IPI International Potash Institute

Potassium and Nitrogen Use Efficiency

Role of potassium in improving nitrogen use efficiency

INTERNATIONAL POTASH INSTITUTE

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IMPORTANCE OF **NITROGEN AND POTASSIUM**

Nitrogen (N) and potassium (K) are essential major nutrients, which play an important role in the growth and development of plants. Plants take up N and K in almost the same quantities but application of these nutrients to crops varies widely.

The role of K in plants

Potassium is essential for photosynthesis, protein synthesis, nitrogen fixation, starch formation and the translocation of sugars. It also:

- Activates over 80 cellular enzymes.
- Improves plant's ability to resist disease and cold.
- Enhances fruit quality.
- Increases root growth and improves drought resistance.

The role of N in plants

- Nitrogen is a building block of all living cells and is an essential constituent of all proteins and enzymes, as well as metabolic processes involved in the synthesis and transfer of energy.
- Nitrogen is also a key component in chlorophyll; the green pigment responsible for photosynthesis in plants.
- Inadequate N in plants leads to stunting and chlorosis (yellowing) of leaves.

A balanced supply of N and K

When N and K are applied separately yield is increased due to application of either of the elements. But, when both N and K are applied together, the increase in yield is greater than the sum of the increase in yield due to N and K separately (Fig. 1).

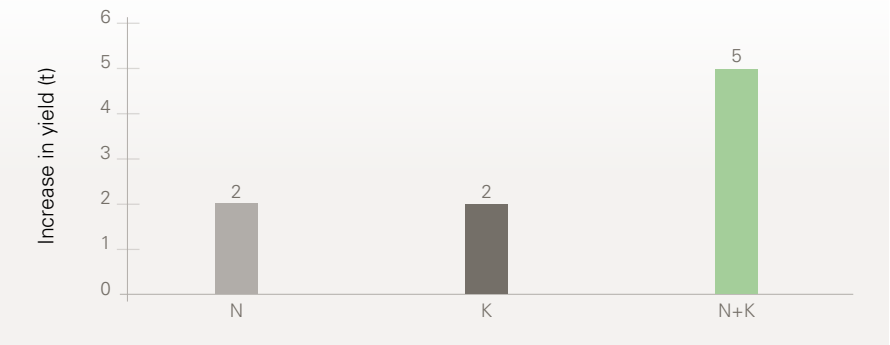


Fig. 1. Interaction effect of N and K.

Fig. 1. indicates that an additional 1 t yield is due to an increase in nitrogen use efficiency (NUE), due to K application.

Potassium improves NUE because it allows better N uptake and utilization (improved N use) resulting in higher yields.

An improved NUE means that farmers may apply less N fertilizer without affecting yield, therefore savings of N fertilizer are achieved with higher profits to the farmer and enhanced environmental stewardship.

NUE AND BALANCED FERTILIZATION WITH K

Many trials conducted by IPI demonstrate the role and scale effect of K on NUE. In these experiments, a typical K application of 30-150 kg K_2O/ha increases NUE by approximately 10-40%.

At a given level of N application, an increasing level of K not only increased the grain yield but also improved the NUE by 6-29% in maize, 18% in sunflower and up to 70% in sugarcane (Table 1).

Table 1. Increase in yield and NUE achieved in IPI on-farm experiments. Source: e-ifc No. 13, 9/2007. IPI.

Crop	Country	Para-meter	N rates	K rates	Yield increase	Increase in NUE
			kg/ha	kg/ha	kg/ha	%
Maize	India	grain	125	30-90	200-1,300	6-29
Maize	China	grain	150-300	75-180	200-1,800	5-29
Maize	Ukraine	grain	30	30	720	15.5
Rice	Bangladesh	grain	100	33-66	690-900	23-30
Rape seed	China	seeds	180	113-188	142-704	35-53
Sugarcane	India	cane	240-340	85-200	2,200	70
Sunflower	Hungary	seeds	80	100-200	200-1,100	10-30
Sunflower	India	seeds	60	30-90	400	18
Wheat	China	grain	180-300	75-150	200-1,370	2-26
Winter rye	Belarus	grain	90	60-120	230-610	10-23

The immediate gain from balanced fertilization with K is illustrated in Fig. 2. At low K level an increase in N supply depressed yield of barley. At medium rates of K, the increased rates of N improved the yield. Maximum yield could only be obtained at high levels of both N and K.

***Plate 1.** Effect of K on ear size of wheat cv. Shatabdi at farmer's field at M. Paltapur village, Dinajpur District, Bangladesh. Source: IPI Coordination India, Sri Lanka and Bangladesh, 2005.*

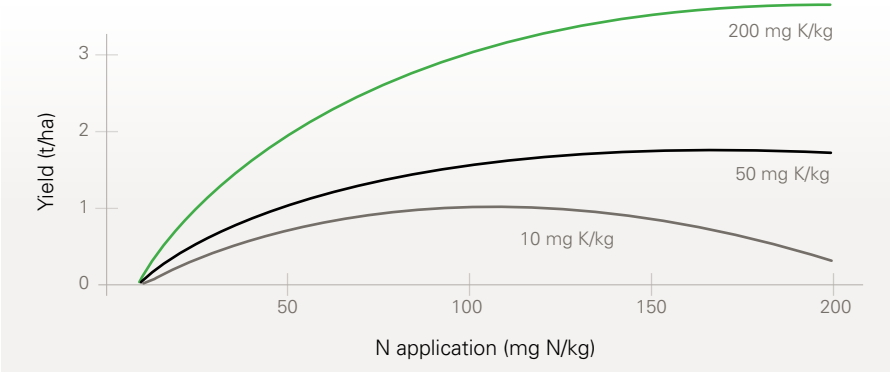


Fig. 2. Effect of N and K interaction on barley yield in hydroponic culture. Source: Macleod, 1969.

Positive N and K interaction in rice is shown in Fig. 3. The benefit in the form of increase in yield with higher N levels is less at low levels of K application but more significant with higher levels of K application. There is better utilization of applied N at high levels of balanced N and K application.

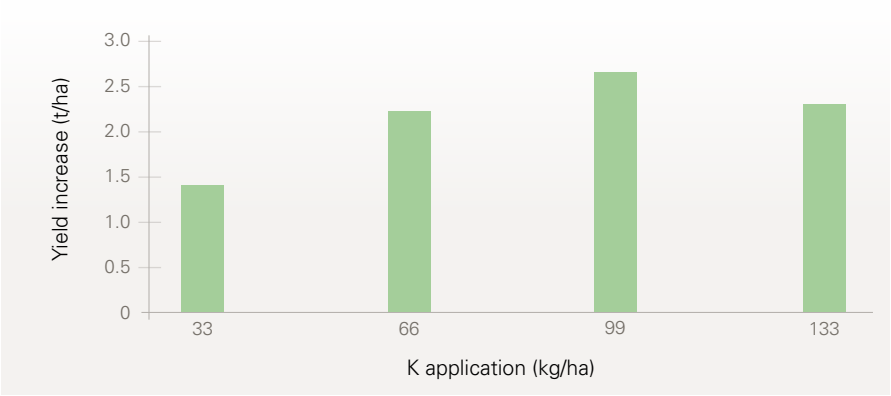
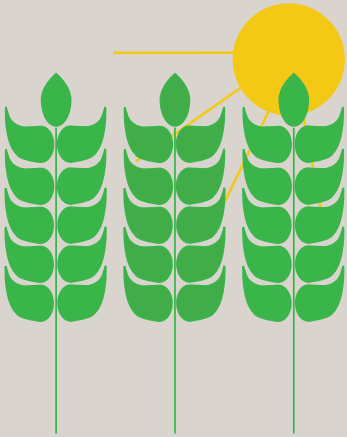


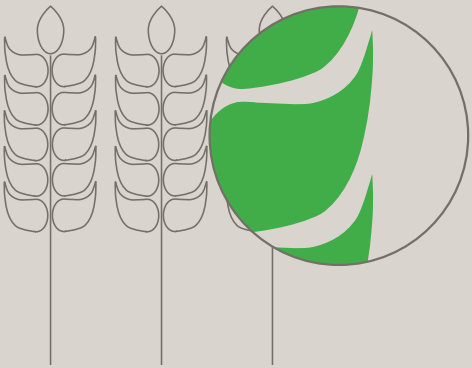
Fig. 3. Effect of K fertilization on yield increase (yield at 160 kg N/ha - yield at 40 kg N/ha) in rice. Source: Mondal et al., 1982.

Use of potassium improves

Nitrogen use efficiency by
20%

Yield and quality of crops by
20%





Tolerance to pests
and disease by
30-100%

Food security by
20%

Greater yield response to N occurs when adequate K is supplied (Table 2).

Table 2. Increase in yield of cassava with increase in K levels at a fixed N level. Source: Muthuswami and Chiranjivi Rao, 1979.

K applied	Increase in yield at 50 kg N/ha
kg K_2O/ha	t fresh tuber/ha
0	3.6
80	10.7
250	14.2

In Tamil Nadu (India) the optimal rate of fertilizer to cassava was found to be 50 kg N/ha and 250 kg K_2O/ha. The interaction of N and K indicated very low yields with the application of N in the absence of K. The yield increased significantly with increased levels of applied K. Potassium application ensured the utilization of N and storage of carbohydrates in roots thus improving the NUE.

N & K INTERACTION AND CROP QUALITY

Protein content and yield of pearl millet

An important aspect of N and K interaction is its effect on crop quality as shown in Table 3. On light textured soils in southern Haryana (India), K application increased the quality of pearl millet by increasing protein content and yield, indicating better utilization of applied N.

Application of K facilitates the uptake and transport of nitrate towards aerial parts of the plant, which in turn enhances the activities of nitrate assimilating enzymes. This increases N utilization in the plant and favors protein formation.

Table 3. Effect of K application on protein content and yield in pearl millet on light textured soils of Haryana. Source: Yadav et al., 2007.

K applied	Protein content	Protein yield
kg K_2O/ha	%	kg/ha
0	9.89	320
20	10.51	335
40	10.95	350
60	11.61	370

Plate 2. Effect of K on yield of pearl millet (Pennisetum glaucum). IPI-HAU experiment at CCS HAU, Regional Research Station, Bawal, Haryana, India. 2002. Source: IPI Coordination India.

Starch content in cassava

The starch content of cassava is positively influenced by the interaction of N and K (Table 4).

Table 4. Effect of N and K interaction on starch yield of cassava. Source: Muthuswami and Chiranjivi Rao, 1979.

	Starch yield of cassava	
	t/ha	
K applied	N applied	
kg K_2O/ha	0 kg N/ha	50 kg N/ha
0	4.63	6.30
100	5.73	7.09
300	5.96	8.94

International Rice Research Institute. Photo: Nancy Castilla

N & K INTERACTION AND DISEASE TOLERANCE

High N application produces soft growth in rice, which is more susceptible to plant diseases (Table 5). However, high K application increases tolerance to diseases.

Table 5. Effect of N, phosphorus (P) and K application on diseases in rice. Source: Ismunadji and Partohardjono, 1979; IPI Research Topics No. 13.

N	P	K	Stem rot	Sheath blight
kg N/ha	kg P_2O_5/ha	kg K_2O/ha	index	index
120	0	0	69.2	59.8
120	60	60	4.4	55.0
120	60	120	1.8	48.0

In rice, the lesion length of bacterial leaf blight grew with increases in levels of applied N both at low and medium levels of applied K (Fig. 4). However, the high level of K significantly reduced lesion length even at the highest level of applied N.

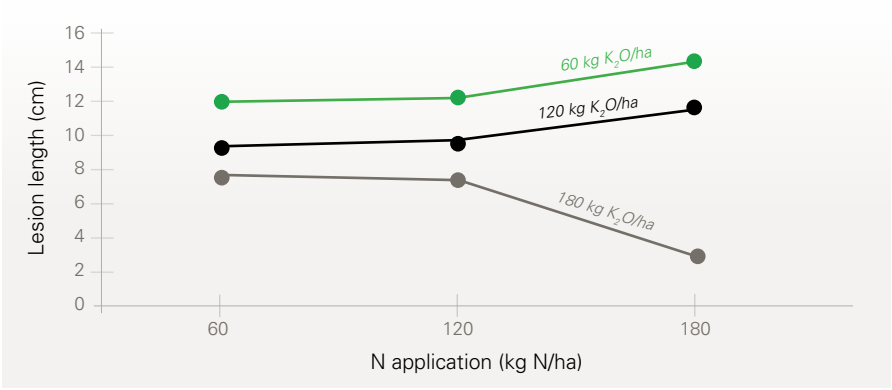


Fig. 4. N and K interaction and bacterial leaf blight of rice. Source: Devadath and Padmanabhan, 1970.

N & K INTERACTION AND ENVIRONMENT QUALITY

Without adequate K, NO_3 accumulates in the roots and a feedback mechanism to the root cells stops further NO_3 uptake. Consequently, NO_3 remains in the soil and is at risk of being lost to the environment, either when leached into surface and groundwater or denitrified and lost to the atmosphere as nitrogen gas or nitrous oxide, a greenhouse gas. On the other hand, with an adequate K supply, increased yields with N are accompanied by larger amounts of N in the crop and thus smaller residues of NO_3 in the soil at harvest. Less residual N means less potential risk of contamination of groundwater.

Adequate K reserves are essential to achieve the best possible response to N and increase maximum N efficiency. Where K reserves had been depleted by not applying K in the past, applying the larger amounts of N is both uneconomic and would have left a large residue of nitrate at risk to loss by leaching and harming the environment.

Potash application in rice crop, India

Studies in Punjab (India) indicate that unbalanced fertilizer application in wheat resulted in decreased NUE, which in turn leads to increasing amounts of unutilized mineral N in soil, which may become a potential source of groundwater pollution (Fig. 5). Increase in NUE due to K application means more N utilization by the crop and less N polluting the environment.

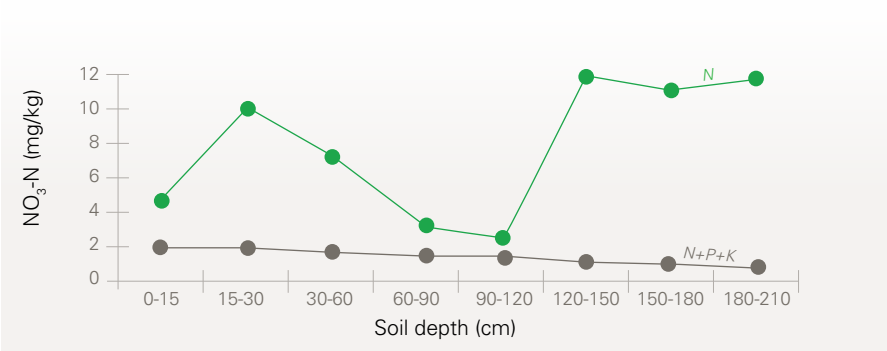


Fig. 5. Effect of fertilization of NO_3-N content in soil profile. Source: Bijay-Singh and Sekhon, 1976.

FINAL **REMARKS**

- Balanced fertilization with K is an immediate, low-cost tool to achieve higher NUE.
- A gain of 20% in NUE can be easily achieved via balanced fertilization with K.
- Adequate K increases both N absorption and reduction to amino acids and protein formation in plants - thus improving yield, crop quality and NUE.
- Balanced fertilization with K increases crop yields and profits while enhancing NUE for the protection of the environment.

REFERENCES

Bijay-Singh, and G.S. Sekhon. 1976. Some Measures of Reducing Leaching Loss of Nitrates Beyond Potential Rooting Zone II. Balanced fertilization. Plant and Soil 44:391-395.

Davadath, S., and S.Y. Padmanabhan. 1970. Approaches to the Control of Bacterial Leaf Blight and Streak Disease of Fice in India. Indian Phytopath. Soc. Bull. 6:5-12.

e-ifc No. 13. 2007. Improving the Efficiency of Nitrogen Use with Potassium: De-Bottlenecking Nitrogen Use Efficiency Through Balanced Fertilization and Adequate Supply of Potassium. International Potash Institute, Switzerland. http://www.ipipotash.org/eifc/2007/13/2/

Gething, P.A. 1993. Improving Returns from Nitrogen Fertilizer; the Potassium-Nitrogen Partnership. IPI Research Topic No. 13 (2nd revised edition), International Potash Institute, Switzerland. 51 p.

Ismunadji, M., and S. Partohardjono. 1979. Recent Research on Potash Application to Lowland Rice in Indonesia. Potash Review. Subj. 9, Suite 43.

Macleod, L.B. 1969. Effects of N, P, and K and their Interactions on the Yield and Kernel Weight of Barley in Hydroponic Culture. Agron. J. 61:26-29.

Mondal, S.S. 1982. Potassium Nutrition at High Levels of N Fertilization on Rice. Potash Review 3:1-4.

Muthuswamy, P., and K. Chiranjivi Rao. 1979. The Influence of Nitrogen and Potassium Fertilization on Tuber Yield and Starch Production in Cassava Varieties. Potash Review. Subj. 27, Suite 91.

Yadav, S.S., Sultan Singh, Abha Tikoo, and J.S. Yadava. 2007. Studies on Potash Responses to Field Crops in Light Textured Soils of Southern Haryana, India. *e-ifc* No. 13. International Potash Institute, Switzerland.

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