CORRELATION BETWEEN ROOT DEVELOPMENT AND RICE GROWTH (KD18) UNDER THE INFLUENCE OF DIFFERENT IRRIGATION REGIMES

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ABSTRACT

Study on growth and development of rice under the influence of different irrigation regimes arranged in greenhouse conditions at Thai Nguyen University of Agriculture and Forestry. The experiment was conducted on Khang Dan 18 rice variety with 5 different irrigation treatments, including flooded treatment during cultivation (F1); alternate between dry and wet every 4 days (F2), 8 days (F3), 12 days (F4) and 16 days (F5). The results show that the irrigating regime significantly affects the growth of rice such as number of branches, plant height, dry mass, leaves and roots. The best growth of rice is at the 4-day alternating between dry and wet, which has 24.2 - 36.9% higher growth rate than the other treatments. Growth factors, such as leaf stem weight, are strongly correlated with root parameters at tillering, dough and maturity. The root parameters are positively correlated with the growth of stems and leaves in the flowering and maturing stage. The higher number of roots significantly leads to the larger root mass, leaf, stem, and total dry matter weight with a confidence level of 95% or more ($P < 0.05$). In order for the rice to grow well, it is necessary to manage irrigation for the best root development especially in the main stages such as tillering, panicle initiation, heading, grain filling, and ripening.

Keywords: *Rice roots; rice; growth; irrigation regime; correlation.*

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TƯƠNG QUAN GIỮA SỰ PHÁT TRIỂN BỘ RỄ VÀ SINH TRƯỞNG CỦA CÂY LÚA (KD18) DƯỚI TÁC ĐỘNG CỦA CÁC CHẾ ĐỘ NƯỚC TƯỚI KHÁC NHAU

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TÓM TẮT

Nghiên cứu sự sinh trưởng và phát triển của cây lúa dưới tác động của các chế độ nước khác nhau được bố trí trong điều kiện nhà kính tại trường Đại học Nông Lâm – Đại học Thái Nguyên. Thí nghiệm được thực hiện trên giống lúa Khang dân 18 (KD18) với 5 công thức tưới nước khác nhau, trong đó có công thức ngập nước trong suốt quá trình canh tác (CT1); các công thức ướt khô xen kẽ 4 (CT2), 8 (CT3), 12 (CT4) và 16 ngày (CT5). Kết quả trên cho thấy chế độ tưới nước ảnh hưởng rõ rệt đến sinh trưởng của cây lúa như số nhánh, chiều cao cây, khối lượng thân, lá, rễ. Sự sinh trưởng của lúa tốt nhất ở chế độ nước ngập khô xen kẽ 4 ngày cao hơn các công thức ngập khô xen kẽ dài ngày từ 24,2 - 36,9%. Các yếu tố sinh trưởng như khối lượng thân lá có mối quan hệ chặt với các chỉ tiêu rễ ở giai đoạn đẻ nhánh, chín sáp và chín hoàn toàn. Các chỉ tiêu về rễ có mối tương quan thuận chặt với chỉ tiêu sinh trưởng thân, lá ở giai đoạn trỗ, chín sáp. Số lượng rễ càng nhiều, khối lượng rễ càng lớn thì khối lượng lá, khối lượng thân, khối lượng chất khô tổng số của cây lúa càng cao với độ tin cậy có ý nghĩa ở mức 95% trở lên ($P < 0,05$). Để cây lúa sinh trưởng phát triển tốt cần chăm sóc về chế độ nước cho bộ rễ phát triển tốt nhất đặc biệt ở các giai đoạn chính như đẻ nhánh, làm đòng, trỗ và chín sáp.

Từ khóa: *Rễ lúa; lúa; sinh trưởng; chế độ nước; tương quan.*

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1. Introduction

The root system plays an extremely important role in the metabolism of rice, it performs activities such as absorbing water, nutrients, minerals and transporting water and nutrients in rice stems [1]. The metabolism of rice not only contributes to growth of leaf stems, resistance to pests, but also directly effects on rice yield and quality.

Mohd Khairi [2] studied the effect of irrigation regimes on the growth and development of rice. The results indicated that alternating dry and wet farming methods significantly reduced plant height (9%), number of branches ($p \leq 0.04$), flowers number ($p \leq 0.024$), firm seed rate ($p \leq 0.037$), yield ($p \leq 0.001$), economic index ($p \leq 0.005$), increase the percentage of dormant ($p \leq 0.011$) compared to the control.

Irrigation regime affects the development of the rice root system, the growth indicators, yield components and productivity [3].

Tsuno and Wang [4] concluded that the condition of drained fields can help the roots system develops better, the roots are more active, and have higher regeneration capacity, resulting in larger leaf, better photosynthesis, and higher productivity. These findings have been supported by two other new studies, the effect of the root system contributes to the rate of photosynthesis [5] and shoot growth is dependent on root development [6].

Root morphology and physiological characteristics are closely related to the growth and development of rice [7]. Mahmoud Toorchi [8] showed that plants height was significantly correlated with maximum root length (0.56). The same dimensional relationship between tree height and maximum root length was also discovered by Champoux [9].

Currently, due to climate change, irrigating conditions for agriculture meets many difficulties, in which rice requires a large amount of water. Studying the relationship between irrigation and the growth of root system, leaf, stem, and productivity is a necessary issue, providing the basis for proposing reasonable cultivation techniques to improve the rice yield.

Objective: Discover the relationship between root growth and rice growth in several major growth stages under the influence of different irrigation regimes to find the most appropriate irrigation regime for rice production.

2. Materials and methods

The experiment was conducted in a greenhouse condition at Thai Nguyen University of Agriculture and Forestry with non hybrid improved rice variety imported from China - Khang Dan 18, including the following treatments: F1: holding wet from transplanting to maturity; F2: draining and wet alternating every 4 days (4 days with water, draining 4 days alternately); F3: draining and wet alternating every 8 days (8 days with water, draining 8 days alternately); F4: draining and wet alternating every 12 days (12 days with water, draining every 12 days alternately); F5: draining and wet alternating every 16 days (16 days with water, draining 16 days alternately). Drained all the water in the pots after the logging time and refill again after dry time.

Fertilizer: 10 tons of manure, 120 N + 100 P_2O_5 + 120 K_2O/ha.

Pots size: being conducted in plastic pots with a diameter of 20 cm, height 30cm. Number of pots: 5 treatments x 5 replications (10 pots/ repetition) = 250 pots. Number of protected pots = 120 pots.

Experiment soil: Light loam is taken from a field plot, dried, crushed, screened and mixed with fertilizer.

Transplanting density: transplant 1 unit / pot.

Sampling method: each period take 9 plants/ treatment at 5 main stages such as: tillering

(45 days after transplanting), panicle initiation (70 days after transplanting), heading (50% rice flowered), grain filling (after flowering 15 days) and ripening (after flowering 30 days). Each stage collected the number of roots (SR), root length (DR), root diameter (DKR), total root mass (PR), the root mass at the soil layer ranges from 0-5 cm (Pr1), the root mass at the soil layer of 5-15 cm (Pr2) and the root mass at the soil layer is of 15-25 cm (Pr3) and plant height (CC), number of tiller (NH), stem weight (PT), leaf weight (Pl), leaf stem weight (Ptl) and total amount of accumulated dry matter (Pts).

Dry mass of roots: plant was randomly picked in each repetition of the experimental treatments; collected the root of 3 layers at 0-5, 5-15 and 15-25cm then washed the mud, put the roots in each cloth bag, then dried to constant weight and weighed.

Dried mass of stems and leaves: Separate stems and leaves to dry till constant weight and weigh.

The growth parameters includes: Number of branches, plant height, dry mass of stem, dry mass of leaves, dry mass of cluster.

The study was conducted under the guidance of the International Rice Research Institute - Standard Evaluation System for Rice - IRRI, 5th edition, 2013 [10].

3. Results and discussion

The results showed that different irrigation regimes affected the soil environment and the nutritional factors at different growth stages, which has an effect on the growth indicators of root system, specifically the total nitrogen content, total phosphorus content, easily digestible phosphorus content and ion exchange capacity with a confidence of 95 - 99.9%.

Irrigation regime has changed the physical, chemical and biological properties of the soil, which influences the development of the root system, resulting the impacts on other parts such as stems, leaves, seeds.

The irrigation regime affects the amount of dry matter in the stems and leaves at the breeding stage, the mass of leaf and stems is reduced by reducing the amount of water supplied at this period.

After transplanting, the longer time of alternating between dry and wet, the lower the mass of stem, leaves and the ability of accumulating dry matter is, which was also confirmed by Amod Kumar Thakur [11].

Correlation between root development and leaf growth

The height, number of branches, stem mass, leaf mass and total accumulated dry matter mass of the different treatments are indicators of rice growth. Rice cultivation with different irrigation regimes had differences in root growth, ability of absorbing water and nutrients, which affects the growth of rice. In order to find out which factors affect the growth indicators, we conducted an experiment about the correlation between root factors and growth indicators of rice over stages.

3.1. At tillering stage

Table 1. *Correlation coefficient of rooting factors with growth indicators at tillering stage*

	SR	DR	DKR	PR	Pr1	Pr2	Pr3
CC	0.74*ns*	0.96**	-0.75*ns*	0.87*ns*	0.85*ns*	0.89*	0.79*ns*
NH	0.55*ns*	0.81*ns*	-0.67*ns*	0.70*ns*	0.75*ns*	0.69*ns*	0.85*ns*
Pl	0.97**	0.86*ns*	-0.99***	0.98**	0.97**	0.97**	0.95*
Pt	0.96**	0.89*	-0.98**	0.98**	0.99***	0.96**	0.98**
Ptl	0.97**	0.88*ns*	-0.99***	0.99***	0.99***	0.97**	0.97**
Pts	0.97**	0.89*	-0.99***	0.99***	0.99***	0.98**	0.97**

*Note: ns - does not make sense; *** - significant at probability level p <0.001; ** -significant at probability level p <0.01; * - means at probability level p <0.05.*

As shown in table 1, at the tillering stage, the growth parameters are very closely related to the root system, in which the indicators such as leaf mass, stem mass, leaf stem mass, dry matter mass of rice were correlated with all rooting factors. Rice height is positively correlated with root length ($p < 0.01$) and root mass at soil layer 5 - 15 cm ($p < 0.05$).

Leaf mass was positively correlated with the number of roots ($p < 0.01$), the total root mass ($p < 0.01$), the root mass in the soil layer 0-5 cm, 5 - 15 cm, 15 - 25 cm ($p < 0.05$ - 0.01) and inversely correlated with root diameter ($p < 0.001$).

The stem mass at this stage is positively correlated with the number of roots, root length, total root mass, root volume at soil layers 5 - 15 cm, 15 - 25 cm ($p < 0.05$ - 0.01) and inversely correlated with the root diameter ($p < 0.01$).

Leaf stem mass is also affected in the same direction by the number of roots, total root mass, root mass at soil layers 0 - 5 cm, 5 - 15 cm, 15 - 25 cm ($p < 0.01$ - 0.001) and inversely correlated with root diameter ($p < 0.001$).

The total accumulated dry matter was also positively correlated with the number of roots, root length, total root mass, root mass at soil layers from 0 - 5cm, 5 - 15 cm, 15 - 25 cm ($p < 0.05$ to 0.001) and inversely correlated with root diameter ($p < 0.001$).

With the above correlation, attention should be paid to the number of roots and the root mass to increase the dry matter weight of the leaves and stems, which will help facilitate the good growth of rice. In order to give more tillering, it is necessary to create conditions for the root system to feed the roots wider, deeper and higher in number of roots, which can increase the height, number of branches, and larger biomass in later stages.

3.2. At the panicle initiation stage

At this stage, the growth parameters was mainly correlated with the root volume at soil layers from 0 - 5 cm, 5 - 15 cm and the total mass of the root system, while other indicators did not have a significant relationship, shown in table 2.

The rice height is positively correlated with root length with a 95% confidence level. The number of tiller was positively correlated with the total root mass ($p < 0.05$), the root mass at the soil layer 0 - 5 cm ($p < 0.05$) and layer 5 - 15 cm ($p < 0.01$).

The leaf mass has a close relationship with the volume of roots at the soil layer 0 - 5 cm, 5 - 15 cm ($p < 0.05$). Stem mass is influenced by root mass at the soil layer from 5 - 15 cm ($p < 0.05$). Mass of leaf stems and total dry matter were positively correlated with total root mass at soil layer 0 - 5 cm ($p < 0.05$) and 5 - 15 cm ($p < 0. 01$).

The above correlations show that at panicle initiation stage, the growth indicators are closely related to root mass, especially root mass at soil layer of 5-15 cm has significant impact on the number of tillers, and mass of leaf stems. Attention should be paid to manage weeding, deep sludge for the best growth and development.

Table 2. *Correlation coefficients of rooting factors with growth factors at panicle initiation stage*

	SR	DR	DKR	PR	Pr1	Pr2	Pr3
CC	0.80*ns*	0.89*	0.25*ns*	0.70*ns*	0.65*ns*	0.55*ns*	0.79*ns*
NH	0.79*ns*	0.66*ns*	-0.37*ns*	0.89*	0.91*	0.97**	0.67*ns*
Pl	0.81*ns*	0.77*ns*	-0.51*ns*	0.85*ns*	0.89*	0.92*	0.62*ns*
Pt	0.76*ns*	0.65*ns*	-0.16*ns*	0.84*ns*	0.82*ns*	0.89*	0.69*ns*
Ptl	0.83*ns*	0.73*ns*	-0.30*ns*	0.904*	0.90*	0.96**	0.71*ns*
Pts	0.85*ns*	0.76*ns*	-0.28*ns*	0.92*	0.92*	0.97**	0.74*ns*

*Note: ns - does not make sense; *** - significant at probability level p <0.001; ** -significant at probability level p <0.01; * - means at probability level p <0.05.*

3.3. At the heading stage

Table 3. *Correlation coefficients of root factors with growth indicators of flowering period*

	SR	DR	DKR	PR	Pr1	Pr2	Pr3
CC	0.98**	0.99***	-0.29*ns*	0.98**	0.91*	0.98**	0.09*ns*
NH	0.95*	0.98**	-0.37*ns*	0.98**	0.79*ns*	0.99**	0.26*ns*
Pl	0.96**	0.98**	-0.32*ns*	0.96**	0.86*ns*	0.98**	0.08*ns*
Pt	0.85*ns*	0.83*ns*	0.08*ns*	0.84*ns*	0.52*ns*	0.84*ns*	0.53*ns*
Ptl	0.94*	0.94*	-0.07*ns*	0.94*	0.69*ns*	0.94*	0.38*ns*
Pts	0.95*	0.95*ns*	-0.10*ns*	0.95*	0.71*ns*	0.95*	0.37*ns*

*Note: ns - does not make sense; *** - significant at probability level p <0.001; ** -significant at probability level p <0.01; * - means at probability level p <0.05.*

As shown in Table 3, growth parameters has a very strong relationship with the number of roots, root length, root mass and root volume at soil layers 5-15 cm.

The height of rice is positively correlated with the number of roots, roots length, root mass at the soil layer 5-15 cm (p <0.05-0.001). The number of heading depends on the number of roots (p <0.05), root length, total root mass and root volume at soil layer 5-15 cm (p <0.01).

Leaf mass is related to the number of roots, root length, total root mass and root mass at soil layer 5-15 cm (p <0.01). Leaf stem mass is correlated with the number of roots, root length, total root mass, root volume at soil layer 5-15 cm with p <0.05. The total amount of dry matter was positively correlated with the number of roots, root mass and the root mass at soil layers 5-15 cm (p <0.05).

At this stage, growth indicators were strongly correlated with the number of roots, root length, total root mass and root mass at 5-15 cm soil layer (p <0.05-0.01).). In order for the rice to grow well, attention should be paid to the conditions that help the root system to grow well in terms of the number of roots, the root length and especially the growth of roots at the soil layer 5-15 cm.

3.4. At grain filling stage

When the stems and leaves are less developed, the dry matter is mainly focused on the rice grain. However, the root system still has certain effects on the growth of rice such as panicle and height. Especially the number of roots, the volume of roots at soil layer 0-5 cm is strongly correlated with all growth indicators.

As shown in Table 4, at this stage, plant height has a positive relationship with the number of roots (p <0.01), root length, total root weight (p <0.05), root volume at soil layer 0-5 cm (p <0.001). The number of grain was positively correlated with the number of roots, root length, total root mass and root mass at the soil layer 0-5 cm (p <0.05).

Table 4. *Correlation coefficient of root factors with growth indicators at stage of milky and dough*

	SR	DR	DKR	PR	Pr1	Pr2	Pr3
CC	0.97**	0.88*	-0.05*ns*	0.92*	0.99***	0.83*ns*	0.58*ns*
NH	0.94*	0.91*	-0.00*ns*	0.95*	0.97**	0.87*ns*	0.67*ns*
Pl	0.89*	0.81*ns*	-0.04*ns*	0.91*	0.89*	0.78*ns*	0.77*ns*
Pt	0.92*	0.79*ns*	0.06*ns*	0.77*ns*	0.91*	0.72*ns*	0.30*ns*
Ptl	0.97**	0.85*ns*	0.03*ns*	0.86*ns*	0.96**	0.79*ns*	0.47*ns*
Pts	0.96**	0.87*	-0.06*ns*	0.93*	0.97**	0.82*ns*	0.63*ns*

*Note: ns - does not make sense; *** - significant at probability level p <0.001; ** -significant at probability level p <0.01; * - means at probability level p <0.05.*

Table 5. *Correlation coefficient of root factors with growth indicators at stage of maturity*

	SR	DR	DKR	PR	Pr1	Pr2	Pr3
CC	0.98**	0.98*	0.85*ns*	0.98**	0.96**	0.95*	0.97**
NH	0.79*ns*	0.90*	0.87*ns*	0.93*	0.93*	0.95**	0.83*ns*
Pl	0.80*ns*	0.91*	0.87*ns*	0.93*	0.93*	0.96**	0.84*ns*
Pt	0.96*	0.92*	0.91*	0.94*	0.94*	0.92*	0.90*
Ptl	0.93*	0.94*	0.92*	0.97**	0.97**	0.96**	0.91*
Pts	0.91*	0.95*	0.93*	0.97**	0.97**	0.98**	0.91*

*Note: ns - does not make sense; *** - significant at probability level p <0.001; ** -significant at probability level p <0.01; * - means at probability level p <0.05.*

Leaf weight was positively correlated with the number of roots, total root mass and root mass at soil layer 0-5 cm ($p < 0.05$). The stem mass correlates with the number of roots, the root mass at the soil layer 0-5 cm ($p < 0.05$). Leaf stem mass was correlated with the number of roots, root mass at the soil layer 0-5 cm at a 99% confidence level. The total dry matter was positively correlated with the number of roots ($p <0.01$), roots length, total root mass ($p <0.05$) and the root mass at the soil layer 0-5 cm ($p < 0.01$).

The relationship between rooting factors and growth indicators, compared with the previous period, shows that there is still a strong correlation with the number of roots, soil root mass from 0-5 cm ($p < 0.05 - 0.001$).

3.5. At the ripening stage

Growth parameters were strongly correlated with rooting parameters, especially root length, total root mass, root volume at soil layer 0-5 cm and 5-15 cm.

Plant height was directly correlated with the number of roots, root length, total root mass and root mass at all 3 soil layers (0-25 cm) with a confidence level of 95 - 99.9%. The number of grain correlated with factors as root length, total root mass, root mass from 0-5 cm ($p <0.05$) and from 5-15 cm ($p < 0.01$). In order to achieve an effective number of ripening grain, it is necessary to influence the environmental factors to maintain the root length, total root mass, root volume from 0-5 cm, 5-15 cm.

The leaf mass at ripening stage is positively correlated with the root length, the total root mass and the root mass at the soil layer 0-5 cm, 5-15 cm with a confidence level of 95-99%. The stems mass has a positive relationship with the number of roots, root length, total root mass and root mass from 0-5 cm, 5-15 cm, 15-25 cm ($p <0.05$). Leaf stem mass and total amount of accumulated dry matter were positively correlated with the number of roots, root length, root diameter ($p <0.05$), total root weight, root mass at soil layer 0- 5 cm, 5-15 cm ($p <0.01$) and 15-25 cm ($p <0.05$) shown in table 5.

4. Conclusion and recommendations

The longer the period of alternating between dry and wet irrigation is, the lower the dry rice accumulation volume. The best growth of rice is in the 4-day alternating dry and wet, which have 24.2 to 36.9% higher than other irrigation treatments. The root parameters are positively correlated with the growth of stems and leaves in the heading and ripening stage. The higher the number of roots, the greater the root mass, the higher the leaf mass, stem mass, and total dry matter volume of rice plants with a confidence level of 95% or more ($P <0.05$).). In order for the rice to grow well, it is necessary to manage both nutrition and irrigation for the best root development especially in the main stages such as tillering, panicle initiation, heading, and grain filling.

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