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# Quality and Yield Enhancement in Fodder Berseem through Zinc and Iron Fertilization

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## ABSTRACT

A field experiment was conducted during *rabi* 2020 for assessment of quality and fodder enhancement of berseem through zinc and iron fertilization at Research Farm, Agronomy Section, ICAR-National Dairy Research Institute, Karnal, Haryana. The experiment was carried out in Randomized Block Design containing seven treatments which were T1: absolute control, T2: RDF, T3: 100%RDF + Zn (basal), T4: 100% RDF + Fe (basal), T5: 100% RDF + 0.5% foliar spray of Zn, T6: 100% RDF + 0.5% foliar spray of Fe, T7: 75% RDF + 0.5% foliar spray of Zn + 0.5% foliar spray of Fe and these were replicated thrice. Results of the experiment showed that higher total green fodder as well as total dry fodder yield (69.82 t/ha and 9.59 t/ha, respectively) were recorded in treatment T3 among different treatments for all the three cuts while, minimum total green as well as dry fodder yield was found in treatment T1 (49.59 t/ha and 6.16 t/ha, respectively). Also, with respect of quality parameters, treatment T3 showed significantly higher dry matter content, crude protein, ether extract and total ash and lower neutral detergent fibre, acid detergent fibre, acid detergent lignin and acid insoluble ash for all the three cuts. In summary, application of 100% RDF along with Zn as basal produced better fodder in terms of yield as well as quality.

**KEYWORDS:** ADF, Crude protein, Fodder, Legume, Livestock, NDF

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## INTRODUCTION

Livestock sector, the backbone of Indian agriculture, contributes 4% to national GDP. As the livestock population increases, requirement of feed and fodders also increases. For maintaining the good health of livestock, good quality green fodders are needed, which can increase the productivity of country's livestock. Among legume fodders in India, Berseem (*Trifolium alexandrinum* L.) is an important winter season fodder, popularly known as "King of Fodder crops". Berseem is recognized as milk yield enhancer in lactating cows and buffaloes (Muhammad et al., 2014). On dry matter basis, green forage of berseem contains 17-22% crude protein, 42-49% neutral detergent fiber, 35-38% acid detergent fiber, 24-25% cellulose and 7-10% hemi cellulose (Feedipedia, 2020). Yield and quality of fodder is largely influenced by the nutrient practices. Most of the times farmers focus on the application of macronutrients while neglecting the micronutrient application. In Haryana, Zn-15.3%, Fe-21.6%, Mn-6.2%, Cu-5.2% and B-3.3 % deficiency in soils has been observed (Shukla et al., 2015**)**. Zinc (Zn) and Iron (Fe) both are essential micronutrients required by both plants and animals for proper functioning and metabolic processes. A small amount of nutrients, mainly Zn, Fe and Mn applied by foliar spraying significantly increases the yield of crops (Sarkar et al., 2007). Looking at the role of Zn and Fe, the present study was undertaken to study the effect of application of these elements on yield and quality of berseem.

## MATERIALS AND METHODS

This experiment was conducted at research block of Agronomy Section, ICAR- National Dairy Research Institute, Karnal in 2020, located at 29°45'N latitude, 76°58'E longitude and at an altitude of 245 m above mean sea level (MSL) under

subtropical climate. The experiment was undertaken in Randomized Block Design with seven number of treatments *viz*., T1: absolute control, T2: RDF, T3: 100%RDF + Zn (basal), T4: 100% RDF + Fe (basal), T5: 100% RDF + 0.5% foliar spray of Zn, T6: 100% RDF + 0.5% foliar spray of Fe, T7: 75% RDF + 0.5% foliar spray of Zn + 0.5% foliar spray of Fe in three replications. Berseem variety BL-42 was taken for experiment. Recommended dose of fertilizers was applied in the ratio of 20: 60: 40 kg NPK $ha^{-1}$.The nutrients N, P and K were supplied through urea, SSP and MOP. Zinc has been applied in the form of zinc sulphate heptahydrate that contains 21% and iron in form of ferrous sulphate which contains 19% iron. According to treatments, basal application is done at the time of sowing and 0.5% foliar sprays at 30 DAS and subsequently after 15 days of 1st cut and 2nd cut. Before sowing, seeds of berseem were treated with liquid rhizobium culture. Hand weeding was done to control post emergent weeds. The crop was irrigated as per the need. First cut was taken at 50DAS and subsequent cut at 40 days interval.

Berseem was harvested from the net plot to avoid border effect and green fodder yield is expressed in t/ha. Dry fodder yield (t/ha) is determined by multiplying green fodder yield with dry matter content.

The proximate principles like CP, EE, total ash were determined as per standard procedures (AOAC, 2005). Similarly, Cell Wall constituents (NDF, ADF, Hemicellulose and ADL) were determined (Van Soest et al. 1991).

**Statistical Analyses**

The data collected during field experiment was analyzed using analysis of variance (ANOVA) as described by Gomez and Gomez (1983) in MS EXCEL. Statistical significance of the experimental data was determined at 5% level of significance by using "F test" and wherever F value was found significant, critical difference (p=0.05) value was calculated.

## RESULTS AND DISCUSSIONS

**Green fodder yield (t/ha)**

The data pertaining to green fodder yield shows significant variation among various treatments and are presented in table 1. With respect to different treatments, treatment T3 showed maximum green fodder yield in all three cuts as well as total (22.50, 22.98, 24.34 and 69.82 t/ha respectively) which was statistically at par with treatment T4 The increment in green fodder yield was 28.3%, 22.7% and 22.9% in 1st, 2nd and 3rd cut respectively over RDF alone while in respect of absolute control increment was 41.1%, 42.3% and 39.1%. The increase in green fodder yield might be due to enhancement of carbohydrate, auxin as well as protein synthesis and their transportation to different organs of plant viz. leaves by the ferti-fortification of zinc. Also, green fodder yield is a ramification of other growth-related parameters such as plant height, number of leaves, no. of regenerated stem etc. Similar findings were reported by Kumar et al. (2016).

**Dry fodder yield (t/ha)**

The data regarding the effect of Zn and Fe ferti-fortification on dry matter yield is represented in Table 1. which shows a significant difference in between various treatment. Among different treatments, treatment T3 in all three cuts shows maximum dry fodder yield 1st (2.28 t/ha), 3rd (3.14 t/ha) and 3rd (4.17 t/ha) which is statistically at par with treatment T4. Application of 100% RDF + Zn (basal) leads to the increment of 34.9%, 31.4% and 32.3% over the RDF alone and 59.4%, 59.3% and 51.1% over the absolute control. It may be due to favorable effect of Zn ferti-fortification on growth parameters like plant height, leaf length, number of leaves etc. which enhanced the area of leaf and finally the photosynthetic efficiency which leads to higher dry matter production. Highest green fodder yield and dry fodder yield attributed in 3rd cut may be because temperature was most favorable for the plant growth while in 1st and 2nd cut lower temperature affected the growth of plant. Similar findings were reported by Sarangthem et al. (2018) and Jha et al. (2015).

Table 1. Effect of Zn and Fe ferti-fortification on green fodder and dry matter yield of berseem fodder

| Treatments | Green fodder yield (t/ha) | | | | Dry fodder yield (t/ha) | | | |
|---|---|---|---|---|---|---|---|---|
| | I cut | II cut | III cut | Total | I cut | II cut | III cut | Total |
| T1- Absolute Control | 15.9 | 16.1 | 17.5 | 49.6 | 1.43 | 1.97 | 2.76 | 6.16 |
| T2- 100% RDF | 17.5 | 18.7 | 19.8 | 56.08 | 1.69 | 2.39 | 3.15 | 7.23 |
| T3- 100% RDF + Zn (basal) | 22.5 | 22.9 | 24.3 | 69.8 | 2.28 | 3.14 | 4.17 | 9.59 |
| T4- 100% RDF + Fe (basal) | 21.1 | 21.3 | 22.9 | 65.4 | 2.08 | 2.83 | 3.84 | 8.76 |
| T5- 100% RDF + 0.5% foliar spray of Zn | 19.7 | 20.3 | 21.2 | 61.2 | 1.85 | 2.68 | 3.44 | 7.98 |
| T6- 100% RDF + 0.5% foliar spray of Fe | 19.4 | 19.8 | 20.9 | 60.2 | 1.82 | 2.61 | 3.37 | 7.81 |
| T7- 75% RDF + 0.5% foliar spray of Zn +0.5% foliar spray of Fe | 19.5 | 20.03 | 21.02 | 60.6 | 1.84 | 2.63 | 3.40 | 7.86 |
| SEM ± | 0.68 | 0.79 | 0.86 | 0.12 | 0.11 | 0.11 | 0.13 | 0.12 |
| LSD ($P = 0.05$) | 2.10 | 2.45 | 2.65 | 0.37 | 0.34 | 0.35 | 0.40 | 0.36 |

**Quality parameters**

To meet the nutritional demand of livestock, well nutritional and good quality fodder is necessary which will increase the productivity of our country's livestock. The data related to quality parameters like dry matter, organic matter, ash, acid insoluble ash, CP, EE, NDF, ADF and ADL content of fodder berseem at each cut are presented:

**Dry matter (%)**

In all three cuts, treatment T3 had more dry matter content (10.14%, 13.67% and 16.73% respectively). The magnitude of increment in T3 in all three cuts was 13.1%, 11.9% and 8.6% respectively over T1 (Table 2).

**Organic matter (%)**

In all three cuts, T1 shows maximum organic matter content (86.83%, 86.77% and 87.63% respectively) while minimum organic matter observed in T3 (85.70%, 85.54% and 85.77% respectively). There are three main structural bio-polymers of organic matter viz., cellulose, hemicellulose and lignin content, therefore, difference in any of these constituents is highly associated with organic matter and mineral matter content (Vassilev et al., 2012).

**Crude protein (%) and yield (kg/ha)**

In all three cuts, treatment T3 recorded maximum crude protein 1st (19.49%), 2nd (19.31%) and 3rd (18.86%) which is statistically at par with treatment T4 (Table 2). The increment by T3 was 6.4%, 6.7% and 9.1% in 1st, 2nd and 3rd cut respectively over RDF alone. It may be because of zinc restorative effect on numerous enzymes like dehydrogenase, peptidase and proteinase as Zn plays vital role in these enzymes as well as synthesis of large amount of amino acids. Similar findings obtained by Chand et al. (2017).

In respect of crude protein yield, in all three cuts, treatment T3 1st cut (444.92 kg/ha), 2nd cut (607.05 kg/ha) and 3rd cut (786.64 kg/ha)) recorded maximum crude protein yield. The increase in T3 was 52.6%, 40.2% and 44.2% in 1st, 2nd and 3rd cut respectively over RDF alone. It may be because crude protein yield depends on crude protein (%) and dry matter yield.

Table 2. Effect of Zn and Fe ferti-fortification on dry matter (%) and organic matter (%) of berseem fodder

| Treatments | Dry matter (%) | | | Organic matter (%) | | | CP (%) | | | CP yield (kg/ha) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I cut | II cut | III cut | I cut | II Cut | III cut | I cut | II cut | III cut | I cut | II Cut | III cut |
| T1- Absolute Control | 8.94 | 12.2 | 15.8 | 86.8 | 86.7 | 87.6 | 18.2 | 18.2 | 18.1 | 259.78 | 358.25 | 499.65 |
| T2- 100% RDF | 9.05 | 12.7 | 15.9 | 86.4 | 86.5 | 86.7 | 19.3 | 19.06 | 19.03 | 307.43 | 454.28 | 600.03 |
| T3- 100% RDF + Zn (basal) | 10.14 | 13.6 | 17.1 | 85.7 | 85.5 | 85.7 | 21.5 | 21.3 | 21.3 | 492.28 | 669.09 | 886.92 |
| T4- 100% RDF + Fe (basal) | 9.85 | 13.3 | 16.7 | 85.9 | 85.9 | 86.05 | 21.4 | 21.2 | 21.1 | 445.42 | 600.61 | 813.66 |
| T5- 100% RDF + 0.5% foliar spray of Zn | 9.41 | 13.2 | 16.2 | 86.1 | 86.1 | 86.2 | 21.2 | 20.9 | 20.8 | 393.19 | 560.82 | 718.63 |
| T6- 100% RDF + 0.5% foliar spray of Fe | 9.39 | 13.1 | 16.09 | 86.3 | 86.3 | 86.4 | 20.8 | 20.6 | 20.6 | 379.27 | 539.00 | 695.53 |
| T7- 75% RDF + 0.5% foliar spray of Zn +0.5% foliar spray of Fe | 9.41 | 13.1 | 16.2 | 86.2 | 86.2 | 86.3 | 21.03 | 20.7 | 20.7 | 386.05 | 545.98 | 706.31 |
| SEm ± | 0.24 | 0.23 | 0.24 | 0.08 | 0.12 | 0.12 | 0.17 | 0.14 | 0.14 | 17.32 | 20.07 | 27.36 |
| LSD ($P = 0.05$) | 0.72 | 0.69 | 0.73 | 0.45 | 0.63 | 0.64 | 0.53 | 0.43 | 0.44 | 53.35 | 61.84 | 84.29 |

Table 3. Effect of Zn and Fe ferti-fortification on EE (%) and yield (kg/ha) of berseem

| Treatments | Ether extract (%) | | | EE yield (kg/ha) | | | Total ash content (%) | | | Acid Insoluble ash (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I cut | II cut | III cut | I cut | II cut | III cut | I cut | II cut | III cut | I cut | II cut | III cut |
| T1- Absolute Control | 2.37 | 2.30 | 2.25 | 33.7 | 45.4 | 61.9 | 13.1 | 13.2 | 12.3 | 2.25 | 2.36 | 2.21 |
| T2- 100% RDF | 2.56 | 2.53 | 2.48 | 40.8 | 60.3 | 78.2 | 13.5 | 13.5 | 13.2 | 2.37 | 2.44 | 2.32 |
| T3- 100% RDF + Zn (basal) | 2.83 | 2.80 | 2.78 | 64.6 | 88.07 | 115.6 | 14.3 | 14.4 | 14.2 | 2.65 | 2.77 | 2.72 |
| T4- 100% RDF + Fe (basal) | 2.82 | 2.75 | 2.67 | 58.5 | 77.8 | 102.9 | 14.07 | 14.09 | 13.9 | 2.63 | 2.69 | 2.67 |
| T5- 100% RDF + 0.5% foliar spray of Zn | 2.71 | 2.72 | 2.65 | 50.3 | 73.02 | 91.1 | 13.8 | 13.9 | 13.7 | 2.60 | 2.66 | 2.65 |
| T6- 100% RDF + 0.5% foliar spray of Fe | 2.64 | 2.65 | 2.58 | 48.1 | 69.2 | 86.9 | 13.6 | 13.6 | 13.6 | 2.50 | 2.58 | 2.51 |
| T7- 75% RDF + 0.5% foliar spray of Zn +0.5% foliar spray of Fe | 2.68 | 2.70 | 2.60 | 49.2 | 71.08 | 88.5 | 13.7 | 13.8 | 13.6 | 2.58 | 2.60 | 2.53 |
| SEm ± | 0.04 | 0.05 | 0.06 | 2.63 | 3.10 | 4.28 | 0.15 | 0.21 | 0.21 | 0.12 | 0.13 | 0.12 |
| LSD ($P = 0.05$) | 0.13 | 0.15 | 0.17 | 8.09 | 9.56 | 13.18 | 0.45 | 0.63 | 0.64 | NS | NS | NS |

**Ether extract (%) and yield (kg/ha)**

Ether extract determines the quantity of fat- and fat-soluble constituents of any fodder. The data presented in the Table 3 regarding ether extract percentage and yield showed significant difference (P<0.05) among different treatments. Maximum EE content in berseem at all three cuts was recorded in T3 (2.83%, 2.80% and 2.78% respectively) which is statistically at par with T4 and T5. The increase in T3 was 10.5%, 10.7% and 12.1% in 1st, 2nd and 3rd cut respectively over T2. It may be because Zn deficiency results in the reduction of total fatty acid content.

With respect to ether extract yield, T3 shows maximum value for ether extract yield in all three cuts (64.63kg/ha, 88.07 kg/ha and 115.66kg/ha respectively). The increment in ether extract yield in treatment T3 was 91.5%, 93.9% and 86.8% in 1st, 2nd and 3rd cut respectively over absolute control while 58.2%, 45.9% and 47.7% respectively over RDF alone.

**Total ash content**

The data presented in the table 3 pertaining to total ash content showed significant difference among different treatments at all three cuts. Maximum ash content in berseem was recorded in treatment T3 (14.30%, 14.46% and 14.23% respectively) while minimum ash content was found in T1 (13.17%, 13.23% and 12.37% respectively). Treatment T3 shows increment of 5.4%, 7.1% and 7.6% in 1st, 2nd and 3rd cut respectively over T2. It can be explained by the fact that zinc application increased minerals such as Mn, Zn, K and Cu content in plant. Also, Zn links positively with K and hence, enhances the absorption of Mn and Cu in plant (Prasad et al., 2016).

**Acid Insoluble ash**

The data in the table 4 represents the acid insoluble ash content which shows non-significant difference (P<0.05) among different treatments at all three cuts. Not with standing, maximum acid insoluble ash content in berseem was recorded in T3 at all three cuts (2.65%, 2.77% and 2.72% respectively).

**Neutral detergent fibre**

The data presented in the table 4 regarding NDF (%) shows significant difference (P<0.05) among different treatments at all three cuts. Maximum NDF content in berseem was recorded in T1 and minimum NDF content observed by treatment T3. Decrement shown by T3 was 6.9%, 8.1% and 6.1% in 1st, 2nd and 3rd cut respectively over T2. Similar findings were reported by Chand et al., 2017 who found that NDF and ADF content decreases due to the application of Zn.

**Acid detergent fibre**

The data in table 4 represents the ADF (%) which shows that there was significant difference (P<0.05) among different treatments at all three cuts. The value for maximum ADF content was recorded in T1 (32.27%, 32.63% and 31.27% in 1st, 2nd and 3rd cut respectively) while minimum value was found in T3 (29.13%, 29.40% and 28.57% in 1st, 2nd and 3rd cut respectively). The reduction in ADF content in T3 was 7.3%, 5.4% and 5.5% in 1st, 2nd and 3rd cut respectively over T2. Similar results were found by Yadav et al. (2023) who delineate that higher fertilizer levels significantly reduced ADF and NDF contents. It may be due to the fact that Zn lessens the fibre and soluble carbohydrate content in fodder hence increases the digestibility (Tsonev & Cebola Lidon, 2012).

**Acid detergent lignin**

Table 4 represents the ADL content which describes that there was significant variation (P<0.05) recorded among the different treatments at all three cuts. Maximum ADL content was recorded in T1 (4.31%, 4.20% and4.17% respectively) whereas minimum ADL content found in T3 (3.70%, 3.63% and 3.57% respectively). The reduction in ADL content in $T_3$ was in tune of 16.4%, 15.7% and 16.8% in 1st, 2nd and 3rd cut respectively over absolute control. Cakmak (2000) delineate the importance of zinc in lignification of plant cell wall. Plant generates reactive oxygen species which is inevitable process and is one of the important characteristics of lignifying cells. Generation of these

species is accelerated by NADPH oxidase enzyme and also, zinc deficiency in the plant is highly associated with the increased activity of NADPH oxidase.

**Hemi-cellulose content (%)**

The data presented in the table 4 regarding hemi-cellulose content shows significant difference ($P<0.05$) among different treatments at all three cuts. Among different treatment, treatment T3 recorded minimum hemi-cellulose content at all three cuts (10.71%, 10.63% and 10.57% respectively) which is at par with T4, T5 while maximum hemi-cellulose content in berseem was recorded in T1 (12.20%, 12.27% and 12.53% respectively). By the application of Zn, hemi-cellulose content decreased at all three cuts by 8.5%, 6.9% and 7.8% respectively over T2.

Table 4. Effect of Zn and Fe ferti-fortification on fiber fractions of berseem fodder

| Treatments | ADF (%) | | | NDF (%) | | | ADL (%) | | | Hemi-cellulose (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I Cut | II cut | III cut | I Cut | II cut | III cut | I Cut | II cut | III cut | I Cut | II cut | III cut |
| T1- Absolute Control | 32.3 | 32.6 | 31.2 | 44.5 | 44.0 | 43.8 | 4.31 | 4.20 | 4.17 | 12.2 | 12.2 | 12.5 |
| T2- 100% RDF | 31.2 | 31.0 | 30.1 | 42.9 | 43.2 | 41.5 | 4.10 | 4.07 | 4.06 | 11.6 | 11.3 | 11.4 |
| T3- 100% RDF + Zn (basal) | 29.1 | 29.4 | 28.5 | 40.1 | 40.03 | 39.1 | 3.70 | 3.63 | 3.57 | 10.7 | 10.6 | 10.5 |
| T4- 100% RDF + Fe (basal) | 29.6 | 29.9 | 28.7 | 40.7 | 40.8 | 40.3 | 3.83 | 3.70 | 3.70 | 11.05 | 10.9 | 11.1 |
| T5- 100% RDF + 0.5% foliar spray of Zn | 30.2 | 30.07 | 29.3 | 41.3 | 41.1 | 40.4 | 3.90 | 3.83 | 3.80 | 11.1 | 11.1 | 11.1 |
| T6- 100% RDF + 0.5% foliar spray of Fe | 30.9 | 30.5 | 29.8 | 42.1 | 42.0 | 41.1 | 4.07 | 3.97 | 3.93 | 11.1 | 11.2 | 11.3 |
| T7- 75% RDF + 0.5% foliar spray of Zn +0.5% foliar spray of Fe | 30.4 | 30.3 | 29.5 | 41.5 | 41.3 | 40.7 | 3.95 | 3.87 | 3.83 | 11.1 | 11.1 | 11.2 |
| SEm ± | 0.45 | 0.33 | 0.34 | 0.42 | 0.63 | 0.41 | 0.09 | 0.07 | 0.07 | 0.15 | 0.17 | 0.20 |
| LSD ($P = 0.05$) | 1.40 | 1.01 | 1.06 | 1.31 | 1.93 | 1.26 | 0.27 | 0.20 | 0.23 | 0.41 | 0.52 | 0.59 |

## CONCLUSION

From the findings of the above experiment, it was concluded that the application of 100% RDF + Zn as basal and 100% RDF + Fe as basal significantly enhanced the yield as well as quality of fodder berseem in comparison to other treatments. Hence, the above treatments can be advised to the dairy farmers for getting higher forage yield.

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