Himachal Journal of Agricultural Research 51(1): 99-104 (2025)

Nutrient uptake and yield of maize as influenced by regular application of fertilizers and amendments in an acid *Alfisol*

Shivani Chadak[1]*, RP Sharma[1], Narender K Sankhyan[1], Rameshwar Kumar[2], Anshu Sharotri[1] and Isha Thakur[1]

Chaudhary Sarwan Kumar Himachal Pradesh Agricultural University, Palampur, India-176062

Manuscript received: 11.03.2025; Accepted: 05.05.2025

Abstract

A study was conducted to assess the influence of regular application of fertilizers and amendments on nutrient uptake and yield of maize under ongoing long-term fertilizer experiment in an acid *Alfisol* of Palampur, Himachal Pradesh. The experiment consisted of eleven treatments which were replicated thrice. The regular conjunctive application of chemical fertilizers and FYM/lime enhanced the yield and N, P and K uptake by maize grain and stover significantly over sole use of recommended dose of fertilizers. The application of FYM and lime along with chemical fertilizers boosted the grain yield of maize by 84 % and 74 %, respectively, over 100 % NPK treatment. However, imbalanced use of nutrients {100 % NP and 100 % NPK(-S)}resulted in reduction in both yield as well as nutrient uptake, compared to 100 % NPK. Conclusively, the study highlights the importance of balanced nutrient application in sustaining maize productivity.

Key words: Maize, yield, nutrient uptake, fertilizers, farmyard manure and lime.

Maize (*Zea mays* L.) is one of the India's most important cereal crops after rice and wheat. Owing to its high genetic potential, the crop has a high nutrient requirement, making it a soil exhausting crop (Ghosh *et al.* 2021). Furthermore, the intensive cropping with high yielding varieties without proper replenishment has resulted in depletion of nutrient base of most of the soils leading to deterioration of soil health and ultimately reduction in the productivity of the crops (Abid *et al.* 2020). Thus, to maintain the productivity along with sustainability of agricultural system, the crop needs balanced application of nutrients (Sharma *et al*. 2016).

Fertilizers undoubtedly have greatest potential in quickly supplying nutrients to the crops. The continuous inadequate and imbalanced application of fertilizers over the years has negatively affected the soil health (Ejigu *et al.* 2021). Furthermore, the declining soil organic carbon stocks and emerging multi-nutrient deficiencies has emphasized the need to incorporate organic manures like FYM/compost into the soil (Sharma *et al*. 2018). The addition of FYM into the soil not only augments the soil organic matter but also supplies broad spectrum of essential nutrients, including both macro- and micro-nutrients (Sharma *et al*. 2014). Incorporating FYM into the soil also helps in improving the physical, chemical and biological properties of soil (Sheoran *et al*. 2017). The acidic nature of soils is also one of the reasons associated with declining crop productivity in the state for which liming is an effective solution. Liming is known to increase the uptake of nutrient by crop by altering the physicochemical properties of soil (Daba *et al.* 2021). However, several studies reported that neither fertilizers nor amendments alone were able to compensate the nutrient's removed by the crops in long run (Ejigu *et al.* 2021). This has raised the concerns about food security and sustainability of the production system. Therefore, integrated application of fertilizers and amendments, such as FYM or lime (in acid soils), has the potential to sustain crop productivity (Suri *et al.* 2022) in the state. Furthermore, conducting long-term experiments is necessary to comprehend the long-term impacts of fertilizers and amendments on sustainability of the production system (Choudhary *et*

[1]Department of Soil Science; [2]Department of Organic Agriculture & Natural Farming
*Corresponding author e-mail id: chadakshivani@gmail.com

al. 2018). Considering the above facts, the study was undertaken with the objective to assess the impact of regular use of fertilizers and amendments on nutrient uptake and yield of maize.

Materials and Methods

Experimental site

The field experiment was conducted during *kharif* 2022 in the ongoing long-term fertilizer experiment which is in progress since *rabi* 1972-73 at research farm of Department of Soil Science, CSK HPKV, Palampur, Himachal Pradesh, India. The experimental site is in the Palam valley of district Kangra at $32^0 6^1$ N latitude and $76^0 3^1$ E longitude and at an elevation of about 1290 m above mean sea level. This region falls under the mid hills sub-humid zone of Himachal Pradesh. The soil of the study area was silty loam in texture and belongs to Alfisol soil order.

Treatment details and crop management

Eleven treatments were tested in a randomized block design with three replications in plots of size $15m^2$ (5 m×3 m). Treatment plan consisted of 50 % NPK (T_1); 100 % NPK (T_2); 150 % NPK (T_3); 100 % NPK + hand weeding (T_4); 100 % NPK + Zinc (T_5); 100 % NP (T_6); 100 % N (T_7); 100 % NPK + FYM @ 10t ha^{-1} (T_8); 100 % NPK (-S) (T_9); 100 % NPK + lime @ 900 kg ha^{-1} (T_{10}); control (T_{11}). Since 2011, the original treatment structure was slightly modified due to the marked build-up of available P, the optimal and super optimal doses of P were reduced by 50 % and in case of 50 % NPK, the addition of FYM @ 5 t ha^{-1} on dry weight basis to maize crop only was also included. FYM was added to maize crop every year. The recommended dose of fertilizer for maize was 120 kg N, 30 kg P and 40 kg K ha^{-1} which was considered 100 % NPK. Maize variety Kanchan Gold was selected for the study. Nitrogen was applied to the crop in spilt doses; half dose of N and full dose of P and K were applied at the time of sowing. The remaining half of N was top dressed in two equal splits at knee high and pre-tasselling stages of crop growth. The source of N was urea, SSP for P except T_9 *i.e.* 100 % NPK (-S), where P was applied through DAP to assess the effect of 'S' free high analysis P fertilizer in crop production and MOP for K. Zinc was applied in 100 % NPK + Zn as zinc sulphate @ 25 kg ha^{-1} till 2010-11 as there is significant build-up of available zinc in these plots. Lime was added in 100 % NPK + lime @ 900 kg ha^{-1} as marketable lime ($CaCO_3$) passed through 100 mesh sieve. Lime application was done every year to maize crop until soil pH is less than 6.3, afterwards it was applied depending upon the pH of the soil. Since the pH of soil during the experiment was 6.23 so it was applied as per recommendation. The crop was cultivated according to state recommended agronomic practices except for the fertilization, which was accomplished as described under treatment plan.

Yield and nutrient uptake analysis

The grain and stover yield were recorded after the harvest of maize. The grain yield of maize was calculated at 15.5 per cent moisture content, whereas stover yield of maize was recorded on air dry basis. The data so obtained was interpreted on hectare basis. The grain and stover samples of maize were ground and digested to measure the content of N using the micro-Kjeldahl method (Jackson 1973), P by the vanado molybdo-phosphoric acid method (Jackson 1973) and K by the flame photometer (Black 1965). The nutrient uptake was calculated by multiplying the per cent concentration of a particular nutrient with grain and stover yields.

Statistical analysis

The data generated from the investigations were subjected to analysis of variance for randomized block design as per the procedure outlined by Gomez and Gomez (1984).

Results and Discussions

It is evident from the data presented in Figure 1 that there was significant effect of regular application of fertilizers and amendments on grain and stover yield of maize. The significantly higher grain and stover yield of maize was recorded under the treatment where combined application of 100% NPK and FYM were done (6.14 and 9.98 t/ha, respectively), which was statistically at par with the treatment where 100% NPK was applied along with lime, compared to control (0.87 and 1.69 t/ha, respectively). The application of FYM along with chemical fertilizers increased the grain and stover yield of maize by 84% and 81%, respectively, over 100% NPK treatment. This might be due to the beneficial effect of FYM addition which provides prolonged and better availability of nutrients during crop growth period and also improves the physico-

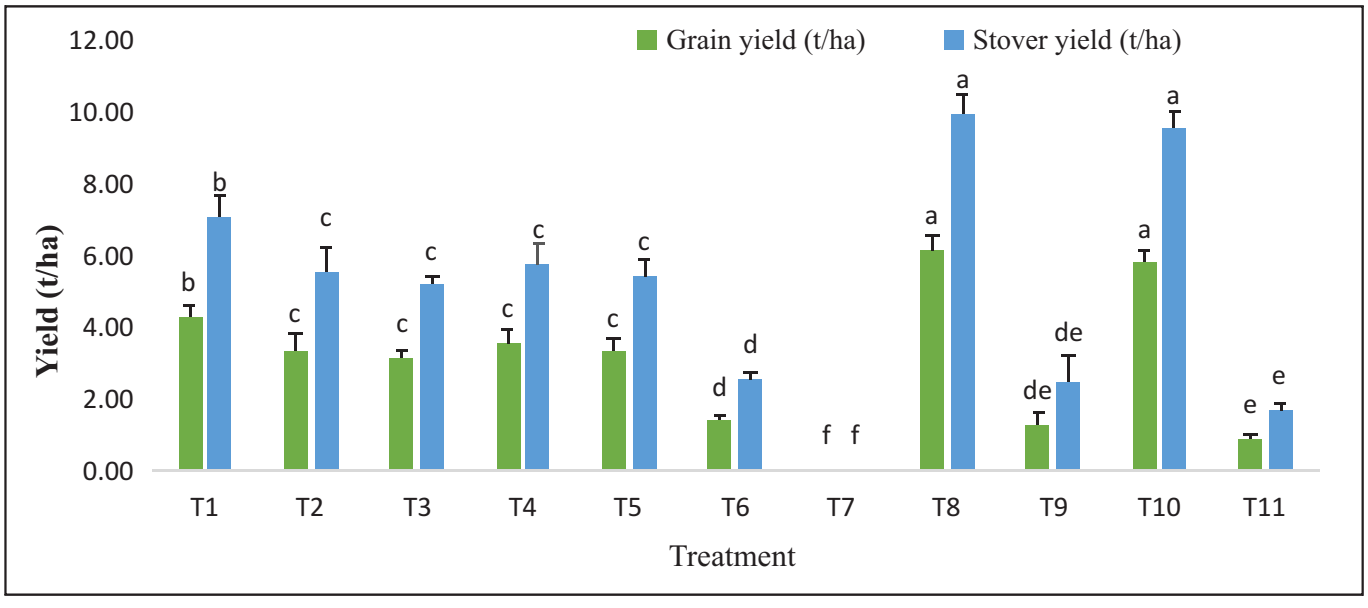

Figure 1: Effect of regular application of fertilizers and amendments on productivity of maize. Bars with different letters within each panel are significantly different (P<0.05). Error bars represent standard deviation of the mean.

chemical properties of soil (Sharma *et al.* 2021; Suri *et al*. 2022). Furthermore, in lime treated plots, the ameliorating effect of lime on soil reaction might have improved the availability of nutrients to crop which in-turn improved the maize yield (Hati *et al.* 2008).

Notably, the yield of maize under super optimal dose of NPK (T_3) was found to be at par with optimal dose of NPK (T_2) which might be due to nutrient imbalance and emerging deficiency of secondary nutrients particularly Mg in the former treatment. Application of 100 % NPK (T_2) recorded significantly higher grain and stover yield of maize than the treatments where potassium (T_6) and sulphur (T_9) were omitted. This highlighted the importance of potassium and sulphur in crop nutrition Thakur *et al*. 2019). The continuous application of 100% N through urea over the years (since 1972) has declined the yield of maize to zero. This might be due to significant decrease in soil pH and increase in the concentration of acidic cations, resulting into deterioration of soil quality in these plots (Chauhan *et al.* 2020).

The long-term application of fertilizers and amendments registered a significant effect on NPK uptake by maize grain and stover as shown in Figure 2

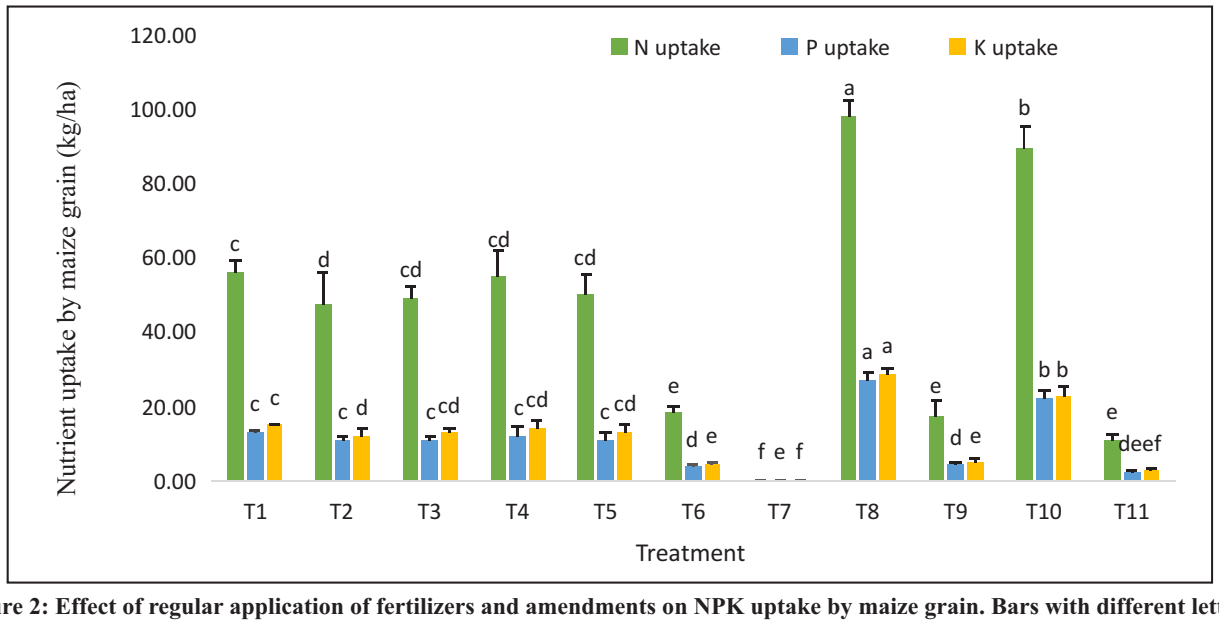

Figure 2: Effect of regular application of fertilizers and amendments on NPK uptake by maize grain. Bars with different letters within each panel are significantly different (P<0.05). Error bars represent standard deviation of the mean.

and 3, respectively. The higher N, P and K uptake by maize grain (98.01, 26.8 and 28.36 kg/ha, respectively) and stover (76.52, 10.42 and 83.2 kg/ha, respectively) were recorded under the treatment where 100 % NPK was applied with FYM (T_8), followed by 100 % NPK + lime (T_{10}) treatment, whereas lower N, P and K uptake by maize grain (10.74, 2.15 and 2.4 kg/ha, respectively) and maize stover (7.55, 0.75 and 7.96 kg/ha, respectively) were recorded under control (T_{11}). The complete omission of K and S from the fertilization schedule in treatment T_6 and T_9, respectively, also resulted in significant reduction in N, P and K uptake by maize grain and stover, compared to 100 % NPK treatment (T_2).

The higher N, P and K uptake in treatment T_8 might be attributed to solubilization of native nutrients, chelation of complex intermediate molecules formed during decomposition of FYM, their mobilization and buildup of different nutrients in different plant parts. Significantly lower nutrient uptake under control plots might be due to continuous removal of native nutrients without any input addition from external sources (Anjali *et al*. 2022). The persistent absence of K and S under treatment T_6 and T_9, respectively, resulted in reduced N, P and K uptake which might be due to imbalanced nutrition in these plots (Chauhan *et al.* 2020).

Correlation between yield and nutrient uptake

Maize grain yield was significantly correlated with N, P and K uptake (Figure 4). A significant and highly

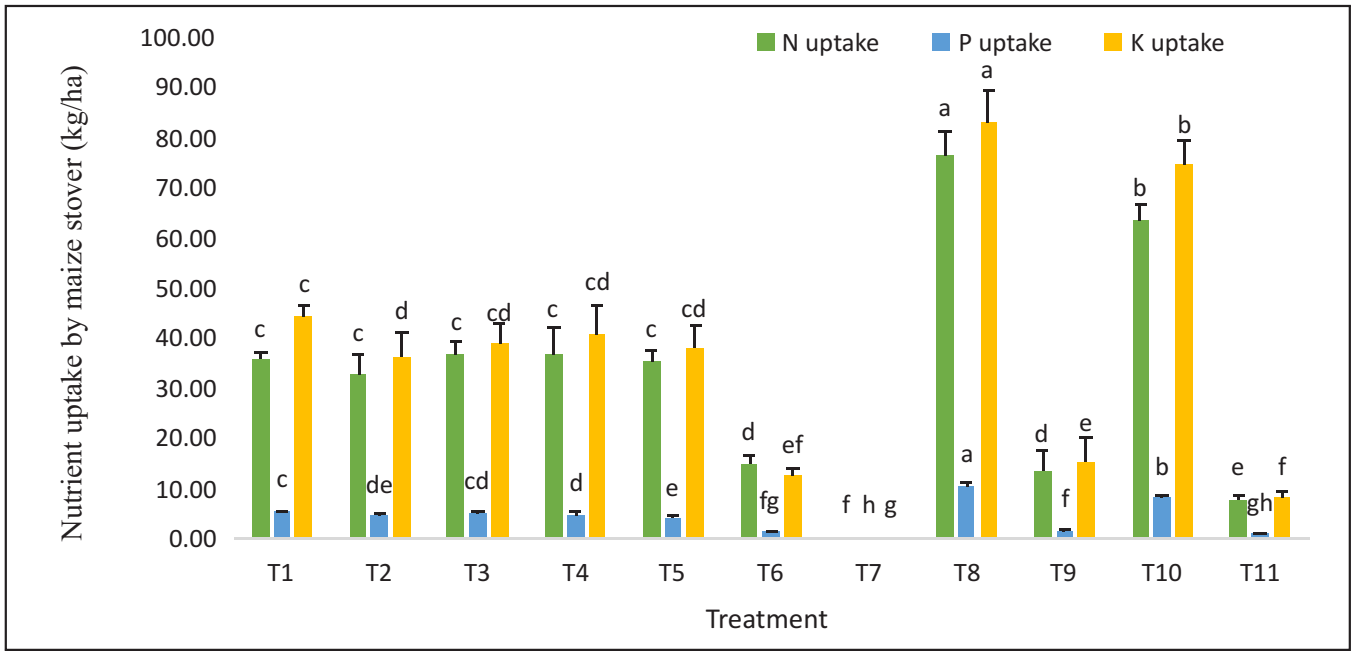

Figure 3: Effect of regular application of fertilizers and amendments on NPK uptake by maize stover. Bars with different letters within each panel are significantly different (P<0.05). Error bars represent standard deviation of the mean.

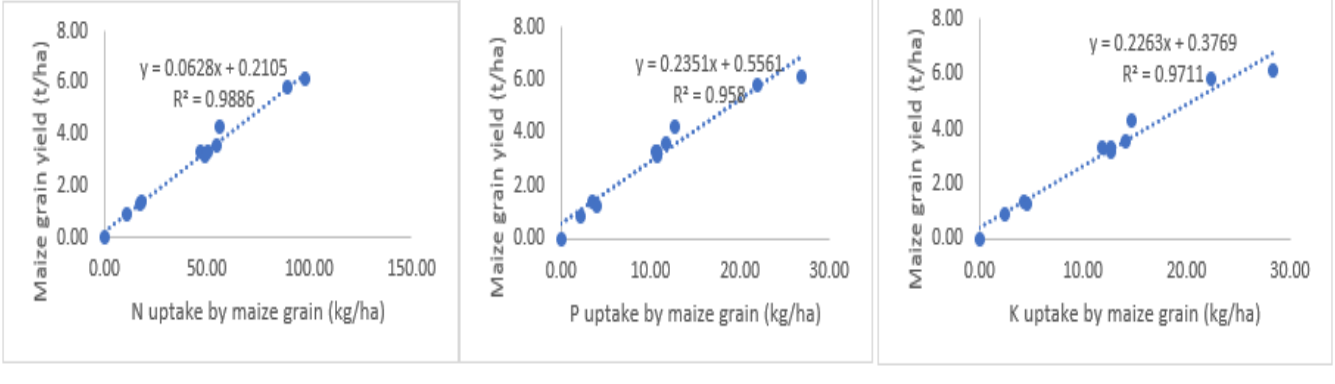

Figure 4. Correlation among maize grain yield and NPK uptake by maize grain

positive correlation was found between maize grain yield and N, P and K uptake (R^2= 0.989, 0.958 and 0.971, respectively). This demonstrated that integrated application of chemical fertilizers and FYM/lime might have enhanced the nutrient availability in soil which led to increase in nutrient uptake, thereby leading to higher yields (Ciampitti and Vyn 2012).

Conclusion

The present study demonstrated that the regular application of 100 % NPK along with FYM/lime outperformed all other treatments with respect to yield and N, P and K uptake by maize grain and stover. By contrast, the imbalanced use of fertilizers led to significant reduction in yield and nutrient uptake by maize as compared to 100 % NPK treatment. Overall, these findings highlight the importance of balanced fertilization strategies (Sharma and Sharma 2016) that include the addition of amendments in combination with fertilizers for securing higher productivity and improving nutrient uptake.

Acknowledgments

The authors are thankful to the Indian Council of Agricultural Research, New Delhi and Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya Palampur for technical guidance and financial support to this research.

Conflict of interest: The authors declare that there is no conflict of interest among the authors in this research paper.

References

Abid M, Batool T, Siddique G, Ali S, Binyamin R, Shahid MJ, Muhammad R, Abdulaziz AA and Mohammed NA 2020. Integrated nutrient management enhances soil quality and crop productivity in maize-based cropping system. Sustainability **12**(23): 10214.

Anjali, Sankhyan NK and Sharma RP 2022. Long-term effect of inorganic fertilizers and amendments on macronutrients uptake and relationship with soil organic carbon under maize-wheat rotation system in an acid Alfisol. Himachal Journal of Agricultural Research **48**(2): 166-174.

Black CA. 1965. Methods of Soil Analysis. Part II. American Society of Agronomy, Madison, Wisconsin, USA.

Chauhan N, Sankhyan NK, Sharma RP, Singh J and Gourav 2020. Effect of long-term application of inorganic fertilizers, farm yard manure and lime on wheat (*Triticum aestivum* L.) productivity, quality and nutrient content in an acid *alfisol*. Journal of Plant Nutrition **43**: 2569-2578.

Choudhary M, Panday SC, Meena VS, Singh S, Yadav RP, Mahanta D, Mondal T, Mishra PK, Bisht JK and Pattanayak A 2018. Long-term effects of organic manure and inorganic fertilization on sustainability and chemical soil quality indicators of soybean-wheat cropping system in the Indian mid-Himalayas. Agriculture, Ecosystems & Environment **257**: 38-46.

Ciampitti IA and Vyn TJ 2012. Physiological perspectives of changes over time in maize yield dependency on nitrogen uptake and associated nitrogen efficiencies: A review. Field Crops Research **133**: 48-67.

Daba NA, Li D, Huang J, Han T, Zhang L, Ali S, Khan MN, Du J, Liu S, Legesse TG and Liu L et al. 2021. Long-term fertilization and lime-induced soil pH changes affect nitrogen use efficiency and grain yields in acidic soil under wheat-maize rotation. Agronomy **11**(10): 2069.

Ejigu W, Selassie YG, Elias E and Damte M 2021. Integrated fertilizer application improves soil properties and maize (*Zea mays* L.) yield on nitisols in northwestern Ethiopia. Heliyon **7**(2).

Ghosh D, Mandal M and Pattanayak SK 2021. Long term effect of integrated nutrient management on dynamics of phosphorous in an acid inceptisols of tropical India. Communications in Soil Science and Plant Analysis **52**(19): 2289-2303.

Gomez KA and Gomez AA 1984. Statistical Procedures for Agricultural Research (2nd ed.), pp. 680. New York: John Wiley and Sons Inc.

Hati KM, Swarup A, Mishra B, Manna MC, Wanjari RH, Mandal KG and Misra AK 2008. Impact of long-term application of fertilizer, manure and lime under intensive cropping on physical properties and organic carbon content of an Alfisol. Geoderma **148**(2): 173-179.

Jackson ML. 1973. Soil Chemical Analysis. Prentice Hall Inc. Englewood Cliffs, New Jersey, USA.

Sharma A and Sharma RP 2016. Effect of boron and lime on productivity of garden pea under acidic soils in north-western Himalayas. Communications in Soil Science and Plant Analysis **47** (3): 291-297

Sharma A, Sharma RP and Singh S 2016. Influence of *Rhizobium* inoculation, split nitrogen applications and plant geometry on productivity of garden pea (Pisum sativum L.) in an acid alfisol. *Legume Research* **39** (6): 955-961

Sharma A, Sharma RP, Katoch V and Sharma GD. 2018. Influence of vermicompost and split applied nitrogen on growth, yield, nutrient uptake and soil fertility in pole type French bean (*Phaseolus vulgaris* L.) in an acid alfisol. Legume Research 41 (1): 126-131

Sharma A, Sharma RP, Sharma GD, Sankhyan NK and Sharma M. 2014. Integrated Nutrient Supply System for cauliflower-french bean-okra cropping sequence in humid temperate zone of north-western Himalayas. Indian J. Hort. **71** (2): 211-216.

Sharma N, Sankhyan NK, Sharma RP, Chakkal AS, Thakur A and Kumar P 2021. Effect of long-term application of fertilizers and amendments on wheat productivity and available nutrient status in an acid Alfisol. Himachal Journal of Agricultural Research **47**(2): 244-250.

Sheoran S, Raj D, Antil RS, Mor VS and Dahiya DS 2017. Productivity, seed quality and nutrient use efficiency of wheat (*Triticum aestivum*) under organic, inorganic and integrated nutrient management practices after twenty years of fertilization. Cereal Research Communications **45**(2): 315-25.

Suri D, Sharma RP, Sankhyan NK and Manuja S 2022. Effect of five decades of application of inorganic fertilizers, farm yard manure and lime on maize and wheat productivity in an acid *Alfisol*. Himachal Journal of Agricultural Research **48**(2): 285-290.

Thakur A, Sharma RP, Sankhyan NK, Sepehya S and Kumar R 2019. Long-term effect of fertilizers and amendments on maize productivity and relationship of soil health parameters with quality traits of maize grains under mid hills sub humid conditions of Himachal Pradesh. Himachal Journal of Agricultural Research **45**(1&2): 25-30.