

**AY2026 Entrance Examination for the Master's Program,
Graduate School of Bioagricultural Sciences, Nagoya University**

Subject chosen	Plant Production Science	For this subject Total pages (1) Page number (1)
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Answer all questions from **【Question 1】** to **【Question 3】** .
Write your answers on separate answer sheets for each **【Question】** .

【Question 1】 Answer all following questions about rice.

- (1) Rice is widely cultivated in paddy fields. In flooded paddy fields, the oxygen concentration in the soil is low and the soil becomes reduced conditions. Explain why rice can grow under these flooded conditions based on its morphological and physiological characteristics.
- (2) Rice cultivated in paddy fields generally maintains a certain level of yield over long periods under continuous cropping even with minimal chemical fertilizer application. Explain the reasons for this based on the characteristics of paddy fields.
- (3) Describe the significance and problems of soil puddling before transplanting in paddy fields in the aspects related to rice growth, environment, and others.
- (4) Rice is sometimes cultivated as upland rice under field conditions without irrigation. Describe the problems in upland rice cultivation and their countermeasures.

【Question 2】 Answer all following questions regarding the following statement.
High temperature at flowering stage and maturity stage causes decrease in yield and grain quality in rice.

- (1) Explain how high temperature above optimum temperature during the flowering stage leads to a decrease in rice yield.
- (2) Describe the mechanism of the decrease in grain quality caused by high temperature during the ripening stage.
- (3) Describe specific measures to avoid or mitigate high-temperature injury from the perspectives of cultivation practices and breeding.

【Question 3】 State what you know regarding the following items (1) to (4).

- (1) Living mulch
- (2) Nitrogen starvation
- (3) No-tillage cultivation
- (4) Optimal leaf area index

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解答例

【Question 1】

(1) (Morphological Characteristics)

Rice possesses well-developed aerenchyma in both its aboveground parts and roots, enabling oxygen supply from the aboveground parts to the roots. This allows adaptation to oxygen deficiency in the soil caused by flooding. Additionally, the formation of a "radial oxygen loss (ROL) barrier" at the root base suppresses radial oxygen release, efficiently delivering oxygen to the root tips.

(Physiological Characteristics)

The roots possess the ability to continue anaerobic respiration to some extent even under low-oxygen conditions. The root tips release oxygen, forming an oxidized microenvironment (oxidation zone) in the rhizosphere. This reduces the toxicity of harmful substances (reduced iron, hydrogen sulfide) produced under reducing conditions.

(2) The following factors are considered:

The slow decomposition of organic matter facilitates the retention of nitrogen and carbon in the soil, enhancing nitrogen supply capacity and nutrient retention.

Nutrients are supplied via irrigation water.

The primary inorganic nitrogen form is NH_4 , which is less prone to leaching.

Paddy soils host diverse nitrogen-fixing organisms like cyanobacteria and photosynthetic bacteria, maintaining high nitrogen-fixing capacity and nitrogen supply.

Reduction processes facilitate the conversion of phosphorus into available forms.

(3) Significance

Leveling the soil.

Suppressing excessive permeability.

Promoting the mineralization of soil nitrogen.

Problems

Discharge of turbid water.

Labor intensity and energy consumption associated with machinery.

(4) Drought is likely to occur; therefore, deep-rooted varieties are often advantageous. Soil-borne diseases and pests associated with continuous cropping are likely to occur. A crop rotation system is effective to prevent the problems.

【Question 2】

(1) High temperature (specifically above 35°C) during the flowering stage causes failure of anther dehiscence and loss of pollen germination ability. This prevents normal pollination and fertilization, leading to an increased percentage of sterile spikelet and a significant decrease in grain yield.

(2) High temperature during the ripening stage decreases the activity of starch synthase and increases the activity of starch-degrading enzymes (alpha-amylase) in endosperm cells. As a result, starch granules are loosely packed with air spaces. These spaces scatter light, causing the grains to appear chalky (white-back or milky-white kernels), which deteriorates the appearance quality of brown rice.

(3) Cultivation practice: Adjusting transplanting dates (shifting earlier or later) to prevent the flowering and ripening stages from coinciding with the peak heat period and lowering water temperature through continuous irrigation with cool water.

Breeding approach: Developing varieties with "early-morning flowering" traits to complete pollination before the temperature rises, and breeding "heat-tolerant varieties" that can maintain starch synthesis capability even under high-temperature conditions.

【Question 3】

(1) Living mulch

A living mulch refers to a plant species- or the cultivation technique involving it-grown together with a main crop (mixed cropping or intercropping) primarily for weed suppression in upland fields. Examples include white clover used as a living mulch with maize (the main crop), or barley used as a living mulch with soybean. In addition to suppressing weeds, living mulches can also function as green manure, potentially promoting main-crop growth and allowing fertilizer reduction. However, if the living mulch grows too vigorously, competition for light, soil moisture, and nutrients becomes intense, resulting in yield losses that resemble weed interference caused by the living mulch itself.

(2) Nitrogen starvation

Nitrogen starvation refers to a condition in which plant-available inorganic nitrogen in the soil (ammonium NH_4^+ and nitrate NO_3^-) becomes insufficient, causing plants to fall into a nitrogen-deficient state. Particularly important is the temporary nitrogen starvation caused by microbial immobilization following the application of high-C/N organic materials such as straw, wood chips, or immature compost. Microorganisms require large amounts of nitrogen for biomass synthesis during decomposition of organic matter and therefore take up inorganic nitrogen from the soil, sharply reducing the nitrogen available to plants. This phenomenon is not permanent; as decomposition progresses, microorganisms release excess nitrogen back into the soil through mineralization, restoring nitrogen availability. Countermeasures include adjusting the timing of organic matter application, combining with mineral nitrogen fertilizer, selecting organic materials with lower C/N ratios, and ensuring sufficient compost maturity.

(3) No-tillage cultivation

No-tillage cultivation is a farming method in which crops are sown directly on the soil surface without plowing or tilling (such as plow turning or rotary tillage), leaving

residues from the previous crop in place. By minimizing soil disturbance, this system offers significant environmental benefits, including prevention of soil erosion, maintenance of soil aggregate structure, increased soil organic matter, and enhanced carbon sequestration. Reduced field operations also save labor, fuel, and time. On the other hand, the absence of tillage can lead to lower soil temperatures and slower early growth, increased weed pressure, and potential carryover of overwintering pests. Therefore, many no-tillage systems rely on integrated herbicide programs, the use of cover crops, and appropriate seeding equipment such as direct seeders. No-tillage cultivation is a key practice in conservation agriculture and sustainable farming, particularly effective in regions prone to soil erosion caused by heavy rainfall.

(4) Optimal leaf area index

The optimal leaf area index (LAI) refers to the leaf area at which the growth rate of a plant population reaches its maximum. Population growth rate is determined by the difference between canopy photosynthesis and canopy respiration. As LAI increases, canopy photosynthesis also increases; however, once LAI becomes sufficiently large, mutual shading among leaves intensifies and photosynthesis no longer increases. In contrast, canopy respiration rises linearly with increasing LAI regardless of shading. Consequently, the population growth rate—defined as the difference between canopy photosynthesis and respiration—peaks at a certain LAI, which is considered the optimal LAI. The optimal value varies depending on canopy architecture and solar radiation conditions but is around 4 for many crop species.

出題意図

【Question 1】

This question is designed to assess basic knowledge about rice cultivations and paddy fields.

【Question 2】

This question is designed to assess the basic knowledge of physiological mechanisms regarding the impact of global warming on rice, specifically focusing on yield and quality. Furthermore, it evaluates the ability to apply this knowledge by proposing specific countermeasures from the perspectives of cultivation practices and breeding.

【Question 3】

This question is designed to assess fundamental knowledge of crop science and cultivation techniques.