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Response of zinc and iron on quality parameters of fodder oat

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Abstract
Forage crops are essential for feeding livestock and can be utilized in various forms, including forage, silage, and hay. Bio fortification is indeed a valuable technique aimed at increasing the nutritional value of forage crops. Method focuses on enhancing the content and bioavailability of essential micronutrients like vitamins and minerals in crops. By the targeted aim and objective, an experiment on "Role of zinc and iron on forage quality of oat" was conducted at Main Forage Research Station, AICRP on Forage Crops and utilization, Anand Agricultural University, Anand during a winter season of 2021-2022 with ten treatments and three replications. Application of 25 kg $ZnSO_4$ and $FeSO_4$ through soil *fb* foliar application (30 and 40 DAS) along with the recommended dose of fertilizer (T_{10}) to fodder oat observed significantly higher dry matter digestibility (60.273%) and total digestible nutrient (53.62%). Dry matter intake (1.790%), relative feed value (83.33%) and relative feed quality (77.96%) were significantly higher by application of recommend dose of fertilizer along with 25 kg $ZnSO_4$ and $FeSO_4$/ha each (T_4). Significantly lower calculated feed value like dry matter intake, total digestible nutrients, relative feed value and relative feed quality was observed in treatment where no application of fertilizers to crop.

Keywords: Fodder oat, biofortification, enrichment, zinc, iron, dry matter intake, dry matter

Introduction
Diverse livestock and crops are found in India, which one consider as largest in the world. Agriculture and animal husbandry are considered as backbone of agricultural and it is directly related with the Indian economics. Day by day increasing demand of quality green fodder but production shortfalls are found in green fodder, dry forage and concentrates. In Gujarat and part of India, fodder oat cultivated during winter, it is major cereal fodder crop for animal feeding. Fodder oat is considered as an essential forage crop because green forage having ability of high palatability, for maintain good health of livestock as well as wider adaptability under wider climatic condition of India, Oats contain good sources of crude protein, crude fiber, vitamins and mineral, which supply through feeding of green fodder. it is high energy rich food, more palatability and useful for making silage, hay etc.
Micronutrients such as zinc, iron, and selenium are indeed crucial for various bodily functions, including growth, development, and the maintenance of the immune system (Shenkin 2006) [5] Under the modern agricultural system, continuous cropping system, high use of chemical fertilizer, non used of organic manure that create deficiency of micronutrients. Food insecurities are being brought on to the world's growing population which also generating a shortage of quality of food and fodder. Among the different micronutrient zinc and iron are major micronutrients and their deficiency was found in soil, animal and human being so it creates malnutrition or hidden hunger in developed countries. Enrichment of green fodder with micronutrients by soil application and foliar spray having greater benefit in livestock production (Saha *et al.*, 2020) [3]. Zinc and iron are the most extensive used micronutrients for production and quality of forage production, Zinc is indeed an essential micronutrient for plants, playing a crucial role in various physiological processes such as cell division, protein synthesis, photosynthesis and respiration and carbohydrate metabolism. It is considered a beneficial nutrient for plant growth and development (Sewhag *et al.*, 2022) [4]. Iron's vital role in oxygen transport, energy production, and numerous enzymatic reactions underscores its essentiality for

life. Its regulation is crucial for maintaining health, making dietary balance important. Iron deficiency is indeed a significant nutritional disorder in many crop plants, leading to various detrimental effects on plant health and productivity. Here are some key points about iron deficiency in crop plants.

Biofortification is indeed a long-term approach aimed at addressing the deficiency of essential nutrients like zinc and iron in crops to meet the nutritional demands for the population by application of targeted fertilizers (Agronomic), breeding and biotechnological approach. By agronomic or breeding crops with higher nutrient content or by enhancing nutrient uptake and utilization in plants, biofortification helps in improving the nutritional value of food staples. This strategy plays a significant role in combating malnutrition and improving public health, specially in regions where deficiencies in key micronutrients are prevalent. An experiment was chosen based on the current need for healthy animal feed in order to increase the quantity and quality of fodder produced.

Materials and Methods

Experiment site and climate

A field experiment was conducted to study response of zinc and iron on green fodder yield and its quality on fodder oat during winter season of 2021-2022 at Main Forage Research Station, AICRP on Forage crops and utilization, Anand Agricultural University, Anand 388001. The research station is located at 22°31'36.5"N 72°57'55.9"E with an altitude of 45.1 meter above mean sea level. Monthly average weather condition of Anand for the period of selected parameters during crop growth season was collected from Department of Agrometeorology, B.A. College of Agriculture, Anand Agricultural University, Anand (Fig. 1).

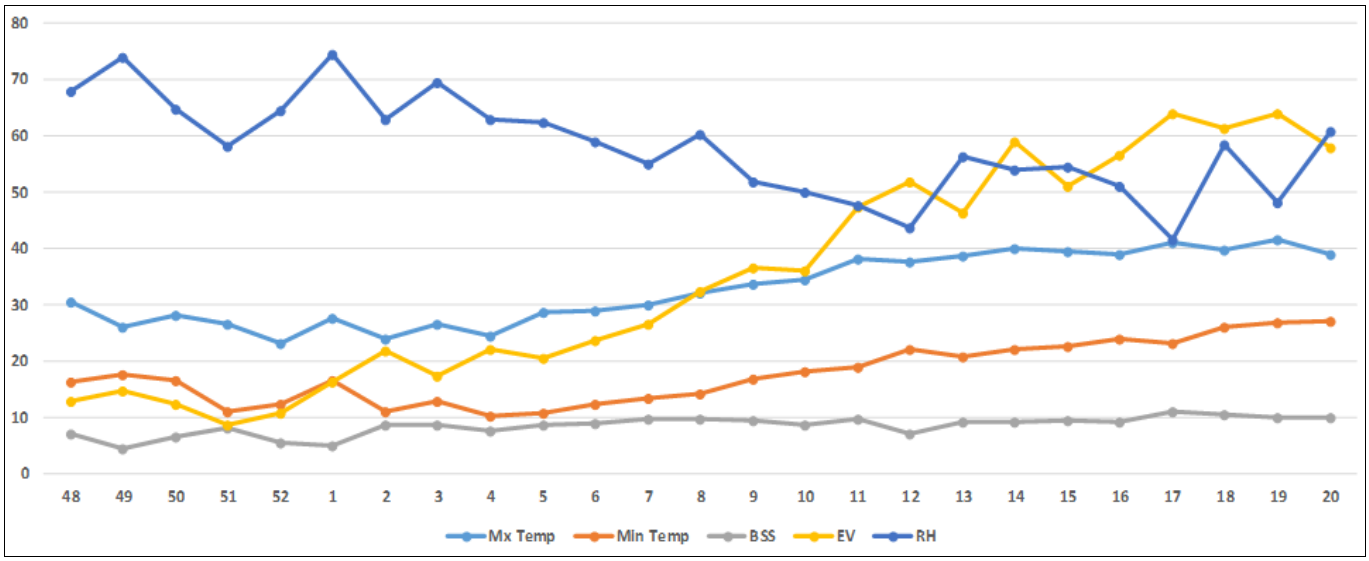

Fig 1: Mean weekly weather parameter recorded during crop growth period

Experiment site soil sample for basic properties

Determining the physico-chemical properties of soil is essential for understanding its fertility and suitability for plant growth. Experiment soil is loamy sand in texture with soil pH (7.60), organic matter content (0.27%), available N (249.15 kg/ha), available P_2O_5 (42.10 kg/ha) and available K_2O (182.00 kg/ha). No waterlog condition was found during experiment period means it is well drain soil.

Table 1: Details of treatment combinations

Sr. No.	Treatment
T_1	Control 100% RDF (80-40-0 NPK kg/ha)
T_2	T_1 + 25 kg $ZnSO_4$ / ha
T_3	T_1 + 25 kg $FeSO_4$ / ha
T_4	T_1 + 25 kg $ZnSO_4$ / ha + 25 kg $FeSO_4$ / ha
T_5	T_1 + FA 0.5% $ZnSO_4$
T_6	T_1 + FA 0.5% $FeSO_4$
T_7	T_1 + FA 0.5% $ZnSO_4$ + FA 0.5% $FeSO_4$
T_8	T_1 + 25 kg $ZnSO_4$ / ha + FA 0.5% $ZnSO_4$
T_9	T_1 + 25 kg $FeSO_4$ / ha + FA 0.5% $FeSO_4$
T_{10}	T_1 + 25 kg $ZnSO_4$ / ha + 25 kg $FeSO_4$ / ha + FA 0.5% $ZnSO_4$ + FA 0.5% $FeSO_4$
FA: Foliar Application of zinc and iron at 30 and 45 DAS	

Experiment design, treatment and crop husbandry

For conducting the selected experiment was established in Randomized Complete Block Desing (RCBD) with three replication and 10 different treatments. The details of treatment are given in Table 01. Fodder oat variety *Kent* was selected and recommended for the region was sown in opened 30 cm row using 80 kg/ha Oat; Kent seed sown in first week of November 2021-2022. Each net plot consists of 10 rows of 4-meter length, with row spacing 30 cm. Crop was received 40 kg N and 40 kg P_2O_5 as basal dose in the form of urea (86.95 kg) and single superphosphate (250 kg), remaining half dose of nitrogen 40 kg N/ha (86.95 kg) was applied after 30 days of sowing. Six to seven surface irrigation at 12 to 15 days interval was applied during crop growth period as and when required with depth of each irrigation at 5 cm. Fodder oat crop was kept weed free throughout growing season by mechanical and chemical method of weed control as well as done one hand weeding at 20 DAS, keep weed free plot. Recommended agronomical practices were adopted for successful fodder oat production. The fodder oat was harvested at 50% flowering stage for green fodder purpose. Total quantity of green fodder received from net plot area in kg/plot afterward it is converted into quintal per hectare. For calculate proximate analysis like dry matter content, crude protein content, acid detergent fiber and neutral detergent fiber, collect 500 g of samples from each net plot area, samples are chaff it into small pieces, put for sun drying 4 to 5 days and after one week it dries in hot dryer. Measure ADF and NDF value from fodder oat sample, same value used for calculating different parameter like dry matter intake, dry matter digestibility, total digestible nutrient, relative feed value and

relative feed quality.

Quality parameter analysis

Dry matter intake, dry matter digestibility, total digestible nutrient, relative feed value (Horrocks and Vallentine, 1999) [1] and relative feed quality (Undersander 2001) [6] are calculated with the following formula (Kashyap *et al*., 2023) [2]. ADF and NDF value are used for calculate following parameters.

Dry matter intake %	DMI = 120/NDR (%)
Dry matter digestibility (%) DMD	DMD = 88.9 - (0.779 × ADF%)
Total digestible nutrients (%) TDN	TDN = (-1.291 × ADF%) + 101.35
Relative Feed value (%) RFV	RFV + (DMI × DMD)/1.29
Relative Feed quality (%)	RFQ = (DMI ×TDN)/1.23

Statistical experiment design

The field experiment was carried out at Main Forage Research Station, Anand Agricultural University, Anand. Set of different treatments imposed in Randomized Complete Block Design (RCBD) with three replications. Collected replicated data for analysis by randomized complete block design by using one way analysis of variance (ANOVA) method. Use of least significant difference value (CD value @5 percent level of significance) for difference of all treatments.

Experiment result

Forage quality referent to the ability of forage to support desired levels of animal performance. In high forage diets, Neutral detergent fiber has a major impact on dry matter intake and digestibility. Application of RDF + 25 kg $ZnSO_4$ / ha + 25 kg $FeSO_4$ / ha reported significantly the highest dry matter intake (1.790%) than rest of treatment. A significantly lower dry matter intake (1.660%) was reported in absolute control treatment. Dry matter digestibility and total digestibility nutrient are also affected by application of zinc and iron with recommended dose of fertilizer (Table 02). Dry matter digestibility (60.273%) and total digestible nutrient (53.92%) was observed higher by application of recommended dose of fertilizer with application of 25 kg zinc and iron through each soil and 0.5% foliar application at 30 and 45 DAS (T_{10}). Relative feed value (RFV) and Relative feed quality (RFQ) are forage quality terms that are used to rank feeds especially forage according to their nutritive value. Application of 25 kg $ZnSO_4$ + 25 kg $FeSO_4$ along with recommended dose of fertilizer (80-40-0 kg NPK/ha) reported significantly higher RFV (83.33%) and RFQ (77.96%). Absolute control (T_1) reported lower total digestible nutrient (49.50%), relative feed value (74.12%) and relative forage quality (66.80%). Treatment T_2 (T_1 + 25 kg $ZnSO_4$ / ha) reported significantly lower dry matter digestibility (55.707%).

Table 2: Effect of treatment on quality parameters of fodder oat

Treatment	DMI (%)	DMD (%)	TDN (%)	RFV (%)	RFQ (%)
1	1.660^{c}	57.167^{c}	49.50^{c}	74.12^{e}	66.80^{c}
2	1.670^{c}	55.707^{c}	49.65^{a}	74.80^{de}	67.50^{bc}
3	1.657^{c}	58.297^{bc}	50.63^{bc}	74.81^{de}	68.14^{bc}
4	1.790^{a}	60.090^{a}	53.60^{c}	83.33^{a}	77.96^{a}
5	1.723^{b}	58.363^{bc}	50.75^{bc}	77.96^{c}	71.07^{b}
6	1.663^{c}	59.437^{ab}	52.52^{ab}	76.68^{cd}	71.08^{b}
7	1.660^{c}	59.380^{ab}	52.43^{ab}	76.31^{cde}	70.65^{b}
8	1.730^{b}	60.173^{a}	53.75^{a}	80.71^{b}	75.60^{a}
9	1.663^{c}	57.853^{c}	49.90^{c}	74.64^{de}	67.53^{bc}
10	1.740^{b}	60.273^{a}	53.92^{a}	81.24^{ab}	76.20^{a}
S.Em±	0.013	0.513	0.85	0.84	3.61

Conclusion

An experiment data presented in Table and discussion on calculated analysis value of oat reported that application of 25 kg $ZnSO_4$ and $FeSO_4$ through soil and foliar application (30 and 40 DAS) along with the recommended dose of fertilizer to fodder oat observed significantly higher dry matter digestibility and total digestible nutrient. Dry matter intake, relative feed value and relative feed quality was significantly higher by application of recommend dose of fertilizer along with 25 kg $ZnSO_4$ / ha + 25 kg $FeSO_4$ / ha. Lower analysis value was observed where no application of recommended dose of fertilizer and no soil and foliar application of zinc and iron to fodder oat.

Data availability statement

The original calculated data contributions presented in the study are included in the article/Supplementary Material. Further, any inquiries can be directed to the corresponding authors.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial relationships that could be construed as a potential conflict of interest.

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