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Assessment of Different Production Systems for Macro and Micronutrient Concentration in Selected *kharif* Crops in Low Hills of Himachal Pradesh

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ABSTRACT

A field experiment was conducted to assess the effect of different crop production systems on major *kharif* crops at Choudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Hill Agriculture Research and Extension Center, Dhualakuan (Himachal Pradesh) India. The experiment comprised of fifteen treatments involving three crop production systems (organic, natural and conventional) in subplot with five crops (maize, okra, sesame, black gram and rice) in the main plot replicated thrice in split-plot design during *kharif* season (July-October) of 2020. Among different production systems, macronutrient contents were found highest under conventional system followed by organic system and lowest in Subhas Palekar Natural Farming system. Sulfur and micronutrient content was recorded highest in organic farming system followed by Subhas Palekar Natural Farming system and lowest in conventional system. Among crops, black gram and sesame grain macro and micro nutrient content was found to be highest and lowest in okra among all crops.

Keywords Conventional, Organic, SPNF, Nutrient content, Okra, Black gram.

INTRODUCTION

Food and nutritional security under changing climate and population explosion is the ultimate challenge ahead in agriculture. The world population is expected to surge from 7.6 billion in 2017 to 8.6 billion in 2030 and 9.8 billion by 2050 (United Nations 2016). Currently, 40% of pregnant women and 42% of children below 5 years of age are anaemic and 17% of the global population is at risk of inadequate Zn intakes (WHO 2021). The task of feeding this growing population with both sufficient food and nutritious is of critical importance. The cause for this is not entirely understood but it is thought to be due to a possible "dilution effect" caused by the increase in grain size and a change in the ratio of bran to endosperm

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in modern varieties (Murphy *et al.* 2008). With the advent of green revolution high yielding cereal crops were developed to feed the starving population that led to a reliance on low micronutrient staples in our diet (Welch and Graham 2004). In order to reduce malnutrition, it is imperative to supply crops with micronutrients in addition to the macronutrients required for plant growth. In the current scenario it is well established that there are methods like foliar spray and crop fortification either by agronomic or by crop improvement methods are effective in increasing nutrient content in our food. However, there are several roadblocks are ahead of its nutrient fixation and low nutrient use efficiency in being the major ones.

Mineral and nutrition accumulation in grain/fruit and straw is a very intricate mechanism that is highly influenced by nutrient management, nutrients fixing capacity of soil, varietal properties and environmental factors. Ensuring nutritional security, greater productivity with fewer resources and building the resilience of smallholder farmers are important in creating a food-secure future. Subhas Palekar natural farming system is one of the potential solutions in the present scenario. Our objective was to assess and comparison of different production systems in terms of grain macro and micronutrient content among variety of *kharif* crops.

MATERIALS AND METHODS

Study area and climate

A field study was conducted during 2020 *kharif* season at Hill Education Research and Extension (HAREC) Dhualakuan. Agro-climatically Dhualakuan falls under the sub-tropical sub humid low hill zone of Himachal Pradesh which is characterized by extreme summers and cool winters. The experimental site, Dhualakuan lies in district Sirmour of Himachal Pradesh about 26 kilometers away from district head quarter, Nahan situated on Ambala-Dehradun Road (NH- 7) located at 30° 4// N latitude and 77° 5// E longitude at an elevation of about 468 meters above mean sea level in North-Western Himalayas. The mean annual rainfall of Dhualakuan is 1480±319 mm. A major portion of the rainfall i.e., about 85% is received during monsoon period from June to September. The mean maximum temperature remains about 38 C during the hottest month of May to June. December to February were the coldest month with minimum temperature and about 2.5-4.5· C and maximum 19-21·C.

Experimental soil and crops

The soil of experimental site is classified *Typic ustipsamments*. The soil of the experimental site is sandy loam in texture with 60%, 25.5% and 14 % of sand, silt and clay, respectively. The soil was normal to slightly alkaline in reaction (pH 6.24) and Electrical conductivity was 352.2 µS m^{-1}. Initially, the soil (0–15 cm depth) was medium in soil organic carbon (SOC) (Walkley and Black easily oxidizable carbon) (6.00 g kg^{-1}), medium in available N (325 kg ha^{-1}), medium in available P (21 kg ha^{-1}) and medium in available K (148 kg ha^{-1}). The crop varieties for maize were Bajaura Makka, for Okra it was Palam Komal for sesame it was Pb Til 1, for black gram it was LTK-4 and for rice it was Kasturi. Crops nutrient requirement as per CSK HPKV Palampur HP has been presented in Table 1.

Analytical methods

The plant and grain samples collected at harvest of selected *kharif* crop were cleaned with double distilled water and tipped with butter paper and air dried first. Then samples were dried in oven at 65°C till constant weight was reached. These samples were powdered in grinder and used for determining concentration of N (micro-kjeldahl method by Jackson (1973), phosphorus by using Vanado-molybdate-phosphoric yellow color method by Jackson (1973), potassium with Di-acid (HNO_3–$HClO_4$) digestion and flame photometric method by Black *et al.* (1965). Sulfur

Table 1. Recommended doses on nutrients of various crops (kg ha^{-1}).

Crop	Nitrogen	Phosphorus	Potassium
Maize	120	60	40
Okra	75	50	50
Sesame	20	60	40
Black gram	20	40	20
Rice	90	40	40

content with Turbidimetric and spectrophotometric method as prescribed by Jackson (1973), micronutrient cations with Di- acid (HNO_3 – $HCLO_4$) digestion and atomic absorption spectrometric method given by Lindsay and Norvell (1978).

Statistical analysis

The treatment was applied in split plot design with crop production systems (3) in sub plot and *kharif* crops (5) in main plot. The treatments were replicated thrice. Their main and interaction effects have been presented in Tables. The data obtained during the investigation was statistically analyzed and the differences among the treatment means were tested for their significance ($p<0.05$) as per the standard statistical methods (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Nutrient concentration in grains

The results on nutrient concentrations in grains/ fruits (okra) of major *kharif* crops under the influence of different production systems have been presented in Tables 2–3.

Table 2. Effect of different production systems and crops on grain/fruit macronutrient (%) concentration. *C×S (1) = Main plot with same level as subplot, C×S (2) = Different or same level at subplot level.`

Treatments	N	P	K	S
Crop production system				
Organic	1.80	0.32	1.27	0.16
SPNF	1.73	0.31	1.03	0.15
Conventional	1.86	0.43	1.56	0.14
SEm (±)	0.05	0.01	0.00	0.01
LSD (0.05)	0.14	NS	NS	NS
Crops				
Maize	1.33	0.44	0.97	0.23
Okra	1.13	0.20	1.19	0.15
Sesame	2.56	0.47	0.88	0.25
Black gram	3.92	0.36	1.26	0.14
Rice	1.95	0.49	1.47	0.11
SEm (±)	0.09	0.01	0.04	0.01
LSD (0.05)	0.31	0.04	0.13	0.04
Interaction C*S (1)*	0.32	NS	NS	0.04
Interaction C*S (2)	0.40	NS	NS	0.05

Table 3. Effect of different production systems and crops on grain/fruit micronutrient concentrations (mg kg^{-1}). *C×S (1) = Main plot with same level as subplot, C×S (2) = Different or same level at subplot level.

Treatments	Zn	Mn	Cu	Fe
Crop production system				
Organic	29.12	28.15	3.38	56.99
SPNF	26.43	29.59	3.21	60.20
Conventional	24.04	20.26	1.89	44.98
SEm (±)	0.70	1.10	0.11	1.50
LSD (0.05)	2.15	3.16	0.33	4.76
Crops				
Maize	10.19	3.91	1.01	27.84
Okra	6.48	9.20	0.65	21.19
Sesame	56.41	75.22	5.41	104.06
Black gram	47.41	30.32	6.01	102.22
Rice	12.16	11.35	1.06	14.99
SEm (±)	1.40	1.80	0.15	3.10
LSD (0.05)	4.55	5.69	0.50	9.16
Interaction C*S (1)*	4.80	7.06	0.73	10.65
Interaction C*S (2)	6.00	8.09	0.78	12.60

The results on nutrient uptake by grain and straw of major *kharif* crops and their total uptake under the influence of different production systems have been presented in the Table 1.

Nitrogen content

The grain N content (Table 2) in crop production systems varied from the lowest of 1.73% in the SPNF system to the highest of 1.86% in the conventional system. The conventional system was found statistically superior to the natural farming system and the organic system was found to be statistically at par with the conventional system. Among *kharif* crops, it varied from 1.13% in okra to 3.92% in black gram crops.

Direct and indirect application of N fertilizer in conventional and organic systems gave better grain N content. The results were in agreement with those of (Ramesh *et al.* 2009, Santhy *et al.* 1998, Sood 2005).

Phosphorus content

Data pertaining to grain phosphorus content have been presented in Table 2. The grain P content varied from the lowest of 0.31% in SPNF to the highest of 0.43% in conventional systems. However, crop production systems could not significantly influence the grain/ fruit phosphorus content.

In crops, okra recorded the lowest fruit P content (0.20%) and highest in rice crop with 0.49% but results were non-significant. Direct application of phosphatic fertilizers and quicker mineralization led to greater uptake and greater content in seed. The good physical condition of soil due to FYM application leads to better root development, hence higher nutrient uptake (Kumar 2008). Slow but steady release of nutrients through organic manure and quick availability of nutrients from an inorganic source led to higher nutrient content in the inorganic treatments. Mishra *et al.* (2006) also reported greater P uptake by wheat crop in treatment where only FYM was applied. The results were also in agreement with the earlier reports of Sharma and Banik (2014) and Sharma *et al.* (2014).

Potassium content

The data pertaining to grain potassium content in crop production systems ranged from 1.03% in SPNF to 1.56% in conventional systems. Potassium content in the organic system was found to be 1.27%. Crop production systems were found to be non-significant in terms of K content.

In *kharif* crops, the sesame crop recorded the lowest K content (0.88%) and highest in rice crop (1.47%), which were again non-significant.

Direct application of potassic fertilizers and quicker mineralization led to greater uptake and greater content in seed (Kumar 2008).

Sulfur content

The data pertaining to grain sulfur content in crop production systems ranged from 0.14% in conventional to 0.16% in the organic system. The crop production system was found to be non-significant in terms of sulfur content. Among crops, the highest grain S content was recorded in sesame crop (0.25%) and lowest of 0.11% in rice crop. With the increasing application of high concentrations of non-S fertilizer and the decreasing application of organic fertilizer, crop S deficiency is becoming more frequent (Kost *et al.* 2008). The organic and natural farming system provides a steady amount of S content to the crops as compared to the conventional system where there was no such application of sulfur.

Zinc content

A perusal of the data showed a significant effect of different crop production systems and crops on Zn content. Grain zinc content in crop production systems varied from 24.04 mg kg^{-1} in conventional to 29.12 mg kg^{-1} in organic systems. The organic system was found statistically superior to SPNF and conventional systems, whereas the natural farming system with grain Mn content of 26.43 mg kg^{-1} was also statistically superior to the conventional system for grain Mn content.

Among *kharif* crops, Zn content varied from the lowest of 6.48 mg ha^{-1} in okra fruit to the highest of 56.41 mg kg^{-1} in sesame seeds. The results were in accordance with Ouda and Mahadeen (2008) in which they reported an increase in micronutrient content after the addition of organic nutrients.

Manganese content

A perusal of the data showed a significant effect of different crop production systems and crops on manganese content. Manganese content by grain/fruit in crop production systems varied from 20.26 mg kg^{-1} g ha^{-1} in conventional to 29.59 mg kg^{-1} in the SPNF system. The natural system was found statistically superior to the conventional system whereas the organic farming system with grain Mn content of 28.15 mg kg^{-1} was also statistically superior to the conventional system for grain Mn content.

Among *kharif* crops, Mn content varied from the lowest of 3.91 mg ha^{-1} in maize crop grains to the highest of 75.22 mg kg^{-1} in sesame seeds. The results were in compliance with reports of Mishra (2008).

Copper content

Grain copper content under different production systems varied from the lowest of 1.89 mg kg^{-1} in the conventional system to the highest of 3.38 mg kg^{-1} in the organic system. The natural production system with grain Cu content of 3.21 mg kg^{-1} was found statistically at par with the organic farming system.

Among *kharif* crops, the lowest grain Cu uptake was recorded in the okra crop (0.65 mg kg^{-1}) and the highest in black gram crop (6.01 mg kg^{-1}).

The greater micronutrients content in the organic system can be explained by the fact that essential input FYM + Vermicompost contributes these micronutrients from its own and it also solubilizes the native content of the micronutrients. The results complied with reports of Mishra *et al.* (2008).

Iron content

A perusal of data showed that different production systems impacted the grain Fe content significantly which varied from 44.98 mg kg^{-1} in the conventional system to 60.20 mg kg^{-1} in the SPNF system. The grain Fe content in the organic system (56.99 mg kg^{-1}) was also found significantly lower than that in the SPNF system.

Different *kharif* crops showed a significant variation in grain Fe content ranging from the highest value of 104.06 mg kg^{-1} in sesame to a minimum of 14.99 mg kg^{-1} in rice crop.

The effect of organic manure on Fe content could be due to the reason that organic carbon acts as a source of energy for soil microorganisms, which upon mineralization releases organic acids that decreased soil pH and improve the availability of Fe (Adediran *et al.* 2004, Bokhtiar and Sakurai 2005).

The organic treatment showed comparatively higher micronutrient content as compared to 100% NPK treatment, the conventional system as well as SPNF system. This could also be because organic systems can supply a sustainable dose of micronutrients in the soil system and that's why organic systems have a greater amount of uptake. It is possibly caused by other benefits of organic matter such as improvements in microbial activities, better supply of secondary and micronutrients which are not supplied by inorganic fertilizers, and lower losses of nutrients from the soil besides supply of N, P and K (Yadav *et al.* 2000, Singh *et al.* 2004).

CONCLUSION

Present investigation revels that among different production systems macronutrients i.e., NPK was recorded highest in conventional system with recommended dose of chemical fertilizers followed by organic system and lowest in SPNF system. Micronutrients and secondary elements were recorded higher under organic system which was followed by SPNF system and lowest in conventional system. Under *kharif* crop seed micronutrient contents were higher under black gram crop.

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