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Short Communication

Effect of long-term application of fertilizers and amendments on wheat productivity and available nutrient status in an acid *Alfisol*

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Abstract

The effect of continuous application of fertilizers and amendments on wheat yield and nutrients in an acid *Alfisol* during *rabi* (2018-19) was evaluated in an ongoing long-term field experiment initiated in 1972 at the research farm of the Department of Soil Science, CSK HPKV, Palampur.The soil of the experimental area was acidic (pH 5.8), silt loam in texture and classified taxonomically as "*Typic Hapludalf*". The highest productivity of wheat was recorded in the treatment comprising 100% NPK + FYM and was statistically at par with treatment receiving 100% NPK with lime. Continuous sole application of N resulted in zero yield. The significantly superior available N and K were registered in treatment receiving 100% NPK + FYM. However, the highest available P was recorded in treatment where NPK at 150 per cent of the recommended dose were applied. The Zn application along with 100% NPK registered the highest value (4.19 mg kg^{-1}) of DTPA extractable Zn and application of 100% NPK + FYM recorded the highest value of DTPA extractable Fe, Cu, and Mn (36.8, 2.26, and 39.65 mg kg^{-1}, respectively). Overall, 100% NPK+ FYM was found to be the best treatment to increase the wheat productivity and maintain nutrients status in the soil on long-term basis.

Key words: *Alfisol*, amendments, available nutrient status, fertilizers, wheat productivity.

Global food demand is escalating exponentially due to ballooning population of 7.8 billion. Major factor concerning the mankind sustenance is food, and the food security has emerged out as a major problem, requiring immediate attention (Zhang 2018). Globally, among cereal crops, wheat (*Triticum aestivum* L.) is the second most important crop after rice. In India, wheat is being cultivated over an area of 29.58 million hectares with a production of 99.70 million tonnes. In Himachal Pradesh, it occupies an area of about 319 thousand hectares with a total production of 565.74 thousand tonnes and an average productivity of 15.30 q ha^{-1} which is statistically lower as compared to average national yield (Anonymous 2018).

Excessive and imbalanced usage of chemical fertilizers during green revolution considerably increased the crop production for a relatively short time, but ultimately deteriorated the soil health and stagnated the crop productivity over long term period. For enhancing and sustaining the crop productivity, there is an urgent need to improve and/or maintain soil fertility status so that ever increasing food demand can be achieved. Balanced fertilization over a long period of continuous cultivation can prevent the loss of soil fertility. Integrated nutrient management (INM) can have a positive impact on soil fertility status, ultimately on crop productivity. Maintaining optimum levels of nutrients in soilis one of the key attributes for sustaining crop productivity (Blair *et al*. 1995; Yan *et al*. 2007).

Long-term fertilizer experiments help to monitor alterations in soil fertility status and crop yields in response to various nutrient management practices. Keeping in view the above facts, current investigation was carried out to evaluate the effects of long-term application of fertilizers and amendments on wheat productivity and nutrient status in an acid *Alfisol* after 46^{th} cropping cycle.

Experimental site

The experimental farm is situated at $31^{0}6^{/}$ N latitude and $76^{0}3^{/}$ E longitude at an altitude of about 1290 meters above mean sea level. The site is situated in the Palam valley of Kangra district under mid hills sub humid zone of Himachal Pradesh. Taxonomically, the soil of the experimental site is classified under suborder *Typic Hapludalf*. The soil was silt loam in texture, strongly acidic with pH 5.8, organic carbon content of 7.9 g kg^{-1} and the content of available N, P, K, DTPA extractable Fe, Mn, Cu and Zn were 736,12.0, 194 kg ha^{-1}, 26.0, 24.3, 0.4 and 1.9 mg kg^{-1}, respectively.

The experiment was laid out in Randomized Block Design (RBD) which consisted of eleven treatments viz.,T_1=50% NPK, T_2=100% NPK, T_3=150% NPK, T_4=100% NPK+ (HW), T_5=100% NPK+ Zn, T_6=100% NP, T_7=100% N, T_8=100% NPK+ FYM, T_9=100% NPK (-S), T_{10}=100% NPK+ Lime, and T_{11}= Control, each allocated randomly according to the random table and replicated thrice. The crop management practices *viz*., application of fertilizers and amendments, sowing, irrigation, inter cultural operations were same as followed by Chauhan *et al*. (2018).

Soil sampling and analysis

The soil samples (0-0.15 m) before sowing and at harvest were collected and air dried. The dried samples were then ground in wooden pestle and mortar and passed through 2 mm mesh sieve. The collected samples were stored in polythene bags for determining available N, P, K and DTPA extractable Fe, Mn, Cu and Zn by employing the methods as referenced by Jackson (1973) and Black (1965).

Statistical analysis

Statistical analysis was done by standard procedures as described by Gomez and Gomez (1984).

Productivity of wheat

Grain, straw, and biological yield of wheat varied from zero in the treatment receiving sole application of N(T_7) to 3.01, 5.01, and 8.02t ha^{-1}, respectively in the treatment where 100% NPK + FYM was applied (T_8) (Table 1). The highest wheat grain yield recorded in treatment $T_8$was statistically at par with the treatment T_{10}, where the recommended dose of NPK was applied along with lime. Continuous use of FYM along with 100 per cent NPK (T_8) increased grain, straw, and biological yield of wheat by 48.2, 53.2, and 51.3 per cent, respectively over 100 per cent NPK alone (T_2). The increase in productivity under treatment T_8, might be due to FYM application that created congenial environment for plant growth and nutrient uptake through its impact on improving the soil physical, chemical and biological properties besides, providing the nutrients (Thakur *et al*. 2019). The higher grain yield in T_{10} might be ascribed to the higher nutrient availability due to ameliorating effect of lime on soil pH (Singh *et al*. 2017). The complete crop failure in treatment T_7, might be due to the acidic nature of urea (N) which led to decline in the soil pH and the continuous mining of nutrients for the last 46 years as a result of intensive cropping. Similar results have also been reported by Brar *et al*. (2015). The lower yield recorded in the control (T_{11}) might be due to the exhausted nutrient pools of the soil in absence of any external nutrient source (Shambhavi *et al*. 2017).

Table 1.Effect of different treatments on wheat productivity

Treatment	Productivity (t ha^{-1})		
	Grain	Straw	Biological
T_1: 50% NPK	1.86	3.07	4.93
T_2: 100% NPK	2.03	3.27	5.29
T_3: 150% NPK	1.67	2.78	4.45
T_4: 100% NPK+ (HW)	2.29	3.80	6.09
T_5: 100% NPK+Zn	1.73	2.89	4.62
T_6: 100% NP	0.90	1.48	2.38
T_7: 100% N	0.00	0.00	0.00
T_8: 100% NPK+FYM	3.01	5.01	8.02
T_9: 100% NPK (-S)	0.86	1.41	2.27
T_{10}:100% NPK+Lime	2.92	4.83	7.75
T_{11}: Control	0.44	0.73	1.18
CD (P=0.05)	0.20	0.47	5.03

Available nutrients status

Available nitrogen (N)

Available N varied from 271 kg ha^{-1} in control (T_{11}) to 389 kg ha^{-1} in the treatment 100% NPK + FYM (T_8) (Table 2). Application of FYM along with 100 per cent NPK (T_8) increased the available N to the tune of 43.5 per cent over 100 per cent NPK (T_2). The increase in the available N might be due to FYM application which might have supplemented the soil N and increased its availability (Verde *et al*. 2013; Sharma 2015). The highest available N recorded in treatment T_8 was statistically at par with the treatment T_3 that received 150 per cent recommended dose of NPK and treatment T_4, receiving recommended dose of NPK with manual weeding. A significant decline in available N was noted in all the treatments over its initial value (736 kg ha^{-1}), however, highest declined of 63 per cent was recorded in the plots receiving no fertilizer or manure (T_{11}). This might be due to the continuous removal of soil N in the absence of external supply of N through fertilizers and manures. Similar results have also been reported by Yang *et al*. (2011); Hemalatha and Chellamuthu (2013) and Sharma *et al*. (2015)

Available phosphorus (P)

Available P varied from 14.3 kg ha^{-1} in treatment receiving the sole application of urea (T_7) to 156.5 kg ha^{-1} in the treatment receiving 150 per cent recommended dose of NPK (T_3) (Table 2). The significantly higher available P recorded in treatment T_3 might be attributed to the addition of P at higher rates. The substantial build-up of available P recorded in all the treatments except in treatment T_{11}, might be attributed to the continuous addition of P through fertilizers, low crop recovery of applied P and its high stability in the form of residual P (Sharma and Gupta 1997). Considerable build up of available P with application of phosphatic fertilizer has also been reported by Biswas and Benbi (1997).

Available potassium (K)

The available K varied from a lowest value of 118 kg ha^{-1} under control (T_{11}) to a highest value of 201 kg ha^{-1} under 100% NPK + FYM (T_8) (Table 2). The higher amount of available K in treatment T_8 might be attributed to the addition of K through FYM applied every year which could supply certain amount of K. Moreover, decomposition of FYM in the soils leads to release of organic colloids which results in increase in CEC, thus enabled the soil to hold more exchangeable K. Similar findings have been reported by Satish *et al*. (2011); Hemalatha and Chellamuthu (2013) and Mazumdar *et al*. (2014).The substantial depletion of available K was recorded in all the treatments except in T_8. The treatment receiving 100% NPK+FYM was theonly treatment in which the K availability increased over the initial value (194 kg ha^{-1}).

Table 2. Effect of different treatments on the available N, P, and K (kg ha^{-1})

Treatment	Available N	Available P	Available K
T_1: 50% NPK	347	56.9	151
T_2: 100% NPK	365	72.3	162
T_3: 150% NPK	369	156.5	181
T_4: 100% NPK+ (HW)	373	88.4	163
T_5: 100% NPK+ Zn	361	81.2	172
T_6: 100% NP	350	103.6	126
T_7: 100% N	333	14.3	126
T_8: 100% NPK+ FYM	389	146.5	201
T_9: 100% NPK (-S)	351	130.2	173
T_{10}:100% NPK+ Lime	358	78.7	167
T_{11}: Control	271	14.8	118
CD (P= 0.05)	20	6.8	12

DTPA extractable iron (Fe)

Significantly higher DTPA extractable Fe (36.80 mg kg^{-1}) was recorded in FYM amended plot (T_8), while the lowest (18.54 mg kg^{-1}) was recorded in the control (T_{11}) (Table 3). Increase in available Fe in FYM amended plot might be due to the direct addition and solubilization of native Fe by organic acids produced from decomposition of added organic source (FYM) and also due to the production of chelating agents that reduced its adsorption, fixation and precipitation (Akbari *et al*. 2011; Verma *et al*. 2012). Comparison among different fertilizer treatments with control indicated that there was a significant increase in DTPA extractable Fe content.

DTPA extractable copper (Cu)

DTPA extractable Cu content varied from 1.39 mg kg^{-1} under control to 2.26 mg kg^{-1} under 100 per cent NPK+ FYM (Table 3). The increase in DTPA extractable Cu with the continuous use of FYM along with chemical fertilizers (T_8) over 100 per cent NPK (T_2) was to the order of 30.6 per cent. Higher content of DTPA extractable Cu in FYM treated plots might be due to the formation of organic chelates, which decreased the Cu susceptibility to adsorption, fixation and precipitation, resulting in their enhanced availability in soil (Verma and Mathur 2007). Also, addition of organic matter to soil encouraged microorganisms, which aided in the liberation of micronutrients (Zhang *et al*. 2015).

DTPA extractable zinc (Zn)

DTPA extractable Zn content varied from 1.12 mg kg^{-1} under control (T_{11}) to 4.19 mg kg^{-1} under 100 per cent NPK + Zn (T_5) (Table 3).The increase in DTPA extractable Zn in 100 per cent NPK + Zn treatment could bedue to the additional input of the nutrient (Zn). The increase in DTPA extractable Zn in organically amended plots (T_8) might be due to mineralization of organically bound forms of Zn in the FYM and also possible addition of Zn as impurity through single superphosphate. Addition of FYM might have resulted in the formation of organic chelates of higher stability as Zn is known to form relatively stable chelates with organic ligands which decrease their susceptibility to adsorption, fixation and/or precipitation (Verma and Mathur 2007).

DTPA extractable manganese (Mn)

DTPA extractable Mn varied from a minimum value of 17.01 mg kg^{-1} in control (T_{11}) to the maximum value of 39.65 mg kg^{-1} under 100 per cent NPK + FYM (T_8) (Table 3).This significant increase in the treatment T_8 might be due to the addition of organic matter through FYM which led to higher values of DTPA extractable Mn than rest of the treatments. The increase in micronutrients concentration in soils with addition of organics might be due to the enhanced microbial activity and consequent release of chelating agents besides the direct addition of these nutrients to the available pool on decomposition of FYM (Bellakki and Badanur 1997). Such an increase in the micronutrient content with the use of FYM along with chemical fertilizers has also been reported by Sharma *et al*. (2000) and Sharma and Subehia (2003).

Table 3. Effect of different treatments on DTPA extractable Fe, Cu, Zn and Mn (mg kg^{-1})

Treatment	Fe	Cu	Zn	Mn
T_1: 50% NPK	28.36	1.75	1.33	21.41
T_2: 100% NPK	32.70	1.73	1.28	22.46
T_3: 150% NPK	33.44	1.72	1.34	25.33
T_4: 100% NPK+ (HW)	32.27	1.81	1.38	24.05
T_5: 100% NPK+ Zn	26.87	1.76	4.19	21.60
T_6: 100% NP	27.56	1.62	1.31	22.24
T_7: 100% N	31.03	1.50	1.38	21.95
T_8: 100% NPK+ FYM	36.80	2.26	2.47	39.65
T_9: 100% NPK (-S)	23.61	1.65	1.47	21.19
T_{10}:100% NPK+ Lime	24.21	1.78	1.34	24.85
T_{11}: Control	18.54	1.39	1.12	17.01
CD (P= 0.05)	4.0	0.09	0.21	2.90

Conclusion

The continuous application of chemical fertilizers along with FYM or lime for 46 years improved the soil nutrient status and wheat yield as compared to unfertilized control, barring sole application of urea, which rendered the soil unproductive. Long-term integrated use of optimal dose of NPK along with amendments (FYM/lime) significantly enhanced the productivity of wheat and available nutrient status of the soil over the use of chemical fertilizers alone.

Conflicts of interest: There is no conflict of interest in this research article.

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