

**EFFECT OF MACRONUTRIENT RATES ON PHYSIOLOGICAL PROCESSES
AND WATER REGIME IN RICE (*Oryza sativa* L.) VARIETIES**

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Abstract

The article investigates the effect of nitrogen (N), phosphorus (P), and potassium (K) application rates on physiological processes and water regime parameters in rice (*Oryza sativa* L.) varieties. The experiments determined the content of chlorophyll "a" and "b" in leaves, photosynthetic intensity, leaf water potential, transpiration rate, and relative water retention. The results showed that increasing macronutrient rates enhanced photosynthetic activity and leaf water content, while certain changes in transpiration processes were observed. Balanced NPK application was found to improve water use efficiency and ensure physiological stability of rice plants.

Keywords: Rice, *Oryza sativa* L., macronutrients, nitrogen, phosphorus, potassium, chlorophyll "a" and "b", photosynthetic intensity, water potential, transpiration, water use efficiency.

Annotatsiya:

Maqolada sholi (*Oryza sativa* L.) navlarida azot (N), fosfor (P) va kaliy (K) meyorlarining fiziologik jarayonlar hamda suv rejimi ko'rsatkichlariga ta'siri tadqiq etildi. Tajribalarda barglardagi xlorofill "a" va "b" miqdori, fotosintez intensivligi, barg suv potentsiali, transpiratsiya tezligi va nisbiy suv saqlanishi aniqlandi. Natijalar makroelementlar meyori oshishi bilan fotosintetik faollik va barg suv miqdori ortishini, shu bilan birga transpiratsiya jarayonlarida ma'lum o'zgarishlar kuzatilishini ko'rsatdi. NPK meyorlarining mutanosib qo'llanilishi sholi navlarida suvdan foydalanish samaradorligini yaxshilab, fiziologik barqarorlikni ta'minlashi aniqlandi.

Kalit so'zlar: Sholi, *Oryza sativa* L., makroelementlar, azot, fosfor, kaliy, xlorofill "a" va "b", fotosintez intensivligi, suv potentsiali, transpiratsiya, suvdan foydalanish samaradorligi.

Аннотация:

В статье исследовано влияние норм азота (N), фосфора (P) и калия (K) на физиологические процессы и показатели водного режима у сортов риса (*Oryza sativa* L.). В опытах определяли содержание хлорофилла «а» и «b» в листьях, интенсивность фотосинтеза, водный потенциал листа, скорость транспирации и относительное водоудержание. Результаты показали, что с увеличением нормы макроэлементов возрастала фотосинтетическая активность и содержание воды в листьях, при этом отмечались определённые изменения в процессах транспирации. Установлено, что сбалансированное применение норм NPK улучшает эффективность использования воды и обеспечивает физиологическую устойчивость растений риса.

Ключевые слова: рис, *Oryza sativa* L., макроэлементы, азот, фосфор, калий, хлорофилл “а” и “b”, интенсивность фотосинтеза, водный потенциал, транспирация, эффективность использования воды.

Introduction

Rice (*Oryza sativa* L.) is one of the major cereal crops of strategic importance for ensuring food security in Uzbekistan. Resolution No. 410 of the Cabinet of Ministers of the Republic of Uzbekistan “On measures to ensure uninterrupted supply of rice products to the population” defines key tasks aimed at stabilizing rice production and increasing agricultural productivity [1].

The physiological status and productivity of rice are directly dependent on mineral nutrition. In particular, macronutrients – nitrogen (N), phosphorus (P), and potassium (K) – play a fundamental role in plant life processes. Nitrogen enhances photosynthetic activity and chlorophyll synthesis; phosphorus is involved in energy metabolism and ATP formation; potassium regulates water balance, osmotic adjustment, and transpiration processes (Taiz & Zeiger, 2010; Marschner, 2012; Yoshida, 1981) [2–6]. Under the climatic conditions of Uzbekistan, water scarcity and insufficient mineral nutrition may negatively affect rice growth and yield formation. Therefore, a comprehensive evaluation of the effects of different NPK application rates on physiological processes and water regime is of considerable scientific and practical importance.

Objective: To determine the effect of macronutrient application rates on physiological processes and water regime in rice varieties and to develop scientifically grounded recommendations for agricultural practice.

Degree of Study of the Problem: The influence of macronutrients on physiological processes and water regime in rice (*Oryza sativa* L.) has been widely investigated by foreign researchers. Taiz and Zeiger (2010) analyzed the effects of macronutrients on photosynthesis, pigment content, and water-use efficiency. Marschner (2012) described the role of mineral nutrition in osmotic regulation, ion balance, and energy metabolism.

Yoshida et al. (1981) experimentally evaluated the effects of nitrogen and phosphorus rates on root development and water regime in rice.

Although studies aimed at increasing rice productivity and improving water-use efficiency have been conducted under the conditions of Uzbekistan, a systematic investigation of the combined effects of macronutrient rates on physiological processes and water regime remains scientifically relevant.

Materials and Methods:

The experiments were conducted at the experimental field of the Rice Research Institute. The study included a control treatment without mineral fertilizers and treatments with various rates of mineral fertilizer application. Macronutrients – nitrogen (N), phosphorus (P), and potassium (K) – were applied at different rates. Fertilizer doses were selected to evaluate their effects on physiological processes and the water regime of plants.

Leaf chlorophyll content was determined spectrophotometrically according to the method of Arnon [9]. Photosynthetic activity, transpiration intensity, and water retention capacity were assessed using standard laboratory procedures in plant physiology [10; 11]. Control and fertilized treatments were analyzed comparatively. The obtained data were processed using statistical methods. Standard error (SE) and coefficient of variation (CV%) were calculated [12].

Results:

According to the 2025 scientific report of the Rice Research Institute, Laboratory of Plant Physiology and Biochemistry, “Study of the relationship between physiological and biochemical processes and growth, development, and yield of rice and soybean plants”:

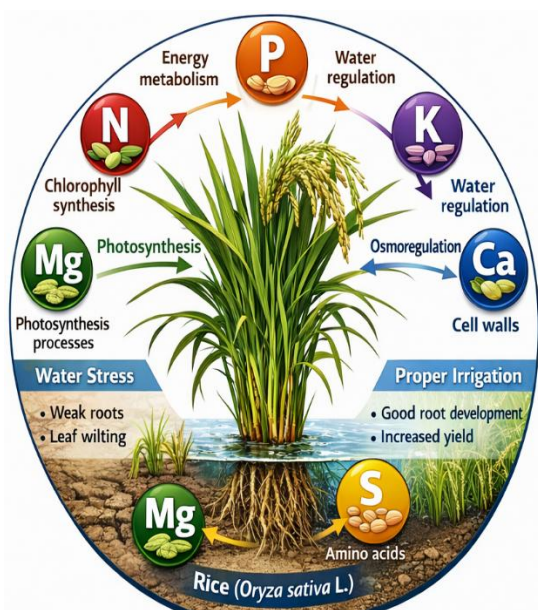
Water balance in plants is a physical process that directly affects the life of all terrestrial species and determines a number of important physiological processes. Water deficiency induces soil drought stress, activates antioxidant defense systems, and disrupts protection mechanisms against reactive oxygen species (ROS) [8]. At the molecular level, stress-responsive genes are activated, and the synthesis of ascorbate peroxidase (APX) enzyme and heat shock proteins (HSPs) increases [7].

The effects of different mineral fertilizer rates on leaf water content, transpiration intensity, and water retention capacity were evaluated for rice varieties “Billur,” “Sadaf,” and “Ziynat” and are presented in the following table:

Table 1. Effect of Macronutrient Rates on Physiological Parameters and Water Regime in Rice Varieties

Fertilizer Rate (N:P:K)	Leaf Water Content, %	± (%) vs Control	Transpiration, mg/g·h	± vs Control	Water Retention Capacity, %	± vs Control 1
Control	91.7	0	342.6	0	65.2	0
P ₁₂₀ K ₁₅₀	92.4	+0.7	348.9	+6.3	61.3	-3.9
N ₁₀₀ P ₁₂₀ K ₁₅₀	93.5	+1.8	365.4	+22.8	64.5	-0.7
N ₁₂₀ P ₁₂₀ K ₁₅₀	94.3	+2.6	398.5	+55.9	55.2	-10.0
N ₁₅₀ P ₁₂₀ K ₁₅₀	94.8	+3.1	385.4	+42.8	60.4	-4.8

Water Balance and Transpiration in Rice: Even under conditions of high air humidity, evaporation from plants is minimal, although they still lose a small amount of water through transpiration. This water loss occurs due to heat energy released during plant respiration.



Transpiration transports water and dissolved nutrients to the upper organs of the plant and ensures the continuous progress of photosynthesis. As a result, conditions are created for the diffusion of carbon dioxide into leaf tissues. Maintaining a lower plant body temperature relative to the surrounding environment enhances tolerance to solar radiation

. The efficiency of enzyme activity, metabolite movement, normal respiratory processes, and adequate water content in plant tissues are all closely associated with transpiration intensity. Only 0.2% of the water absorbed by plants is assimilated, while the remaining 99.8% is lost through evaporation. During the vegetative period, plants transpire large quantities of water. One of the key indicators of water exchange is the water retention capacity of tissues, which significantly affects physiological processes and yield formation [13].

Conclusion:

Leaf water content: Increasing fertilizer doses positively affected leaf water content. The highest value (94.8%) was observed under the $N_{150}P_{120}K_{150}$ combination, indicating that nitrogen and potassium promote water accumulation in leaves.



Figure 1: Processes conducted in collaboration with international researchers and the research team.

Transpiration intensity: The $N_{120}P_{120}K_{150}$ and $N_{150}P_{120}K_{150}$ treatments significantly increased transpiration (398.5 and 385.4 mg/g·h, respectively), reflecting more active water flow and accelerated physiological processes. In contrast, transpiration was relatively low in the control and $P_{120}K_{150}$ treatments.

Water retention capacity: The lowest water retention (55.2%) was recorded in the $N_{120}P_{120}K_{150}$ treatment, likely due to higher transpiration and metabolic activity. In the control, water retention was highest (65.2%), indicating that plants conserve water more efficiently when less fertilizer is applied.

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