Indian Journal of Agronomy **60** (4): 511–515 (December 2015)

Research Paper

Yield and nutrient uptake of maize (*Zea mays*)–wheat (*Triticum aestivum*) cropping system as influenced by integrated potassium management

SANJEEV KUMAR[1], SHIVA DHAR[2], ASHOK KUMAR[3] AND DILEEP KUMAR[4]

ICAR-Indian Agricultural Research Institute, New Delhi 110 012

Received : October 2014; Revised accepted : November 2015

ABSTRACT

A field experiment was conducted during the rainy (*kharif*) and winter (*rabi*) seasons of 2010–11 and 2011–12 at the Indian Agricultural Research Institute, New Delhi, to study the performance of maize (*Zea mays* L.)–wheat [*Triticum aestvum* (L.) emend. Fiori & Paol.] cropping system with integrated potassium fertilization through muriate of potash and farmyard manure. The experiment was laid out in a randomized block design, consisting of 10 treatments and replicated thrice. All the treatments with potassium irrespective of sources resulted in significantly increased grain yield, straw yield and nutrient uptake in soil. The application of 60 kg K through muriate of potash + 30 kg K through farmyard manure resulted in the highest grain yield (4.9 t/ha) and stover yield (6.8 t/ha) in maize and grain yield (5.4 t/ha) and straw yield (8.6 t/ha) in wheat which was found significantly superior to grain yield (2.5 t/ha) and stover yield (4.9 t/ha) in maize and grain yield (3.8 t/ha) and straw yield (7.4 t/ha) of wheat in the control. All treatments applied with farmyard manure showed higher nutrient uptake as well as increased nutrient availability in soil over the control.

Key words : Farmyard manure, Maize–wheat cropping system, Nitrogen uptake, Yield

Potassium (K) is among the most essential nutrients for plant growth and large amounts are taken from the root zone by most of the crops (Steingrobe and Claassen 2000). It is very crucial for its interaction both antagonistic and synergistic with essential macro and micro nutrients (Dibb and Thomson, 1985). Increased availability of K improves the physical quality, disease resistance, and shelf-life of fruits and vegetables used for human consumption and feeding value of grain and forage crops (Rehm *et al.*, 1983).

Unfortunately, application of K did not receive due attention, for most Indian soils were believed to be 'adequate' in native K supply. The removal of K by plants has been observed to be comparatively higher than the removal of nitrogen but the consumption ratio of N : K_2O is 7:1 (Maene, 2001). Unlike N, application of K is often inadequate when compared to the amount required by the crops particularly in India. As a consequence, a continuous mismatch between nutrient removal and replenishment has been observed in various cropping systems even at the recommended levels of fertilizer application (Yadav *et al.*, 1998). Nambiar and Ghosh (1984) indicated that after 8–11 years of continuous cropping, available potassium in soils declined under most of the long-term fertilizer experiments where potassium was not applied. In plots receiving N and P, the drop in available K was faster in the initial years than in the later ones. There is a growing evidence of increasing deficiency of potassium (K) as a result of imbalanced use of nitrogen (N) and phosphorus (P). Even under optimum rates of NPK application in long-term experiments, the K balance under most of the soil and cropping systems was negative. The results of long-term experiments clearly demonstrated that mining of soil K occurred with NP and even with NPK application. The reports on maize–wheat cropping system on alluvial soil at Ludhiana indicated that the system started drawing non-exchangeable K when exchangeable K fell below the critical limits. Thus, very low K fertility status of the soils started limiting the responses to N and P (Singh and Swarup, 2000).

Keeping in view the above facts the present study was undertaken to see the effect of applied organic and inorganic K sources on yield and nutrient uptake in maize and wheat crop under maize–wheat cropping system to maintain crop productivity and soil fertility.

[1]**Corresponding author Email:** bhanusanjeev@gmail.com

[1]Scientist (Agronomy), IIFSR, Modipuram, Meerut 250 110; [2]Principal Scientist, Division of Agronomy, Indian Agricultural Research Institute, New Delhi 110 012; [3]Principal Scientist, Indian Institute of Maize Research, New Delhi 110 012; [4]Scientist, CSWCRTI, Regional Centre, Agra, Uttar Pradesh 282 006

MATERIALS AND METHODS

The field experiment was conducted during the rainy (*kharif*) and winter (*rabi*) seasons of 2010–11 and 2011–12 at Research Farm of the Indian Agricultural Research Institute, New Delhi (28.35' N, 77.12' E and at 228.6 m above mean sea-level). The soil had pH 8.0, containing 0.4% organic carbon, 173.2 kg/ha available N, 13.8 kg/ha available P, and 261 kg/ha available K. The experiment was carried out using randomized block design with 3 replications and 10 treatment combination under different sets of treatment for both maize (*kharif*) and wheat (*rabi*) season at fixed site. Recommended dose of 150 kg N/ha and 26 kg P/ha were applied to maize through urea and diammonium phosphate respectively. The full dose of P, K and 50 kg N/ha were applied basal and the remaining 100 kg N/ha was given in 2 equal splits–30 days after sowing (DAS) and 60 DAS. Muriate of potash (MoP) and farmyard manure (FYM) were used as sources of potassium and applied as per treatments. The nitrogen and phosphorus content of DAP and FYM were compensated in all the treatments by adjusting amount of urea and DAP. In wheat, the recommended dose of P, K and 60 kg N/ha were given basal and remaining 60 kg N/ha was given in 2 equal splits as 30 kg N/ha at 30 DAS and 60 DAS. Similarly, potassium was applied as per treatments: No K to maize and wheat -– K_0 (M) – K_0 (W), 60 kg K/ha through muriate of potash (MOP) in maize and no K in wheat – MoP_{60} (M) – K_0 (W), 30 kg K through MoP and 30 kg K through FYM in maize and 60 kg K through MoP in wheat – MoP_{30} + FYM_{30}(M) – MoP_{60} (W), 60 kg K through MoP and 30 kg K through FYM in maize and no K in wheat – MoP_{60} + FYM_{30} (M) – K_0 (W), 30 kg K through MoP and 30 kg K through FYM in maize and no K in wheat – MoP_{30} + FYM_{30} (M) – K_0 (W), no K in maize and 60 kg K through MoP in wheat – K_0 (M) –MoP_{60} (W), no K in maize and 30 kg K through MoP and 30 kg K through FYM in wheat – K_0 (M)– MoP_{30} + FYM_{30} (W), 60 kg K through MoP in maize and 30 kg K through MoP and 30 kg K through FYM in wheat – MoP_{60} (M) – MoP_{30} + FYM_{30} (W), 60 kg K through MoP in maize and 60 kg K through MoP in wheat – MoP_{60} (M)– MoP_{60} (W), no K in maize and 60 kg K through MoP and 30 kg K through FYM in wheat – K_0 (M) –MoP_{60} + FYM_{30} (W). All the nutrients were given broadcast and thoroughly mixed in the soil before sowing. The varieties used were 'PEHM 2' for maize and 'HD 2967' for wheat. The spacing adopted was 60 cm × 20 cm for maize and 22.5 cm row spacing for wheat. The seed rate used for maize was 20 kg/ha and wheat 100 kg/ha.

At maturity, plants of maize and wheat were harvested from the net plot area of 4.8 m^2 and 4.5 m^2 from the centre of each plot were harvested manually. The above-ground biomass/ha was calculated based on the dried plant samples. The yield/ha was calculated based on the dried plant samples. After grinding, the dried material was analysed for nitrogen, phosphorus and potassium in grain and stover/ straw samples of maize and wheat by following standard procedure (Prasad *et al.,* 2006). After harvesting of each crop, the soil was analysed for available nutrient by following standard procedure.

The experimental data were statistically analysed for the differential effect of treatments by applying 'Analysis of Variance' (ANOVA) technique for randomized block design in maize and wheat as per the standard procedures and correlation studies were done by using SPSS (16.0). The system economics was tested as per the technique of randomized block design.

RESULTS AND DISCUSSION

Yield of maize and wheat

All the treatments applied with K showed significant superiority to no-K treatments for both grain and stover/ straw yields in maize and wheat crop (Table 1). In case of maize application of 90 kg K in the treatment MoP_{60} + FYM_{30} (M) – K_0 (W) recorded the highest grain yield and straw yield over the remaining treatments. The treatment MoP_{60} + FYM_{30} (M) – K_0 (W) was followed by treatment MoP_{30} + FYM_{30} (M) – MoP_{60} (W) and MoP_{30} + FYM_{30} (M) – K_0 (W) which were found at par with each other and significantly superior to treatment received 60 kg K through MoP alone and treatment with no potassium. In case of wheat, application of 90 kg K in the treatment K_0 (M) – MoP_{60} + FYM_{30} (W) resulted in the highest grain (5.4 t/ha) and straw yield (8.6 t/ha). Application of 60 kg potassium supplemented with 30 kg K through MoP + 30 kg K through FYM was at par with treatment applied K irrespective of the source. The increase in grain yield was owing to the application of potassium, as it plays a vital role in many plant processes including photosynthesis, translocation of photosynthates, protein synthesis, activation of plant enzymes etc which leads greater number of grains/cob and 1,000-grain weight in maize (Mumtaz *et al.,* 2009, Tabatabii *et al.,* 2011; Kumar *et al.,* 2015a) and different levels of NPK and FYM alone or in combination also had significant effect on spikes/m, grains/spike, biological yield and thousand grain weight which leads to higher yields (Rehman *et al.,* 2008) . Similar results were also reported by Kumar *et al.,* (2015b) and Kumar *et al*., (2015c).

Nutrient uptake

Integrated potassium management significantly affected the nutrient uptake in maize and wheat (Table 2). All the treatments applied with potassium were signifi-

Table 1. Effect of integrated potassium management on yield (t/ha) of maize and wheat crop under maize–wheat cropping system (pooled mean of 2 years)

Treatment	Maize		Wheat	
	Grain	Stover	Grain	Straw
K_0 (M) – K_0 (W)	2.5	4.9	3.8	7.4
MoP_{60} (M) – K_0 (W)	3.6	5.7	4.1	7.9
MoP_{30} + FYM_{30} (M) – MoP_{60} (W)	4.3	6.3	5.0	8.3
MoP_{60} + FYM_{30} (M) – K_0 (W)	4.9	6.8	4.3	7.9
MoP_{30} + FYM_{30} (M) – K_0 (W)	4.3	6.2	4.1	7.9
K_0(M) – MoP_{60} (W)	2.6	5.1	4.8	8.0
K_0(M) – MoP_{30} + FYM_{30} (W)	2.6	5.1	5.2	8.4
MoP_{60} (M) – MoP_{30} + FYM_{30} (W)	3.6	5.8	5.1	8.5
MoP_{60} (M) – MoP_{60} (W)	3.6	5.8	4.8	8.1
K_0 (M) – MoP_{60} + FYM_{30} (W)	2.7	5.2	5.4	8.6
SEm±	0.2	0.2	0.2	0.4
CD (P=0.05)	0.5	0.6	0.5	1.0

Table 2. Effect of integrated potassium management on available nutrient (kg/ha) at the end of 2 crop cycle (pooled mean of 2 years)

Treatment	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
K_0 (M) – K_0 (W)	157.4	12.9	173.1
MoP_{60} (M) – K_0 (W)	158.2	14.2	201.6
MoP_{30} + FYM_{30} (M) – MoP_{60} (W)	179.0	15.3	227.7
MoP_{60} + FYM_{30} (M) – K_0 (W)	176.7	14.1	237.7
MoP_{30} + FYM_{30} (M) – K_0 (W)	177.9	14.2	219.9
K_0(M) – MoP_{60} (W)	158.1	14.0	196.7
K_0(M) – MoP_{30} + FYM_{30} (W)	176.2	14.9	201.3
MoP_{60} (M) – MoP_{30} + FYM_{30} (W)	177.8	15.1	215.0
MoP_{60} (M) – MoP_{60} (W)	157.6	14.7	207.4
K_0 (M) – MoP_{60} + FYM_{30} (W)	170.5	14.4	198.7
SEm±	1.6	0.2	2.9
CD (P=0.05)	4.7	0.6	8.4

cantly superior to no-potassium treatments. In case of maize, treatment MoP_{60} + FYM_{30} (M) – K_0 (W) showed the highest uptake of N in grain and straw, P grain and straw, N grain and straw; whereas in wheat the highest uptake of N and straw, of P in grain and straw and of N straw was recorded with treatment K_0 (M) – MoP_{60} + FYM_{30} (W). The increased uptake of different nutrients were observed due to increased level of potassium, as it plays a vital role in translocation of nutrients that leads to increased nutrients uptake in plants. Potassium has synergistic effect on uptake of nitrogen and other nutrients due to which all the treatments applied with potassium showed superiority to the control. Baque *et al*. (2006) reported that uptake of N, P and K was enhanced with increasing levels of K. Eldardiry *et al*. (2010) reported that application of different K levels results in differential nitrogen uptake by wheat grains.

Nutrient availability

Decline was recorded in nitrogen, phosphorus and potassium after completion of 2 crop cycle (Table 3). The continuous mining of nutrient by the crop resulted in the decline in the nutrient availability irrespective to applied dose of nutrient. All the treatments applied with FYM showed better nutrient availability to than the remaining treatments. After completion of 2 crop cycles, the highest availability of N, P and K was observed with treatment MoP_{30} + FYM_{30} (M) – MoP_{60} (W). This increase in availability of nutrient in treatment applied with FYM may be owing to the fact that FYM provides a slow–release supply of organically bound nutrients such as nitrogen, phosphorus and other nutrients. It enhances chelation and thus availability of trace elements to plants. The FYM accelerates mineral weathering and aids in solubilization of plant nutrients from otherwise insoluble minerals. It also provides slowly available carbon and energy source to support a large diverse, metabolically active microbial community which further helps in solubilization and availability of nutrients to crop plants (Wolf and Wagner, 2005).

Table 3. Effect of integrated potassium-management on nutrient uptake (kg/ha) of maize and wheat crop in maize–wheat cropping system (pooled mean of season years)

Treatment	Maize						Wheat					
	N uptake		P uptake		K uptake		N uptake		P uptake		K uptake	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
K_0(M) – K_0(W)	38.2	10.2	8.0	2.6	10.3	64.4	54.6	24.0	10.3	4.1	16.5	90.4
MoP $_{60}$ (M) – K_0 (W)	60.9	19.2	12.3	3.6	18.3	88.9	61.3	28.2	11.3	4.4	18.4	97.6
MoP_{30} + FYM_{30} (M) – MoP_{60} (W)	77.7	22.7	15.3	4.5	24.0	109.1	85.6	31.1	17.1	5.2	27.4	123.1
MoP_{60} + FYM_{30} (M) – K_0 (W)	92.5	28.5	18.4	5.3	29.8	127.0	67.2	28.6	12.2	4.6	19.8	101.7
MoP_{30} + FYM_{30} (M) – K_0 (W)	76.0	20.8	15.2	4.4	22.8	106.6	63.7	27.4	11.6	4.5	18.8	98.8
K_0(M) – MoP_{60} (W)	40.3	11.7	8.4	2.8	11.1	68.0	79.9	28.1	15.6	5.0	26.0	116.5
K_0(M) – MoP_{30} + FYM_{30}(W)	40.9	11.9	8.6	2.8	11.1	69.5	91.7	33.4	17.9	5.3	29.6	126.3
MoP_{60} (M) – MoP_{30} + FYM_{30} (W)	62.8	19.7	12.5	3.8	19.2	92.6	90.0	34.0	17.4	5.4	29.1	127.2
MoP_{60} (M) – MoP_{60} (W)	62.2	19.0	12.4	3.7	19.0	92.4	83.1	30.2	15.5	5.0	26.1	118.0
K_0 (M) – MoP_{60} + FYM_{30} (W)	42.4	11.9	8.9	2.9	11.8	71.7	98.2	35.4	19.0	5.5	31.6	139.7
SEm±	3.3	1.2	0.6	0.2	1.2	4.3	3.9	2.4	0.7	0.2	1.0	4.8
CD (P=0.05)	9.5	3.3	1.7	0.5	3.3	12.2	11.2	6.8	2.0	0.6	2.8	13.7

System economics

System economics (Table 4) revealed significant differences in monetary returns in the treatments applied with potassium over no potassium. Maximum gross returns and net returns were recorded from treatment MoP_{30} + FYM_{30} (M) – MoP_{60} (W) which was found significantly superior to the control K $(M)_0$ – K_0 (W) with gross return of 1,00,159 and net return of ₹60,735. In case of benefit: cost ratio treatment MoP_{30} + FYM_{30} (M) – MoP_{60} (W), MoP_{60} + FYM_{30} (M) – MoP_0 (W) and MoP_{60} (M) – MoP_{60} (W) were found at par and recorded the benefit: cost ratio of 1.9 which was significantly to benefit: cost ratio of 1.5 in control.

It can be concluded that integrated application of potassium increases yield and nutrient uptake. The application of FYM causes better nutrient availability which results better uptake of nutrients from soil compared to no application of potassium or application of potassium through MoP alone.

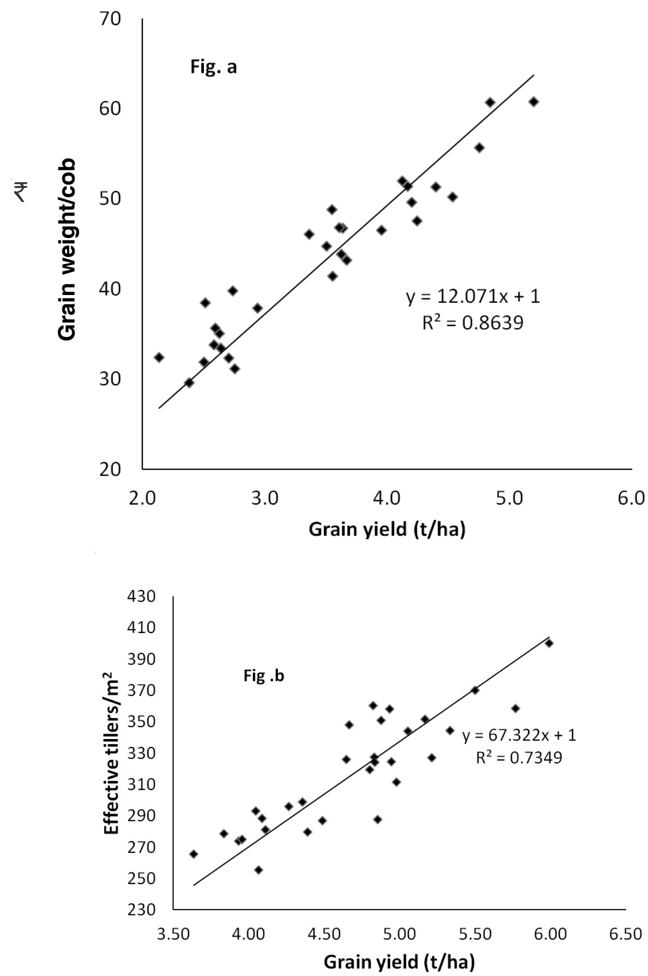

Fig. Relationship between grain yield and grain weight/cob of maize (a) and between grain yield and effective tillers/m^2 of wheat (2011–12) (b)

Table 4. Effect of integrated potassium management on system economics of maize–wheat cropping system (pooled mean of 2 years)

Treatment	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	Benefit: cost ratio
K_0 (M) – K_0 (W)	39,423	1,00,159	60,735	1.5
MoP_{60} (M) – K_0 (W)	41,158	1,16,494	75,336	1.8
MoP_{30} + FYM_{30} (M) – MoP_{60} (W)	46,198	1,36,324	90,126	1.9
MoP_{60} + FYM_{30} (M) – K_0 (W)	45,331	1,32,871	87,540	1.9
MoP_{30} + FYM_{30} (M) – K_0 (W)	44,464	1,24,184	79,720	1.8
K_0 (M) – MoP_{60} (W)	41,158	1,15,233	74,075	1.8
K_0 (M) – MoP_{30}+ FYM_{30}(W)	44,464	1,21,380	76,917	1.7
MoP_{60} (M) – MoP_{30} + FYM_{30} (W)	46,198	1,31,138	84,940	1.8
MoP_{60} (M) – MoP_{60} (W)	42,892	1,26,451	83,559	1.9
K_0 (M) – MoP_{60} + FYM_{30} (W)	45,331	1,25,155	79,824	1.8
SEm±		4,595	4,595	0.1
CD (P=0.05)		13,652	13,652	0.3

Pearson's correlation matrix between grain yield and yield attributes

A significant positive correlations (Fig. 1a) was observed (P=0.01) between grain yield and grain weight/cob in maize (r^2=0.8639) and between grain yield and effective tillers/m^2 (r^2=0.7349 in wheat crop. This correlation implies that application of potassium provides in better yield attributes which ultimately results in higher grain yield.

REFERENCES

Baque, M.A., Karim, M.A., Hamid, A. and Tetsushi, H. 2006. Effects of fertilizer potassium on growth, yield and nutrient uptake of wheat (*Triticum aestivum*) under water stress conditions. *South Pacific Studies* **27**: 25–35.

Dibb, D.W. and Thomson, W.R. 1985. Interaction of potassium with other nutrients. *Potassium in Agriculture*, pp. 515–32. Munson, R.D. (Eds). A Wiley–Interscience publication, Madison, The USA.

Eldardiry, I.E., El Hady, M.A. and El Ashry, S.M. 2010. Effect of water regime and potassium application on water relations and nutrients uptake of wheat plant. *International Journal Academic Research* **2**: 75–82.

Kumar, S., Shiva Dhar, Kumar, D. Kumar, B., Meena, R.L., and Hariom. 2015b. Productivity enhancement and Bio fortification of crop residue in maize–wheat cropping system through integrated potassium management. *Range Management and Agroforestry* **35**(2): 220–26.

Kumar, S., Shiva Dhar, Meena, R. L. and Hariom. 2015a. Productivity enhancement and biofortification in maize–wheat cropping system through integrated potassium management. *Indian Journal of Agricultural Sciences* **85**(1): 97–101.

Kumar, S., Shiva Dhar, Meena, R.L. and Hariom. 2015c. Potassium management for better root growth and yield of maize and wheat crop in maize–wheat cropping system. *Indian Journal of Agricultural Sciences* **85**(2): 251–55.

Maene, L. 2001. Global potassium fertilizer situation: current use and perspectives. *Proceedings of International Symposium on Role of Potassium in Nutrient Management for Sustainable Crop Production in India*, pp. 21–33, 3–5 December, 2001, New Delhi.

Mumtaz, A., Cheema, M., Iqbal, Z.A, Cheema, B.U. and Rafique, M. 1999. Response of hybrid maize to potassium. *International Journal of Agriculture and Biology* **4**: 267–69.

Nambiar, K.K.M and Ghosh, A.B. 1984. Highlights of Research of Long-Term Fertilizer Experiments in India (1971–82). *LTFE Research Bulletin* No.1. pp. 100.

Prasad, R., Shivay, Y.S., Kumar, D. and Sharma, S.N. 2006. *Learning by doing exercise in soil fertility - A practical manual for soil fertility*. pp.8–38. Division of Agronomy, Indian Agricultural Research Institute, New Delhi.

Rehm, G.W., Sorensen, R.C. and Wiese, R.A. 1983. Application of phosphorus, potassium and zinc to corn grown for grain or silage: Nutrient concentration and uptake. *Soil Science Society of America Journal* **47**: 697–700.

Rehman, S., Khalil, S.K., Rehman, A. and Saljoqi, A.U.R. 2008. Organic and inorganic fertilizers increase wheat yield components and biomass under rainfed condition. *Sarhad Journal of Agriculture* **24**: 11–20.

Sharma, S.P. and Subehia, S.K. 2003. Effects of twenty-five years of fertilizer use on maize and wheat yields and quality of an acidic soil in the western Himalayas. *Experimental Agricultur*e. **39**: 55–64.

Singh, G.B. and Swarup, A. 2000. Lessons from long-term fertility experiments. *Fertilizer News* **45**: 13–24.

Steingrobe, B. and Claassen, N. 2000. Potassium dynamics in the rhizosphere and K efficiency of crops. *Journal Plant Nutrient Soil Science* **163**: 101–06.

Tabatabaii, E.S., Yarnia, M., Benam, M.B.K and Tabrizi, E.F.M. 2011. Effect of potassium fertilizer on corn yield (*Jeta* cv.) under drought stress condition *American–Eurasian Journal of Agriculture and Environment Science* **10**: 257–63.

Wolf, D.C. and Wagner, G.H. 2005. Carbon transformations and soil organic matter formation. *Principles and Applications of Soil Microbiology*, 320 pp. Edn 2 Pearson Education Inc., New Jersey.

Yadav, R.L., Prasad, K. and Gangwar, K.S. 1998. Prospects of Indian Agriculture with special reference to nutrient management under irrigated systems. (In:) *Long-term Fertility Management through Integrated Plant Nutrient Supply*, pp 1–335. Swarup, A., Reddy, D.D. and Prasad, R.N. (Eds). Indian Institute of Soil Science, Madhya Pradesh.