The Pharma Innovation Journal 2021; 10(10): 2356-2361

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(10): 2356-2361
© 2021 TPI
www.thepharmajournal.com
Received: 02-07-2021
Accepted: 13-09-2021

Adesh
M.Sc. Scholar, Department of agronomy, Acharya Narendra Deva. University of Agriculture & Technology, Ayodhya, Uttar Pradesh, India

RP Singh
Assistant Professor, Department of Agronomy, Acharya Narendra Deva University of Agriculture and Technology Kumarganj, Ayodhya, Uttar Pradesh, India

Srishti Singh
M.Sc. Scholar, Department of agronomy, Acharya Narendra Deva. University of Agriculture & Technology, Ayodhya, Uttar Pradesh, India

Ram Pratap Pal
M.Sc. Scholar, Department of agronomy, Acharya Narendra Deva. University of Agriculture & Technology, Ayodhya, Uttar Pradesh, India

Deepraj Verma
M.Sc. Scholar, Department of agronomy, Acharya Narendra Deva. University of Agriculture & Technology, Ayodhya, Uttar Pradesh, India

Corresponding Author:
RP Singh
Assistant Professor, Department of Agronomy, Acharya Narendra Deva University of Agriculture and Technology Kumarganj, Ayodhya, Uttar Pradesh, India

Effect of micronutrient application on growth, yield and quality of fodder maize (*Ziya maize* L.) and fodder sorghum (*Sorghum bicolor* L.)

Adesh, RP Singh, Srishti Singh, Ram Pratap Pal and Deepraj Verma

Abstract
The experiment was conducted at GBP Farm, Acharya Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Ayodhya, (U.P.) to study the bio-fortification with zinc sulphate and iron sulphate to enhancing micronutrient concentration in fodder maize & sorghum crops during the *Kharif* season of 2020. In factorial RBD with three replication; Keeping the present treatment was carried out with fourteen combination treatments *viz.*- Fodder maize + 0 kg $ZnSO_4$ ha^{-1} (T_1) and Fodder maize + 10 kg $ZnSO_4$ ha^{-1} as basal + 0.5% $ZnS0_4$ foliar spray at 45 DAS (T_2) and Fodder maize+ 10 kg $FeSO_4$ ha^{-1} as basal + 0.5% $FeSO_4$ foliar spray at 45 DAS(T_3) and Fodder maize +10 kg $ZnSO_4$ ha^{-1} +10 kg $FeSO_4$ ha^{-1} as basal + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ as foliar spray at 45 DAS (T_4) and Fodder maize + 20 kg $ZnSO_4$ ha^{-1} as basal + 0.5% $ZnS0_4$ foliar spray at 45 DAS (T_5) and Fodder maize + 20 kg $FeSO_4$ ha^{-1} as basal + 0.5% $FeSO_4$ foliar spray at 45 DAS (T_6) and Fodder maize + 20 kg $ZnSO_4$ ha^{-1} + 20 kg $FeSO_4$ ha^{-1} as basal +0.5% $ZnSO_4$ + 0.5% $FeSO_4$ as foliar spray at 45 DAS (T_7) fodder sorghum + 0 kg $ZnSO_4$ ha^{-1} (T_8) and fodder sorghum +10 kg $ZnSO_4$ ha^{-1} as basal + 0.5% $ZnS0_4$ foliar spray at 45 DAS (T_9) and fodder sorghum+ 10 kg $FeSO_4$ ha^{-1} as basal + 0.5% $FeSO_4$ foliar spray at 45 DAS (T_{10}) and fodder sorghum + 10 kg $ZnSO_4$ ha^{-1} +10 kg $FeSO_4$ ha^{-1} as basal + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ as foliar spray at 45 DAS(T_{11}) and fodder sorghum+ 20 kg $ZnSO_4$ ha^{-1} as basal + 0.5% $ZnS0_4$ foliar spray at 45 DAS (T_{12}) and fodder sorghum + 20 kg $FeSO_4$ ha^{-1} as basal + 0.5% $FeSO_4$ foliar spray at 45 DAS (T_{13}) and fodder sorghum + 20 kg $ZnSO_4$ ha^{-1} + 20 kg $FeSO_4$ ha^{-1} as basal +0.5% $ZnSO_4$ + 0.5% $FeSO_4$ as foliar spray at 45 DAS (T_{14}). The Treatment 20 kg $ZnSO_4$ ha^{-1} + 20 kg $FeSO_4$ ha^{-1} as basal +0.5% $ZnSO_4$ + 0.5% $FeSO_4$ as foliar spray at 45 DAS levels was found significant effect on growth of fodder maize and sorghum which was at par with 10 kg $ZnSO_4$ ha^{-1} + 10 kg $FeSO_4$ ha^{-1} as basal +0.5% $ZnSO_4$ + 0.5% $FeSO_4$ as foliar spray at 45 DAS (T_4) treatment the growth stages of the crop.

Keywords: Bio-fortification, fodder maize, sorghum, iron, zinc, LAI

Introduction
In impoverished nations, notably Asia and Africa, where cereals are staples, agronomic biofortification is the simplest and fastest technique to biofortify cereal grains with zinc, iron, or other micro mineral elements. It is the only way to reach the poorest of the impoverished rural populations, who cannot afford mineral supplements or animal by-products. From the agronomic biofortification viewpoint, foliar application is better and requires lesser amount of zinc and iron fertilizers than their soil application (Nissar *et al.,* 2019) [21]. Biofortification is the process that aims to increase the concentration of nutrients in edible portions of crop plants either through fertilization (agronomic biofortification) or plant breeding (genetic biofortification). Biofortification of sorghum by increasing mineral micronutrients (especially iron and zinc) in the grains provides a sustainable solution to iron and zinc deficiency (Pfeiffer and McClafferty, 2007) [24].

Agriculture plays a crucial role to provide bread and butter to more than half of the population of India despite its falling contribution to India's GDP **(**Sasmal, 2016) [25]. Among different enterprises under the giant umbrella of the agricultural production system; livestock is the most prominent one. According to the 19th livestock census; India has a livestock population of 512.06 million, which is the largest in the world (Anon., 2018) [1]. In India, the total area under cultivated fodder is 8.3, m ha, on individual crop basis *kharif* sorghum amongst covered the area 2.6 m ha with production of 92.30 m t and green fodder productivity 35.5 t ha^{-1} while, maize forage crops grown with their area 0.9 m ha with as production of 27.45 m t and green fodder productivity 30.5 t ha^{-1} (Pal, 2016) [22].

It appears is a terrific pressure of livestock on available total feed and fodder, as land available for fodder production has been decreasing. At present, the country faces a net deficit of 61.1% green fodder, 21.9% dry crop residues and 64% concentrate feed of forage and roughage is presented. To face the current level of livestock production and its annual growth in population, the deficit in all components of fodder, dry crop residues and feed has to be met from either increasing productivity, utilizing total feed resources, increasing land area (not possible due to human pressure for food crops) or through the adoption of some innovative strategies. On the dry weight basis, average nutritional content in fodder maize is 20.5-24.7% dry matter (DM), 5.5-8.7% crude protein (CP), 23.1-30.2% crude fibre (CF), 64. 1-72.8% neutral detergent fibre (NDF), 38.3-46.8% acid detergent fibre (ADF) and 6.0-8.0% ash (Chaudhary *et al.*, 2012) [7]. Maize (*Zea maize L.*) is one of the most prominent forage crops not only in India but throughout the world owing to its higher growth rate and yield, wider adaptability, higher digestibility, more palatability and lack of any potential anti-nutritional factor (Hedayetullah and Zaman, 2018) [11].

Sorghum (*Sorghum bicolor* L.) is a member of the grass family (Poaceae). It is a tall annual plant with an adventitious root system. It is drought and heat resistant fodder crop with fairly high biomass (Iqbal & Iqbal, 2015) [12]. Sorghum (*Sorghum bicolor* L.) is the major staple food for millions of rural poor in arid and semi-arid regions of the world. Fodder maize and sorghum are the major plants species that are cultivated and harvested for feeding the animals in the form of forage (cut green and fed fresh), silage (preserved under anaerobic condition) and hey (dehydrated green fodder). In India, Maharashtra and Karnataka are the major sorghum producing and consuming states. The per capita consumption of the sorghum is 75 kg grain per year in major sorghum areas in India (Kumar *et al.* 2013) [15]. The area under *kharif* sorghum is less as compared to *rabi* sorghum. *Rabi* sorghum is the major dry land crop currently grown over an area of 3.89 m ha with a production of 3.14 mt and productivity of 808 kg per hectar (Anon., 2014) [2]. Sorghum, an ancient cereal grain that is a major crop in India and Africa, has long been known as a gluten-free grain option for celiac disease and gluten sensitivity sufferers. New molecular evidence confirms that sorghum is completely gluten-free and reports that the grain provides health benefits that make it a worthy addition to any diet. Sorghum is abundant in unsaturated lipids, protein, fibre, and minerals including phosphorus, potassium, calcium, and iron, and has a high nutritional value. Further more, it has more antioxidants than blueberries and pomegranates. According to recent research, sorghum use reduces the incidence of colon and skin cancer more than other grains due to phytochemicals, and other characteristics can enhance cardiovascular health and lower cholesterol. Sorghum is the fifth most produced grain in the world, behind wheat, corn, rice and barley. Because it is drought-resistant, thrives in arid regions, and requires less water than wheat, the grain is considered inexpensive and simple to farm (Siddique, 2013) [27].

Iron is one of the micronutrients for normal plant growth. Though Fe is the fourth most abundant element in the earth crust, it is the third most limiting nutrient for plant growth (Zuo and Zhang, 2011) [31]. In plants, Fe is involved in a variety of essential chemicals and physiological processes. It is necessary for the action of ALA synthase, which catalyses the first known step in the tetrapyrrole role biosynthesis route leading to chlorophyll production, and hence is responsible for much of the green colour of growing plants. Iron plays an important role in electron transfer in photosynthesis, respiration, nitrogen fixation as well as in DNA synthesis. Khurana *et al.* (2002) [14]. Iron deficiency is a frequent nutritional disease that causes chlorosis, low yield, and a loss in nutritional quality in many agricultural plants (Zhang *et al.* 2008) [30].

Zinc is an essential micronutrient for various functions in plant's life cycle (Hafeez *et al.*, 2013) [10]. Zn as a metal, acts as co-factor in all six classes of enzymes (e. g. oxidoreductase, transferases, hydrolases, lyases, isomerases and ligases) (Tapiero and Tew, 2003) [28]. Zn regulates auxin synthesis, pollen formation, gene expression and antioxidant's production with in plant tissues (Luo *et al.* 2010) [16]. Zn deficiency decreases photosynthetic rate, produces small chlorotic leaves and induces sterility of spikes in wheat. The overall output decreases and fungal infection increases with Zn deficiency (Cakmak *et al.*, 2000) [6]. Zn nutrition regulates water uptake and transport, decreases the adverse effect of heat and salt stress (Peck *et al.*, 2010) [23], regulates the tryptophan production which is precursor of indole acetic acid (IAA) (Alloway *et al.*, 2004; Brennan *et al.*, 2005) [3, 5].

Materials and Method

The experiment was conducted during *kharif* season 2020 at Genetics and Plant Breeding Farm, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U. P.), situated at of 26° 47' North latitude and of 82° 12' East longitude, with an altitude of 113 meters above the mean sea level. The experimental site is situated in main campus of university on east of Ayodhya – Raibareilly road at the distance of 42 km Ayodhya district headquarter. The total rainfall of 853.8 mm was received during crop growing season of 2020. The soil of the experimental field was silty loam in texture having slightly alkaline in reaction (pH 8.7), low in organic carbon (0.25%) and available nitrogen (180.80 kg ha^{-1}), but medium in available phosphorus (16.20 kg ha^{-1}) and potassium (256.10 kg ha^{-1}) during crop season. The total rainfall experienced during the crop growth season was 853.10 mm in 2020. Tested variety of fodder crops used in this experiment were (Maize) African Tall & (Sorghum) SSV 74 respectively. During the *kharif* season, an experiment was laid out in factorial randomized block design (FRBD) with fourteen treatment combination and replicated three time *viz*., Fodder maize + 0 kg $ZnSO_4$ ha^{-1} (T_1) and Fodder maize + 10 kg $ZnSO_4$ ha^{-1} as basal + 0.5% ZnS0₄ foliar spray at 45 DAS (T_2) and Fodder maize+ 10 kg $FeSO_4$ ha^{-1} as basal + 0.5% $FeSO_4$ foliar spray at 45 DAS(T_3) and Fodder maize +10 kg $ZnSO_4$ ha^{-1} +10 kg $FeSO_4$ ha^{-1} as basal + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ as foliar spray at 45 DAS (T_4) and Fodder maize + 20 kg $ZnSO_4$ ha^{-1} as basal + 0.5% $ZnS0_4$ foliar spray at 45 DAS (T_5) and Fodder maize + 20 kg $FeSO_4$ ha^{-1} as basal + 0.5% $FeSO_4$ foliar spray at 45 DAS (T_6) and Fodder maize + 20 kg $ZnSO_4$ ha^{-1} + 20 kg $FeSO_4$ ha^{-1} as basal +0.5% $ZnSO_4$ + 0.5% $FeSO_4$ as foliar spray at 45 DAS (T_7) sorghum + 0 kg $ZnSO_4$ ha^{-1} (T_8) and sorghum +10 kg $ZnSO_4$ ha^{-1} as basal + 0.5% $ZnS0_4$ foliar spray at 45 DAS (T_9) and sorghum+ 10 kg $FeSO_4$ ha^{-1} as basal + 0.5% $FeSO_4$ foliar spray at 45 DAS (T_{10}) and sorghum + 10 kg $ZnSO_4$ ha^{-1} +10 kg $FeSO_4$ ha^{-1} as basal + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ as foliar spray at 45 DAS(T_{11}) and sorghum+ 20 kg $ZnSO_4$ ha^{-1} as basal + 0.5% $ZnS0_4$ foliar spray at 45 DAS (T_{12}) and sorghum + 20 kg $FeSO_4$ ha^{-1} as basal + 0.5% $FeSO_4$ foliar spray at 45 DAS (T_{13}) and sorghum + 20 kg $ZnSO_4$ ha^{-1} + 20 kg $FeSO_4$ ha^{-1} as basal +0.5% $ZnSO_4$

+ 0.5% $FeSO_4$ as foliar spray at 45 DAS (T_{14}). All growth, yield and quality characters were recorded with standard procedures. The data relating to each character were analyzed as per the procedure of analysis of variance and significance was tested by "F" test (Gomez and Gomez 1984) [9].

Result and Discussion

Growth parameter

Table 1: Effect of zinc sulphate and ferrous sulphate on initial plant population & plant height of fodder maize and sorghum crops

Treatments	Initial plant population (per meter row length)	Plant height (cm)	
		30 days after sowing	60 days after sowing
Factor A.- Cereal fodder			
(C_1) Maize (var. African tall)	6.84	42.90	121.64
(C_2) Sorghum (Var. SSV-74)	7.13	44.61	131.86
SEM±	0.11	0.807	1.649
CD at 5%	NS	NS	4.795
Factor B.- zinc ($ZnSo_4$) & iron ($FeSo_4$)			
(T_1)0 kg $ZnSO_4$ per hectare	7.0	41.50	121.05
(T_2)10 kg $ZnSO_4$ per hectare as basal + 0.5% $ZnS0_4$ foliar spray at 45 DAS	6.50	43.45	126.28
(T_3)10 kg $FeSO_4$ per hectare as basal + 0.5% $FeSO_4$ foliar spray at 45 DAS	7.10	42.85	125.03
(T_4)10 kg $ZnSO_4$ per hectare +10 kg $FeSO_4$ per hectare as basal + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ as foliar spray at 45 DAS	7.00	44.10	128.53
(T_5)20 kg $ZnSO_4$ per hectare as basal + 0.5% $ZnS0_4$ foliar spray at 45 DAS	7.35	43.85	127.67
(T_6)20 kg $FeSO_4$ per hectare as basal + 0.5% $FeSO_4$ foliar spray at 45 DAS	7.00	44.65	127.79
(T_7)20 kg $ZnSO_4$ per hectare + 20 kg $FeSO_4$ per hectare as basal +0.5% $ZnSO_4$ + 0.5% $FeSO_4$ as foliar spray at 45 DAS	6.95	45.90	130.90
SEM±	0.20	1.510	3.086
CD at 5%	NS	NS	NS

Effect of zinc sulphate and ferrous sulphate on initial plant population & plant height of fodder maize and sorghum crops

The initial plant population per meter row length on fodder maize and sorghum perusal of data presented in Table 1. Cereal fodders maize and sorghum have non- significant effect on plant population. Similarly, application of level zinc sulphate and ferrous sulphate also has non-significant effect on initial plant population. The data of plant height on fodder maize and sorghum recorded at 30, 60, DAS of crop growth have been presented in Table 1. Clearly reveal that the plant height increase consistently from 30 DAS stage to 60 DAS stage under different nutrient ($ZnSO_4$& $FeSO_4$) treatments. Different between plant height of fodder maize and sorghum were found non-significant at 30 DAS while at 60 DAS was found significant. Sorghum has more plant height over fodder maize. Application of zinc sulphate & iron sulphate levels also had non-significant effect on plant height of both the cereal fodder at all stages.

Effect of zinc sulphate and ferrous sulphate on number of leaves & leaf area index of fodder maize and sorghum crops

Data pertaining to number of leaves on fodder maize and sorghum presented in Table 2. Number of leaves of cereal fodder was found significant at all stages of crop growth. Fodder Sorghum have a more number of leaves over fodder Maize. Similarly, application of zinc sulphate & iron sulphate levels on number leaves 30 and 60 DAS stage was found to be significant. More number of leaves recorded under 20 kg $ZnSO_4$ per hectare + 20 kg $FeSO_4$ per hectare as basal +0.5% $ZnSO_4$ + 0.5% $FeSO_4$ as foliar spray at 45 DAS (T_7) produces more number of leaves over all Zinc sulphate and ferrous sulphate levels which at par 20kg $FeSO_4$ per hectare as basal + 0.5% $FeSO_4$ foliar spray at 45 days after sowing(T_6) while significantly superior over 0 kg $ZnSO_4$ per hectare (T_1), 10 kg $ZnSO_4$ per hectare as basal + 0.5% $ZnS0_4$ foliar spray at 45 DAS(T_2), 10 kg $FeSO_4$ per hectare as basal + 0.5% $FeSO_4$ foliar spray at 45 DAS(T_3), 10 kg $ZnSO_4$ per hectare +10 kg $FeSO_4$ per hectare as basal + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ as foliar spray at 45 DAS(T_4), and 20 kg $ZnSO_4$ per hectare as basal + 0.5% $ZnS0_4$ foliar spray at 45 DAS(T_5). Similar trend was recorded at 60 DAS stage. Similar results have also been reported by Fageria, (2001) [8]. Leaf area index recorded at 30 and 60 DAS of fodder maize and sorghum have been presented in Table 2. Leaf area Index was found significant at all stages of crop growth. Fodder sorghum have more leaf area index over fodder maize. At 30 DAS different zinc sulphate & ferrous sulphate levels were found non-significantly affecting the leaf area index at earlier stage but in later growth stage, its impact was significantly. Among Zinc sulphate & ferrous sulphate level 20 kg $ZnSO_4$ per hectare + 20 kg $FeSO_4$ per hectare as basal +0.5% $ZnSO_4$ + 0.5% $FeSO_4$ as foliar spray at 45 were significant more leaf area index over all stage which was at par with 20 kg $FeSO_4$ per hectare as basal + 0.5% $FeSO_4$ foliar spray at 45 DAS (T_6) and significantly higher than rest of treatment. Similar result found Verma *et.at* (2005) [29]. That leaf area index 7.2 to 7.8 with the application 0f 5 kg per hectare zinc compared to that of control (no zinc) from an experiment conducted on silt clay loam soils of Pant Nagar, Uttaranchal in fodder sorghum. Similar result found Mahdi *et al.* (2012) [17] reported a significant increase in leaf area of fodder maize with 10 kg per hectare basal application of zinc over no zinc in an experiment conducted on silt loam of Srinagar, Jammu and Kashmir.

Table 2: Effect of zinc sulphate and ferrous sulphate on number of leaves & leaf area index of fodder maize and sorghum crops

Treatments	Number of leaves		Leaf area index (LAI)		
	30 DAS	60 DAS	30 DAS	60 DAS	At harvest
Factor A.- Cereal fodder					
(C_1) Maize (var. African tall)	3.99	15.14	0.87	2.39	2.53
(C_2) Sorghum (Var. SSV-74)	4.20	15.96	0.94	2.52	2.67
SEM±	0.073	0.249	0.008	0.024	0.044
CD at 5%	0.211	0.723	0.024	0.071	0.129
Factor B.- zinc ($ZnSo_4$) & iron ($FeSo_4$)					
(T_1)0 kg $ZnSO_4$ per hectare	3.40	12.90	0.87	2.03	2.15
(T_2)10 kg $ZnSO_4$ per hectare as basal + 0.5% $ZnS0_4$ foliar spray at 45 DAS	3.90	14.85	0.91	2.34	2.48
(T_3)10 kg $FeSO_4$ per hectare as basal + 0.5% $FeSO_4$ foliar spray at 45 DAS	3.60	13.65	0.90	2.15	2.28
(T_4)10 kg $ZnSO_4$ per hectare +10 kg $FeSO_4$ per hectare as basal + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ as foliar spray at 45 DAS	4.20	15.95	0.92	2.51	2.85
(T_5)20 kg $ZnSO_4$ per hectare as basal + 0.5% $ZnS0_4$ foliar spray at 45 DAS	4.10	15.60	0.91	2.46	2.61
(T_6)20 kg $FeSO_4$ per hectare as basal + 0.5% $FeSO_4$ foliar spray at 45 DAS	4.50	17.10	0.91	2.69	2.66
(T_7)20 kg $ZnSO_4$ per hectare + 20 kg $FeSO_4$ per hectare as basal +0.5% $ZnSO_4$ + 0.5% $FeSO_4$ as foliar spray at 45 DAS	4.95	18.80	0.94	2.96	3.14
SEM±	0.136	0.465	0.015	0.045	0.083
CD at 5%	0.395	1.353	NS	0.132	0.242

Table 3: Effect of zinc sulphate and ferrous sulphate on yield and quality of fodder maize and sorghum crops

Treatments	Green fodder yield (qha^{-1})	Dry fodder yield (qha^{-1})	Crude protein yield ($q\ ha^{-1}$)	Protein content (%)	Crude fiber (%)
Factor A.- Cereal fodder					
(C_1) Maize (var. African tall)	477.26	117.04	6.95	8.14	62.17
(C_2) Sorghum (Var. SSV-74)	554.90	151.41	7.55	11.45	50.39
SEM±	9.256	1.572	0.094	0.178	0.517
CD at 5%	26.907	4.569	0.274	0.517	1.504
Factor B.- zinc ($ZnSo_4$) & iron ($FeSo_4$)					
(T_1)0 kg $ZnSO_4$ per hectare	467.65	121.90	7.01	8.59	52.43
(T_2)10 kg $ZnSO_4$ per hectare as basal + 0.5% $ZnS0_4$ foliar spray at 45 DAS	511.31	132.95	7.27	9.72	57.16
(T_3)10 kg $FeSO_4$ per hectare as basal + 0.5% $FeSO_4$ foliar spray at 45 DAS	485.7	125.35	7.08	8.92	54.05
(T_4)10 kg $ZnSO_4$ per hectare +10 kg $FeSO_4$ per hectare as basal + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ as foliar spray at 45 DAS	544.60	141.80	7.39	10.53	57.95
(T_5)20 kg $ZnSO_4$ per hectare as basal + 0.5% $ZnSO_4$ foliar spray at 45 DAS	529.30	137.90	7.40	10.27	58.33
(T_6)20 kg $FeSO_4$ per hectare as basal + 0.5% $FeSO_4$ foliar spray at 45 DAS	519.20	135.20	7.14	6.69	55.17
(T_7)20 kg $ZnSO_4$ per hectare + 20 kg $FeSO_4$ per hectare as basal +0.5% $ZnSO_4$ + 0.5% $FeSO_4$ as foliar spray at 45 DAS	554.80	144.50	7.47	10.85	58.89
SEM±	17.316	2.941	0.177	0.333	0.968
CD at 5%	50.338	8.548	NS	0.967	2.813

Yield and Quality parameter

Effect of zinc sulphate and ferrous sulphate on yield and quality of fodder maize and sorghum crops: Green fodder yield (qh^{-1}) and Dry fodder yield ($q\ h^{-1}$) on fodder maize and sorghum presented in Table-3. Green fodder yield and Dry fodder yield of fodder maize was found significant over sorghum. Highest green fodder yield was recorded fodder sorghum (554.90 q ha^{-1}) over the fodder maize (477.26 q ha^{-1}) with 20 kg $ZnSO_4$ ha^{-1} + 20 kg $FeSO_4$ ha^{-1} as basal +0.5% $ZnSO_4$ + 0.5% $FeSO_4$ as foliar spray at 45 DAS (T_7) produces significant more green fodder yield over 0 kg $ZnSO_4$ ha^{-1} (T_1) and 10 kg $FeSO_4$ ha^{-1} as basal + 0.5% $FeSO_4$ foliar spray at 45 DAS(T_3), while at par with all rest levels of $ZnSO_4$ and $FeSO_4$ treatments. 10 kg $ZnSO_4$ ha^{-1} +10 kg $FeSO_4$ ha^{-1} as basal + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ as foliar spray at 45 DAS (T_4), 20 kg $ZnSO_4$ ha^{-1} as basal + 0.5% $ZnS0_4$ foliar spray at 45 DAS (T_5), 20 kg $FeSO_4$ ha^{-1} as basal + 0.5% $FeSO_4$ foliar spray at 45 DAS (T_6) and 10 kg $ZnSO_4$ ha^{-1} as basal + 0.5% $ZnS0_4$ foliar spray at 45 DAS (T_2). Highest dry fodder yield q ha^{-1} was recorded fodder sorghum (151.41 q ha^{-1}) over the fodder maize (117.04 q ha^{-1}) with 20 kg $ZnSO_4$ ha^{-1} + 20 kg $FeSO_4$ ha^{-1} as basal +0.5% $ZnSO_4$ + 0.5% $FeSO_4$ as foliar spray at 45 DAS (T_7) produces significant more dry fodder yield over with 0 kg $ZnSO_4$ ha^{-1} (T_1), 10 kg $ZnSO_4$ ha^{-1} as basal + 0.5% $ZnS0_4$ foliar spray at 45 DAS (T_2), 10 kg $FeSO_4$ ha^{-1} as basal + 0.5% $FeSO_4$ foliar spray at 45 DAS (T_3) and 20 kg $FeSO_4$ ha^{-1} as basal + 0.5% $FeSO_4$ foliar spray at 45 DAS(T_6) while at par with all rest $ZnSO_4$ and $FeSO_4$ treatments. 10 kg $ZnSO_4$ ha^{-1} +10 kg $FeSO_4$ ha^{-1} as basal + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ as foliar spray at 45 DAS (T_4) and 20 kg $ZnSO_4$ ha^{-1} as basal + 0.5% $ZnS0_4$ foliar spray at 45 DAS (T_5) which at par with 20 kg $ZnSO_4$ ha^{-1} + 20 kg $FeSO_4$ ha^{-1} as basal + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ as foliar spray at 45 DAS (T_7). Similar results have also been reported by Meena (2010) [18] and meena (2013) [19]. Crude protein yield (q ha^{-1}), Protein content (%) and crude fiber (%) on cereal fodder maize and sorghum presented in Table 3. Data pertaining to Sorghum was significant more crude protein yield with fodder maize. 20 kg $ZnSO_4$ per hectare + 20 kg $FeSO_4$ per hectare as basal +0.5% $ZnSO_4$ + 0.5% $FeSO_4$ as foliar spray at 45 DAS(T_7) produced significant more crude protein yield 0 kg $ZnSO_4$ per hectare (T_1), 10 kg $ZnSO_4$ per hectare as basal + 0.5% $ZnS0_4$ foliar spray at 45 DAS(T_2), 10 kg $FeSO_4$ per hectare as basal + 0.5% $FeSO_4$ foliar spray at 45 DAS(T_3), 20 kg $FeSO_4$ per hectare as basal + 0.5% $FeSO_4$ foliar spray at 45 days after sowing(T_6) while at par with. 10 kg $ZnSO_4$ per hectare +10 kg $FeSO_4$ per hectare as basal + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ as foliar spray at 45 DAS(T_4) and 20 kg $ZnSO_4$ per hectare as basal + 0.5% $ZnS0_4$ foliar spray at 45 DAS(T_5). Similar result was also been reported by Naik *et al. (*2007*)* [20] and Joshi *et al.* (2007) [13]. Fodder sorghum and maize were found significant. Sorghum takes more protein content (%) over fodder maize. Similarly, application of zinc sulphate and ferrous sulphate have non-significant impact on protein content % of cereal fodder crops. Crude fiber on cereal fodder maize and sorghum presented in Table 3. Fodder sorghum was significant more Crude fiber content (%) with fodder maize. Similarly, application of zinc sulphate and ferrous sulphate levels 20 kg $ZnSO_4$ per hectare + 20 kg $FeSO_4$ per hectare as basal +0.5% $ZnSO_4$ + 0.5% $FeSO_4$ as foliar spray at 45 DAS produced significant more crude fiber **(**%)0 kg $ZnSO_4$ per hectare (T_1), 10 kg $ZnSO_4$ per hectare as basal + 0.5% $ZnS0_4$ foliar spray at 45 DAS(T_2), 10 kg $FeSO_4$ per hectare as basal + 0.5% $FeSO_4$ foliar spray at 45 DAS(T_3), 20 kg $FeSO_4$ per hectare as basal + 0.5% $FeSO_4$ foliar spray at 45 days after sowing(T_6) while at par with. 10 kg $ZnSO_4$ per hectare +10 kg $FeSO_4$ per hectare as basal + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ as foliar spray at 45 DAS(T_4) and 20 kg $ZnSO_4$ per hectare as basal + 0.5% $ZnS0_4$ foliar spray at 45 DAS(T_5). Similar result was also have been reported by bhoya *et al.* (2013) [4] and shanthi *et al.* (2012) [26].

Conclusion

Above overall study, it is recommended that application of zinc sulphate and ferrous sulphate significantly influenced the growth, quality parameters, green fodder yield and the best treatment 10 kg $ZnSO_4$ per hectare +10 kg $FeSO_4$ per hectare as basal + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ as foliar spray at 45 DAS was because maximum yield may not always be the ultimate goal. In modern farming maximum profit is more important than maximum yield. But overall study, the 20 kg $ZnSO_4$ per hectare + 20 kg $FeSO_4$ per hectare as basal +0.5% $ZnSO_4$ + 0.5% $FeSO_4$ as foliar spray at 45 DAS, respectively, increased the green fodder yield and quality of fodder maize and sorghum by increasing crude protein.

Acknowledgement

Authors are highly thankful to Department of Agronomy, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya for providing all the necessary facilities and kind support.

References

1. Anonymous. Livestock Census Report.2018. Department of Animal Husbandry and Dairying. Government of India 2018.
2. Anonymous 2014. www.Indiastat.com.
3. Alloway BJ. In zinc in soil and crop nutrition. International Zinc Association. Brussels, Belgium 2004.
4. Bhoya M, Chaudhari PP, Raval CH, Bhatt PK. Effect of nitrogen and zinc on yield and quality of fodder sorghum (*Sorghum bicolor* (L.) Moench) varieties. Forage Research 2013;39(1):24-26.
5. Brennan RF. Zinc Application and its availability to plants. Ph. D. dissertation, School of Environmental Science, Division of Science and Engineering, Murdoch University 2005.
6. Cakmak I. Role of Zinc in protecting plant cells from reactive oxygen species. New Phytol 2000;146:186-205.
7. Chaudhary DP, Kumar A, Mandhania SS, Srivastava P, Kumar RS. Maize as Fodder? An alternative approach., Directorate of maize research, (Indian council of agricultural research) Pusa New Delhi 2012a, 1-32, *www.maizeindia.org*.
8. Fageria VD. Nutrient interactions in crop plants. Journal of Plant Nutrition 2001;24(8):1269-1290.
9. Gomez KA, Gomez AA. Statistical Procedures for Agriculture Research, 2nd edition, John Wiley and Sons, New York 1984.
10. Hafeez B, Kanif YM, Saleem M. Role of Zinc in plant nutrition- A Review. Am. J Experi. Agric 2013;3(2):374-391.
11. Hedayetullah M, Zaman P. Forage Crops of the World, Volume I: Major Forage Crops. CRC Press. Waretown, USA 2018.
12. Iqbal MA, Iqbal A. Overview on sorghum for food, feed, forage and fodder: Opportunities and problems in Pakistan's perspectives. American Eurasian Journal of Agricultural and Environmental Sciences 2015;15:1818-1826.
13. Joshi YP, Verma SS, Bhilare RL. Effect of zinc levels on growth and yield of oat (*Avena sativa* L.). Forage Research 2007;32(4):238-239.
14. Khurana MPS, Bansal RL, Bhatti DS. Managing zinc anda iron in *kharif* crops. Intensive Agriculture 2002.
15. Kumar AA, Reddy BVS, Ramaiah B. Biofortification for combating micronutrient malnutrition: Identification of commercial sorghum cultivars with high grain iron and zinc concentrations. Indian Journal of Dryland Agricultural Research and Development 2013;28(1):95-100.
16. Luo ZB, He XJ, Chen L, Tang L, Gao SHUN, Chen FANG. Effect of zinc on growth and antioxidents responses in Jatropha curcas seedlings. Int. J Agric. Biol 2010;12:119-124.
17. Mahdi SS, Hasan B, Singh L. Influence of seed rate, nitrogen and zinc on fodder maize (*Zea mays*) in temperate conditions of Western Himalayas. Indian Journal of Agronomy 2012;57(1):85-88.
18. Meena LR, Mann JS, Chaturvedi OH, Gill SC. Response of newly developed forage sorghum genotypes to zinc levels and *Azospirillium* under semi-arid conditions of Rajasthan. Forage Research 2010;36(3):128-132.
19. Meena SK, Mundra SL, Singh P. Response of maize (*Zea mays* L.) to nitrogen and zinc fertilization. Indian Journal of Agronomy 2013;58(1):127-128.
20. Naik BR, Devi SKB, Shanthi M, Chiranjeevi CH. Optimization of sulfur and zinc levels for enhancement of seed production of forage based cropping system maize (seed)- cowpea (fodder) lucerene (seed). National synopsis. A New Vista to Forage Crop Research 2007, (56).
21. Nissar R, Zahida R, Kanth RH, Manzoor G, Shafeeq R, Ashaq H *et al.* Agronomic biofortification of major cereals with zinc and iron- A review. Agricultural Reviews 2019;40(1):21-28.
22. Pal MS. Prospects of forage-based crop diversification. National group meet (*kharif*) of AICRP on forage crops

& utilization SKUAST-K, Srinagar 2016, 110-115.
23. Peck AW, McDonald GK. Adequate zinc nutrition alleviates the adverse effects of heat stress in bread wheat. Plant Soil 2010;337:374-389.
24. Pfeiffer WH, McClafferty B. Harvest Plus: Breeding crops for better nutrition. Crop Science 2007;47:S88-S105.
25. Sasmal J. Resources, Technology and Sustainability. Springer publication. Singapore 2016.
26. Shanthi M, Nagalaksmi D, Naik BR, Chandrika V, Chiranjeevi CH. Study on forage quality of various maize cultivars produced under different use patterns. Forage Research 2012;37(4):234-237.
27. Siddique A. Sorghum Health Benefits: Grain is gluten free, high in nutritional value 2013.
28. Tapiero H, Tew KD. Trace elements in human physiology and pathology: zinc and metallothioneins. Biomed. Pharmacother 2003;57:399-411.
29. Verma SS, Singh N, Joshi YP, Deorari V. Effect of nitrogen and zinc on growth characters, herbage yield, nutrient uptake and quality of fodder sorghum (*Sorghum bicolor*). Indian Journal of Agronomy 2005;50(2):167-169.
30. Zhang J, Wu LH, Wang MY. Iron and zinc biofortification in polished rice and accumulation in rice plant (*Oryza sativa* L.) as affected by nitrogen fertilization. Acta Agriculturae Scandinavica Section B–Soil and Plant Science 2008;58(3):267-272.
31. Zuo Y, Zhang F. Soil and crop management strategies to prevent iron deficiency in crops. Plant Soil 2011;339(1-2):83-95.