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Suraj Singh Patel
Research Scholar, Department of
Soil Science, Faculty of
Agriculture, Prof. Rajendra Singh
(Rajju Bhaiya) University, Naini,
Prayagraj, Uttar Pradesh, India

Tarun Kumar
Assistant Professor, Department of
Soil Science, Faculty of
Agriculture, Prof. Rajendra Singh
(Rajju Bhaiya) University, Naini,
Prayagraj, Uttar Pradesh, India

Ayush Pandey
Research Scholar, Department of
Soil Science, Faculty of
Agriculture, Prof. Rajendra Singh
(Rajju Bhaiya) University, Naini,
Prayagraj, Uttar Pradesh, India

Vimlesh Kumar
Research Scholar, Department of
Soil Science, Faculty of
Agriculture, Prof. Rajendra Singh
(Rajju Bhaiya) University, Naini,
Prayagraj, Uttar Pradesh, India

Shivam Gupta
Research Scholar, Department of
Soil Science, Faculty of
Agriculture, Prof. Rajendra Singh
(Rajju Bhaiya) University, Naini,
Prayagraj, Uttar Pradesh, India

Corresponding Author:
Tarun Kumar
Assistant Professor, Department of
Soil Science, Faculty of
Agriculture, Prof. Rajendra Singh
(Rajju Bhaiya) University, Naini,
Prayagraj, Uttar Pradesh, India

Influences of zinc and boron on physico-chemical properties of soil of lentil (*Lens culinaris* L.)

**Suraj Singh Patel, Tarun Kumar, Ayush Pandey, Vimlesh Kumar and
Shivam Gupta**

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Abstract

A field experiment was conducted under rainfed conditions at the farm of the department of soil science and agricultural chemistry at Prof. Rajendra Singh (Rajju Bhaiya) university Prayagraj, Uttar Pradesh, India, to assess the effects of nutrient management on the physiochemical characteristics of soil and lentil crops. It consists Nine treatment combination including various mixtures of inorganic fertilizers (Zinc, Boron and NPK) were used in the study with Randomized Block Design (RBD). These treatments combination used T₁ (Control), T₂ (NPK @ 50%), T₃ (NPK @ 100%), T₄ (Zinc@ 50%), T₅ (Zinc @ 100%), T₆ (Boron 50%), T₇ (Boron @ 100%), T₈ (NPK @ 50% + Zinc @ 50% + Boron @ 50%), T₉ (NPK @ 100% + Zinc @ 100% + Boron @ 100%). The result shows that application of different levels combination of Zinc, Boron and NPK increased growth and yield of Lentil crop. In this research the particle density of soil represented non-significance. It was observed that among the application of all treatment combinations T₉ shows the superiority in Pore Space (47.48%), Water holding capacity (49.25%) and Organic Carbon level of 0.39%. In terms of post-harvest nutrient availability, treatment T₉ recorded the maximum levels of Available Nitrogen (309.6 kg ha⁻¹), Available Phosphorus (20.26 kg ha⁻¹) and Available Potassium (216.1 kg ha⁻¹). Thus, concluded that integrated application of Zinc (Zn), Boron (B) and NPK (T₉) ensure optimal yield while maintaining and improving soil health, promoting environmental sustainability. in almost all the aspect in compare to T₁ (control).

Keywords: Lentil, Zn, B, NPK, soil health

Introduction

A nutrient-rich food legume, lentil (*Lens culinaris* Medic.), is a member of the Fabaceae family and is frequently referred to as an old crop in modern times. It is a grain legume with a high nutrient content that is grown in temperate climates. Its seed is a good source of fiber (4 g), ash (2.1 g), calcium (68 mg), phosphorus (325 mg), iron (7.0 mg), sodium (29 mg), potassium (780 mg), thiamine (0.46 mg), riboflavin (0.33 mg), and niacin (1.3 mg). It also has a relatively higher content of dietary protein (340–346 g). Among all the winter season legumes, lentil is the most abundant supply of vital amino acids (lysine, arginine, leucine, and other S-containing amino acids).

In recent years, the use of pulses, including lentils, is increasingly gaining recognition as ingredients in a variety of food product applications. This trend has aligned well with the heightened concerns about the environmental impact of producing and consuming meat. Recent trends show that consumers are reducing or foregoing meat consumption and shifting to nonmeat foods produced in a sustainable manner. Thus, environmental concern, coupled with a number of health issues stemming from meat consumption, has resulted in the ever-growing popularity of plant-based food products, which cater to many consumers far beyond the traditional vegan and vegetarian consumers. This article reviews the composition and nutrient profile of raw lentils and the effects that various cooking and processing methods have on compositional and nutrient profile of lentils (Hill *et al.*, 2022) ^[10].

The production of pods and seeds, as well as cell division, depends greatly on boron. Through seed treatment, foliar sprays, and soil fertilization, these micronutrients can be supplied to crops. Each technique has the potential to have an impact on the micronutrient nutrition of plants, both directly in the treated plant and in the offspring plants through nutrient enrichment of the parent

plant's seeds (Singh *et al.*, 2015) ^[21].

Micronutrients play an important role in increasing yield of pulses through their effect on the plant itself and on the nitrogen fixing by symbiotic process. Zinc is an essential trace element which is required in about 200 enzymes and transcription factors. Zn plays a major role in auxin metabolism, nitrogen metabolism, influence on the activities of enzymes (e.g. dehydrogenase and carbonic anhydrase, proteinases and peptidases) and cytochrome C synthesis, stabilization of ribosomal fractions and protection of cells against oxidative stress. Zn deficiency in field crops leads to poor growth interveinal chlorosis and necrosis of lower leaves. Plants emerged from seeds with low concentrations of Zn could be highly sensitive to biotic and abiotic stress (Mishra *et al* 2018) ^[13].

Lentil is the richest source of important amino acids (lysine, arginine, leucine, and other S- containing amino acids) among all the winter season legumes". Pulses contribute about 10% of the daily protein intake and 5% of energy intake and hence are of particular importance for food security in low-income countries. Globally, in 2017, pulses accounted for 85.40 million hectares of global crop area producing 87.40 million tonnes of grain with an average productivity of 1023 kg ha⁻¹. However, still the production of pulses is not keeping pace with a minimum requirement of 60 g of protein per day to human beings (Anonymous., 2018) ^[2]

Materials and Methods

The course of present investigation entitled "Influences of Zinc and Boron on Physico- Chemical Properties of Soil of Lentil (*Lens culinaris* L.)" comprise of a field experiment which was carried out at the Soil Science Research Farm, Prof. Rajendra Singh (Rajju Bhaiya) University Naini, Prayagraj during *Rabi* season 2025-26. The maximum temperature of the location ranges between 46°C – 48°C and seldom falls below 40°C-50°C. The relative humidity ranges between 20-94%. The average rainfall of this area is around 1100 mm annually. Soil samples were taken from 0-15 and 15-30 cm soil depth randomly prior to tillage operations, air dried and passed through 2 mm sieve. Then the composite soil sample was taken for mechanical and chemical analysis. Bouyoucos Hydrometer method (1927) was used for the mechanical analysis of soil to determine sand, silt and clay fraction in the sample. The experiment was laid out in a Randomised Block Design with nine treatments replicated thrice. T₁(Control), T₂(NPK @ 50%), T₃(NPK @ 100%), T₄(Zinc @ 50%), T₅(Zinc @ 100%), T₆(Boron 50%), T₇(Boron @ 100%), T₈(NPK @ 50% + Zinc @ 50% + Boron @ 50%), T₉(NPK @ 100% + Zinc @ 100% + Boron @ 100%).

Bulk density, Particle density, Pore space and Water holding capacity analyzed by Measuring cylinder method given by Muthuvel *et al.*, 1992 ^[14], Soil pH analyzed by Digital pH meter given by M. L. Jackson, 1958 ^[11]. Electrical conductivity analyzed by Digital conductivity meter given by Wilcox, 1950 ^[28], Organic carbon analyzed by Wet oxidation method given by Walkley and Black, 1947 ^[27], Available Nitrogen analyzed by Modified alkaline permanganate oxidation method given by Subbiah and Asija, 1956 ^[23], Available Phosphorus Analyzed by Olsen's extraction followed by Spectrophotometric method given by Olsen *et al.*, 1954 ^[16], Available Potassium analyzed by Neutral normal ammonium acetate extraction followed by Flame photometric method given by Toth and Prince, 1949 ^[26]. Available Zinc Analyzed by Tandon extraction followed by DTPA (Diethylenetriaminepentaacetic acid) extraction for micronutrients given Tandon and ICAR surveys., 1970s–1980s. Available Boron Analyzed by Sachan extraction followed by

DTPA (Diethylenetriaminepentaacetic acid) extraction for micronutrients given Sachan *et al.*, 2021–22, CSAUA&T Kanpur.

Results and Discussion

Bulk density (Mg m-3)

The data depicted in table 1 and fig. 1 shows the Bulk density (Mg m-3) of soil influenced by inorganic fertilizers. The maximum bulk density of soil was recorded 1.29 Mg m-3 at 0-15 cm and 1.27 Mg m-3 at 15-30 cm in treatment T₉ (NPK @ 100% + Zn @ 100% + B @ 100%) followed by 1.28 Mg m-3 at 0-15 cm and 1.26 Mg m-3 at 15-30 cm in treatment T₈ (NPK @ 50% + Zn @ 50% + B @ 50%) and minimum bulk density of soil was recorded 1.21 Mg m-3 at 0-15 cm and 1.19 Mg m-3 at 15-30 cm in treatment T₁ [control (NPK @ 0% + Zn @ 0% + B @ 0%)] respectively.

The mean value of bulk density of soil (Mg m-3) was found non-significant. It was also observed the bulk density of soil was gradually increased with an increase in dose of different levels of inorganic fertilizer. The effect of different levels of inorganic fertilizer and bio fertilizer on bulk density of soil was also found non-significantly. Because the presence of different levels of inorganic fertilizer in optimum amount increase bulk density of soil. It's containing higher amount of sand, silt and clay particle.

Particle density (Mg m-3)

The data depicted in table 1 and fig. 1 shows the particle density (Mg m-3) of soil influenced by inorganic fertilizers. The maximum particle density of soil was recorded 2.65 Mg m-3 at 0-15 cm and 1.63 Mg m-3 at 15-30 cm in treatment T₉ (NPK @ 100% + Zn @ 100% + B @ 100%) followed by 2.64 Mg m-3 at 0-15 cm and 2.62 Mg m-3 at 15-30 cm in treatment T₈ (NPK @ 50% + Zn @ 50% + B @ 50%) and minimum particle density of soil was recorded 2.55 Mg m-3 at 0-15 cm and 1.54 Mg m-3 at 15-30 cm in treatment T₁ [control (NPK @ 0% + Zn @ 0% + B @ 0%)] respectively.

The mean value of particle density of soil (Mg m-3) was found non-significant. It was also observed the bulk density of soil was gradually increased with an increase in dose of different levels of inorganic fertilizer, and organic manure. Similar result has been recorded by (Chanu *et al.*, 2020) ^[6].

Pore space (%)

The data depicted in table 1 and fig. 1 shows the Pore space (%) of soil influenced by inorganic fertilizers. The maximum pore space of soil was recorded 47.48% at 0-15 cm and 46.23% at 15-30 cm in treatment T₉ (NPK @ 100% + Zn @ 100% + B @ 100%) followed by 45.78% at 0-15 cm and 42.94% at 15-30 cm in treatment T₈ (NPK @ 50% + Zn @ 50% + B @ 50%) and minimum pore space of soil was recorded 38.52% at 0-15 cm and 37.47% at 15-30 cm in treatment T₁ [control (NPK @ 0% + Zn @ 0% + B @ 0%)] respectively.

The mean value of pore space of soil was found significant. It was also observed the bulk density of soil was gradually increased with an increase in dose of different levels of inorganic fertilizer. Similar result has been recorded by (Chanu *et al.*, 2020) ^[6].

Water holding capacity (%)

The data depicted in table 1 and fig. 1 shows the water holding capacity (%) of soil influenced by inorganic fertilizers. The maximum water holding capacity of soil was recorded 49.25% at 0-15 cm and 47.41% at 15-30 cm in treatment T₉ (NPK @ 100% + Zn @ 100% + B @ 100%) followed by 46.87% at 0-15 cm and 45.95% at 15-30 cm in treatment T₈ (NPK @ 50% + Zn @ 50% + B @ 50%) and minimum water holding capacity of soil was recorded 42.31% at 0-15 cm and 40.55% at 15-30 cm in treatment

T₁ [control (NPK @ 0% + Zn @ 0% + B @ 0%)] respectively. The mean value of water holding capacity (%) of soil was found significant. It was also observed the bulk density of soil was

gradually increased with an increase in dose of different levels of inorganic fertilizer, and organic manure. Similar result has been recorded by (Rani *et al.*, 2017 and Yadav *et al.*, 2018) ^[19, 29].

Table 1: Effect of organic and inorganic fertilizers on Bulk density (Mg m⁻³), Particle density (Mg m⁻³), Pore space (%) and Water holding capacity (%) of soil

Treatments		Bulk density (Mg m ⁻³)		Particle density (Mg m ⁻³)		Pore space (%)		Water holding capacity (%)	
		0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
T ₁	Control	1.21	1.19	2.55	2.54	38.52	37.47	42.31	40.55
T ₂	NPK @ 50%	1.25	1.21	2.57	2.55	40.21	39.36	44.60	44.56
T ₃	NPK @ 100%	1.24	1.20	2.56	2.52	41.64	40.93	42.77	44.30
T ₄	Zn @ 50%	1.25	1.23	2.59	2.57	44.37	42.89	45.95	45.31
T ₅	Zn @ 100%	1.27	1.24	2.60	2.58	43.63	42.15	39.55	40.23
T ₆	B @ 50%	1.23	1.25	2.63	2.60	45.74	44.19	41.40	43.05
T ₇	B @ 100%	1.22	1.26	2.61	2.59	47.48	47.99	42.10	42.71
T ₈	NPK @ 50% + Zn @ 50% + B @ 50%	1.28	1.26	2.64	2.62	45.78	42.94	46.87	45.95
T ₉	NPK @ 100% + Zn @ 100% + B @ 100%	1.29	1.27	2.65	2.63	47.48	46.23	49.25	47.41
F-Test		NS	NS	NS	NS	S	S	S	S
S. Ed. (±)		-	-	-	-	1.44	1.38	1.01	1.53
C.D. at 5%		-	-	-	-	3.08	2.93	2.15	3.26

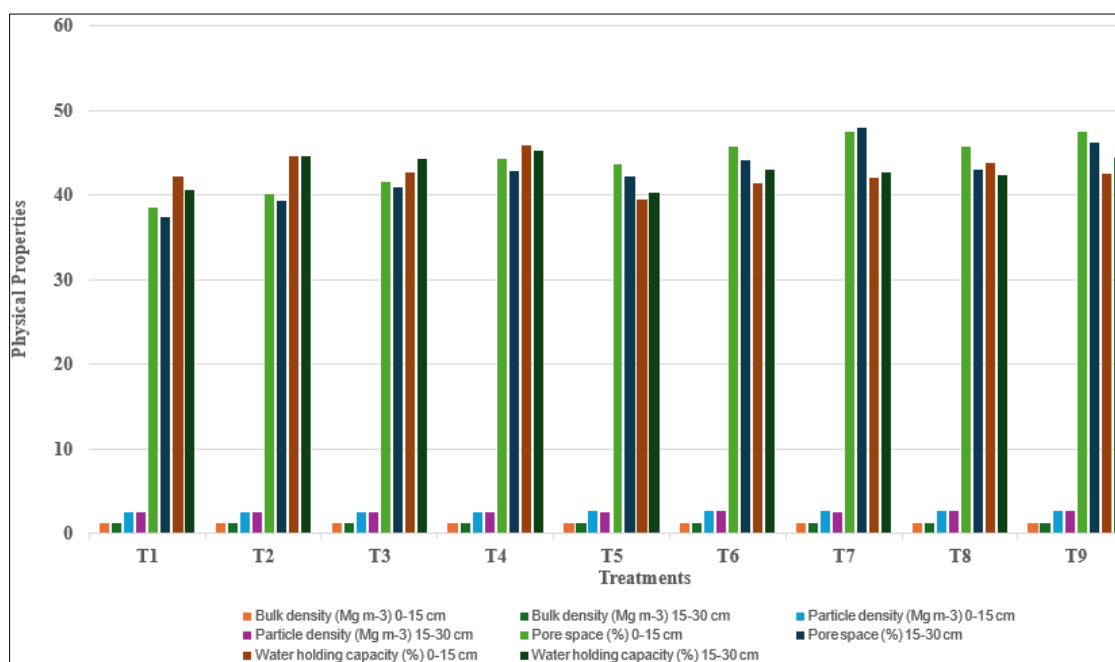


Fig 1: Effect of organic and inorganic fertilizers on Bulk density (Mg m⁻³), Particle density (Mg m⁻³), Pore space (%) and Water holding capacity (%) of soil.

Soil pH (1:2.5) w/v

The data depicted in table 2 and fig. 2 shows the pH of soil as influenced by inorganic fertilizers. The maximum pH of soil was recorded 7.62 at 0-15 cm and 7.66 at 15-30 cm in treatment T₉ (NPK @ 100% + Zn @ 100% + B @ 100%) followed 7.59 at 0-15 cm and 7.60 at 15-30 cm in treatment T₈ (NPK @ 50% + Zn @ 50% + B @ 50%) and minimum pH of soil was recorded 6.25 at 0-15 cm and 6.20 at 15-30 cm in treatment T₁ [control (NPK @ 0% + Zn @ 0% + B @ 0%)] respectively.

The mean value of pH of soil was found non-significant. Application of NPK, Zn and B one of the most important approaches on improving soil physical-chemical characters. These results indicated that the soil values of pH were increased by NPK, Zn and B. Similar result has been recorded by (Rani *et al.*, 2017 and Yadav *et al.*, 2018) ^[19, 29].

Soil EC (dSm-1)

The data depicted in table 2 and fig. 2 shows the soil EC of soil

as influenced by inorganic fertilizers. The maximum EC of soil was recorded 0.43 dSm⁻¹ at 0-15 cm and 0.40 dSm⁻¹ at 15-30 cm in treatment T₉ (NPK @ 100% + Zn @ 100% + B @ 100%) followed by 0.45 dSm⁻¹ at 0-15 cm and 0.41 dSm⁻¹ at 15-30 cm in treatment T₈ (NPK @ 50% + Zn @ 50% + B @ 50%) and minimum EC of soil was recorded 0.33 dSm⁻¹ at 0-15 cm and 0.30 dSm⁻¹ at 15-30 cm in treatment T₁ [control (NPK @ 0% + Zn @ 0% + B @ 0%)] respectively.

The mean value of EC (dSm⁻¹) of soil was found non-significant. Application of NPK, Zn and B one of the most important approaches on improving soil. It was also observed that EC of soil were gradually increased with increasing dose of NPK, Zn and B. Similar result has been recorded by (Das *et al.*, 2020 and Panday *et al.*, 2017) ^[8, 17].

Organic carbon (%)

The data depicted in table 2 and fig. 2 shows the organic carbon of soil as influenced by inorganic fertilizers. The maximum

organic carbon of soil was recorded 0.39% at 0-15 cm and 0.37% at 15-30 cm in treatment T₉ (NPK @ 100% + Zn @ 100% + B @ 100%) followed by 0.37% at 0-15 cm and 0.36% at 15-30 cm in treatment T₈ (NPK @ 50% + Zn @ 50% + B @ 50%) and minimum organic carbon of soil was recorded 0.23% at 0-15 cm and 0.21% at 15-30 cm in treatment T₁ [control (NPK @ 0% + Zn @ 0% + B @ 0%)] respectively.

The mean value of organic carbon (%) of soil was found non-

significant. Besides addition of inorganic fertilizers, the added inorganic sources to the treatment plot itself not influenced the soil root growth system, resulting in addition of greater root biomass and root exudates to the soil and also not observed that it might be due to build up effect of organic matter in surface soil, overall leads to ultimately not affect in soil organic carbon. Similar result has been recorded by (Gabr *et al.*, 2007 and Rani *et al.*, 2017)^[9, 19].

Table 2: Effect of organic and inorganic fertilizers on pH, EC (dSm-1), and Organic carbon (%) of soil.

		pH		EC (dSm-1)		Organic carbon (%)	
		0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
T ₁	Control (NPK @ 0% + Zn @ 0% + B @ 0%)	6.25	6.20	0.33	0.30	0.23	0.21
T ₂	NPK @ 50%	6.50	6.70	0.45	0.44	0.26	0.25
T ₃	NPK @ 100%	6.75	6.73	0.41	0.40	0.29	0.27
T ₄	Zn @ 50%	6.85	6.80	0.39	0.34	0.33	0.30
T ₅	Zn @ 100%	7.12	7.60	0.44	0.31	0.34	0.32
T ₆	B @ 50%	7.25	7.40	0.42	0.25	0.35	0.35
T ₇	B @ 100%	7.53	7.64	0.44	0.38	0.36	0.34
T ₈	NPK @ 50% + Zn @ 50% + B @ 50%	7.59	7.60	0.45	0.41	0.37	0.36
T ₉	NPK @ 100% + Zn @ 100% + B @ 100%	7.62	7.66	0.43	0.40	0.39	0.37
	F-Test	NS	NS	NS	NS	NS	NS
	S.Ed. (±)	-	-	-	-	-	-
	C.D. at 5%	-	-	-	-	-	-

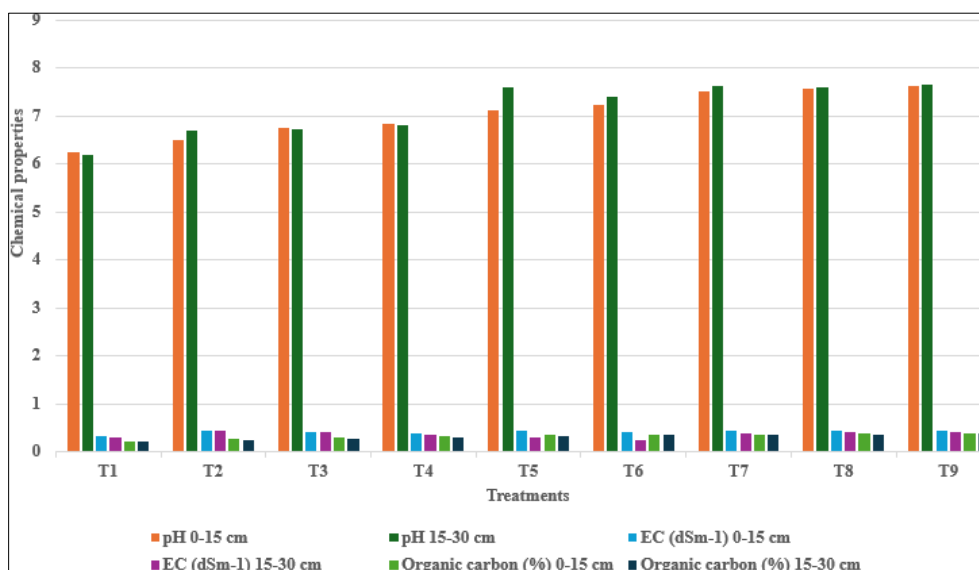


Fig 2: Effect of organic and inorganic fertilizers on pH, EC (dSm-1), and Organic carbon (%) of soil.

Available nitrogen (kg ha⁻¹)

The data depicted in table 3 and fig. 3 clearly shows the available nitrogen (kg ha⁻¹) of soil as influenced by organic and inorganic fertilizers. The maximum available nitrogen of soil was recorded 315.2 kg ha⁻¹ at 0-15 cm and 312.5 kg ha⁻¹ at 15-30 cm in treatment T₉ (NPK @ 100% + Zn @ 100% + B @ 100%) followed by 310.4 kg ha⁻¹ at 0-15 cm and 308.6 kg ha⁻¹ at 15-30 cm in treatment T₈ (NPK @ 50% + Zn @ 50% + B @ 50%) and minimum available nitrogen of soil was recorded 285.3 kg ha⁻¹ at 0-15 cm and 287.6 kg ha⁻¹ at 15-30 cm in treatment T₁ [control (NPK @ 0% + Zn @ 0% + B @ 0%)] respectively.

The mean value of available nitrogen (kg ha⁻¹) of soil was found significant. The nitrogen has its major significant role in completion of crop life cycle. Balanced use of nitrogen (N) fertilizers could play a pivotal role in increasing the yields. In addition to supplying a nutrient for plant growth, N application could enhance drought tolerance of plant to increase yield. Among the limiting factors, proper level and ratio of NPK are of

prime importance. Similar result has been recorded by (Toppo *et al.*, 2017 and Singh *et al.*, 2015)^[25, 22].

Available phosphorus (kg ha⁻¹)

The data depicted in table 3 and fig. 3 clearly shows the available phosphorus (kg ha⁻¹) of soil as influenced by organic and inorganic fertilizers. The maximum available phosphorus of soil was recorded 24.5 kg ha⁻¹ at 0-15 cm and 23.9 kg ha⁻¹ at 15-30 cm in treatment T₉ (NPK @ 100% + Zn @ 100% + B @ 100%) followed by 21.50 kg ha⁻¹ at 0-15 cm and 20.80 kg ha⁻¹ at 15-30 cm in treatment T₈ (NPK @ 50% + Zn @ 50% + B @ 50%) and minimum available phosphorus of soil was recorded 16.40 kg ha⁻¹ at 0-15 cm and 15.90 kg ha⁻¹ at 15-30 cm in treatment T₁ [control (NPK @ 0% + Zn @ 0% + B @ 0%)] respectively.

The mean value of available phosphorus (kg ha⁻¹) of soil was found significant. Similar result has been recorded by (Rajput, R. L. and Kushwah, S. S., 2005 and Bhat *et al.*, 2013)^[18, 4].

Available potassium (kg ha⁻¹)

The data depicted in table 3 and fig. 3 clearly shows the available potassium (kg ha⁻¹) of soil as influenced by organic and inorganic fertilizers. The maximum available potassium of soil was recorded 215.5 kg ha⁻¹ at 0-15 cm and 212.3 kg ha⁻¹ at 15-30 cm in treatment T₉ (NPK @ 100% + Zn @ 100% + B @ 100%) followed by 210.4 kg ha⁻¹ at 0-15 cm and 207.8 kg ha⁻¹ at 15-30 cm in treatment T₃ (NPK @ 100% + Zn @ 0% + B @ 0%) and minimum available potassium of soil was recorded 180.3 kg ha⁻¹ at 0-15 cm and 182.6 kg ha⁻¹ at 15-30 cm in treatment T₁ [control (NPK @ 0% + Zn @ 0% + B @ 0%)] respectively.

The mean value of available potassium (kg ha⁻¹) of soil was found significant. Similar result has been recorded by (Rajput, R. L. and Kushwah, S. S., 2005 and Bhat *et al.*, 2013) [18, 4].

Available Zinc (ppm)

The data depicted in table 3 and fig. 3 clearly shows the available Zinc (ppm) of soil as influenced by organic and inorganic fertilizers. The maximum available Zinc of soil was recorded 0.45 ppm at 0-15 cm and 0.42 ppm at 15-30 cm in treatment T₅ (NPK @ 0% + Zn @ 100% + B @ 0%) followed by 0.40 ppm at 0-15 cm and 0.38 ppm at 15-30 cm in treatment T₉ (NPK @ 100% + Zn

@ 100% + B @ 100%) and minimum available Zinc of soil was recorded 0.30 ppm at 0-15 cm and 0.28 ppm at 15-30 cm in treatment T₁ [control (NPK @ 0% + Zn @ 0% + B @ 0%)] respectively.

The mean value of available Zinc (ppm) of soil was found significant. Similar result has been recorded by (Tandon *et al.*, 1987) [24].

Available Boron (ppm)

The data depicted in table 3 and fig. 3 clearly shows the available Zinc (ppm) of soil as influenced by organic and inorganic fertilizers. The maximum available Boron of soil was recorded 1.20 ppm at 0-15 cm and 1.18 ppm at 15-30 cm in treatment T₇ (NPK @ 0% + Zn @ 0% + B @ 100%) followed by 1.15 ppm at 0-15 cm and 1.12 ppm at 15-30 cm in treatment T₉ (NPK @ 100% + Zn @ 100% + B @ 100%) and minimum available Boron of soil was recorded 0.70 ppm at 0-15 cm and 0.67 ppm at 15-30 cm in treatment T₁ [control (NPK @ 0% + Zn @ 0% + B @ 0%)] respectively.

The mean value of available Zinc (ppm) of soil was found significant. Similar result has been recorded by (Sachan *et al.*, 2022) [20].

Table 3: Effect of organic and inorganic fertilizers on Available Nitrogen, Phosphorus, Potassium, (kg ha⁻¹) Zinc and Boron

Treatments		Available nitrogen (kg ha ⁻¹)		Available phosphorus (kg ha ⁻¹)		Available potassium (kg ha ⁻¹)		Available Zinc (ppm)		Available Boron (ppm)	
		0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
T ₁	Control (NPK @ 0% + Zn @ 0% B @ 0%)	283.9	283.2	15.23	15.06	180.8	180.6	0.33	0.31	0.70	0.67
T ₂	NPK @ 50%	305.5	304.3	18.70	18.44	206.1	205.3	0.28	0.27	0.78	0.77
T ₃	NPK @ 100%	306.4	305.7	19.55	19.21	211.1	210.2	0.42	0.37	0.81	0.80
T ₄	Zn @ 50%	290.4	290.0	16.71	16.45	182.9	182.7	0.40	0.39	0.82	0.80
T ₅	Zn @ 100%	292.4	291.7	18.50	18.42	186.4	185.6	0.46	0.44	0.86	0.85
T ₆	B @ 50%	294.3	293.9	18.90	18.70	190.8	189.9	0.32	0.32	1.03	1.01
T ₇	B @ 100%	296.4	296.0	17.73	17.50	196.6	196.1	0.35	0.34	1.20	1.18
T ₈	NPK @ 50% + Zn @ 50% + B @ 50%	309.6	308.9	20.26	20.03	201.2	200.0	0.36	0.36	0.96	0.95
T ₉	NPK @ 100% + Zn @ 100% + B @ 100%	314.5	313.5	23.58	23.37	216.1	215.1	0.43	0.42	1.15	1.12
F-Test		S	S	S	S	S	S	S	S	S	S
S.Ed. (±)		0.215	0.567	0.243	0.240	0.155	0.500	0.004	0.016	0.011	0.012
C.D. at 5%		0.459	1.207	0.518	0.512	0.330	1.064	0.009	0.035	0.024	0.026

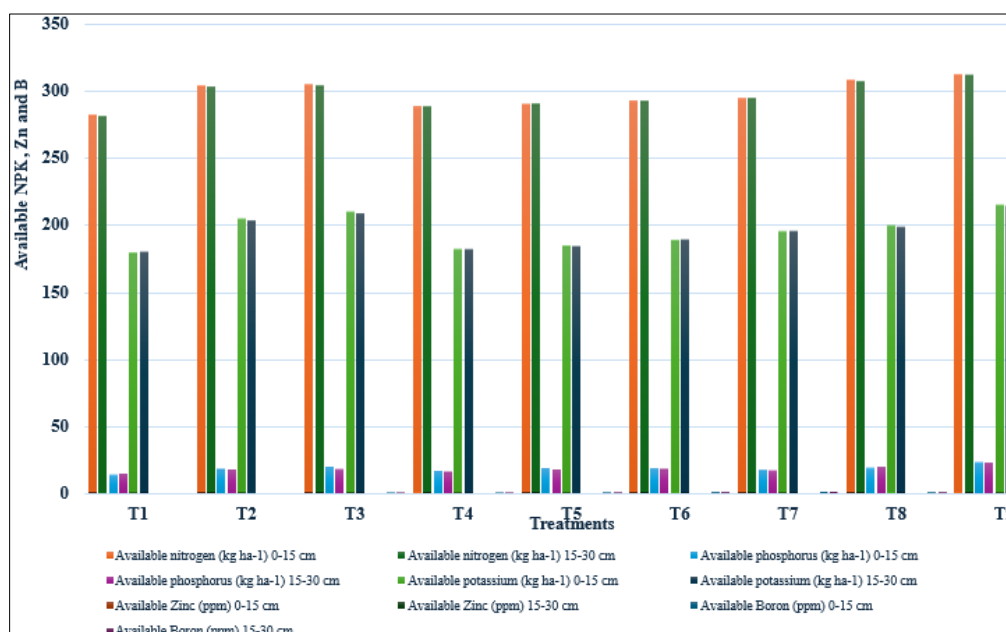


Fig 3: Effect of organic and inorganic fertilizers on Available Nitrogen, Phosphorus, Potassium, (kg ha⁻¹) Zinc and Boron (ppm)

Conclusion

On the basis of experimental study, it was concluded that integrated use of NPK fertilizers in combination with Zinc and Boron found better in respect to growth, yield and soil characters of Lentil crop. However, the treatment receiving chemical fertilizers with Zinc and Boron T₉ (NPK @ 100% + Zn @ 100% + B @ 100%) proved better in respect to, physical and chemical health of Lentil. The integrated use of chemical fertilizers with Zinc and Boron enhanced the soil fertility status in respect of Bulk density, Particle density, Pore space and Water holding capacity in the soil. The maximum improvement in soil health was noticed where Zinc, Boron was applied with chemical fertilizers. Therefore, the T₉ treatment proved better for production of Lentil crop and may be recommended to the farmers for better production and sustainable agriculture.

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