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Knowledge Paper 201 - Supplement

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The 321 L/kg Question

How Climate Changes Rice Water Requirement Without Recreating the Water Demand of Flooded Rice

321 L/kg is the observed PQNK field reference under the stated environment. Additional water demand depends on the atmosphere and soil - not on a biological requirement to flood rice.

REFERENCE CONDITION	PQNK FIELD REFERENCE	WHAT MAY INCREASE DEMAND
About 70% relative humidity	321 L/kg paddy	Lower relative humidity
About 5 km/h wind	1,600 kg/acre	Higher wind velocity
Ambient temperature up to about 40 C	513,950 L/acre crop-life water	Higher temperature / radiation

The climatic values above describe the reference conditions supplied with the PQNK field observation. They are not presented as a universal rice-water coefficient.

1. Why This Supplement Is Necessary

KP-201 compares mature PQNK rice with conventional flooded rice. The comparison records approximately 321 litres of applied water per kilogram of paddy under PQNK against 4,699 litres/kg in the conventional flooded reference. This is approximately a 7:100 relationship in applied water.

A question raised from Saudi Arabia exposed an important point that deserves explicit clarification. The 321 L/kg figure and the 7:100 production-system comparison are related, but they are not the same claim.

The 7:100 ratio describes the difference between two production systems. The 321 L/kg figure is the measured PQNK field reference under the environmental conditions represented by that crop. Climate can change the plant-side water demand, while the irrigation method changes how much additional water is lost before it becomes productive.

2. The Reference Environment Behind 321 L/kg

The PQNK field comparison represented conditions of approximately 70% relative humidity, around 5 km/h wind velocity and ambient temperature reaching about 40 C. Under those conditions, 1,600 kg of paddy per acre was produced with approximately 513,950 litres of applied crop-life water, equivalent to 321 L/kg.

For PQNK interpretation, this is our present productive-water field reference. It should not be converted into a universal physiological constant for rice. The figure was derived from field water applied and paddy produced; it was not obtained by independently measuring leaf transpiration alone.

Its importance is that mature PQNK removes much of the avoidable field-level water use associated with flooded cultivation. Consequently, the measured applied-water figure approaches productive crop use much more closely than the total water supplied to a flooded field.

3. Water Uptake and Transpiration

Water enters the plant through the roots and serves essential physiological functions. It is the medium in which dissolved mineral nutrients move from the soil into the plant and within plant tissues. It supports photosynthesis, cell expansion and transport processes, and it is central to temperature regulation.

Most water taken up by a healthy crop ultimately leaves through the stomata as transpiration. The rate is not fixed. It responds to the atmosphere surrounding the leaf.

Therefore, the statement that rice water is lost only through evaporation and not through transpiration is too absolute. PQNK does not eliminate transpiration; productive transpiration is part of plant function. What PQNK seeks to eliminate is avoidable non-productive water loss created by the production system.

4. What Changes the Requirement Above the 321 L/kg Reference?

The amount of water required above the reference condition depends principally on atmospheric and soil conditions.

Higher ambient temperature increases the energy available for evaporation and can increase the crop's cooling requirement. Lower relative humidity increases the drying power of the air. Higher wind velocity continually replaces moist air around the leaves with drier air and can increase transpiration. Stronger solar radiation can further increase both leaf temperature and evaporative demand.

These variables interact. Relative humidity alone cannot determine the adjustment. For example, 50% relative humidity at a moderate temperature is not physiologically equivalent to 50% relative humidity at 45 C. Wind can further change the result.

The combined atmospheric effect is better understood through evaporative demand and vapour-pressure deficit. PQNK therefore does not prescribe one climatic correction for every location.

5. Nutrient-Carrying Water and Environmental Adjustment

The 321 L/kg reference should be understood as the field water associated with productive crop function under the stated PQNK environment. Water taken up by the roots carries dissolved nutrients and supports the plant's biological processes; most of it subsequently returns to the atmosphere through transpiration.

When the atmosphere becomes hotter, drier or windier than the reference environment, additional water may be required because the plant must replace water lost more rapidly through transpiration and because some additional evaporation can occur from the field environment.

This additional requirement is therefore an environmental adjustment above the reference field condition. It should not be confused with the enormous additional water applied merely to maintain a flooded rice field.

6. A Practical Working Allowance for Hotter, Drier Conditions

For preliminary planning in substantially drier air, an allowance above the 321 L/kg reference can be considered. A 20% increase gives approximately 385 L/kg of paddy:

321 x 1.20 = approximately 385 L/kg.

This 20% is a working PQNK planning assumption, not a measured universal correction factor. Actual demand may be lower or higher depending on temperature, relative humidity, wind, radiation, canopy, soil moisture and crop condition.

The field must therefore determine the final requirement through Soil Moisture Management. Irrigation is applied to maintain the required moist and aerated root-zone condition. At harvest, measured irrigation divided by measured paddy yield gives the actual litres per kilogram for that environment.

7. Why Low Rainfall Does Not Automatically Mean Higher Plant Requirement

Rainfall and plant water requirement must also be separated. Rainfall is one source from which the root zone receives water. Low rainfall means irrigation may need to provide more of the crop's requirement; it does not by itself mean that the plant must transpire proportionately more.

The plant-side requirement is influenced by atmospheric demand and crop physiology. The source side is supplied by rainfall, dew or condensation where meaningful, stored soil moisture, capillary contribution where present, and irrigation.

In Saudi Arabia, very low rainfall can therefore shift a much larger share of the water supply toward irrigation. At the same time, hotter and drier air may increase productive crop-water demand. These are two separate effects and should be measured separately.

8. Dew, Atmospheric Humidity and Mulch

The four-source PQNK water concept does not assume that rainfall, dew, atmospheric moisture and capillary movement contribute equally everywhere.

Where humidity is high and night conditions favour condensation, dew and moisture captured at or near the surface may contribute to the soil-water economy. In a dry inland environment their contribution can be much smaller.

Mulch nevertheless remains important. Its dependable role is not merely to absorb atmospheric humidity. It protects water already present in the soil by shielding the surface from direct solar radiation and wind, moderating temperature and reducing non-productive evaporation. Thus, lower humidity can reduce one potential source of moisture without removing the conservation value of mulch.

9. Why the 93% Saving Changes With the Comparison Irrigation Method

The approximately 93% reduction in KP-201 is relative to the stated conventional flooded-rice reference of 4,699 L/kg. Flooding creates water demands and losses that are additional to productive plant use.

If rice is already being grown with drip, sprinkler or another efficient non-flood irrigation method, the baseline water application will be lower. The percentage saving when that system is compared with PQNK must therefore change, even if relative humidity remains above 50%.

This does not change the PQNK plant-water reference. It changes the denominator against which the percentage saving is calculated.

Accordingly, three questions must always be kept separate: mature PQNK versus flooded rice; mature PQNK versus another efficient irrigation method; and mature PQNK under one climate versus mature PQNK under another climate.

10. What This Means for Saudi Arabia

For a Saudi Arabian PQNK rice trial, the 321 L/kg figure can be used as the present reference point, not as a promised result.

Where average humidity is lower, temperature is higher or wind is stronger than the reference environment, productive crop-water demand can rise. Irrigation will also have to replace a larger share of water because rainfall and possibly dew contribute less.

An initial planning figure around 385 L/kg, representing a 20% allowance above the 321 L/kg reference, may be useful for designing a trial. It must then be tested by actual field measurement.

The important Saudi question is therefore not whether the Pakistan 93% saving can simply be copied. It is how much water mature PQNK rice requires under Saudi atmospheric conditions, and how that measured requirement compares with flooded rice and with efficient non-flood irrigation under exactly the same environment.

11. How the Saudi Trial Should Be Measured

A useful comparative trial should record applied irrigation water, rainfall, relative humidity, ambient temperature, wind velocity, solar conditions, soil moisture at several depths, crop development and final paddy yield.

Ideally, the same rice variety should be compared under conventional flooded production, an efficient non-flood irrigation treatment where practical, and mature PQNK. The treatments should share the same climatic period and comparable soil conditions.

This would allow us to separate productive crop-water demand from avoidable production-system losses. It would also show how much of the PQNK water figure changes because of atmospheric demand and how much of the conventional figure is created by the irrigation architecture itself.

12. The Clarification to Carry Back Into KP-201

The 321 L/kg figure should be described as the measured PQNK field water-productivity reference under approximately 70% relative humidity, around 5 km/h wind velocity and ambient temperatures reaching about 40 C. It represents total applied crop-life water divided by paddy yield and should not be described as a direct measurement of transpiration alone.

Physiologically, water taken up by the roots supports nutrient transport and other plant functions, while most of it ultimately leaves through transpiration. Additional water above the reference field figure may be required when higher temperature, lower humidity, stronger wind, greater radiation or soil conditions increase water demand.

The 7% versus 100% comparison is separate. It describes mature PQNK against the stated conventional flooded-rice system. If the comparison system uses efficient drip, sprinkler or another non-flood method, that percentage relationship will change because the baseline has changed.

321 L/kg = the observed PQNK field reference under the stated environment.

Additional water = local climatic and soil adjustment where required.

4,699 L/kg = the stated conventional flooded-field application, not the physiological requirement of the rice plant.

Conclusion

The Saudi Arabia question strengthens KP-201 because it forces us to separate plant physiology from irrigation practice. Rice needs water, and productive transpiration cannot be eliminated. What can be eliminated or greatly reduced is the non-productive water use created by maintaining an unnecessarily flooded production environment.

The 321 L/kg PQNK result provides a reference under the stated field conditions. If temperature rises, humidity falls, wind strengthens or other environmental factors increase evaporative demand, the crop may require additional water. That addition should compensate for the changed environment, not recreate the thousands of litres associated with flooded cultivation.

Rainfall determines how much water nature contributes. Atmospheric conditions influence how rapidly the crop and field lose it. Soil condition determines how effectively it is stored and made available. Irrigation supplies the remaining deficit. PQNK integrates all four through Soil Moisture Management.

THE 321 L/kg REFERENCE IS ENVIRONMENT-SPECIFIC.
THE 7:100 RATIO IS PRODUCTION-SYSTEM-SPECIFIC.
THE PRINCIPLE IS UNIVERSAL; THE WATER BALANCE IS LOCAL.

Source and Editorial Note

This supplement clarifies the interpretation of the water-use figures presented in KP-201, Rice Is Not the Problem. The Way We Grow Rice Is. The climatic values used here - approximately 70% relative humidity, around 5 km/h wind and ambient temperature reaching about 40 C - are the reference conditions supplied for the PQNK field observation. The 321 L/kg figure is calculated from applied crop-life water and paddy yield; it is not presented as an independently measured transpiration coefficient.

The proposed 20% allowance for substantially hotter and drier conditions is a working planning assumption for future field testing. It should not be represented as a universal agronomic coefficient until measured across climates. Actual irrigation remains governed by local Soil Moisture Management and measured crop response.