

(Provisional Translation)

Autonomous Agri-machinery Test (rice transplanters)

Main Test Methods and Criteria

November 2020, Adopted

April 2021, Revised

April 2021 (Ver1.1)

National Research and Development Agency
National Agriculture and Food Research Organization (NARO)

(Note) The purpose of this provisional translation is only for reference.
For authenticity, please refer to NARO's Japanese texts available at:
https://www.naro.go.jp/laboratory/iam/contents/test/pdf/kensa_002_010_3.pdf.

Table of contents

1. Scope	1
2. Terms and definitions	1
3. Test methods	2
3-1 Test items	2
3-2 Test conditions	2
3-3 Inspections and test methods	2
3-3-1 Structural inspection	2
3-3-2 Manual mode function test	3
3-3-3 Operation state indication function test	3
3-3-4 Prevention of running out the paddy field function test	4
3-3-5 Other necessary safety function test	5
3-3-6 Operability test	5
4. Criteria of the test	6
Supplementary Provisions (Optional test)	8

1. Scope

The methods and criteria of this test are applied to a rice transplanter (hereinafter referred to as transplanter), which autonomously operates in a paddy field without an onboard operator but is subject to the operator's supervision located in or near the paddy field.

2. Terms and definitions

The terms used in the methods and criteria for this test are as follows:

(1) Autonomous operation

Autonomous operation means the transplanter autonomously performs farm work operation using signals such as GNSS and camera images.

(2) Autonomous mode

Autonomous mode means a state of the transplanter in which autonomous operation is enabled.

(3) Manual mode

Manual mode means a state of the transplanter in which autonomous operation is disabled.

(4) Operation state

Operation state means the transplanter is in the following state; autonomous operation state, autonomous operation enabled state, and autonomous operation disabled state.

(5) Autonomous operation state

Autonomous operation state means the transplanter is in autonomous operation.

(6) Autonomous operation enabled state

Autonomous operation enabled state means the transplanter can start autonomous operation when the operator instructs it to start.

(7) Autonomous operation disabled state

Autonomous operation disabled state means the transplanter cannot start autonomous operation despite the operator instructing it to start.

(8) Hazard zone

Hazard zone is an area where the movement of the transplanter may lead to severe damage to a person/obstacle around the transplanter.

(9) Warning zone

Warning zone is an area around the transplanter where people/obstacles around the transplanter may enter the hazard zone.

(10) Operation zone

Operation zone means an area inside the paddy field where the operator instructs the

transplanter to operate autonomously.

3. Test methods

3-1 Test items

The test will be conducted on the following inspection and test items.

(1) Structural inspection

(2) Manual mode function test

(3) Operation state indication function test

(4) Prevention of running out the paddy field function test

(5) Other necessary safety function test

(6) Operability test

3-2 Test conditions

(1) Measuring instrument

Measuring instruments shall be verified and corrected.

(2) Discontinuation of Test

The inspection and test shall be discontinued for the following occasions:

a) When the transplanter to be inspected is different from its normal state (the state in which the transplanter has been manufactured as designed and the quality is guaranteed), or when a proper inspection or test cannot be performed due to the occurrence of damage, abnormality, etc.

Notwithstanding the above, inspection and test can be continued when the inspecting agency recognizes that the reason for the damage/abnormality cannot be attributed to the applicant or that the damage/abnormality is minor, and by replacing the parts, a proper inspection or test can be promptly continued.

b) An occasion the applicant requests to discontinue the inspection and/or test.

3-3 Inspections and test methods

3-3-1 Structural inspection

(1) Purpose

This inspection checks the equipment required for autonomous operation.

(2) Inspection and test items

- a) Autonomous mode/manual mode switching device
- b) Indicator displaying the operation state (hereinafter referred to as the indicator)
- c) System required for autonomous operation
- d) Function to prevent running out the paddy field
- e) Other necessary equipment, etc.

3-3-2 Manual mode function test

(1) Purpose

This test checks the transplanter's behaviors in the autonomous operation disabled state.

(2) Test conditions

- a) The transplanter shall be placed on a flat and paved surface.
- b) The test shall be conducted with the transplanter parked.

(3) Test method

- a) Check the behaviors of the transplanter in manual mode when the operator instructs it to start autonomous operation.

3-3-3 Operation state indication function test

(1) Purpose

This test checks that the operator can recognize the transplanter's operation state using indicators.

(2) Test conditions

- a) The transplanter shall be placed on a flat and paved surface.
- b) The test shall be performed on the transplanter in autonomous mode, parked, and in operation.

(3) Test method

- a) Check the indication when the transplanter is in autonomous operation state.

- b) Check the indication when the transplanter is in autonomous operation enabled state.
- c) Check the indication when the transplanter is in autonomous operation disabled state.

3-3-4 Prevention of running out the paddy field function test

(1) Purpose

This test checks the transplanter's function, which prevents the transplanter from running out of the paddy field, surrounded by ridges.

(2) Test conditions

- a) The transplanter shall be placed on a flat and paved surface.
- b) The test shall be performed with the transplanter moving in autonomous operation mode with no seedlings on board.
- c) A simulated ridge is shown in Fig.1
- d) Simulated ridges are placed in front or rear depending on the direction of the transplanter's movement so that the transplanter tilts forward or backward as crossing the simulated ridges (Fig. 2).

(3) Test method

Check the behavior of the transplanter when crossing simulated ridges both backward and forward.

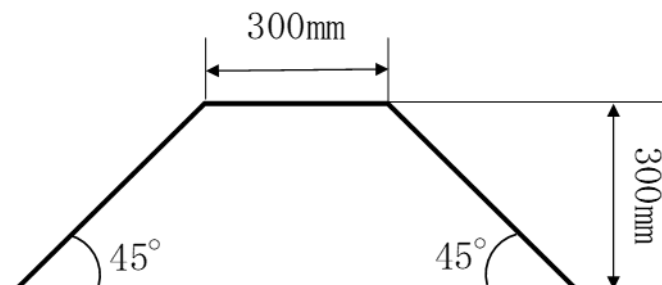


Fig. 1 Dimensions of a simulated ridge (cross-sectional view)



Fig. 2 Relative positions of the transplanter and simulated ridges

3-3-5 Other necessary safety function test

(1) Purpose

This test checks the operability of the pendant control device, etc., and safety functions in case of a communication failure.

(2) Test conditions

- a) The transplanter shall be placed on a flat paved surface.
- b) The test shall be performed on the transplanter in the autonomous mode parked or in operation as needed.

(3) Test method

- a) Check the procedure to start the autonomous operation.
- b) Check the transplanter's behaviors when the operator instructs the transplanter to stop during the autonomous operation.
- c) Check the transplanter's behaviors when a communication failure occurs between the pendant control device and the transplanter during autonomous operation.
- d) Check other functions that are considered necessary for safety.

3-3-6 Operability test

(1) Purpose

This test checks the operability and safety of the transplanter throughout the procedures of autonomous operations, including establishing an operation zone and supplying seedlings.

(2) Test conditions

- a) The test shall be conducted in a field of 10 acres or more.
- b) The test shall be performed on the transplanter in autonomous mode, moving at the machine's permissible maximum speed.

(3) Test method

- a) In principle, a rectangular operation zone of 10 acres (50m x 20m) or more shall be established in a field.
- b) The inspecting agency shall set the transplanter in the autonomous operation mode for the test, instruct the transplanter to complete all the autonomous operations and works in the established operation zone, and check the behaviors of the transplanter.

4. Criteria of the test

The criteria of this autonomous agri-machine test for transplanters are as follows:

- (1) In the inspection of 3-3-1, the equipment necessary for autonomous operation is installed, and the equipment that requires the operator's inputs for operation is positioned so that it can be safely and easily handled by the operator in the normal working position. In addition, the functions and operation methods of the equipment are indicated. Furthermore, the transplanter shall have a function to remain inside the operation zone during autonomous operation.
- (2) In the 3-3-2 test, the autonomous operation cannot be started in manual mode.
- (3) In the 3-3-3 test, the state of the transplanter is indicated correctly, and the operator can easily recognize the state of the transplanter.
- (4) In the test of 3-3-4, the transplanter, including its planting mechanism, shall stop while crossing a simulated ridge.
- (5) In the 3-3-5 test, the pendant control device has a safeguard to prevent incorrect operation.
- (6) In the 3-3-5 test, the transplanter, including its planting mechanism, shall stop when the operator instructs the machine to stop using the pendant control device.
- (7) In the 3-3-5 test, the transplanter, including its planting mechanism, shall stop autonomously when a malfunction happens, such as a communication failure between the transplanter and the pendant control device.
- (8) In the 3-3-5 test, there must be no defects in the functions for safety. In addition,

when there is a failure in the system required for autonomous operation, the transplanter shall not start autonomous operation.

(10) In the 3-3-6 test, there shall be no significant defects in operability and safety.

Supplementary Provisions (Optional test)

1 Person/obstacle detection function test

(1) Purpose

This test checks that the transplanter detects a person or an obstacle approaching without contact in autonomous operation. And warns people in the surroundings and stops autonomously.

(2) Test conditions

- a) The transplanter shall be placed on a flat and paved surface.
- b) The test shall be performed with the transplanter moving (permissible maximum speed) in autonomous mode.
- c) The test obstacle shall conform with ISO18497: 2018 (Fig. 3).
- d) The test obstacle shall be placed, both in front or behind the transplanter, on the center line of the roll axis direction of the transplanter (hereinafter referred to as the center line) as well as on the straight lines parallel to the center line passing through the outermost side (including folded marker) of the transplanter (Fig. 4).

(3) Test method

1) Test in the warning zone

- a) With the test obstacle placed in front of the transplanter, as the transplanter moves forward, check the behaviors of the transplanter when the test obstacle enters the warning zone.
- b) With the test obstacle placed behind the transplanter as the transplanter moves backward, check the behaviors of the transplanter when the test obstacle enters the warning zone.

2) Test in the hazard zone

- a) With the test obstacle placed in front of the transplanter, as the transplanter moves forward, check the behaviors of the transplanter when the test obstacle enters the hazard zone.
- b) With the test obstacle placed behind the transplanter, as the transplanter moves backward, check the behaviors of the transplanter when the test obstacle enters the hazard zone.

2. Criteria of the test

(1) In the test of 1-(3)-1), a warning signal shall be issued.

(2) In the test of 1-(3)-2), the transplanter and its planting mechanism must not come into contact with the test obstacle. Also, the transplanter, including its planting mechanism, shall stop.

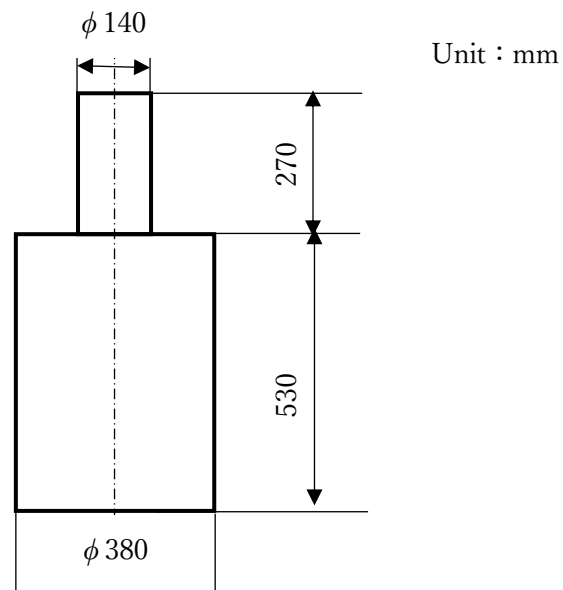


Fig. 3 Test obstacle (conform with ISO18497: 2018)

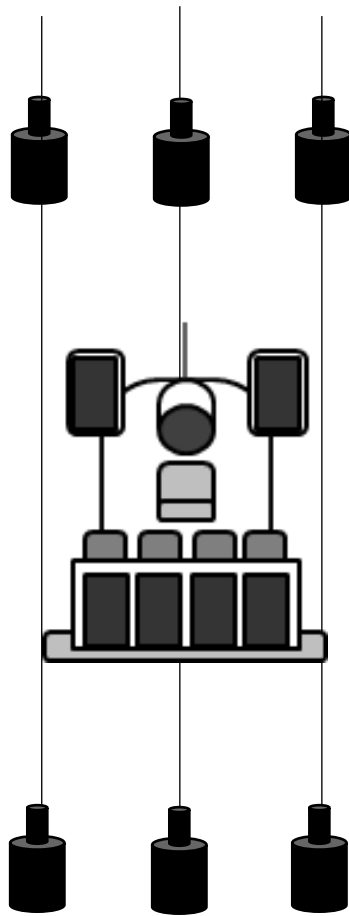


Fig. 4 Relative positions of the transplanter and test obstacles