Transparent-compartmental pot for root study

Kitti Wongpichet [1*]

ABSTRACT: Studies of plant roots come in various techniques. Almost all methods of studies include the whole root system of a single plant or a group of plants. The objective of this investigation was to develop a special pot that was able to separate a plant's roots to grow into different compartments in order to open a new window in crop root study. Iterative work was carried out comprising development, testing, and improvement of a transparent-compartmental (TC) pot. This TC pot was made of transparent acrylic with cementing glue. It looked like a double pyramid - one inside another - with a mouth on top of the outer piece. Fins along the spines of the inner piece divided this pot into four separate compartments, while the basal fins acted as pot base preventing leakage of planting medium. Both pieces could be held together by bolts and nuts at their bases; and they sat firmly on an edged tray. Tests of these TC pots were done by planting rice, and then rice roots were guided to grow into each compartment. Planting in plastic pails were also done for comparison. The results were satisfactory. Rice roots grew separately into all four compartments. Over all root and shoot growths of rice grown in the TC pots and plastic pails were normal and similar. (**Key words:** transparent-compartmental pot, root separation, rice)

Introduction

Crop root studies are not popular among researchers due to the inconveniences, dirty and tedious work involved. Traditional methods for root studies are carried out in various ways. At the field level, a number of plants are grown in a plot; then root samples are taken periodically by digging up the whole plant for examination, and/or are taken from different depths and locations around the plant. An alternative method at a greenhouse level, a plant is grown in a pot; then at desired growth stage the pot is removed for root study. These are tedious, laborious, and destructive methods.

Later, an underground structure called 'rhizotron' (Northern Research Station, 2007) has been developed enabling researchers to study on-the-site and continuous root growth of larger plants and trees. This facility serves very well for root studies. However, the high construction costs prohibit its uses in the less-funded institutions.

To overcome limitations in crop root studies, some specially designed containers have been available in recent years. For example, a container designed by James et al. (1985) with stereomicroscope, Green (2006)'s pot with water supply from underneath, and Caruso et al. (nd)'s container that divides plant roots into upper and lower parts. However, the above techniques are for studying all roots of a group of plants or a single plant growing in the same environment or experimental treatment. In some instances or for detailed studies, researchers might want to study the effects of different treatments on different roots of the same plant. Therefore, the objective of this investigation was to develop a special pot that enabled us to separate a plant's roots to grow into different compartments.

[1] Faculty of Agriculture, Ubon Ratchathani University, Ubon Ratchathani 34190, Thailand.

* Corresponding author: kitti@agri.ubu.ac.th

Materials and methods

This project was done at the Faculty of Agriculture, Ubon Ratchathani University, Thailand during February to November 2007.

A transparent-compartmental (TC) pot was designed, pre-examined, and then developed as in **Figure 1**. This pot looked like a double pyramid - one inside another. The outer piece had a small upside down pyramid as a mouth on top and a big pyramid as a body. The inner piece was another smaller pyramid; along each spine of this one was a 'fin' from top to bottom. Also, there were four horizon fins around the base of this inner piece. When superimposed, the tip of the inner piece was at the neck of the outer piece. All four fins of the inner piece inserted fitly into the corners of the corresponding outer piece dividing the pot into four separate compartments. The bottom fins acted as pot base. For version 1 TC pot, corresponding walls of the outer and inner pieces were in parallel fashion (2 cm apart), while the second version had a wider gap at the lower portion (4 cm). To prevent unexpected separation, bolts and nuts could be used at the base to hold both pieces together; and they sat firmly on a square and edged tray.

The making of this pot began with a mock-up made of 'Future Board' to an exact proportion and readjustment was made where necessary. Then, the shape and size of each piece of the board was transferred onto a transparent acrylic sheet (2 mm) and cut. 'BOND' cement was used to glue each piece of acrylic together.

The dimensions (W x L x H) of this pot were 29 x 29 x 25 cm^3.

Two versions of prototype pots were tested iteratively by growing direct seeded 'KDML 105' rice. Dry coarse sand - filled through the mouth - was used as planting medium. The pot was wrapped around with a black plastic rubbish bag and placed outdoor. Two to three rice seeds were sown directly on the pot mouth. When seedlings established, only one seedling per pot was kept and roots around its crown were directed to grow into the nearby compartments. However, in the final test with PC pots, rice seeds were pre-germinated in a Petri dish, and then all primary and secondary roots - except adventitious roots - of the seedlings (14 days after planting; DAP) were cut off before transplanting. Rice plants in all tests received adequate water daily and granular fertilizer (21-24-12) weekly.

Two TC pots were tested each time and rice was also planted in two plastic pails for comparison. At the end of each test (30-48 DAP), rice growth stage was identified according to IRRI (2000). Then root data were collected and plant growth was compared.

Results and Discussion

1. Development of TC pot

A prototype pot was developed as in **Figure 1**. Transparent acrylic sheets proved to be an ideal material for construction of this pot - for relatively small sized plants. Materials used could be purchased in the local stores and were easy to manipulate. The transparency of the acrylic sheet enabled us to inspect parts of the roots visually from outside of the pot. To prevent light interference of root growth, black plastic sheet was used to wrap around the pot.

The pot mouth connected to all four compartments of the TC pot enabling dry sand to be poured in as planting medium. If needed, water could be used to compact the sand inside each compartment. All four horizon fins around the base of the inner piece prevented sand from running out of the pot.

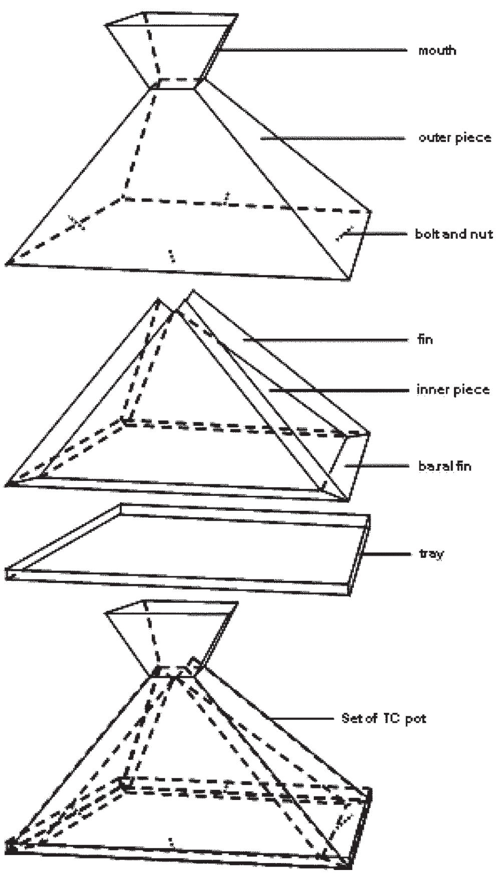

Figure 1 Schematic design of a set of transparent-compartmental (TC) pot.

The joining point on the top of all compartments of the pot was the position for seed or seedling placement. The bottom of each compartment diverged out diagonally. This allowed root growth in downward fashion and also created a room inside for extra root observation, or extra treatment for example light treatment.

Fins along the spines of the inner piece partitioned this TC pot into four separate compartments from a common place. These enabled us to direct plant roots to grow into each compartment. Different treatments could be applied to different set of roots of a single plant growing in this pot. This might open another new window in root study.

The outer piece of the pot prevented planting material moving out. After watering for a few days, the planting material would set. This allowed us to lift the outer piece up for a closer root inspection or sample taking, and then put back for further study.

2. Tests of TC pot

Repetitive tests - in rice up to growth stage 2 (IRRI, 2000) or early tillering stage - with some modifications were done to examine the applicability of this TC pot.

Test 1 terminated at early rice growth stage 2 for preliminary inspection. Even though rice grown in TC pots (version 1) seemed to be slightly inferior, overall root and shoot growths of both pot treatments were normal and the same (**Table 1**). In a TC pot, all four compartments had comparable amount of rice roots. It should be noted that almost all of the rice roots observed after seedling stage are adventitious roots (Purseglove, 1985)

The number of visible roots (both thick and thin roots)/ plant in test 2 was almost the same in both pot types (**Table 1**). In TC pots of version 2 (wider lower portion), each compartments had unequal number of rice roots. Since rice was direct seeded and those roots were not guided initially into the compartments. However, length of the longest roots of rice grown in plastic pails seemed to be shorter due to root breakage while digging up the rice plant. Overall root and shoot growths in TC pot were normal.

In test 3, rice grown in plastic pails had a greater number of visible roots (both thick and thin roots - (**Table 1**) probably due to the favorable rainfall in August and a larger amount of sand for roots to explore. The shorter length of longest roots in plastic pails was also due to root breakage during plant dug up. In this test, roots of rice grown in TC pots (version 2) were guided initially to grow into the nearest compartments. Consequently, the number of visible roots in each compartment was comparable but the length of root was not uniform (**Table 2**). Overall root and shoot growths were also normal.

Rice grown in plastic pails in test 4 also had a greater number of visible roots (both thick and thin roots - **Table 1**). Roots of rice grown in TC pots (version 2) were also guided initially to grow into the nearest compartments resulting in a comparable amount of roots, except one compartment (**Table 2**). It should be noted that the number of thick roots was comparatively low. Overall root and shoot growths were also normal.

Table 1 Growth of 'KDML 105' rice in plastic pails and transparent-compartmental (TC) pots placed outdoor during rainy season.

	Growth stage	No. of visible roots / plant	Length of longest roots (cm)	Overall root growth	Plant height (cm)	No. of tillers / plant	Overall shoot growth
Test 1 (Version 1 TC pot)							
Plastic pail	2	NA[1/]	4	normal	34	NA	normal
TC pot	2	NA	4	normal	32	NA	normal
Test 2 (Version 2 TC pot)							
Plastic pail	2	41	27	normal	63	2	normal
TC pot	2	40	30	normal	63	2	normal
Test 3 (Version 2 TC pot)							
Plastic pail	2	57	16	normal	59	4	normal
TC pot	2	35	22	normal	57	3	normal
Test 4 (Version 2 TC pot)							
Plastic pail	2	39	21	normal	54	2	normal
TC pot	2	26	24	normal	52	2	normal

[1/] NA = not available

Table 2 Root growth of 'KDML 105' rice in different compartments of transparent-compartmental (TC) pots placed outdoor during rainy season.

	Compartment			
	1	2	3	4
Trial 3 (Version 2 TC pot)				
No. of visible roots	9	12	7	7
Length of longest root (cm)	21	28	21	17
Overall root growth	normal	normal	normal	normal
Trial 4 (Version 2 TC pot)				
No. of visible roots	9	4	7	6
No. of thick roots	2	2	1	1
Length of longest root (cm)	23	27	20	24
Overall root growth	normal	normal	normal	normal
Test 5 (Version 2 TC pot)				
No. of visible roots	6	7	5	5
No. of thick roots	1	2	1	1
Length of longest root (cm)	22	23	18	22
Overall root growth	normal	normal	normal	normal

In test 5, primary and secondary roots of rice seedlings were severed before transplanting into TC pots (version 2). It was hoped that this would stimulate adventitious root growth. However, data in Table 2 and the observation concluded that the presence or absence of both primary and secondary roots did not affect on rice root and shoot growths during early growth.

All tests showed that this TC pot was able to separate roots of a rice plant to grow into different compartments. Root monitoring and sample taking could be done easily. However, only rice - a monocot with fibrous root system - was tested.

Conclusions

A prototype of transparent-compartmental pot was developed. This pot was made of acrylic enabling us to monitor parts of root visually and indestructively. The four compartments of this pot enabling a plant's roots to grow separately. The outer piece of this double pyramid structure allowed us to lift it up for a closer inspection and sample taking.

Acknowledgement

This project was supported financially from the Faculty of Agriculture, Ubon Ratchathani University, Thailand.

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