Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(2): 1791-1794
Received: 01-01-2020
Accepted: 03-02-2020

Bharti B
M.Sc. Department of Soil Science, COA, CSK HPKV, Palampur, Kangra, Himachal Pradesh, India

Sharma RP
Principal Scientist, Department of Soil Science, COA, CSK HPKV, Palampur, Kangra, Himachal Pradesh, India

Corresponding Author:
Bharti B
M.Sc. Department of Soil Science, COA, CSK HPKV, Palampur, Kangra, Himachal Pradesh, India

Long term effect of chemical fertilizers and amendments on yield and uptake of wheat in an acid Alfisol

Bharti B and Sharma RP

Abstract
The present investigation was carried out in the ongoing long term fertilizer experiment at Department of soil science, CSKHPKV Palampur. The influence of thirty six years of cropping with different chemical fertilizers and amendments on the contents on the yield and uptake of macronutrients *i.e.* nitrogen, phosphorus and potassium was investigated in an Acid Alfisol. Continuous combined use of chemical fertilizers and FYM and manual weeding in 100% NPK treated plots resulted in significant increase in the yield of wheat compared to rest of the treatments. The highest productivity was recorded where FYM and lime was added in combination. Continuous application of chemical fertilizers either alone or in combination with FYM or lime influenced significantly the uptake of nitrogen, phosphorus and potassium. The accumulation of macronutrients was found highest in those treatments where FYM and lime was added in combination.

Keywords: Productivity, farm yard manure, lime, uptake

Introduction
With the advent of modern agriculture, farmers are either using restricted amount of organics or no organics. As a result of such nutrient management practices, many of the productive soils are becoming unproductive. This has led to decreasing yield trend even with optimum use of fertilizers particularly under the situations where high yielding varieties are being used. The problem is more severe in acid soils which are under intensive cropping. To secure India's food and nutritional demands, maintenance of soil health is indispensable. Chemical fertilizers alone are unable to maintain the long-term soil health and crop productivity (Subba Rao & Srivastava 1998) [1] as they lack in secondary and micronutrients. Continuous cropping and long-term fertilization are liable to change soil properties and crop productivity. Long-term fertilizer experiments provide the best possible base to monitor changes in soil quality and crop productivity due to continuous manuring and cropping and hence to evolve future strategies for maintaining soil health and enhancing crop yields.

Materials and Methods
The present study was carried out in an ongoing long-term fertilizer experiment started during 1972-73 (rabi) at the research farm of College of Agriculture, Palampur 1290 meters above mean sea level (amsl). The area falls in the wet temperate zone with annual rainfall of 2500-3000mm with the maximum (75 %) received during the wet season (June-September).The mean maximum temperature remains about 31^0C during the hottest months of May to June. December to February are the coldest months with minimum temperature of about 5 0C. Soil of the study area was silty loam in texture and classified as Typic Hapludalf. The soil had pH 5.8; organic carbon 7.9 g kg-1; and 12.1 [cmol (p+) kg-^{1}] soil. It contained 736, 12 and 194.2 kg ha-1 soil of available N ($KMnO_4$-N), P (Olsen's-P) and K (Neutral 1N NH_4OAc-K), respectively. The experiment was started with 11 treatment combinations replicated three times in randomized block design with 15 m^2 plot for each treatment. The experiment initially comprised of 10 treatments each replicated four times in randomized block design (RBD). The 11th treatment consisting of 100 per cent NPK (-S) was introduced in *kharif*, 1981. Treatments were, T1-control; T2-100% N; T3-100% NP; T4- 100% NPK; T5- 100% NPK + FYM @10 t ha-1 (to maize crop only); T6-100% NPK + lime (lime was applied @ 900 kg ha-1 till the pH attained at neutrality); T7-100 % NPK + Zn; T8-100% NPK + Hand Weeding (HW); T9-100% NPK (-S), P through DAP; T10-150% NPK (super optimal) and T11- 50% NPK (sub optimal). After the harvest of wheat, the data was recorded for the grain and straw yield both on dry weight basis. The grain and straw samples were dried in an oven for 60°C.

The samples then ground on wiley mill connected to the stainless steel parts to pass the 1mm sieve. The samples were kept in paper bag for further analysis. The standard procedure were used to determine the relative concentration of nitrogen, phosphorus and potassium were micro kjeldahl method (Jackson, 1973) [2], vanedo-molybdo-phosphoric acid method (Jackson, 1973) [2] and wet digestion method (Black, 1965) [3], respectively.

Results and Discussions

Effect of chemical fertilizers and amendments on crop yield and NPK uptake

Productivity of wheat

The data revealed that grain and straw yield of wheat (2008-09) varied from 0.00 to 31.23 q ha^{-1} and 0.00 to 65.77 q ha^{-1}, respectively. Continuous application of 100% N alone for thirty six years resulted in zero yield level. Application of P along with N (T_3) recorded 7.13 and 16.09 q ha^{-1} higher grain and straw yield over control, respectively. Balanced fertilization (100% NPK) led to 76 and 63 per cent increase in grain and straw yield, respectively, over NP treatment. Omission of S (100% NPK-S) recorded significant lower yield than balanced fertilization (100 % NPK). Combined application of FYM along with 100 % NPK (T_5) resulted in significantly higher wheat yield of both grain and straw in comparison to 100 % NPK and 150 % NPK. The yield recorded with 100% NPK + lime was statistically at par with 100% NPK + FYM. Super-optimal dose of NPK (150%) was found statistically at par with 100% NPK. Total biological yield followed the similar trend as observed in grain and straw yield.

The omission of chemical fertilizers and amendments in control plots for the last thirty six years resulted in low yield due to continuous mining of the nutrients. Application of N alone continuously for thirty six years resulted in zero yield. A number of workers elsewhere in the country (Sinha *et al.* 1997 [4]; Santhy *et al.* [5] 1998; Swarup 2000) [6] reported degradation of soils in plots treated with nitrogen alone over a period of time, thereby resulting in low yield. It may be due to increase in soil acidity resulting in increased concentration of various toxic elements especially Al, which adversely affects the crop growth.

The NP application improved the yield in comparison to control. Phosphorus influences the root proliferation and thereby the crop growth. High P fixing capacity of these soils resulting in less availability of labile P to the crop plants might be responsible for spectacular responses to added P. Moreover, P application reduces the concentration of toxic elements; thereby affecting crop yield (Verma and Singh, 1996) [7]. Decrease in crop yield in the absence of K has also been reported by Rao and Khera (1995) [8]. They attributed such a drastic decline in yield to the low photosynthetic efficiency and various physiological disorders in the absence of sufficient amount of available K.

Higher productivity under FYM treatment may be ascribed to the beneficial effects of FYM on soil productivity (Brady and Weil 2002) [9]. The organic manure supplies macro and micro nutrients and complexing agents to soil which maintain balanced supply of nutrients to plants. Besides, organic manures improve physical and biological soil environment. The application of N, P and K at super-optimal level (150 %) decreased the productivity probably due to emerging deficiencies of secondary nutrients particularly Mg in the present soil (Sharma *et al.* 2002) [10].

Table 1: Effect of long-term use of chemical fertilizers and amendments on productivity of wheat (q ha^{-1})

Treatment	Productivity		
	Grain	**Straw**	**Total**
T_1: Control	3.87	10.68	14.55
T_2: 100% N	0.00	0.00	0.00
T_3: 100% NP	11.00	26.67	37.67
T_4: 100% NPK	19.33	43.57	62.90
T_5: 100% NPK+ FYM	31.23	65.77	97.00
T_6: 100% NPK+ lime	28.57	60.20	88.77
T_7: 100% NPK+ Zn	18.47	42.67	61.14
T_8: 100% NPK+ HW	20.47	48.67	69.14
T_9: 100% NPK (-S)	13.30	27.33	40.63
T_{10}: 150% NPK	17.33	33.77	51.10
T_{11}: 50% NPK	15.20	40.90	56.10
CD (P= 0.05)	3.02	8.24	10.79

Significantly higher yield was recorded in the plots where lime was applied periodically along with 100 % NPK in comparison to 100 % NPK alone. This may be attributed to increase in soil pH upon the addition of lime which decreases the active forms of Al and soil acidity, thereby improving conditions for crop growth (Verma 2002) [11].

Nutrient uptake by wheat

Nitrogen uptake

A perusal of data revealed that uptake of nitrogen by wheat grain and straw varied from 6.0 to 60.0 kg ha^{-1} and 5.0 to 37.7 kg ha^{-1}, respectively. Similarly, the total N uptake varied from 11.0 to 80.8 kg ha^{-1}. The plots receiving 100 % N did not produce any yield due to which nutrient uptake in these plots could not be determined. Total N uptake in control was significantly lower than the rest of the treatments. Whereas, 100 % NPK + FYM was found significantly superior over rest of the treatments. Continuous application of 100 %.

Table 2: Effect of long-term use of chemical fertilizers and amendments on N uptake by wheat (kg ha^{-1})

Treatment	Uptake		
	Grain	**Straw**	**Total**
T_1: Control	6.0	5.0	11.0
T_2: 100% N	0.0	0.0	0.0
T_3: 100% NP	20.7	13.4	34.1
T_4: 100% NPK	30.5	22.8	53.3
T_5: 100% NPK+ FYM	60.0	37.7	97.7
T_6: 100% NPK+ lime	48.0	32.8	80.8
T_7: 100% NPK+ Zn	32.1	24.6	56.7
T_8: 100% NPK+ HW	36.5	27.3	63.8
T_9: 100% NPK (-S)	21.6	14.7	36.3
T_{10}: 150% NPK	28.0	22.1	50.1
T_{11}: 50% NPK	23.1	17.3	40.4
CD (P= 0.05)	6.27	5.38	10.36

NPK, 100 % NPK + Zn and 150 % NPK with N uptake of 53.3, 56.7 and 50.1 kg ha^{-1} were at par. Suboptimal dose of fertilizer (50 % NPK) recorded significantly lower N uptake in comparison to 100 % NPK. However, 100 % NPK (-S) and 100 % NP were statistically at par with total N uptake values of 34.1 and 36.3 kg ha^{-1} respectively.

Since continuous application of 100 % N alone has led to degradation of soil and wheat productivity decreased to zero level. Therefore, nitrogen uptake was zero in 100 % N treated plots. The increased uptake in rest of the treatments over control was due to increased level of nutrition resulting in increased productivity level. Application of sub-optimum dose also had less value for N uptake than that of optimum dose due to low crop yield in this treatment. In 100 % NPK (-S) plots, the yield was low due to S deficiency, so the N uptake was also low. The use of FYM with 100 % NPK led to favorable soil environment besides, nutrients supply which improved crop growth and increased wheat yield that resulted in higher uptake of N. The increase in N uptake in fertilized plots compared to the control plots might be due to N supply through external inputs and because of prolific root system under balanced application of nutrients.

Phosphorus uptake

With the application of 100 % N where no yield was recorded, P uptake in wheat grain ranged from 1.0 kg ha^{-1} in control to 9.26 kg ha^{-1} in 100 % NPK + FYM. Control was statistically inferior to rest of the treatments, while P uptake in wheat grain was at par in 100% NPK + FYM and 100 % NPK + lime. FYM and lime application with 100 % NPK recorded maximum uptake of P. The treatments like 100 % NP and 100 % NPK (-S) with 3.59 and 4.45 kg ha^{-1} P uptake in wheat grain, respectively, were at par. Total P uptake in 100 % NPK + Zn and 150 % NPK were significantly superior to 50 % NPK.

In case of wheat straw, P uptake varied from 0.18 in control to 1.56 kg ha^{-1} in 100 % NPK + lime. The treatments comprising 100 % NPK + FYM and 100% NPK + lime treatments with uptake values of 1.36 and 1.56 kg ha^{-1} were statistically at par. P uptake value recorded at 50 % NPK was significantly lower than 100 % NPK. Total P uptake in 100 % NPK + lime and 100 % NPK + FYM treatments was at par and significantly superior to other treatments. Omission of K and S reduced the P uptake by 41 and 29 per cent respectively in comparison to balanced fertilization. Sub-optimal dose of NPK (T_{11}) resulted in significantly lower P uptake than 100 % NPK (T_4).

The low P uptake values under control plots could be due to lower yields as continuous cropping without any external inputs decreased native P supply. When K application was omitted, considerable reduction in P uptake was noticed.

Table 3: Effect of long-term use of chemical fertilizers and amendments on P uptake by wheat (kg ha^{-1})

Treatment	Uptake		
	Grain	Straw	Total
T_1: Control	1.00	0.18	1.17
T_2: 100% N	0.00	0.00	0.00
T_3: 100% NP	3.59	0.59	4.18
T_4: 100% NPK	6.13	0.91	7.04
T_5: 100% NPK+ FYM	9.26	1.36	10.62
T_6: 100% NPK+ lime	9.07	1.56	10.63
T_7: 100% NPK+ Zn	5.42	0.81	6.23
T_8: 100% NPK+ HW	6.38	0.96	7.35
T_9: 100% NPK (-S)	4.45	0.56	5.01
T_{10}: 150% NPK	5.27	0.86	6.13
T_{11}: 50% NPK	4.29	0.52	4.82
CD (P= 0.05)	0.99	0.23	1.15

As K became limiting nutrient in crop production. The higher P uptake values in FYM might be due to the fact that organic materials form chelates with Al^{3+} and Fe^{3+} resulting in low P fixing capacity. Lime precipitates the Al^{3+} at high pH and thereby making P readily available to growing crops. Moreover, both these amendments improved the productivity appreciably.

Potassium uptake

Data on potassium removal by wheat crop (grain, straw and total) are presented in table 4.20. Potassium uptake by wheat grain and straw varied from 1.33 to 13.12 and 4.67 to 54.48 kg ha^{-1}, respectively, excluding 100 % N treated plots. Application of chemical fertilizers either alone or in combination with amendments increased the K uptake significantly over control except in case of 100 % N alone. A perusal of the data revealed that K uptake by wheat grain in 100 % NPK treatment increased by 5.82 kg ha^{-1} over untreated plots. Application of 100 % NPK + FYM recorded highest K uptake of 13.12 kg ha^{-1} in wheat grain. FYM and lime amended plots were significantly superior over rest of the treatments. A reduction of 2.91 kg ha^{-1} in K uptake by wheat grains was noted in 100 % NP treated plots in comparison to 100 % NPK treated plots. Continuous application of 100 % NPK + FYM recorded highest K uptake by straw (54.58 kg ha^{-1}) and was significantly superior over rest of the treatments. The treatments comprising 100 % NP and 100 % NPK (-S) were at par in respect of S uptake in wheat straw.

In general, the K uptake by wheat in different treatments followed the trend as per the yield. Total uptake by wheat varied from 6.00 kg ha^{-1} to 67.70 kg ha^{-1}. Total K uptake in control and 100 % NP treated plots was at par and significantly inferior to rest of the treatments except 100 % NPK (-S). The total K uptake was much higher than added rates, particularly with the integrated use of chemical fertilizers and amendments. FYM and lime amended plots showed an increase of 28.42 and 16.62 kg ha^{-1} in total K uptake over 100 % NPK, respectively. Application of 100 % NP, 100 % NPK (-S) and 50 % NPK resulted in 25.73, 22.13 and 15.93 kg ha^{-1} reduction in total K uptake in comparison to 100 % NPK treatment.

Table 4: Effect of long-term use of chemical fertilizers and amendments on K uptake by wheat (kg ha^{-1})

Treatment	Uptake		
	Grain	Straw	Total
T_1: Control	1.33	4.67	6.00
T_2: 100% N	0.00	0.00	0.00
T_3: 100% NP	4.24	9.31	13.55
T_4: 100% NPK	7.15	32.13	39.28
T_5: 100% NPK+ FYM	13.12	54.58	67.70
T_6: 100% NPK+ lime	10.43	45.46	55.90
T_7: 100% NPK+ Zn	7.38	26.84	34.22
T_8: 100% NPK+ HW	8.46	42.70	51.16
T_9: 100% NPK (-S)	5.62	11.53	17.15
T_{10}: 150% NPK	6.23	30.98	37.21
T_{11}: 50% NPK	5.05	18.31	23.35
CD (P= 0.05)	1.95	6.99	8.33

Potassium uptake in 100 % N treated plots was zero as the continuous use of 100 % N alone had led to degradation of the soils resulting in zero productivity level. Complete exhaustion of native nutrients in control plots because of their continuous removal in the absence of nutrients addition from any external source resulted in low productivity and K uptake by grain and straw by wheat. Omission of K and S resulted in low yield and therefore lesser K uptake as compared to balanced fertilization. Moreover, K was not added in the NP treatment continuously and hence lesser K uptake in this plot is obvious. All the treatments had significantly higher K uptake values except 100 % NP over untreated plots which might be due to the addition of K through muriate of potash over the years. Application of FYM along with recommended dose of fertilizers recorded highest K uptake which might be due to the favourable conditions of crop growth in these plots and supply of K (0.4 %) through FYM in addition to chemical fertilizers. Positive influence of lime on K uptake is due to the improvement in soil pH and crop yield.

Similar positive influence of inorganics alone or in combination with organics on NPK uptake by wheat has also been observed by Singh and Sarkar (2001) [12], Pathak *et al.*

(2005) [13], Mann *et al.* (2006) [14] and Prasad *et al*. (2010) [15] under varied agro-climatic conditions.

Conclusions

- The continuous use of chemical fertilizers and amendments for thirty six years in an acid Alfisol brought out increase in the yield of the wheat crop.
- Relative concentration of nitrogen, phosphorus and potassium were higher in the plots which received organics and inorganics compared to the plots receiving only chemical fertilizers (100 % NPK) for thirty six years. The uptake of these macronutrients was highest where FYM and lime was added in combination.

References

1. Subba Rao A, Srivastava S. Role of plant nutrients in increasing crop productivity. Indian Journal of Fertilizer. 1998; 43(4):65-75.
2. Jackson ML. Soil Chemical Analysis. Prentice Hall Inc. Englewood Cliffs, New Jersey, USA, 1973.
3. Black CA. Methods of soil analysis. Part II. Chemical and mineralogical properties. American society of Agronomy, Madison, Wisconsin, USA, 1965.
4. Sinha SK, Singh VN, Singh KP. Effect of continuous application of manures and fertilizers on available nutrients in an alluvial soil. Journal of Research (BAU). 1997; 9:163-166.
5. Santhy P, Jayasree Sankar S, Muthuvel P, Selvi D. Long term fertilizer experiments – Status of N, P and K fractions in soil. Journal of the Indian Society of Soil Science. 1998; 46(3):395-398.
6. Swarup A. Long-term fertilizer experiments to study changes in soil quality, crop productivity and sustainability. Indian Institute of Soil Science, Bhopal, 2000.
7. Verma TS, Singh S. Effect of lime and gypsum on different forms of soil aluminium and acidity and crop yields in acid Alfisols of Himachal Pradesh. Journal of the Indian Society of Soil Science. 1996; 44:417-421.
8. Rao S, Khera MS. Consequences of potassium depletion under intensive cropping (India). Better Crops. 1995.79:24-25.
9. Brady NC, Weil RR. The nature and properties of Soils. Thirteenth edition. Pearson Education (Singapore) Pte. Ltd., Indian Branch. New Delhi, 2002.
10. Sharma SP, Subehia SK, Sharma PK. Long term effects of chemical fertilizers on soil quality, crop productivity and sustainability. Research Bulletin CSK Himachal Pradesh Krishi Vishvavidyalaya, 2002, 33.
11. Verma S. Studies on long term effects of chemical fertilizers and amendments on phosphorus dynamics and its budgeting in wet temperate zone soils of Western Himalayas. *Msc. Thesis*, Department of soil Science, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur, India, 2002.
12. Singh Surendra, Sarkar AK. Balanced use of major nutrients for sustaining higher productivity of maize-wheat cropping system in acidic soils of Jharkhand. Indian Journal of Agronomy. 2001; 46(4):605-610.
13. Pathak SK, Singh SB, Jha RN, Sharma RP. Effect of nutrient management on nutrient uptake and changes in soil fertility in maize-wheat cropping system. Indian Journal of Agronomy. 2005; 50(4):269-273.
14. Mann KK, Brar BS, Dhillon NS. Influence of long-term use of farmyard manure and inorganic fertilizers on nutrient availability in a Typic Ustochrept. Indian Journal of Agricultural Sciences. 2006; 76(9):477-480.
15. Prasad J, Karmakar S, Kumar R, Mishra B. Influence of integrated nutrient management on yield and soil properties in maize-wheat cropping system in an alfisol of Jharkhand. Journal of the Indian Society of Soil Science. 2010; 58:200-204.