Effect of Long-term Drip Fertigation on Root Growth of Lychee and Soil pH

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Abstract Through field experiment, we explore the impact of long-term drip fertigation on growth and distribution of lychee root and changes of soil pH in different layers of soil in lychee garden. The results show that drip fertigation can significantly promote the growth of lychee roots, and increase the contact area of root and soil; if it experiences six years of drip fertigation successively, the dry weight of root, root length and surface area of root in soil in drip fertigation area, will be 2.29 times, 2.17 times and 2.25 times that in non-drip fertigation area, respectively. The lychee root is mainly distributed in 0 –40 cm layer of soil, but there is conspicuous difference between drip fertigation area and non-drip fertigation area in terms of root distribution in 0 –20 cm and 20 –40 cm layer of soil. Drip fertigation is more favorable for the root to go deep inside the soil. Under long-term drip fertigation, the soil acidification in lychee garden is prominent, and in comparison with non-drip fertigation area, there is the greatest decline in soil pH in 10 –20 cm layer of soil in drip fertigation area, reaching 1.47 units.

Key words Drip fertigation, Lychee, Root, Soil pH

pH is an important basic property of soil, and also an important indicator for evaluating various kinds of soil reaction. The study of Wang Hui and other scholars has shown that the irrational fertilization is one of the important cause of soil acidification, such as too much use of nitrogen fertilizer and other chemical fertilizers and organic fertilizers, improper application ratio of ammonium nitrogen and nitrate fertilizer [1 –7]. The study of Tan Junli and other scholars has shown that the planting years and irrigation and fertilization modes of different crops, are another cause of soil acidification [8 –11]. The study of Fan Qingfeng and other scholars draws the conclusion that compared with open field cultivation, with the extension of cultivation time in land protected, the soil pH tends to decline [12 –14]. Intensified soil acidification will not only lead to a decline in the effectiveness of soil nutrient elements, affecting the normal growth of the plants, but also increase the activity of certain heavy metals in the soil and change the ecological environment of the original soil, doing harm to the safe production of agricultural products, therefore, it is worth further attention [15 –17].

Lychee (litchi chinensis Sonn.) is one of the most important fruits in the southern regions of China, with strong export competitiveness. Good water and fertilizer management is an important guarantee for high yield and quality of lychee. Drip fertigation technology is regarded as the integrated management technical measure for the development of modern agriculture, and its prominent features and advantages of saving water, saving fertilizer, improving crop yields and promoting product quality, have increasingly won the favor of the growers in the world [18]. The study results of Zhang Chenglin, *et al.*, show that the rational application of drip fertigation technology can significantly improve the yield of lychee, increase the proportion of large fruits, and ensure the high and stable yield of lychee [19]. The studies of Kong Qinghua and other scholars point out that drip fertigation can effectively regulate the distribution of crop roots and promote root growth [20 –22], but the studies on growth of lychee root under the condition of long-term drip fertigation have not yet been reported. Therefore, this study conducts survey and analysis of growth and distribution of lychee root, and soil pH under the condition of long-term drip fertigation. The research results will provide a theoretical basis for the promotion and application of drip fertigation technology in lychee production.

1 Materials and methods

1.1 Overview of the test plot The test plot is located in one branch of Xili fruit field, Nanshan District, Shenzhen City, Guangdong Province, where the soil type is lateritic earth, and the area of this branch is 52 hm^2. The main crops planted are lychee, and the varieties include Guiwei, Nuomici, Feizixiao and so on. The drip fertigation system includes water source, automation control system, fertilizing system, plumbing system, water dropper and monitoring component of soil moisture. In November 2000, the installation and adjustment of the entire system are completed. The emitting pipe is laid along the cultivation direction of lychee, and one emitting pipe is laid in each line of lychee. The spacing between water droppers is 75 cm, and the flow rate of water dropper is 2.3 L/H. The soil moisture is monitored by tensiometer; irrigation water is from Xili Lake; the pH is 6.5 –7.0.

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1.2 Test processing From February 2001, this lychee garden began to use drip fertigation technology. All top-dressing includes $CO(NH_2)_2$, KCl, $MgSO_4$ and so on, which are applied through the drip fertigation system. The main application time is around the growth stage of autumn treetop, flowering season, fruiting period of lychee annually; ordinary superphosphate, peanut bran, chicken manure, and so on, are applied along the canopy drip line in the form of basic fertilizer.

The survey of growth of lychee root, distribution of lychee root, and soil pH was conducted in November 2003 and November 2006.

1.3 Collection and measuring of lychee root Collection of lychee root: 3 lychees are randomly selected from the growing area of Guiwei (seedlings bent and pruned without taproot) for investigation, and one lychee is one repetition.

The collection area of lychee root in drip area and non-drip fertigation area can be seen in Fig. 1.

The specific sampling method is as follows: within the canopy drip line of lychee, digging a soil mass with length of 80 cm, width of 80 cm, and depth of 60 cm, along laying direction of emitting pipe and outside the edge of drip line taking the water dropper with the shortest distance away from the drip line as center. And then collecting the lychee root in three different depths (0 – 20 cm, 20 – 40 cm, 40 – 60 cm) from the top to the down, taking out and washing the lychee roots distributed at all levels. In material scanner, root image analysis software WinRHIZO is used for analysis and processing, to measure the total length of root, surface area of root. After the scanning is completed, the root is collected, dried and weighed. The collection method of root in non-drip fertigation area is the same as that in drip irrigation area.

1.4 Collection and measuring of soil sample Collection of soil sample: 3 lychees are randomly selected in Guiwei growing area for investigation, and one lychee is one repetition. The collection area of soil sample in drip irrigation area and non-drip fertigation area can be seen in Fig. 1. The specific sampling method is as follows: within the canopy drip line of lychee, digging a soil mass with length of 80 cm, width of 80 cm, and depth of 80 cm, along laying direction of emitting pipe and outside the edge of drip line, taking the water dropper with the shortest distance away from the drip line as center. In 0 – 80 cm below the water dropper, collecting one soil sample per 10 cm vertically, 8 soil samples in total; in 40 cm below water dropper, collecting samples horizontally, and similarly, collecting one soil sample per 10 cm, 8 soil samples in total. The collection method of root in non-drip fertigation area is the same as that in drip irrigation area.

Measuring of soil samples: after drying, the soil samples are ground, passing 1mm sieve, for the measuring of pH. The measuring of pH: suspension is obtained by soil and water ratio of 2.5:1, and suspension is oscillated for 30min, then handheld pH meter METTLER MP120 is used for measuring.

1.5 Statistical analysis of data Excel 2003 and SAS 8.1 software are used for data analysis; Excel 2003 is used for drawing figure; significance analysis is completed using *t*-test.

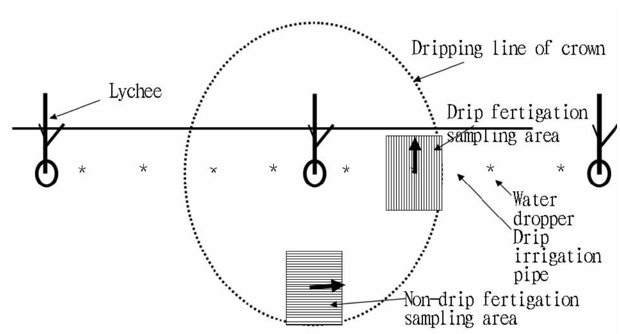


Fig. 1 Distribution of collected soil and lychee root sample

2 Results and analysis

2.1 The impact of long-term drip fertigation on growth and distribution of lychee root The root is a vital organ for crops absorbing water and nutrients. The quantity of root, root length, and size of surface area of root reflect the size of the root absorption capacity. The study of Kong Qinghua indicates that under the condition of drip irrigation, through controlling irrigation and application rate of fertilizer, we can significantly promote the root growth of green pepper, and make more roots grow in deeper soil layers [20]. The study by Hu Xiaotang has indicated that under the condition of drip irrigation under film, keeping the water capacity of field at 75% is conducive to the promotion of root growth of cotton, but keeping too great capacity of field is not conducive to root growth of cotton [23]. The test results show that (Table 1, Table 2), in terms of the root distribution, within the range of areas surveyed, the lychee root is mainly distributed in the 0 – 40 cm soil layer, and the roots distributed in 40 – 60 cm layer of soil are rare. And the survey results in 2003 and 2006 show the same patterns of change. Taking the data in 2003 as an example, the dry weight of root in 0 – 40 cm layer of soil approximately accounts for 94.5% of the soil root biomass surveyed in drip fertigation area; root length and surface area of root also account for 90.2% and 92.6% of the total amount. The dry weight of root in 0 – 40 cm layer of soil in non-drip fertigation area approximately accounts for 94.9% of the soil root biomass surveyed, root length and surface area of root also account for 96.1% and 95.3% of the total amount.

In terms of the distribution of root biomass in the same layer of soil, the survey data in 2003 and 2006 also show the same law. Taking the data in 2003 as an example, in the drip fertigation area, the root length of lychee root in 0 – 20 cm layer of soil and surface area of root account for 56.92% and 59.07% of the total root length and total root surface area, respectively, conspicuously less than 66.78% and 67.36% in 0 – 20 cm layer of soil in non-drip fertigation area. It indicates that under the condition of drip fertigation, by controlling the application rate of fertigation, we can effectively regulate the distribution area of the crop root, and it helps the root grow in deeper soil, and is conducive to improving the possibility of withstanding drought, heat and other adverse climatic conditions.

In terms of the total root, in 2003, the dry weight of root, root length and surface area of root in soil in drip fertigation area, were 1.93 times, 1.92 times and 1.88 times that in non-drip fertigation area, respectively. But in 2006, the dry weight of root, root length and surface area of root in soil in drip fertigation area, were 2.29 times, 2.17 times and 2.25 times that in non-drip fertigation area, respectively. With the extension of the drip fertigation period, the difference between the two tends to be further increased. It shows that the reasonable application of drip fertigation technology can prominently promote the crop root growth, and increase the contact area between the roots and soil.

Table 1 Comparison of Guiwei lychee root between drip fertigation area and non-drip fertigation area in 2003

Sampling area		Dry weight of root//g	Root length//cm	Surface area of root//cm^2
Drip fertigation area	0 – 20 cm	149.1 ±8.0	9 886.9 ± 98.8	4 411.4 ±115.4
	20 – 40 cm	58.5 ±4.4	5 776.9 ±306.4	2 507.7 ±136.4
	40 – 60 cm	12.0 ±1.1	1 706.7 ± 79.7	549.1 ± 18.2
Non-drip fertigation area	0 – 20 cm	73.2 ±4.3	6 035.9 ±331.8	2 681.1 ±178.0
	20 – 40 cm	34.6 ±2.9	2 648.1 ±208.0	1 112.9 ± 69.9
	40 – 60 cm	5.8 ±1.0	355.0 ± 18.3	186.3 ± 10.2

Note: The data in the table are the mean ± standard error repeated 3 times.

Table 2 Comparison of Guiwei lychee root between drip fertigation area and non-drip fertigation area in 2006

Sampling area		Dry weight of root//g	Root length//cm	Surface area of root//cm^2
Drip fertigation area	0 – 20 cm	208.9 ±9.5	15837.9 ±513.2	7244.0 ±495.6
	20 – 40 cm	73.8 ±3.8	10860.3 ±290.4	3961.1 ±167.4
	40 – 60 cm	16.2 ±1.1	2078.3 ± 58.7	884.3 ±107.4
Non-drip fertigation area	0 – 20 cm	82.5 ±4.2	8803.2 ±140.9	3391.2 ±249.4
	20 – 40 cm	40.9 ±2.6	4058.7 ± 85.7	1779.9 ±105.1
	40 – 60 cm	7.0 ±0.8	380.5 ± 12.7	213.2 ± 21.2

Note: The data in the table are the mean ± standard error repeated 3 times.

2.2 The impact of long-term drip fertigation on changes of soil pH in different layers of soil in lychee garden

2.2.1 Changes of soil pH in different layers of soil in drip fertigation area and non-drip fertigation area. Changes in soil pH are affected by soil texture, climate, and many other factors. Wang Jinghua points out that the red soil makes poor performance of buffering on the acid, vulnerable to the impact of environmental factors [24]. The study of Haynes also finds that long-term drip application of ammonium nitrogen and urea in soil, easily leads to local soil acidification in fertilization area, and the soil acidification phenomenon is even more evident in some soil with poor buffering [25–26]. As shown in Fig. 2, the two survey results of soil pH in drip fertigation area and non-drip fertigation area in the year 2003 and 2006 both show the same pattern of change. Taking the results in the year 2003 as an example, under the condition of long-term drip fertigation, the soil pH in drip fertigation area of lychee is lower than the soil pH in non-drip fertigation area of lychee, in all vertical layers of soil from 0 to 80 cm; △pH of soil in non-drip fertigation area and drip fertigation area in 0 – 10 cm, 10 – 20 cm, 20 – 30 cm, 30 – 40 cm, 40 – 50 cm, 50 – 60 cm, 60 – 70 cm and 70 – 80 cm layer of soil vertically is 0.67, 1.47, 0.42, 0.37, 0.47, 0.38, 0.39 and 0.48 units, respectively. No matter whether in drip fertigation area or non-drip fertigation area, with increase in the depth of layer of soil, pH value first sharply declines, then changes slowly, for example, in drip fertigation area, the soil pH in 0 – 10 cm, 10 – 20 cm, 20 – 30 cm layer of soil is 7.26, 5.23, 4.53, respectively, and the soil pH in 20 – 80 cm layer of soil changes in the narrow range 4.53 – 4.24. The possible reason is that on the one hand, the soil pH is impacted by long-term drip fertigation, with prominent acidification; on the other hand, impacted by improving soil through application of lime under the tree crown, the regulation effect of acidity of surface soil is good, and the regulation effect of acidity of deep soil is not satisfactory.

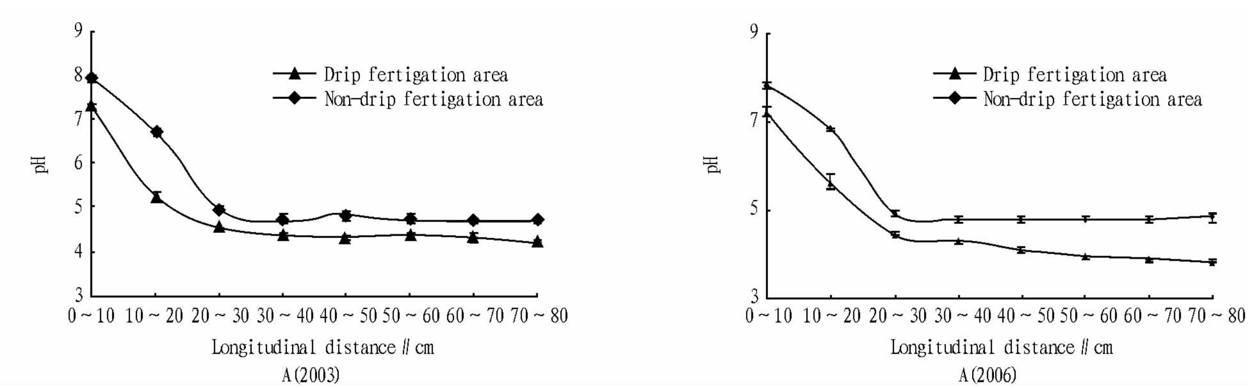
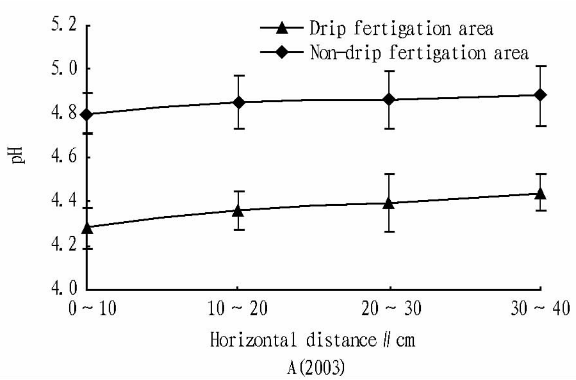


Fig. 2 pH distribution of soil section with different planting years in drip fertigation area and non-drip fertigation area

2.2.2 Changes of soil pH in the same layer of soil but different horizontal distances in drip fertigation area and non-drip fertigation area. Fig. 3 is horizontal pH distribution of soil 40 cm deep inside with different planting years in drip fertigation area and non-drip fertigation area, from which we can find that the survey results in two years are similar. Taking the survey results in the year 2003 as an example, the soil pH in drip fertigation area is lower than that in non-drip fertigation area, in horizontal 0 – 10 cm, 10 – 20 cm, 20 – 30 cm, 30 – 40 cm; △pH of soil in non-drip fertigation area and drip fertigation area in horizontal 0 – 10 cm, 10 – 20 cm, 20 – 30 cm, 30 – 40 cm is 0.52, 0.49, 0.47 and 0.44, respectively, and the horizontal soil pH in drip fertigation area tends to rise gradually with increase in horizontal distance. It indicates that under the condition of drip fertigation, with the increase in horizontal distance (*i. e.* away from the drip fertigation area), the acidification degree of soil decreases.



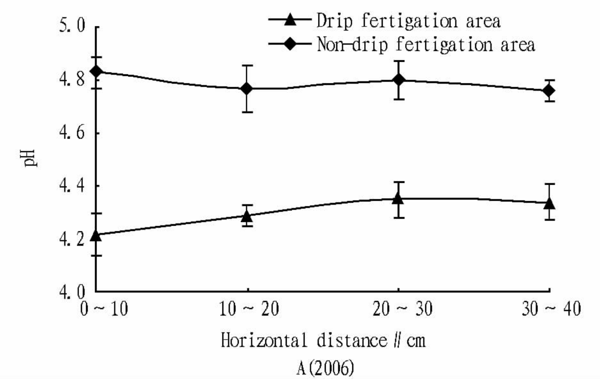


Fig. 3 Horizontal pH distribution of soil 40 cm deep inside with different planting years in drip fertigation area and non-drip fertigation area

3 Conclusions

First, reasonable application of drip fertigation can significantly promote the growth of lychee roots, and increase the contact area of root and soil. In this experiment, if it experiences three years of drip fertigation successively, the dry weight of root, root length and surface area of root in soil in drip fertigation area, will be 1.93 times, 1.92 times and 1.88 times that in non-drip fertigation area, respectively; if it experiences six years of drip fertigation successively, the dry weight of root, root length and surface area of root in soil in drip fertigation area, will be 2.29 times, 2.17 times and 2.25 times that in non-drip fertigation area, respectively.

Second, the survey results show that the lychee root is mainly distributed in 0 – 40 cm layer of soil, but there is conspicuous difference between drip fertigation area and non-drip fertigation area in terms of root distribution in 0 – 20 cm and 20 – 40 cm layer of soil. Drip fertigation is more favorable for the root to go deep inside the soil. In the survey results in 2003, in the drip fertigation area, the root length of lychee root in 0 – 20 cm layer of soil and surface area of root account for 56.92% and 59.07% of the total root length and total root surface area, respectively, conspicuously less than 66.78% and 67.36% in 0 – 20cm layer of soil in non-drip fertigation area.

Third, under long-term drip fertigation, the soil acidification in lychee garden is prominent, and in comparison with non-drip fertigation area, there is the greatest decline in soil pH in 10 – 20 cm layer of soil in drip fertigation area, reaching 1.47 units.

References

[1] WANG H, DONG YH, AN Q, *et al.* Change in pH and salinity of vegetable soil under intensive cultivation[J]. Soils, 2005, 37(5): 530 – 533. (in Chinese).
[2] ZHANG YC, WANG JD, SHEN MX, *et al.* Effects of long-term fertilization on soil acidification in Taihu lake region[J]. Acta Pedologica Sinica, 2010, 47(3): 465 – 472. (in Chinese).
[3] LIANG MQ, XUE J, FAN YL, *et al.* Studies on soil acidification of navel orange orchards in Ganzhou City, Jiangxi Province[J]. South China Fruits, 2010, 39(4): 6 – 8, 13. (in Chinese).
[4] LI ZD, WANG YH, LI LY. Orchard soil acidification status in Jiaodong Peninsula of Shandong Province and control techniques[J]. Phosphate & Compound Fertilizer, 2009, 24(6): 80 – 81. (in Chinese).
[5] MENG L, DING W, CAI Z. Long-term application of organic manure and nitrogen fertilizer on N_2O emissions, soil quality and crop production in a sandy loam soil[J]. Soil Biology and Biochemistry, 2005, 37(11): 2037 – 2045.
[6] POSS R, SMITH CJ, DUNIN FX, *et al.* Rate of soil acidification under wheat in a semi-arid environment[J]. Plant and Soil, 1995, 177(1): 85 – 100.
[7] LILIENFEIN J, WILCKE W, VILELA L, *et al.* Effect of no-tillage and conventional tillage systems on the chemical composition of soils solid phase and soil solution of Brazilian savanna oxisols[J]. Journal of Plant Nutrition and Soil Science, 2000, 163: 411 – 419.
[8] TAN JL, KANG YH, JIAO YP, *et al.* Effects of cropping years on soil salinity and pH value in fields under drip irrigation condition[J]. Transactions of the Chinese Society of Agricultural Engineering, 2009, 25(9): 43 – 50. (in Chinese).
[9] LOU YL, GUAN LZ, WANG LL, *et al.* Changes of pH and enzyme activities in soils for different tobacco cropping years[J]. Plant Nutrition and Fertilizer Science, 2007, 13(3): 531 – 534. (in Chinese).
[10] YU N, ZHANG YL, HUANG Y, *et al.* Micro-scale spatial variability of surface soil pH under different irrigation methods in greenhouse[J]. Soils, 2008(5): 828 – 832. (in Chinese).
[11] DENG SL, WANG L, TU PF, *et al.* Effect of nitrogen fertigation on acidification of latosolic red soil[J]. Chinese Journal of Tropical Crops, 2009, 30(9): 1295 – 1300. (in Chinese).
[12] FAN QF, ZHANG YL, CHEN Z, *et al.* Acidity characteristics and acidification mechanism of soils in protected fields[J]. Acta Pedologica Sinica, 2009, 46(3): 466 – 471. (in Chinese).
[13] FAN QF, ZHANG YL, CHEN Z. Effects of protected field vegetable

cultivation on soil salinity accumulating and pH[J]. Journal of Soil and Water Conservation, 2009, 23(1): 103 – 106. (in Chinese).
[14] ZENG XB, BAI LY, SU SM, *et al*. Acidification and salinization in greenhouse soil of different cultivating years from Shouguang City, Shandong[J]. Acta Ecologica Sinica, 2010, 30(7): 1853 – 1859. (in Chinese).
[15] HUANG YX, ZENG XB, ZHANG YZ, *et al*. Tea garden soil acidification and its impact on soil fertility in hillock of Hunan Province [J]. Chinese Journal of Soil Science, 2010, 41(3): 633 –638. (in Chinese).
[16] ZHAO J, FENG WQ, QIN YS, *et al*. Effects of application of nitrogen, phosphorus and potassium fertilizers on soil pH and cadmium availability[J]. Acta Pedologica Sinica, 2010, 47(5): 953 – 961. (in Chinese).
[17 RONG QT, YANG CM, XU WB. Soil acidification research progress [J]. Advances in Earth Sciences, 1996, 11(4): 396 – 401. (in Chinese).
[18] YOSEF BB. Advances in fertigation[J]. Advances in Agronomy, 1999, 65: 1 –55.
[19] ZHANG CL, XIE YH, LI K, *et al*. Utilization of the fertilizing technique by drop irrigation on litchi[J]. Guangdong Agricultural Sciences, 2002(2): 31 –33. (in Chinese).
[20] KONG QH, LI GY, WANG YH, *et al*. Influences of subsurface drip irrigation and surface drip irrigation on bell pepper growth under different fertilization conditions[J]. Transactions of the Chinese Society of Agricultural Engineering, 2010, 26(7): 21 – 25. (in Chinese).
[21] DENG LS, ZHANG CL. Effect of nitrogen fertilizer fertigation on the growth of banana root system[J]. Soil and Fertilizer Sciences in China, 2007(6): 71 –73, 84. (in Chinese).
[22] XU SJ, WU XM, REN Z, *et al*. Effects of drip irrigation technology on orange growth[J]. South China Agriculture, 2008, 2(4): 7 –9. (in Chinese).
[23] HU XT, CHEN H, WANG J, *et al*. Effects of soil water content on cotton root growth and distribution under mulched drip irrigation[J]. Scientia Agricultural Sinica, 2009, 42(5): 1682 – 1689. (in Chinese).
[24] WANG JH, ZHANG XN, YU TR. On sensitivity of southern China red soil to acid rain[J]. Acta Pedologica Sinica, 1994, 31(4): 348 –355. (in Chinese).
[25] HAYNES RJ, SWIFT RS. Effect of trickle fertigation with three forms of nitrogen on soil PH, levels of extractable nutrients bellow the emitter and plant growth[J]. Plant and Soil, 1987, 102: 211 – 221.
[26] STOCK PR, JERIE PH, CALLINAN APL. Subsurface drip irrigation in raised bed tomato production Ⅱ Soil acidification under current commercial practice[J]. Australian Journal of Soil Research, 2003, 41: 1305 –1315.

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[27] LIU X, HAN Q, XU J. Ultrasonic extraction of proanthocyanidins from Litchi chinensis Sonn. [J]. Medicinal Plant, 2010, 1(11):96 – 99.
[28] KUANG SZ, TIAN SY, LI CY, *et al*. Effect models of nitrogen, phosphorus and potassium fertilizer formulation in banana[J]. Agricultural Science & Technology, 2010, 11(9 –10): 130 –135.
[29] WANG J, GUAN XY, CHEN Y, *et al*. Effects of different solid drip – irrigation special – purpose fertilizer applied to cotton in plastic mulched/Drip irrigated system[J]. Journal of Anhui Agricultural Sciences, 2011, 39(27):16530 –16532. (in Chinese).
[30] ZHU GW, ZHOU T, YAO S. Advances in the use of exogenous plant growth regulators on litchi[J]. Agricultural Science & Technology, 2010, 11(6): 65 –70, 78.
[31] HUA DL, CHEN QL, LI M, *et al*. Diurnal variation of soil moisture characteristics of gobi drip irrigation in jujube[J]. Journal of Anhui Agricultural Sciences, 2012, 40(6):3310 –3313. (in Chinese).

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problems, like water conservancy development. Based on affectional bond of social common value, the social interaction attitude, value mentality and cultural model will come into being spontaneously, but the common value based on current overall rural situations is extremely vulnerable. Cultivating rural community common value is an indispensible section in this period of market failure, government withdrawal and disintegration of many farmers' cooperative organizations. Thus, it is required to value the cultivation of rural community common value based on trust, and build long-term mechanism of water conservancy, to welcome new phase of water conservancy development.

References

[1] LU YG. How does a water conference shock eight members of the standing committee[N]. China Youth Daily, 2011 –07 –13. (in Chinese).
[2] SUO LS. Water resource sustainable development strategy in China [M]//WANG X. Social source power economy. Beijing: China Renmin University Press, 2004. (in Chinese).
[3] CHEN XW. Speeding socialism new rural construction[J]. China Economic and Trade Herald, 2011(1): 13 –16. (in Chinese).
[4] CHEN L. Develop a new situation of water conservancy construction and management[J]. People's Tribune, 2011(18): 10 – 12. (in Chinese).
[5] LAHN EGGERTSSON. Economic behavior and institutions [M]. Beijing: The Commercial Press, 2008. (in Chinese).
[6] STEVEN G MEDEMA. Cos economics[M]. Shanghai: Shanghai People's Press, 2010. (in Chinese).
[7] QIN H. Ten theories on tradition[M]. Shanghai: Fudan University Press, 2010. (in Chinese).
[8] LIANG H. China in Liangzhuang[M]. Nanjing: Jiangsu People's Publishing House, 2010. (in Chinese).
[9] FERDINAND T. Community and society[M]. Translated by LIN RY. Beijing: The Commercial Press, 1999. (in Chinese).
[10] TANG XY. Theory and practice of community management[M]. Guangzhou: South China University of Technology Press, 2010. (in Chinese).

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[11] WEI GL, WANG YK, YANG T, *et al*. Research on root distribution characteristics of *Ziziphus jujube* cv. Lizao under drip irrigation condition[J]. Journal of Anhui Agricultural Sciences, 2010, 38(12): 6136 –6137, 6139. (in Chinese).
[12] ZHU WF, DAN JM. A note on the reasons of high level of agricultural fertilization of farmers[J]. Agricultural Science & Technology, 2011, 12(10): 1556 –1560.
[13] WANG XL, YANG XY, HUANG JJ, *et al*. The effect of comprehensive application technology drip irrigation system on the growth of sugarcane[J]. Journal of Anhui Agricultural Sciences, 2011, 39 (27):16530 –16532. (in Chinese).
[14] HUANG SM, BAO DJ, ZHANG SQ, *et al*. Research on effects of remediation by fertilization on off-balanced fluvo-aquic soils in nutrient[J]. Agricultural Science & Technology, 2010, 11(9 –10): 126 –129, 135.
[15] DENG LS, TU PF, GONG L, *et al*. Effect of boron drip fertrgation on growth and nutrients absorption of bananas[J]. Journal of Anhui Agricultural Sciences, 2012, 40(2): 691 –693. (in Chinese).