Consequences of Potassium Depletion under Intensive Cropping

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Consequences of potassium (K) depletion were demonstrated with sudan grass in this study. Rebuilding fertility of K-depleted soils in India may require even higher rates due to the negative effects of imbalanced nutrient use.

POTASSIUM content of India's soils has traditionally been considered as adequate. In recent years, however, there has been a growing awareness of the importance of K in crop production.

Under continuous cropping, fertilizer-responsive varieties with improved management practices can remove more than 400 kg K/ha/year. It is estimated that a 6.1 t/ha grain crop in a rice-wheat system will remove 150 kg K/year from soil. In the absence of fertilizer K . . . or with low levels of applied K . . . continuous cropping will result in the depletion of soil K reserves. Even soils which are initially well supplied with K will become deficient under such management.

Recent increases in prices of K fertilizers have added to the existing problem of exploitation of soil K under continuous cropping without fertilizer K. Consumption of K fertilizers has decreased drastically. For the country as a whole, the drop in K fertilizer consumption during 1992-93 was 46.7 percent compared to 1991-92, leading to an imbalanced fertilizer consumption ratio of 12.7:3.9:1.0 ($N:P_2O_5:K_2O$), far different from the 4:2:1 which is considered a balanced ratio. The present study was initiated to demonstrate the possible consequences of soil K depletion under intensive cropping.

Experimental

Eight representative surface (0-15 cm) samples of illitic alluvial soils from intensively cultivated fields and of varying K contents were collected. Samples were taken from farms adjoining the National Capital Region, Delhi. Soils were sandy to loamy sand in texture, alkaline in reaction (pH 8.1 to 9.0), with available K contents of 3.5 to 17.4 mg K_2O/g soil.

Soils were depleted of K by growing sudan grass (60 plants/pot) in 3 kg of soil by providing all essential nutrients except K. Seven harvests were taken at 35 day intervals (total of 245 days). After the third harvest, soils were processed and

Table 1. Average K uptake values in K-depletion experiments.

Soil Series	K uptake by harvest, mg/100g soil 1	2	3	4	5	6	7	Total K uptake, mg/100g soil
1–Hamidpur	19.22	10.63	3.94	4.13	2.63	2.10	1.84	44.49
2–Hisar	19.84	11.31	4.06	4.91	3.43	2.26	1.92	47.73
3–Kakra	15.12	9.91	3.92	3.98	2.40	1.96	0.98	38.27
4–Thaska	18.12	10.02	3.89	3.98	2.52	1.97	1.02	41.52
5–Manesar	17.27	9.97	2.68	3.27	2.11	1.86	0.97	38.13
6–Khoh	14.86	7.94	3.66	3.82	2.33	1.85	0.99	34.45
7–Palam	8.74	5.6	1.99	2.01	1.42	0.94	0.45	21.15
8–Mehrauli	17.94	10.8	4.04	4.43	2.94	1.90	1.68	43.77
Mean	16.39	9.52	3.52	3.82	2.47	1.86	1.23	38.81

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fresh sudan grass seeds were sown. At each harvest, plant samples were analyzed for K uptake. Soils were analyzed for exchangeable K.

Results

Potassium uptake. Intensive cropping in the absence of fertilizer K reduced K uptake drastically after the first harvest (**Table 1**). Significant reductions continued up to the third harvest; thereafter, the rate of decrease was low. In the fourth harvest, a small increase in K uptake was observed, probably because of the greater ability of the resown crop to extract non-exchangeable K from soil. Potassium uptake was higher in soils rich in initial K (Hisar and Hamidpur) compared to the poor K soil (Palam).

Table 2. Mean dry matter yield of sudan grass in seven harvests.

Harvest number						
1	2	3	4	5	6	7
0.87	0.62	0.34	0.42	0.32	0.26	0.21
Dry matter yield, g/100g soil						

Crop yield. Dry matter yield in the third harvest was less than half that of the first harvest. In the fourth harvest, there was a slight increase in dry matter yield because it was a resown crop (**Table 2**). Yields in subsequent harvests were reduced to one-third of the first harvest. Such drastic yield reductions might be due in part to low photosynthetic efficiency, impaired aeration and various physiological disorders in the absence of sufficient amounts of available K. Varying yield reductions were observed among soils. High K (Hisar, Mehrauli and Hamidpur) soils maintained relatively higher yield levels up to the seventh harvest followed by medium K soils (Kakra, Thaska, Manesar and Khoh) which maintained more or less higher yields up to the sixth harvest. In the seventh crop harvest, yields on medium K soils fell below the high K soils. Lowest yields, even in the first harvest, were recorded on the low K (Palam) soil. Yield in the first harvest from this soil was comparable with yield of the fourth harvest of the high K soils.

Dependence on reserve K. The contribution of non-exchangeable K to total K uptake in 245 days of cropping was in the order of 73.2 to 93.9 percent (**Table 3**). The share of non-exchangeable K increased with cropping time. The contribution of non-exchangeable K was at its maximum when exchangeable K in soils was at its minimum. Contributions of non-exchangeable and available K were inversely related. That is, high K soils had the lower contribution from non-exchangeable K, whereas in the poor K soil, most K uptake was from non-exchangeable K reserves (**Figure 1**).

Fertilizer K requirement per unit increase in available K. Fixation studies before and after K depletion of test soils (**Table 3**) reveal that unit fertilizer K requirement per unit increase in available K was substantially increased with K depletion. All soils except Palam required around 1.2 units

Table 3. Potassium taken up from non-exchangeable sources and units of fertilizer K required per unit increase in available soil K.

Soil series	Total K uptake in 7 harvests, mg/100g soil	K taken up from non-exchangeable sources: mg K/100g soil	K taken up from non-exchangeable sources: % share of total uptake	Unit fertilizer K rate to increase soil test level by one unit: Before K depletion	Unit fertilizer K rate to increase soil test level by one unit: After K depletion
1–Hamidpur	44.5	32.58	73.2	1.15	3.03
2–Hisar	47.7	36.83	77.2	1.11	2.56
3–Kakra	38.1	32.19	84.1	1.18	2.56
4–Thaska	41.5	31.73	76.4	1.27	2.27
5–Manesar	38.1	31.72	83.2	1.37	2.86
5–Khoh	34.5	27.82	80.8	1.27	2.78
7–Palam	21.2	19.85	93.9	3.85	5.26
8–Mehrauli	43.8	34.23	78.3	1.27	2.63

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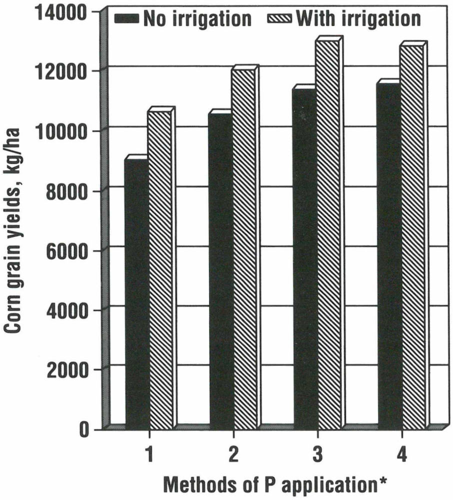

Figure 2. Corn grain yields, with and without irrigation and P addition. **(Argentina)**

***1 = Control (No P), 2 = P beside the seed, 3 = P in narrow bands and 4 = P in wide bands.**

and by supplemental irrigation, but no significant interaction was found amongst them. Irrigation produced higher yields than without irrigation (12,190 vs. 10,700 kg/ha). Yield was highest when P was banded in either wide or narrow bands (**Figure 2**).

Yield differences due to placement methods were associated with P concentrations in the plant and number of kernels per ear.

Conclusion

This study clearly shows that the method and depth of P incorporation affected fertilizer use efficiency and that the best yields occurred with greater distribution of P applied in the top 30 cm of the soil profile. This better distribution allowed a higher absorption of P, higher P contents in the plant, improved crop growth and higher grain yields.

Supplemental irrigation resulted in even better P absorption by the corn plants, causing higher grain yields than in plots without irrigation.

Neither soil P nor moisture deficiencies were severe enough to trigger a positive interaction between P placement and supplemental irrigation.

Under the conditions of southeast Buenos Aires Province, it is possible to obtain yield responses with deeper P applications, in soils with moderate contents of available P and in years with moisture deficits, especially in the months of January and February. ■

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of fertilizer K per unit increase in available K before K depletion. After K depletion, the requirement rose to 2.5 to 3 units. The previously K depleted (Palam) soil required 3.85 units, even before K depletion and 5.26 with K depletion. Therefore, if present-day imbalanced fertilizer consumption continues . . . without K or with little K fertilizer . . . a situation will arise where there will be a need to increase K fertilizer rates by five to six times over recommended rates to obtain optimum soil K levels.

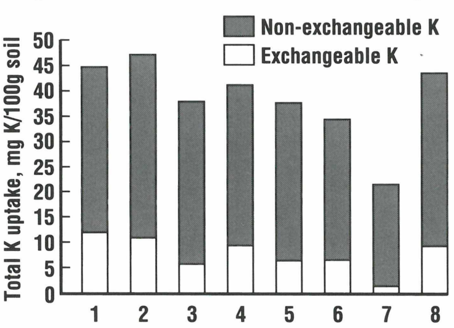

Figure 1. Relative contribution of K sources in eight soils toward K removals by seven cuts of sudan grass.

Conclusion

Our study clearly demonstrates the negative consequences of depleting soil K with intensive cropping without adequate K fertilization. Until potash prices stabilize in India, a majority of farmers will not purchase K fertilizers to feed K-starved soils. Depletion of soil K represents a deterioration of soil fertility and a loss in productivity. Infertile soils cannot support good crops and fulfill agricultural production targets which are being set by planners in order to feed the increasing population of India. ■