, which was conducive to plant growth. The application effect of the sludge extract diluted 600 times was the best, without difference from the effect of commercial foliar fertilizer.

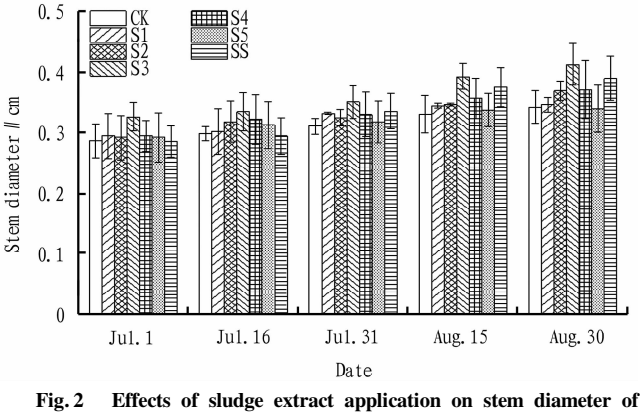

Fig. 2 Effects of sludge extract application on stem diameter of *Zinnia elegans*

3.3 Yield and flower diameter In the process of flower production, flower diameter is one of the important indicators to measure the quality and ornamental value of flowers[22]. Seen from Fig. 3, flower diameter sorting of *Z. elegans* was: SS > S3 > S1 > S2 > CK > S4 > S5, and flower diameter in S1, S2, S3 and SS

processing groups respectively increased by 6.03%, 2.71%, 8.89%, and 13.61% when compared with CK. Among them, flower diameter in SS and S3 processing groups was obviously larger than that in other processing groups, and there was no significant difference between S1, S2 and control group. Flower diameter in S4 and S5 processing groups was smaller than control. The main reason was that too high extract concentration could damage the flower bud of the plant, and then affect the flowering quality of *Z. elegans*. The results showed that the appropriate dilution concentration of the extract had a promoting effect on the flowers of *Z. elegans*, and the best dilution concentration of the sludge extract for the flower diameter of *Z. elegans* was 600 times.

Flower yield is also another indicator to measure the quality of flowers. Flower yield includes fresh weight and dry weight. The study showed that the fresh weight results of *Z. elegans* flowers after applying the extracts of different concentrations were as follows: S3 > SS > S2 > S4 > S1 > CK > S5. Among them, fresh weight of *Z. elegans* flowers in S2, S3 and SS processing groups was obviously larger than CK, and they increased by 54.23%, 41.90%, and 54.01%, respectively. When compared with CK, fresh weight of flower in S1 and S4 processing groups increased by 14.25% and 14.45%, and fresh weight of flower in S5 processing group was smaller than CK. Dry weight sequence of *Z. elegans* flowers was: SS > S3 > S1 > S2 > S4 > CK > S5. The dry weight of flower in S3 processing group (1.94 g) was lower than SS processing group (2.75 g), but was still higher than CK, and they differed by 2.3 times. Except S5 processing group, dry weight of flower in other processing groups was all higher than CK. Therefore, spraying sludge extract with proper dilution concentration can improve the yield of *Z. elegans* flowers and promote the unfolding of flowers.

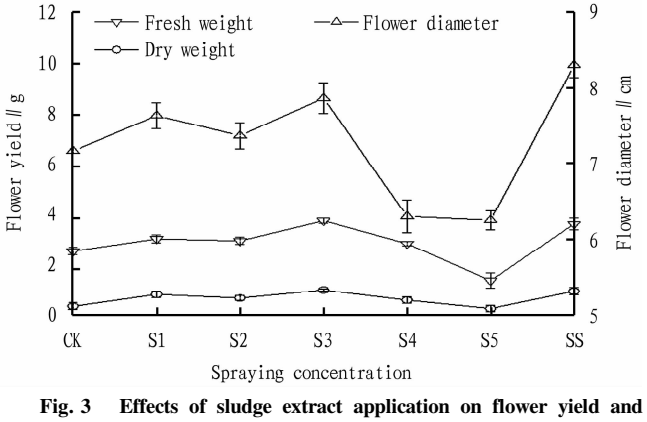

Fig. 3 Effects of sludge extract application on flower yield and flower diameter of *Zinnia elegans*

3.4 Biomass Flower biomass is the sum of plant quality and flower yield. Seen from Table 1, biomass sequence of *Z. elegans* processed by different dilution concentrations was: S3 > SS > S1 > S2 > CK > S4 > S5. Biomass in S3 processing group was the highest (18.16 g), which increased by 24.63% than CK (14.57 g), and biomass in S1, S2 and SS processing groups was also higher than CK. Mass rule of plant processed by different dilution concentrations was S3 > S1 > S2 > SS > CK > S4 > S5, and there was no significant difference between plants. Moreover, biomass in S4 and S5 processing groups decreased than CK. It illustrated that too high spraying concentration can inhibit the quality of *Z. elegans*. Flower yield sequence was: S3 > SS > S1 > S2 > S4 > CK > S5, and its rule was roughly consistent with biomass. When the concentration of sludge extract was too high, the flower yield increased first and then decreased. Seen from the results of biomass, plant mass and flower yield, the sludge extract can promote the growth of *Z. elegans*, but it could inhibit its growth when the dilution concentration was too high. Among them, dilution ratio in S3 processing group was the best, with the most obvious effect.

Table 1 Effects of sludge extract application on plant weight of *Zinnia elegans* g

Processing	Plant mass	Flower yield	Biomass
CK	11.83 ± 3.06 a	2.74 ± 0.56 a	14.57 ± 1.61 ab
S1	13.17 ± 2.75 a	3.23 ± 0.19 a	16.40 ± 2.23 b
S2	13.13 ± 2.63 a	3.12 ± 1.21 b	16.25 ± 3.21 b
S3	14.25 ± 2.14 a	3.91 ± 0.78 b	18.16 ± 2.61 b
S4	11.40 ± 0.93 a	2.94 ± 0.67 b	14.34 ± 1.98 ab
S5	10.71 ± 0.46 a	1.37 ± 1.04 a	12.08 ± 2.87 b
SS	13.00 ± 1.73 a	3.78 ± 0.41 b	16.78 ± 0.89 a

4 Discussion

Foliar fertilizer is a kind of fertilizer that plants absorb the needed nutrients through foliar spraying during the growth process and then play a basic role[23]. It could directly participate in metabolism and organic synthesis, and its fertilizer effect is better than that of soil fertilization. Foliar fertilizer could promote the synthesis of plant photosynthetic pigments and photosynthetic intensity, and make up for the lack of soil fertility[24]. According to difference of specific components, foliar fertilizer could be divided into six classes by the Ministry of Agriculture: macroelement water-soluble fertilizer, microelement water-soluble fertilizer, amino acid water-soluble fertilizer, humic acid water-soluble fertilizer, agricultural and forestry water retaining agent, and others[7,25]. According to the function, it is divided into nutritive and regulatory type[26]. Amino acid foliar fertilizer can not only promote plant growth, but also prevent and control pests and diseases. It can also chelate with trace elements to make full use of nutrients, so it is widely used[27]. Sludge is the waste discharged from the sewage treatment plant, with a huge output, and it contains relatively rich nutrients such as protein[28]. It can be prepared into amino acid fertilizer and applied to agriculture and forestry to realize the resource utilization of sludge.

Among the amino acid water-soluble fertilizers developed in the market at present, they need to be diluted 500 – 1 000 times when applied[29]. When studying the effects of plant growth regulator on the growth and flowering of *Z. elegans*, Sun Chen *et al.*[30] obtained that the dilution concentration of plant growth regulator in *Z. elegans* planting was 800 – 1 000 times. Wang Haibo *et al.*[31] studied the effects of amino acid selenium foliar fertilizer on growth quality of Muscat grape, and obtained that dilution concentration of amino acid selenium foliar fertilizer was be-

tween 500 and 600 times. The research by Liao Haiyan *et al.* [32] showed that when amino acid fertilizer was used in garden plants, the dilution of 500 times had a better effect on the growth of grass flowers and hanging plants. The research by Yuan Zuhua *et al.* [33-34] showed that spraying amino acid water-soluble fertilizer on pepper and lettuce can significantly increase the number of leaves, plant height, plant width and other growth indicators. Fan Yanxia *et al.* [35] studied the effects of several foliar fertilizers on the ornamental effect of chrysanthemum, and it showed that spraying foliar fertilizer had significant effect. Similar to the previous research results, spraying sludge extract with appropriate dilution concentration can better promote the growth of flowers. However, when the concentration was too high, the phenomenon of drug damage would occur, which could cause greater damage to plants and thus inhibit their growth. The research by Gao Xiangbin *et al.* [36-37] also showed that too low or too high application concentration was unfavorable to plant growth.

In this paper, *Z. elegans* was taken as research object. Through plant height, stem diameter, flower yield, plant mass and other growth indicators, the effect of sludge extract on the growth of *Z. elegans* was judged, which could provide theoretical basis for planting *Z. elegans* in the future.

5 Conclusions

Spraying the sludge extract with a dilution concentration of 600 times on *Z. elegans* can improve the quality and ornamental value of its flowers, and the effect was close to or higher than that of commercial foliar fertilizer. The further preparation of the sludge extract into amino acid foliar fertilizer and its application in the garden plants can realize the resource utilization of sludge, bring economic benefits and provide a new way for sewage treatment plants in China, with a good development and application prospect.

References

[1] OU YY, WANG JX, PI J. Effects of sewage sludge compost on the growth and development of *Zinnia elegans*[J]. Journal of Hebei Normal University of Science & Technology, 2021, 35(1): 41 - 44. (in Chinese).

[2] XU QQ, HUANG CT, YANG WJ, *et al.* Research progress on resource utilization of municipal sludge[J]. Journal of Heilongjiang Vocational Institute of Ecological Engineering, 2020, 33(2): 1 - 3. (in Chinese).

[3] YU J, TIAN NN, WANG KJ. Discussion on the technical policy of sludge treatment and disposal in China[J]. China Water & Wastewater, 2005, 21(8): 84 - 87.

[4] LI Y. Effect of municipal sludge directly applied to farmland on physical and chemical properties of soil[D]. Xi'an: Xi'an University of Architecture and Technology, 2019. (in Chinese).

[5] SHIER WT, PURWONO SK. Extraction of single-cell protein from activated sewage sludge: Thermal solubilization of protein[J]. Bioresource Technology, 1994, 49(2): 157 - 162.

[6] YANG JX, SHI RY. Application status of amino acid foliar fertilizer[J]. Rural Economy and Science-Technology, 2019, 30(24): 28, 112. (in Chinese).

[7] CUI LF, YANG C, YANG AA, *et al.* Evaluation of fertilizer efficiency of sludge extract and its effects on growth of *Tagetes erecta* L.[J]. Northern Horticulture, 2021(3): 76 - 82. (in Chinese).

[8] ZHANG AF, QU XN, LIU XA. Effect of sewage treatment plant sludge on the growth of landscaping plants[J]. South China Agriculture, 2014, 8(21): 140 - 141. (in Chinese).

[9] YANG Y, LI M, WANG S, *et al.* Study on the land application effect of activated sludge compost[J]. Journal of Engineering of Heilongjiang University, 2016, 7(2): 59 - 63. (in Chinese).

[10] LIAN P, FAN ZZ, GUO DC, *et al.* Effects of mixed composting of municipal sludge and garden waste on soil microbial biomass carbon, nitrogen and enzyme activities in forest land[J]. Acta Scientiae Circumstantiae, 2018, 38(7): 2842 - 2848. (in Chinese).

[11] DENG JF, LONG CY, LU JY. Effects of urban sludge and rice straw mixed as substrate on the growth of *Ilex chinensis*[J]. Phosphate & Compound Fertilizer, 2019, 34(2): 44 - 45. (in Chinese).

[12] ZHANG DC, ZHANG Y, JIN Y, *et al.* Application of urban sludge and garden leaves mixed as greening substrate in *Lolium perenne*[J]. Phosphate & Compound Fertilizer, 2019, 34(1): 39 - 40. (in Chinese).

[13] WANG W. Advances in garden wastecompost used as herbaceous flowers substrate[J]. Hubei Agricultural Sciences, 2021, 60(24): 11 - 15. (in Chinese).

[14] ZHANG LL, YAO JG, LI T, *et al.* Effects of tanning waste hydrolysate foliar fertilizer on cucumber[J]. Hunan Agricultural Sciences, 2017(9): 46 - 48. (in Chinese).

[15] SHI ZF, LIU W, LIU XJ, *et al.* The preparation of amino acid foliar fertilizer from residual activated sludge[J]. Shandong Chemical Industry, 2015, 44(10): 189 - 199. (in Chinese).

[16] QIU JR, GUO XF, WEI ZB, *et al.* Research advance in agricultural application of municipal sewage sludge[J]. Journal of Agro-Environment Science, 2010, 29(S1): 300 - 304. (in Chinese).

[17] CUI J, DONG AJ, ZHANG WJ, *et al.* Experimental investigation of extracting protein by alkaline thermal sludge hydrolysis from sludge[J]. Chinese Journal of Environmental Engineering, 2009(10): 163 - 166. (in Chinese).

[18] HE YF, YANG FL, HU SW, *et al.* Promoting high-temperature hydrolysis under alkaline condition[J]. Environmental Science, 2008(8): 2260 - 2265. (in Chinese).

[19] LI YX, CHEN TB, LUO W, *et al.* Contents of organic matter and major nutrients and the ecological effect related to land application of sewage sludge in China[J]. Acta Ecologica Sinica, 2003, 23(11): 2464 - 2474. (in Chinese).

[20] CUI LF. Study on the application of surplus sludge extract of sewage treatment plant in landscaping[D]. Guiyang: Guizhou Minzu University, 2020. (in Chinese).

[21] WANG J. Study on the influence of environmental factors on flower growth and its regulation effect[D]. Xianyang: Northwest A&F University, 2005. (in Chinese).

[22] WEI M, ZHU YL, ZHAI YN, *et al.* Effects of potassium application on growth and bloom of *Zinnia elegans*[J]. Journal of Agricultural Science and Technology, 2019, 21(1): 148 - 153. (in Chinese).

[23] FENG T, YU WW, CHAI Y, *et al.* Effect of foliar fertilizer application on safflower growth and flower production[J]. Northern Horticulture, 2012(21): 135 - 137. (in Chinese).

[24] YU LP. Effect and technology of foliar fertilization on vegetables[J]. Hubei Plant Protection, 2004(2): 34. (in Chinese).

[25] XIAO BY, LIU JX. Impacts of different pretreatments on characteristics of excess sludge[J]. Environmental Science, 2008, 29(2): 327 - 331. (in Chinese).

[26] FENG T, YU WW, CHAI Y, *et al.* Effect of foliar fertilizer application on safflower growth and flower production[J]. Northern Horticulture, 2012(21): 135 - 137. (in Chinese).

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economic base, and the economic base determines the superstructure. Therefore, the essence of rural revitalization lies in the development of productive forces, and the improvement of production relations and the optimization of rural governance on this basis. The development of rural productive forces promoted by the development of new agricultural business entities, the evolution of rural production relations on this basis, and the resulting changes in the rural governance body and the optimization of governance structure, constitute a new foundation of rural revitalization and rural governance in the new era. This not only reflects the dialectical relationship between rural productive forces and production relations, economic base and superstructure, but also enriches and develops a new rural governance system with the combination of self-rule, rule of law and rule of virtue.

References

[1] GUO QH. Functional orientation of new agricultural business entities and institutional supply of growth[J]. China Rural Economy, 2013,(4): 4-11. (in Chinese).

[2] CHEN XW. Accelerating the development of modern agriculture[J]. Theoretical Reference, 2013,(8): 12-14. (in Chinese).

[3] SONG HY, ZHAO H. Conceptual characteristics and institutional innovation of new agricultural business entities[J]. New Financial Review, 2014,(3): 122-139. (in Chinese).

[4] CHEN XH. Vigorously cultivate new agricultural business entities: Speech at the annual meeting of China Agricultural Economics Association[J]. Agricultural Economic Issues, 2014, 35(1): 4-7. (in Chinese).

[5] Analysis of influencing factors and trend prospect of China's agricultural products trade[EB/OL]. Sina. com. (2017-05-03)[2018-11-18]. http://finance. sina. com. cn/money/future/agri/2017-05-03/doc-ifyetxec7452237. shtml. (in Chinese).

[6] CHEN XW. The urgency of China's grain supply side reform[J]. China Rural Discovery, 2016,(3): 1-9. (in Chinese).

[7] China's agricultural non-point source pollution is not optimistic, livestock manure is the biggest source[EB/OL]. China News Network. (2015-04-14)[2018-11-18]. http://www. chinanews. com/gn/2015/04-14/7206316. shtml. (in Chinese).

[8] ZHENG FT. How to make green the source power of agricultural supply-side reform[N]. Shanghai Securities News, 2017,(012). (in Chinese).

[9] Constitution of the People's Republic of China[EB/OL]. Xinhuanet. (2018-03-22)[2018-11-18]. http://www. xinhuanet. com/politics/2018lh/2018-03/22/c_1122572202. htm. (in Chinese).

[10] FENG XY, KE RS, LI RQ. Village-level organizations and village governance in China[M]. Beijing: China Social Sciences Press, 2009. (in Chinese).

[11] Revitalize collective assets, increase development vitality and let farmers share the fruits of reform and development. Official website, Ministry of Agriculture of the People's Republic of China[EB/OL]. (2017-01-03)[2018-11-18]. http://jiuban. moa. gov. cn/zwllm/tpxw/201701/t20170103 _ 5423298. htm. (in Chinese).

[12] At the end of 2016, there were 1.794 million farmers' professional cooperatives in China[EB/OL]. China Information Network. (2017-03-24)[2018-11-18]. http://www. ce2293. com/show. asp? ID = 2911. (in Chinese).

[13] Special regulations to support new agricultural business entities: A number of dividends will land[EB/OL]. Yangguang. com. (2017-04-28)[2018-11-18]. http://country. cnr. cn/mantan/20170428/t20170428 _ 523730606. shtml. (in Chinese).

[14] Xi Jinping presided over the thirty-fourth meeting of the Central Leading Group for Comprehensively Deepening Reform, emphasizing expanding the breadth and depth of reform supervision work and improving the effectiveness of finding and solving problems[EB/OL]. CCTV. (2017-04-19)[2018-11-18]. http://cpc. people. com. cn/shipin/n1/2017/0419/c243247-29222707. html. (in Chinese).

[15] XUE Y, TAO Y, ZHANG CQ. American experts say that the modern industrialized agricultural model is unsustainable[EB/OL]. Xinhuanet. (2015-06-07)[2018-11-18]. http://www. xinhuanet. com//world/2015-06/07/c_1115536720. htm. (in Chinese).

[16] DANG GY. Review and prospect of rural governance reform in China[J]. Social Science Front, 2008,(12): 23-27. (in Chinese).

[17] WANG SC. Cultivating core subjects for modern agricultural construction[EB/OL]. China Net. (2013-04-24)[2018-11-18]. http://finance. cnwest. com/content/2013-04/24/content_9050834. htm. (in Chinese).

[18] ZHANG HY, LI WY. New agricultural business entities: Present situation and development[J]. China Farmers Cooperatives, 2014,(10): 48-51. (in Chinese).

(From page 47)

[27] LI XM, LONG JJ, ZHOU Y, *et al*. Application and research progress of foliar fertilizer[J]. Journal of Anhui Agricultural Sciences, 2017, 45(3): 127-130. (in Chinese).

[28] CAI JX, ZHANG PY, ZHANG GM. Research progress on reutilization of protein from municipal sludge[J]. Environmental Engineering, 2019, 37(3): 17-22. (in Chinese).

[29] KE YC, CAO M, YANG XF, *et al*. Effects of spraying different concentrations of organic silicon fertilizer on yield and quality of tropical melon[J]. Journal of Southern Agriculture, 2015, 46(1): 53-57. (in Chinese).

[30] SUN C, WANG KF, DONG R, *et al*. Effects of different plant growth regulators on growth and florescence of *Zinnia elegans*[J]. Hubei Agricultural Sciences, 2018, 57(4): 75-78. (in Chinese).

[31] WANG HB, WANG XD, YAO XY, *et al*. Application effect of amino acid selenium leaf fertilizer on Muscat Hamburg grape[J]. Sino-Overseas Grapevine & Wine, 2011(5): 49-51. (in Chinese).

[32] LIAO HY, TANG TL, LIANG T. Preliminary study on the effect of applying amino acid fertilizer to garden plants[J]. Southern Horticulture, 2013, 24(4): 25-26. (in Chinese).

[33] YUAN ZH, DING ZY, DENG GQ. Effects of amino acid fertilizer on production trait of pepper[J]. Journal of China Capsicum, 2006(4): 32-33. (in Chinese).

[34] SHENG YN, YANG YJ, CHEN LP. Effect of foliar application of amino acid water soluble fertilizer on yield and quality of lettuce[J]. Liaoning Agricultural Sciences, 2019(4): 29-31. (in Chinese).

[35] FAN YX, LIU SF, JI H, *et al*. Effects of different foliar fertilizers on the ornamental effect of *Chrysanthemum*[J]. Northern Horticulture, 2010(10): 130-131. (in Chinese).

[36] GAO XB, ZHANG XS, LIU T, *et al*. Effect of different liquid fertilizer on biomass of *Tagetese recta*[J]. Northern Horticulture, 2009(9): 152-153. (in Chinese).

[37] WANG SY, LIN PK, WANG HK, *et al*. Influence of soil with addition of municipal sludge on growth of *Zoysia matralla* and *Cosmos bipinnatus*[J]. Chinese Journal of Environmental Engineering, 2015, 9(1): 374-380. (in Chinese).