

## STUDY ON FACTORS OF INJECT LARGE VOLUME LIQUID INTO TRUNK

Sucheng Shang, Hao Zhou, Xue Chang, Mingxing Liu, Na Li and Qingqing Shang

College of Mechanical and Electronic Engineering, Nanjing Forestry University, Nanjing, China.

Email: qqshnfu@126.com

### ABSTRACT

The influencing factors of large volume liquid injection with tree trunk injector are described in this paper. Comparing with the analysis and verification of the existing methods of large volume liquid fertilization such as spraying and transfusion technology, this paper puts forward the necessity and preponderance of large volume liquid injection with tree trunk injector. Through the effect analysis of tree trunk injection, seven influencing factors are proposed, including the requirements of time, injector, injector needle head, sealing, operation, prevention and cure target, and injecting chemicals. Meanwhile, the detailed solution is also discussed. Finally, the results of the contrast tests validate that the large volume liquid injection with tree trunk injector can reduce the air pollution, prevent the diseases and insect pests rapidly, and satisfy the microelement fertilizer application. This technology will have tremendous social benefits and economical profits in practice.

**Keywords:** Tree trunk injection, large volume liquid, Pesticide, Microelement fertilizer.

### 1. INTRODUCTION

As a new method of trees fertilization, tree trunk injection has obvious advantages, such as no pollution to environment, no limits of fertilization surrounding, long period of validity and obvious efficiency. Liquid medicine can be distributed rapidly and uniformly to every part of the tree by tree transpiration. The obvious effect could achieve in ten days after the fertilization with the tree trunk injection.

The traditional pesticide spraying technology may pollute the environment, and accidentally injure the natural enemies for insect pests. Additionally, the pesticide spraying is affected obviously by weather changes and limited by fertilization range, and it may poison human beings and animals accidentally. Furthermore, the pesticide sprayed on the leaves will lose mostly by wind and rain, so the utilization rate of pesticide applied by this technology is only 20%.

Compared with the traditional pesticide spraying, the tree trunk injection technology has features as follows: 1) long period of validity. The efficacy of pesticide applied by tree trunk injection degrades very slowly and can last two years while that applied by spraying can only last 4 weeks at most. Particularly, it has good control effect on those pests which have long emergence period and overlapping generations; 2) good effect. After the pesticide injected into tree trunk, it can be conveyed to every parts of the tree by tree transpiration, and stay no leaks; 3) no limitation to the height of the tree. Existing equipment's are limited to their delivery lift, so they can hardly spray pesticide to the all leaf of tall trees. On the contrast, the tree trunk injection technology injects pesticide into the tree trunk directly with no drift and drip, so it don't scatter in the air or infiltrate into the earth and water.

Meanwhile, the tree trunk injection is good to protect environment, which doesn't accidentally injure the natural

enemies for insect pests or other living beings. So this technology needs less pesticide and has higher efficiency and lower costs.

### 2. AVANTAGES AND DISADVANTAGES OF EXISTING METHOD OF LARGE VOLUME LIQUID FERTILIZATION

According to the existing transfusion method of large volume liquid fertilization, it has to drill a hole on the tree trunk, hang one bottle within liquid fertilizer beside the tree and apply fertilizer with the transfusion manner. Inside the tree, the fertilizer can be conveyed to the leaves through the trunk catheters. By this means, it can achieve the purpose of fertilization or pest's prevention. Recently, it has popularized in garden and fruit trees planting.

The advantage is that the fertilizer or pesticide enters into the tree without being affected by the root system soil condition. So it can save fertilizer or pesticide, water, manpower and so on, and it has high efficiency. But there have been some questions in the application of this transfusion technology: 1) Too frequent operation may cause the mechanical injury easily. On one hand the drill is hard to operate, on the other hand, this operation may causes difficult-healed scars on the tree which will suffer some parasitic hymenopterans attack. This will influence the health of the ornamental trees. 2) Not all kinds of fertilizer and pesticide medicine are appropriate for this transfusion technology except the ones who can be conveyed through the trunk catheters. 3) The transfusion technology may cause locally medicine damage in the tree. 4) The transfusion technology provides fertilizer and pesticide medicine without pressure, and takes a lot of time (the dropping frequency is a

drop per ten seconds). Besides, the fertilizer and pesticide medicine long-exposed under the sun may cause the metamorphism. 5) That the transfusion needs hang the bottles for all trees in the garden will increase the costs. Therefore, this transfusion technology usually just becomes the complementarity for the general methods.

### 3. MECHANISM OF LARGE VOLUME FERTILIZATION

Chemicals, such as systemic insecticide, mineral, plant growth regulator are stored in the xylem temporary by high-pressure injection, and then they are conveyed to the ends of the braches by transpiration pull. During the process of conveying, these chemicals can be conveyed longitudinally, with large capacity and high speed. At the same time, they are diffusing transversely, with small capacity and low speed. So the nutrient or pesticide can not only be conveyed, diffused, stored and metabolized from root to treetop leaves, it can also be transferred to root via the sieve tube members with descending liquid, or it directly be conveyed, diffused, stored and metabolized from tree xylem to phloem. The technology of large volume injection makes use of the capacity of transmission and diffusion of tree to realize the purpose of controlling pests and regulating the growth of tree by balancing the chemicals distribution in the tree body.

### 4. SEVEN INFLUENCING FACTORS OF LARGE VOLUME TREE TRUNK INJECTION

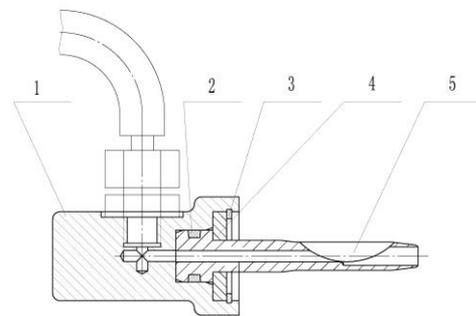
(1) Time of fertilization: the process of fertilization should be done during the time when the tree transpiration pull is large, usually in the phase of growing leaves from May to September, winter is inadvisable.

(2) The performance requirement of injector: injector can exert certain pressure, which can inject the nutrient or pesticide into the target. It found that, the needed pressure during the poplar tree trunk injection is about 15MPa. The existing high-pressure large volume tree trunk injector (6HZ-0503) which was invented by Nanjing Forestry University meet the demand of high pressure, its highest pressure is 32MPa.

(3) Requirement of injector needle head: reasonable structure, the needle head with certain intensity and rigidity can inject and withdraw easily from the target without bending and deformation.

Through the research of tree structure and tree trunk wood properties, we designed the injector needle head with ring-shaped automatic output crumbs blade on the basis of having researching the wood mechanical property of standing tree, as shown in Fig.1.

We do not need to drill a hole in the tree trunk in advance with this needle, just squeeze it into tree trunk directly. It can cut off wood fiber and have a good connection with the tree transfusion tissue. Besides, it applies seal located in cambium layer; the seal which have good performance of sealing can expand itself but not crack.



1. Base; 2.O-ring; 3.Spring ring; 4. Gasket; 5. Needle head

**Figure 1.** The injector needle head of the tree trunk

(4) Requirement of sealing: the target and needle head give a good seal, which prevents the chemicals from leaking out of the target. With the help of self-expanded seal and the link of high-pressure hose and airframe, it has good performance of sealing.

(5) Requirement of operation: the process of injecting operation should be continuous and stable, so there will not be the cracks at the injecting site. It will also ensure sealing integrity, make the process stably and ensure the large volume injecting smoothly. Adopting high-pressure hose link can solve the problem effectively and reduce the difficulty of operation.

(6) Requirement of prevention and cure target: there is transfusion tissue which can deliver a certain amount of chemicals to the right place, the wound which caused by needle head will heal during one growing season. By the poplar injecting experiment, we found that italian poplar can meet this requirement and achieve good effectiveness.

(7) Requirement of injecting chemicals: injecting chemicals can suit the remedy to the case, and play a good role in prevention and cure. The alkaloid chemicals named “Zhangdekuai” which was invented by Nanjing Forestry University research group, produced by Jiangsu BoHua biological technology Co., Ltd. achieved good effectiveness in the experiment. It produced huge economic benefits in Shandong, Henan, Anhui and Jiangsu province.

### 5. EXPERIMENTS AND APPLICATION

(1) “Zhangdekuai” and tree trunk injector: Alkaloid chemicals named “Zhangdekuai” and high-pressure large volume tree trunk injector (6HZ-0503) used in the experiment are invented by Nanjing Forestry University research group and produced by Jiangsu BoHua biological technology Co., Ltd.

(2) The place and tree species of experiment: There are three study plots, Fanlou , Zhuyao and Xiaoyao. The trees in the experiment are 8-10-year I-69 poplar trees; each study plot picks out 30 injected trees and normal trees as the control group.

(3) Experimental method: Take out a pack of “Zhangdekuai” injection solution, make it dissolved in 200 milliliters of 95% alcohol (Denatured alcohol is forbidden, for that contains methanol, which will result in death of the tree), add the treated water to 2000 milliliters, the solution can't be used until uniform dissolution.

Before injection, measure the diameter at breast height, determine the amount of injection solution, injection holes of each tree, injection times of each hole. Then inject at the place of bottom of trunk (10-15cm above the ground will be the best), make sure the needle is perpendicular to the tree. The poplar tree which needs two or more injections should be symmetrical injected around the trunk.

(4) Measurement of the diameter at breast height and profits of increased timber production: Before injection, paint the trunk red with brush in diameter at breast height, measure the diameter at breast height where painted before injection. Measure it again after poplar stops growing in autumn. The subtraction results of two measurements are growth of the diameter at breast height. It is calculation of earnings below:

Calculation of volume growth rate: (volume growth of injected poplar – volume growth of compared poplar) / volume growth of compared poplar × 100%.

Calculation of profit growth: calculate volume per cubic meters at 600 yuan, so the profit is volume growth times 600. Average profit per tree which injected “Zhangdekuai” = average profit per injected tree – average profit per tree compared.

Calculation of input-output ratio: calculate the price of every pack of chemicals at 30 yuan. Input of test trees = [average injected dosage (ml) × 30 yuan / 2000 ml + service fee per tree 0.2 yuan (including instrument wastage fee)] × samples of test trees. The ratio of input and profit is the ratio of input and output.

(5) Result of experiment: Application effects show as Table 1, Table 2 and Table 3 below.

**Table 1.** Result of injecting “Zhangdekuai” in Zhuyao (2004.6.30—2004.12.13) 200ml (2 times)

Treatment	Control group	Solution injected
Samples	30	30
Volume growth rate(m3)	1.0009	1.3315
Profit(yuan)	600.54	798.9
Volume growth rate		33.0%
ΔProfit(yuan)		198.36
Input-output ratio		1:4.7

**Table 2.** Result of inject “Zhangdekuai” in Fanlou (2004.7.1—2004.9.21) 200ml (2 times)

Treatment	Control group	Solution injected
Samples	30	30
Volume growth rate(m3)	0.8476	1.2025
Profit(yuan)	508.56	721.5
Volume growth rate		41.9%
ΔProfit(yuan)		212.94
Input-output ratio		1:4.1

**Table 3.** Comparison of every factor average per poplar

Treatment	Average volume growth per tree (m3)	Average volume growth rate per tree	Average profit per tree (yuan)	Average added profit per tree (yuan)
Zhuyao Solution injected	0.0444	32.9%	26.63	6.61
Zhuyao Control group	0.0334		20.02	
Fanlou Solution injected	0.0401	41.9%	24.05	7.10
Fanlou Control group	0.0283		16.95	
Xiaoyao Solution injected	0.0162	49.8%	9.74	3.24
Xiaoyao Control group	0.0108		6.50	

## 6. CONCLUSIONS

Comparing with the analysis and verification of the existing methods of large volume liquid fertilization such as spraying and transfusion technology, the paper puts forward the necessity and preponderance of large volume liquid injection with tree trunk injector. Through the effect analysis of tree trunk injection, seven influencing factors are proposed and the detailed solution is also discussed. Finally, the contrast tests are applied to validate that the large volume liquid injection with tree trunk injector has tremendous social benefits and economical profits.

## ACKNOWLEDGMENT

Supported by research fund of the national natural science foundation of China (51208263), hereby thanks.

## REFERENCES

- Shang Q. Q., Zhao B. G., Zhang Y. Q., Study On a High Pressur and Large Capacity Tree Trunk Injector, *Journal Of Nanjing Forestry University*, 2009, (05): 101-104 (In Chinese).
- Li X., Qin F., Zhou Z. B., Han J. L., et al, The Analysis of Appliance with the Applying Pesticide by Injection for Trees and Design of 6HZ.D625B Type Tree Syringe, *Forestry Machinery & Woodworking Equipment*, 2000, (08): 6-8 (In Chinese).
- Wen J. H., Sui J. L., Hang Suspending-Bottle on the Fruit Trees, *Agriculture Knowledge*, 2004, (7): 14 (In Chinese).
- Li Y.Y., Cautiously When Hang Suspending-Bottle on the Fruit Trees, *Pesticide Market News*, 2009, (18): 42(In Chinese).
- Zhou N. N., Study on Correlation between Fertilizer Concentration of Suspending-Bottle Transfusion and Yield of Green Orange, *Journal of Anhui Agricultural Sciences*, 2010, (17):8930-8935 (In Chinese).

6. Feng J. C., Ji J. Q., The Application of Tree Suspending-Bottle Transfusion on Drought Emergency of Fruit Trees, *Water Saving Irrigation*, 2009, (7): 54-55 (In Chinese).
7. Wang H. R., Study on the Application of Suspending-Bottle Transfusion on Garden Trees Transplantation, *Northern Horticulture*, 2009, (2): 210 (In Chinese).
8. Kobza M., Juhasova G., Adamcikova K., et al, Tree Injection in the Management of Horse-Chestnut Leaf Miner, *Cameraria Ohridella* (Lepidoptera: Gracillariidae), 2011, 1(3-4):139-143.
9. Darrietort G., Lecomte P., Evaluation of a Trunk Injection Technique to Control Grapevine Wood Diseases, *Phytopathologia Mediterranea*, 2007, 4(1): 50-57.
10. Barney D. L., Trunk Injection of Iron Compounds as a Treatment for Overcoming Iron Chlorosis in Apple Trees, *Hort Science*, 1985, 20(2): 236-238.
11. Fernandez-Escobarr, Barrancod Benllochm, Overcoming Iron Chlorosis in Olive and Peach Trees Using a Low-Pressure Trunk Injection Method, *Hort Science*, 1993, 28(3): 192-194.
12. Shang Q. Q., Tan Q. W., Zhang Y. Q., The Study of Motorized Trunk Treatment with Advance and Retreat Injection Needle and Its Clamping Structure, *The 2nd International Conference on Mechanic Automation and Control Engineering (MACE 2011)*, Proc. IEEE, 5: 4616-4619.