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# 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

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**Abstract**

**This study was undertaken in an on-going long-term fertilizer experiment, initiated during 1972-73 at Experimental Farm of Department of Soil Science, CSK HPKV Palampur to work out the relationship of soil health parameters with quality of maize in an acid Alfisol. The soil of the experimental site was silt loam and classified taxonomically as *Typic Hapludalf*. The experiment consisted of eleven treatments with varying levels of NPK fertilizers, and FYM & lime as amendments. Continuous application of fertilizers and amendments for forty-six years significantly influenced the yield of maize. The highest grain (46.5 q ha$^{-1}$) and stover yield of maize (77.0 q ha$^{-1}$) was recorded in the 100 per cent NPK + FYM treatment and was at par with 100 per cent NPK + lime. Continuous omission of S and K decreased the grain yield by 55 and 53 per cent, respectively, whereas regular application of N alone resulted in zero yield. Soil health parameters and grain quality traits were assessed and the relationship between soil health parameters and quality traits of maize grains was worked out. Correlation studies revealed that soil organic carbon exhibited a positive and significant relationship with non- reducing sugar (r = 0.737**). Similar positive relationship was found between porosity and non-reducing sugars (r =0.940**). There was a positive and significant relationship between dehydrogenase activity and reducing sugars (r = 0.866**). Invariably, bulk density exhibited negative and significant relationship with different quality traits of maize grains.**

**Key words**: Correlation, fertilizers, FYM, grains quality traits, maize, soil health parameters, yield.

Maize is one of the most important cereal crops of Himachal Pradesh and is grown in an area of 294 thousand ha with a total production of 784.29 thousand tonnes (Anonymous 2016). However, the average yield of maize in Himachal Pradesh (2.68 t ha$^{-1}$) is much less than world average yields (4.92 t ha$^{-1}$). Keeping in view the importance of this crop in the staple diet of people of Himachal Pradesh, there is a great need to increase the production of maize per unit area as well as to produce grains of superior nutritional quality.

One of the most effective ways to increase crop productivity and quality is through proper nutrient management. Balanced application of nutrients plays a key role in maintaining the soil health and sustaining the crop productivity. A healthy soil can produce higher crop yields with better quality. There are direct or indirect relationships of soil properties with crop yield and grain quality traits (Singh *et al*. 2019). Therefore, present study was undertaken to know the relationship of soil health parameters with quality traits of maize grains.

## Materials and Methods

A field experiment was conducted on maize crop (Kanchan Gold hybrid) in *kharif* 2017 in an on-going long-term fertilizer experiment under maize-wheat cropping system, which was initiated during rabi 1972-73, at experimental farm of Department of Soil Science, CSK HPKV, Palampur (32°6′ N, 72°3′ E, 1290 m above mean sea level). The experimental site lies in mid hills sub humid agro-climatic zone. During crop duration, a total rainfall of 2604.7 mm was received and the average weekly minimum and maximum temperature ranged between 23.9 to 30.6 and 14.0 to 20.6 °C, respectively. The soil of

experimental site was silt loam and taxonomically classified as *Typic Hapludalf*. At the start of experiment (1972-73), the soil was acidic in reaction (pH 5.8), with organic carbon content 7.9 g $kg^{-1}$, available N 736, available P 12 and available K 194 kg $ha^{-1}$.

The eleven treatments were as follows: $T_1$-50% NPK, $T_2$-100% NPK, $T_3$-150% NPK, $T_4$-100% NPK + Hand weeding (HW), $T_5$-100% NPK + Zn @ 25 kg $ha^{-1}$ through $ZnSO_4$, $T_6$-100% NP, $T_7$-100% N, $T_8$-100% NPK + FYM @ 10 t $ha^{-1}$ (to maize crop only), $T_9$-100% NPK (-S), $T_{10}$-100% NPK + lime @ 900 kg $ha^{-1}$, $T_{11}$-Control.The experiment was conducted in randomized block design with three replications The recommended dose for maize crop is 120 kg N, 60 kg $P_2O_5$ and 40 kg $K_2O$ $ha^{-1}$. Due to marked buildup of available P, the optimal and sub-optimal doses of P were reduced by 50% from *kharif* 2011 and application of FYM @ 5 t $ha^{-1}$ was included in $T_1$.

After the harvest of maize, grain and stover yield were recorded. Soil samples (0-0.15m and 0.15-0.30 m depth) collected after the harvest of maize were analyzed for various physical, chemical and biological soil health parameters, employing standard methods. Maize grain samples collected at the time of harvesting of crop were dried in an oven at 60°C, finely ground and standard procedures were used to determine various quality parameters and nutrient content of grains. The relationship of soil health parameters with maize qualitytraitswas worked out by computing simple correlation coefficients by following standard procedure as described by Gomez and Gomez (1984).

## Results and Discussion

### Maize productivity

The yield of maize was significantly influenced by continuous application of fertilizers and amendments for forty-six years. The highest grain (46.5 q $ha^{-1}$) and stover yield (77.0 q $ha^{-1}$) was recorded in 100% NPK + FYM ($T_8$), followed by 100% NPK + lime ($T_{10}$), after 46 cropping cycles (Table 1). This might be due to the improved soil properties and balanced supply of nutrients to the crop. Rajneesh *et al*. (2017) also reported significantly higher yield of maize due to the application of FYM or lime along with recommended dose of NPK in comparison to 100% NPK alone. Hand weeding ($T_4$) increased the maize yield by 16.6 per cent over chemical weed control ($T_2$), which can be attributed to the increased organic matter content in the plots due to recycling of the weeds in same plot, thereby, leading to improved physical properties and microbial processes in the soil. The continuous omission of S and K in 100% NPK (-S) and 100% NP reduced the maize yield by 55.1 and 52.6 per cent as compared to 100 per cent NPK, respectively. Continuous application of N alone through urea ($T_7$) resulted in sharp decline in soil pH which might have increased the concentration of Al ions to toxic levels, thereby leading to zero productivity. Majhi *et al*. (2018) also reported the deleterious effects of sole application of urea on yield of maize.

### Relationship of soil health parameters with maize quality traits

Coefficients of correlation (r) were worked out between chemical, physical & biological soil health parameters and quality traits of maize grains.

### Correlation between chemical soil health parameters and grain quality traits

In case of chemical soil health parameters, there was a positive and significant correlation of soil organic carbon (OC) with all maize quality parameters except moisture content (Table 2). However, soil pH showed a significant and positive correlation with all maize quality traits. Available N exhibited a positive and significant correlation with reducing and non-reducing sugar, crude protein, P, Ca, Mg and Fe content of maize grain. A positive and significant relationship of available P was recorded with all maize quality parameters at 5 per cent level of significance. The highest value of coefficient of correlation of available P was with P content of maize grain (r = 0.680**) and lowest with moisture content (r = 0.372**). Available K, S, exchangeable Ca and Mg and DTPA (diethylene triamine penta acetic acid) extractable Cu exhibited a significant and positive correlation with all the quality parameters of maize grain except moisture content. Correlation between DTPA extractable Fe, Mn and Zn and maize grain quality parameters was non-significant at 1 per cent level of significance, except DTPA extractable Zn and reducing sugars (r = 0.429**). DTPA extractable Zn had a significant and positive correlation with non-reducing sugars (r = 0.384*) and Fe content (r = 0.344*) at 5 per cent level of significance. DTPA extractable Mn showed a significant positive correlation with non-reducing sugar (r = 0.386*), P content (r = 0.373*) and Mg content (r = 0.378*). Kuppusamy *et al.* (2017) also observed positive and significant correlation between soil chemical properties and nutrient content of rice grain in the

**Table 1. Effect of continuous use of fertilizers and amendments on productivity of maize**

| Treatment | Productivity (q ha$^{-1}$) | |
|---|---|---|
| | Grain | Stover |
| $T_1$: 50% NPK | 30.7 | 51.3 |
| $T_2$: 100% NPK | 31.5 | 52.7 |
| $T_3$: 150% NPK | 27.5 | 46.1 |
| $T_4$: 100% NPK + HW | 36.6 | 61.6 |
| $T_5$: 100% NPK + Zn | 30.1 | 50.3 |
| $T_6$: 100% NP | 14.9 | 25.3 |
| $T_7$: 100% N | 0.0 | 0.0 |
| $T_8$: 100% NPK + FYM | 46.5 | 77.0 |
| $T_9$: 100% NPK (-S) | 14.1 | 23.9 |
| $T_{10}$: 100% NPK + lime | 43.2 | 73.4 |
| $T_{11}$: Control | 6.4 | 11.2 |
| CD (P=0.05) | 4.9 | 7.5 |

soils of South Korea. A negative relationship was found between moisture content and DTPA extractable Mn (r = -0.355*) and DTPA extractable Fe (r = -0.362*).

**Correlation between physical soil health parameters and grain quality traits**

It is clear from the data (Table 3) that physical soil health parameters *viz*., porosity and water holding capacity (WHC) were positively and significantly correlated with all maize quality traits except moisture content. Bulk density (BD) showed a significant but negative correlation with all the maize quality traits. Highest value of coefficient of correlation between soil physical parameters and quality traits was recorded between soil porosity and non-reducing sugars (r = 0.940**), followed by reducing sugars (r = 0.911**).

**Correlation between biological soil health parameters and grain quality traits**

As regards the biological soil health parameters, there was a significant and positive correlation of biological soil health parameters with all grain quality traits except moisture content, which was non-significant (Table 4). The highest value of coefficient of correlation for microbial biomass carbon (MBC) was recorded with non-reducing sugars (r = 0.861**), followed by reducing sugars (r = 0.856**) and lowest with total carbohydrate content (r = 0.541**). Microbial biomass nitrogen (MBN) exhibited a significant positive correlation with all grain quality parameters, except total carbohydrates and starch which was non-significant at 1 per cent level of significance. Highest value of coefficient of correlation for microbial biomass nitrogen was recorded with Mg content (r = 0.788**). Dehydrogenase activity (DHA) showed highest correlation with reducing sugar content of maize grain (r = 0.866**) and least with total carbohydrate content of maize grain (r = 0.565**). Pooniya and Shivay (2015) also reported a strong significant positive correlation between microbial biomass carbon and protein content of rice grain in the soils of Delhi.

**Table 2. Coefficients of correlation (r) between chemical soil health parameters and maize quality traits**

| Quality traits | Chemical soil health parameters | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH | OC | Avail N | Avail P | Avail K | Avail S | Exch. Ca | Exch. Mg | DTPA Mn | DTPA Zn | DTPA Fe | DTPA Cu |
| Reducing sugar | 0.742** | 0.703** | 0.431** | 0.480** | 0.674** | 0.517** | 0.736** | 0.735** | 0.324 | 0.429** | 0.025 | 0.677** |
| Non-reducing sugar | 0.734** | 0.737** | 0.470** | 0.529** | 0.702** | 0.591** | 0.771** | 0.767** | 0.386* | 0.384* | 0.073 | 0.720** |
| Crude fat | 0.646** | 0.408* | 0.215 | 0.524** | 0.466** | 0.466** | 0.533** | 0.457** | -0.002 | 0.227 | -0.167 | 0.427* |
| Crude fibre | 0.669** | 0.440* | 0.225 | 0.513** | 0.484** | 0.466** | 0.557** | 0.488** | 0.023 | 0.217 | -0.155 | 0.454** |
| Crude protein | 0.668** | 0.555** | 0.354* | 0.572** | 0.600** | 0.568** | 0.650** | 0.573** | 0.158 | 0.304 | -0.036 | 0.557** |
| Moisture | 0.452** | 0.035 | -0.087 | 0.372** | 0.170 | 0.225 | 0.181 | 0.090 | -0.355* | 0.051 | -0.362* | 0.078 |
| Carbohydrates | 0.651** | 0.357** | 0.147 | 0.494** | 0.423* | 0.398* | 0.481** | 0.414* | -0.056 | 0.191 | -0.223 | 0.379* |
| Starch | 0.678** | 0.405* | 0.178 | 0.491** | 0.456** | 0.413* | 0.520** | 0.463** | -0.015 | 0.226 | -0.203 | 0.422* |
| Ash | 0.683** | 0.484** | 0.276 | 0.532** | 0.539** | 0.483** | 0.584** | 0.530** | 0.074 | 0.275 | -0.127 | 0.491** |
| P | 0.680** | 0.681** | 0.475** | 0.680** | 0.726** | 0.605** | 0.722** | 0.685** | 0.373* | 0.276 | 0.086 | 0.676** |
| Ca | 0.657** | 0.636** | 0.525** | 0.604** | 0.704** | 0.666** | 0.809** | 0.658** | 0.294 | 0.318 | 0.067 | 0.622** |
| Mg | 0.575** | 0.669** | 0.541** | 0.665** | 0.745** | 0.700** | 0.759** | 0.632** | 0.378* | 0.273 | 0.162 | 0.659** |
| Fe | 0.542** | 0.682** | 0.545** | 0.655** | 0.718** | 0.700** | 0.678** | 0.610** | 0.298 | 0.344* | 0.173 | 0.693** |

** Significant at 1 per cent level of significance * Significant at 5 per cent level of significance

**Table 3. Coefficients of correlation (r) between physical soil health parameters and maize quality traits**

| Quality traits | Physical soil health parameters | | |
|---|---|---|---|
| | Bulk Density | Porosity | Water Holding Capacity |
| Reducing sugar | -0.890** | 0.911** | 0.829** |
| Non-reducing sugar | -0.927** | 0.940** | 0.851** |
| Crude fat | 0.733** | 0.758** | 0.599** |
| Crude fibre | -0.756** | 0.778** | 0.628** |
| Crude protein | -0.826** | 0.847** | 0.718** |
| Moisture | -0.424* | 0.453** | 0.257 |
| Total Carbohydrates | -0.689** | 0.715** | 0.552** |
| Starch | -0.729** | 0.754** | 0.598** |
| Ash | -0.783** | 0.808** | 0.808** |
| P | -0.856** | 0.870** | 0.870** |
| Ca | -0.886** | 0.901** | 0.901** |
| Mg | -0.886** | 0.892** | 0.892** |
| Fe | -0.884** | 0.891** | 0.891** |

** Significant at 1 per cent level of significance * Significant at 5 per cent level of significance

**Table 4. Coefficients of correlation (r) between biological soil health parameters and maize quality**

| Quality traits | Biological soil health parameters | | |
|---|---|---|---|
| | MBC | MBN | DHA |
| Reducing sugar | 0.856** | 0.749** | 0.866** |
| Non-reducing sugar | 0.861** | 0.749** | 0.860** |
| Crude fat | 0.589** | 0.446** | 0.618** |
| Crude fibre | 0.618** | 0.469** | 0.642** |
| Crude protein | 0.731** | 0.607** | 0.741** |
| Moisture | 0.228 | 0.058 | 0.274 |
| Total Carbohydrates | 0.541** | 0.381* | 0.565** |
| Starch | 0.588** | 0.428* | 0.612** |
| Ash | 0.674** | 0.522** | 0.694** |
| P | 0.821** | 0.728** | 0.764** |
| Ca | 0.825** | 0.774** | 0.827** |
| Mg | 0.820** | 0.788** | 0.793** |
| Fe | 0.814** | 0.725** | 0.693** |

** Significant at 1 per cent level of significance * Significant at 5 per cent level of significance

## Conclusions

On the basis of findings of present study, it can be concluded that integration of organic manure and chemical fertilizers is essential to realize the higher productivity of maize crop. Moreover, application of lime with chemical fertilizers is equally effective in increasing the productivity of maize in acid soils. Imbalanced fertilization resulted in significant reduction in maize productivity. Therefore, it is necessary to apply nutrients in a balanced manner to check the degradation of soil health. It can further be inferred from the study that most of the soil health parameters had positive and significant relationship with nutritional parameters of maize. Thus, maintenance of soil health on sustainable basis is of utmost importance to enhance the productivity as well as quality of maize.


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