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EFFECT OF IRON AND MOLYBDENUM ON YIELD AND NODULATION OF LENTIL

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ABSTRACT

A field experiment was conducted to assess the effect of iron (Fe) and molybdenum (Mo) on yield and nodulation of lentil (*Lens culinaris* Medic) at Agriculture Research Farm (N) Mingora Swat during 2014 - 2015. The experiment was laid out in a randomized complete block design (RCBD) with three replications. Basal dose of NPK @ (20-60-60 kg ha^{-1}) were applied to the entire treatments plot in the form urea, SSP and SOP. Iron was applied at the rate of 0.5 and 1.0 kg ha^{-1} in the form of ferrous sulphate ($FeSO_4.7H_2O$) and molybdenum was applied at the rate of 0.05 and 0.10 kg ha^{-1} in the form of ammonium molybdate {$(NH_4)_6Mo\ O_{24}.4H_2O$)} as foliar spray. The results showed that application of iron and molybdenum significantly increased the grain yield, biomass yield, harvest index (%), 1000 seed weight (g), total N uptake, protein content, number of total and active nodules $plant^{-1}$. It was observed that combined application of iron and molybdenum significantly produced greater crop yields and more nodulation than the sole application of iron or molybdenum. These results suggested that combined application of iron @ 1.0 kg ha^{-1} and molybdenum @ 0.10 kg ha^{-1} as foliar spray significantly enhanced the crop yields and root nodulation in lentil under the agro-climatic conditions of Swat valley. It is therefore recommended that Fe and Mo may be applied to lentil in Swat valley for better crop yields and greater root nodulation.

Keywords: lentil, iron, molybdenum, yield, nodulation, swat.

INTRODUCTION

Lentils (*Lens culinaris* Medic) belong to family *Leguminasae*. Lentil is a nutritious food legume. It is one of the oldest annual grains legumes more consumed and cultivated in the world and mostly eaten as dhal. Lentil is originating from South Western Asia as early as 6000 B.C. Lentil is rich in protein and also contains high concentration of essential amino acid as isoleucine and lysine, as well as other nutrients like nutritive fiber, folate, vitamin B1, and minerals (Rozan *et al*., 2001). Lentil is also known as a 'poor man's meat' because of its rich protein content. In South East Asia lentil is also equally liked by all socioeconomic groups (Bhatty, 1988). Lentil is commonly consumed as thick soup made from whole grain or split pulse commonly known as 'dhal'. Its seeds can be fried and used for eating; lentil flour is also best for making soups, purées of stews, and mixed with cereals for making bread and pastries and also used for softness of food (Williams and Singh, 1988). Lentil is used as a basic dish, side dish or in salads in the subcontinent of Indus - Pakistan and in the Middle East and mixing with soups in many other countries. In some places it is used as alternate of meat in vegetarian diets. Lentil is predominantly grown in South East Asia. Many countries of the world produce and cultivated lentil among these India, Canada, Turkey, Bangladesh, Iran, China, Nepal and Syria are the most famous countries for the production and cultivation of lentil. In Pakistan, lentil is cultivated in winter as an important pulse crop after chickpea in an area of 19.6 thousand hectares with an annual production of 9.7 thousand tones with an average grain yield production of 541kg ha^{-1} (GOP, 2013) which is very low and cannot meet the demand of increasing population. Area under lentil crop cultivation is gradually declining due to the attack of several diseases and infestation of weeds.

Lentil is not only best for the people but it is also the valuable feed for animals due to the presence of high digestibility protein, calcium and phosphorous compared to wheat straw (Zeidan, 2006). Cultivation of lentil improves the health of soil by adding nitrogen and organic matter, this way it provides sustainability to cropping systems by means of cereal. Resembling with other legumes crops lentil has also the capability of fixing atmospheric nitrogen through symbiotic relationship with *Rhizobia*. This ability of fixing nitrogen of lentil may provide a chance to recover nitrogen status of soil and crop yield (Ahmed *et al.,* 2008). Lentil crop require nitrogen for their growth and development approximately 85% of nitrogen necessity of lentil is fulfilled with the help of atmospheric nitrogen fixation during symbiotic relationship of lentil roots with microorganism such as *Rhizobium* bacteria in the field and due to which yield could be increased up to 2 ton ha^{-1} (Bisen *et al*., 1980).

Micronutrients are required by the plants in less amount but must be available to plants for better growth and production. Iron is an essential key enzymes co-factor which performs different function in breakdown of hormone and also take part in many chemical reactions takes place in plants (Kerkeb and Connolly, 2006). When plant root cells take Fe, it must be transported to the leaves. Phloem is the main tissue in plant which transports food from leaves to all parts of the plant. In phloem iron is transported as Fe (III) and probably makes complexes with citrate (Cataldo *et al*., 1988). Transportation of iron in apoplast is indispensable for its assimilation progression by root cells (Zhang *et al*., 1991). The reduction in iron and its transportation in overall mesophyll cells plasma membrane is a very important step that can disturb iron shortage through increasing apoplast pH (Kosegarten *et al*., 1999). Iron is not a part of chlorophyll, but it is also essential for its biosynthesis. Therefore, iron deficiency causes lack of chlorophyll in plants and causes chlorotic (Katyal and Randhawa., 1983). But in excessive amount iron on the other hand, results in the oxidative stress. Oxidative stresses in turn result in over activity of different oxygen elements such as superoxide radicals, hydrogen peroxide and radical of hydroxyl quite of which being generally effect the biotic and abiotic factors of plants (Polle and Rennenberg, 1993). In some cases it is possible to reduce the symptoms of iron shortage and toxicity by increasing or decreasing the concentration of nutrients. Molybdenum (Mo) is essential micronutrient that higher plants obtain from the soil and make it effective for their growth and development. Since the molybdenum (Mo) is needed for nitrogenase, an enzyme which involved in nitrogen fixation process in plants, leguminous crops growth in acidic soil may be Mo-deficient (Mandal *et al*., 1998), although the plant Mo demand is very low. It is known that the lacking of micronutrients is also increasingly in the Nutrition of humans. The important role of Mo in higher plants is that it performs basic functions in the mononuclear enzymes of Mo, which redeem a vital responsibility in some of the metabolic progression and regulate ascorbate-glutathione in plants. Lacking of molybdenum in plants causes decrease in chlorophyll content and also creates some abnormal changes in plant chloroplast. But on the other hand if Mo fertilizer provided to the plant generally accelerate the photosynthetic activities and products of photosynthesis. Molybdenum is also needed for the formation of nitrate reductase enzyme in crops which redeems a supplementary role in the symbiotic N_2 fixation. Nitrogen that fixes form an enzyme called nitrogenase this enzyme is produce by the presence of molybdenum and iron in the plants and lacking of these elements, the fixation of nitrogen cannot happen and due to which the nitrogenase enzyme cannot produce by plants. Many experiments have been investigated on the effects of micronutrients on different grain legumes and found significant reports (Bhuiyan *et al.,* 2008; Verma *et al.,* 1988; Tiwari *et al.,* 1989 and Zaman *et al.,* 1996). As other micronutrients, Fe and Mo perform an important role in increasing the production of pulses and legumes due to its effects on growth of plant and nitrogen fixation process. This study was therefore planned to assess the effect of iron (Fe) and molybdenum (Mo) on yield and nodulation of lentil in the Swat valley.

MATERIALS AND METHODS

A field experiment was carried out to determine the effect of iron and molybdenum on yield and nodulation of the lentil (*Lens culinaris* Medik) at Agriculture Research Farm Mingora Swat during 2014-2015. The Swat is located 34.3 and 35.53 L, N and 71.50 and 72.50 degree lon E, 873 to 2300 ms above sea level and other environmental factor like rain, temperature and humidity are 737.3 to 1200 nm, 11.25 to 25.68 ^{o}C and 24 to 68 % respectively(Metrological reports the Swat ARI, Mingora, Pakistan). Total area of Swat is 5065 km^2 in which about 9528 hectare area are under cultivation.

Lentil (Mansehra-89) seeds were sown in RCBD design having three replications. Plot area was 4 m × 3 m (12 m^2), row to row and plant to plant distance was kept 30 and 20 cm. Iron @ 0.5 and 0.1 (ferrous sulfate 20.5% Fe) and molybdenum (ammonium molybdate 54% Mo) @ 0.05 and 0.10 kg ha^{-1} were applied as foliar spray in 2 splits at young leaves stage and flowering stage (20 days interval). The treatments combination were T_1 (Control), T_2 Fe @ 0.5 kg ha^{-1}, T_3 Fe @ 1.0 kg ha^{-1}, T_4 Mo @ 0.05 kg ha^{-1}, T_5 Mo @ 0.10 kg ha^{-1}, T_6 Fe @ 0.5 kg ha^{-1} + Mo @ 0.05 kg ha^{-1}, T_7 Fe @ 0.5 kg ha^{-1} + Mo @ 0.10 kg ha^{-1}, T_8 Fe @ 1.0 kg ha^{-1}+ Mo @ 0.05 kg ha^{-1}, T_9 Fe @ 1.0 kg ha^{-1} + Mo @ 0.10 kg ha^{-1}. N P K (20 60 60 kg ha^{-1}) was applied as basal dosage before sowing.

Table-1. Physico-chemical properties of experimental soil.

Soil properties	Units	Values
Total Nitrogen	%	0.03
Sand	%	3.2
Clay	%	26.8
Silt	%	70.0
Soil Texture	-	Silt loam
pH (e)	-	6.5
EC	m.mohs cm^{-1}	0.167
Organic matter	%	1.2
Lime	%	2.6

The physico-chemical characteristics of the experimental soil (Table-1) showed that the textural class of the soil was silt loam, non-saline and somewhat acidic in reaction with pH (6.5), non calcareous and with an average amount of organic matter (1.2 %), medium in Mehlic-3 and the total nitrogen was found in small quantity (0.03).

Measurement of crop parameters

Nodulation and nodules activity

At early flowering stage after 50 to 70 days of sowing, 5 plants from each treatment plot were collected randomly for the determination of nodules numbers and nodules activity plant^{-1}. Plants were gently uprooted and carefully removed the soil from roots using tap water. Then washed the roots with distilled water, blotted with tissue paper and counted the number of nodules. Nodules were detached from the roots and cut into two pieces and observed for the inside color for nodules activity. If it was pink/red the nodules were classed as active and as capable to fix atmospheric nitrogen and if white they were classed as inactive. The pink/red color was due to the presence of leghaemoglobin.

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Biomass yield (kg ha^{-1})

At harvesting plant from each treatment plot was sun drying and the biomass/straw was weighted by electronic scale and then converted to kg per hector by the following formula.

$$\text{Biomass yield (kg ha}^{-1}) = \frac{\text{Biomass yield(g) x 10000}}{\text{Area x 1000}}$$

Grain yield (kg ha^{-1})

The harvested plants were threshed manually to find out grain yield using electronic scale and recorded as kg ha^{-1} using the following formula.

$$\text{Grain yield (kg ha}^{-1}) = \frac{\text{Grain yield(g) x 10000}}{\text{Area x 1000}}$$

Harvest index (%)

Harvest index was calculated using the following expression:

$$\text{H.I} = \frac{\text{Grain Yield}}{\text{Biomass Yield}} \text{ x 1000}$$

1000 seed weight (g)

One 1000 seed were randomly collected from the grains of each treatment plot and weighted using electronic balance.

Total plant N

Fresh leaves from each treatment were selected washed with distilled water kept under shed for dry then for full drying leaves were kept in the oven at 78 °C for 48 hours to a constant weight while seeds were taken after harvesting for N content determination. Leaves and seeds were grinded with a mini grinder followed by acid wet digestion (Benton *et al*., 1991). Nitrogen content was determined by micro Kjeldhal (Mulvaney, 1996).

Protein content (%)

Protein content was determined by multiplying N content of seed with the conversion factor of 6.25 (Anonymous, 1990).

Total N uptake (kg ha^{-1})

Total N uptake was estimated using the following formula:

$$\text{Plant total N uptake (kg ha}^{-1}) = \frac{\text{Seed N content x Seed yield}}{100} + \frac{\text{Straw N content x Straw yield}}{100}$$

Soil and plant Analysis

Determination of total N content

The Whole N in soil and plant was determined by the procedure Kjeldahl as described in Bremner (1996). In this method, 0.5g of the sample was digested by 3-4 mL concentrated H_2SO_4 in the presence of digestion mixture (K_2SO_4, $CuSO_4$ and selenium powder) till the digest turned clear. After refrigeration, the summary was transferred to 100 ml volumetric flask and distilled water was added to arrange a volume. Twenty ml of summary were distilled then in the presence of 5 ml solution (NaOH and boric acid solution). The concentrate was then titrated and titration was done against standard M HCl 0.005. At the same time a blank reading was also taken and total percent of nitrogen was deliberated as follow:

$$\text{Total N\%} = \frac{\text{ml of HCl used (sample – blank) x N of HCl x 100 x 70}}{\text{0.5 x 20 x 10000}}$$

Electrical conductivity

The Soil Electrical conductivity (E.C) was determined in (1:5) soil water suspension. In this method, 10 g sample of soil was added in 50 ml distilled water and shaken it for 30 minutes. After the filtration, EC was estimated with EC meter (DDC-308A Conductivity meter), (Mclean, 1982).

Soil pH

Soil pH was determined in 1:5 soil water suspensions; 50 ml Distilled water was added to 10g soil sample and shaken it for 30 minutes. Soil pH was then found out with the help of pH meter (In the laboratory pH level 1) (Rhoades and Loveday., 1990).

Organic Matter

One gram of soil sample was added to $K_2Cr_2O_7$ and 20 ml of concentrated H_2SO_4 solution and keep for 1 minute to cool. After cooling, 200 ml of distilled water were added and filtered. After filtrations add 5-6 drops ortro-phenopthroline while titration against 0.5 Fe $SO_4.7H_2O$ till the color change from greenish to dark brown. A blank reading was also directed at that time. The organic matter was then computed with the formula (Nelson and Sommers., 1996).

$$\text{Organic matter (\%)} = \frac{\text{(meq } K_2Cr_2O_7\text{-meq Feso}_4\text{)x meq of C}}{\text{Weight of dry sample x (0.75)}}$$

Where 0.75 is derived from the assumption that only 75% of organic matter is oxidized in this method and Meq of C is 0.003.

Lime content ($CaCO_3$)

Five gram of soil sample was mixed with 50 ml of 0.5N HCl. And keep in electro thermal for heating till boiling start. After boiling the filtration process was done, the suspension was then titrated against 0.25N NaOH in the presence of an indicator (phenapthaline) (Ryan *et al*., 2000). The lime content was then calculated by the following formula:

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$$\% \ CaCO_3 = \frac{meq \ HCl - meq \ NaOH \times 0.05 \times 100}{Weight \ of \ sample}$$

Soil Texture

In this method, 150 ml distilled water and 10 ml of 1 N Na_2CO_3 was added to 50 g of dry soil sample in a dispersion cup. The suspension was transferred to 1 L Buocous cylinder and made the volume up to the mark and shake while time was noticed. After 40 sec hydrometer was inserted for finding silt + clay content, 2nd reading was taken after 2 hours for %clay. For accurate results temperature was noted in both readings. Percent sand was calculated by the difference between silt and clay. Textural class was estimated using the textural triangle (Koehler *et al*., 1984).

Statistical analysis

Statistical analysis was done using ms statistics software 8.1. The means were contrasted by means of LSD test at 0.05 level of probability, when the F-values were significant (Jan *et al*. 2009).

RESULTS AND DISCUSSIONS

Grain yield (kg ha^{-1})

Data presented in Table-2 showed that both Fe and Mo applied alone or combined significantly increased grain yield of lentil over control. Results further revealed that highest grain yield 1767 kg ha^{-1} were obtained with foliar spray of iron @1.0 and molybdenum @ 0.10 kg ha^{-1}. This was however statistically at par with treatments receiving Fe, Mo or both at any rate in this experiment. This might be due that soil of the experimental site was low in available Fe and Mo. It is widely known that Fe helps improve the chlorophyll content necessary for photosynthetic activities. Moreover, Fe and Mo are integral components of nitrogenase enzyme which are essential for symbiotic N_2 fixation. These findings are supported by Sharief and Said (1998) found that foliar application of micronutrients either separately or in combination significantly improved the grain yield of lentil. The grain yield of chickpea was significantly increased with the application of iron and molybdenum (Khan *et al*., 2014). Similar results were also found by Zeidan *et al*. (2006) reported that yield and yield components of lentil were enhanced significantly with the foliar spray of micronutrients.

Biomass yield (kg ha^{-1})

Data regarding biomass yield of lentil Table-2 indicated that Fe and Mo significantly enhanced biomass yield of lentil over control. The maximum biomass yield 4930 kg ha^{-1} was obtained with foliar application of iron at 1.0 kg ha^{-1} and molybdenum at 0.10 kg ha^{-1}. This was somewhat statistically similar with other treatments getting Fe, Mo or both in this experiment. This was because of experimental site soil was poor both in available Fe and Mo. Fe and Mo play a vital role in photosynthetic activities and also involve in nitrogenase enzyme responsible for symbiotic N_2 fixation. These results are in harmony with those of Sarivestava and Ahlavat (1995) stated that iron and molybdenum drastically improve biomass yield of chickpea. Sawires (2001) also found similar observations reported that Mo, Fe and Zn application at 15-30 mg/kg increased biomass yield of chickpea.

Harvest index (%)

Date in Table 2 determine that maximum harvest index of 38.36 % was obtained with combined foliar application of Fe at 1.0 kg and Mo @ 0.10 kg ha^{-1}. However, this was statistically alike to all other treatments except control and Fe at 0.5 kg ha^{-1}. It was however evident that both Fe and Mo applied alone or combined produced statistically higher harvest index over control. It was stated earlier that soil of the experimental site was lacking in Fe and Mo. Related findings were also stated by Togay *et al*. (2008) stated that phosphorus and molybdenum applications significantly increased the harvest index of lentil. Molybdenum application along with seed inoculation with *rhizobium* strain significantly increased the harvest index of mungbean (Tahir *et al*., 2011). Ahlawat *et al*. (2007) also found that harvest index of chickpea increased with the increase in molybdenum sources.

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Table-2. Effect of iron and molybdenum on yield and yield parameters of lentil.

Treatments	**Grain yield** (kg ha^{-1})	**Biomass yield** (kg ha^{-1})	**1000 seed weight** (g)	**Harvest index** (%)
Control	1293 b	4163 c	28.95 f	31.09 c
Fe 0.5 Fe kg ha^{-1}	1693 a	4577 b	30.95 e	34.52 b
Fe 1.0 Fe kg ha^{-1}	1757 a	4827 ab	31.80 de	36.41 ab
Mo 0.05 kg ha^{-1}	1747 a	4850 ab	32.39 cd	36.02 ab
Mo 0.10 kg ha^{-1}	1753 a	4860 ab	32.95 bc	36.27 ab
Fe 0.5 kg ha^{-1} + Mo 0.05 kg ha^{-1}	*1750 a*	4810 ab	*32.54 bcd*	36.38 ab
Fe 0.5 kg ha^{-1} + Mo 0.10 kg ha^{-1}	1753 a	4867 ab	32.98 bc	36.04 ab
Fe 1.0 kg ha^{-1} + Mo 0.05 kg ha^{-1}	1720 a	4853 ab	33.54 b	35.36 ab
Fe 1.0 kg ha^{-1} + Mo 0.10 kg ha^{-1}	1767 a	4930 a	34.72 a	38.36 a
LSD (0.05)	182.63	291.57	1.0881	3.1705

Means with similar alphabets in columns and rows are not significantly different from one another at $p<0.05$ using LSD.

1000 seed weight (g)

Data regarding thousand seed weight of lentil as affected by iron and molybdenum are shown in Table-2. The results showed that one thousand seed weight of lentil was significantly enhanced with foliar spray of Fe and Mo. Thousand seed weight was linearly enhanced with the application of Fe and Mo. Highest thousand seed weight (34.72 g) was observed for treatment receiving combined application of Fe at 1.0 kg and Mo at 0.10 kg ha^{-1} while lowest thousand seed weight (28.95 g) was produced in the control. These results suggested that both Fe and Mo applied alone or combined significantly increased 1000 seed weight of lentil over control. It might be due that soil of the experimental soil was deficient in available Fe and Mo. Our findings are in line with Rabbani *et al.* (2005) reported that *rhizobium* inoculants along with P and Mo produced significantly higher thousand seed weight of legumes. Khan *et al*. (2014) observed that maximum 1000-seed weight of chickpea (*Cicer arietinum*) was obtained from those treatment plots where Mo and Fe were applied.

Total N uptake kg ha^{-1}

Data presented in Table 3 showed that total N uptake of lentil was significantly improved with both Fe and Mo applied alone or combined over control. The results further revealed that maximum (90.40) kg ha^{-1} total N uptake of lentil was obtained with treatments receiving combined foliar application of iron at 1.0 kg ha^{-1} and molybdenum at 0.10 kg ha^{-1} followed by treatment (74.36) kg ha^{-1}receiving iron at 1.0 kg and molybdenum at 0.05 kg ha^{-1}. This was however statistically similar with all other treatments except treatment receiving Fe alone at 0.5 kg ha^{-1} in this experiment, while the minimum (60.28) kg ha^{-1} was recorded in control. This might be due to low content of Fe and Mo in the experimental soil. Our results are supported by Maurya *et al*. (1993) stated that N uptake was enhanced with Mo application in black gram. The N content in shoots and root and total N uptake in chickpea were significantly increased with iron and molybdenum application (Khan *et al*., 2014).

Protein content (%)

Data on protein content in Table 3 divulged that iron and molybdenum significantly increased protein content in lentil over control. The results further revealed that maximum protein content (28.03 %) of lentil was obtained for treatments receiving foliar application of iron @ 1.0 and molybdenum @ 0.10 kg ha^{-1} followed by treatment (27.31 %) where combined foliar application of iron and molybdenum @1.0 kg and 0.05 kg ha^{-1} were applied. This was however statistically at par with treatment receiving Fe, Mo or both in at any rate in this experiment. Fe and Mo are the basic constituents of the chlorophyll which helps improve the chlorophyll content and enzyme activation necessary for photosynthetic activities. Moreover Fe and Mo are integral components of nitrogenase enzyme which are essential for symbiotic N_2 fixation. These findings are similar to those of Togay *et al.* (2008) who observed that protein content of lentil was significantly affected by phosphorus and molybdenum. Oguz (2004) also found that increasing Mo application up to 6 g kg^{-1}considerably affected the protein content in chickpea.

Nodules number plant^{-1}

Data regarding nodules number plant^{-1} of lentil as affected by Fe and Mo are shown in Table-3. Results showed that both Fe and Mo applied alone or combined significantly increased number of nodules in lentil over control. Results indicated that maximum nodules number (32) in lentil was obtained for treatment receiving foliar application of iron @ 1.0 kg ha^{-1} and molybdenum @ 0.10 kg ha^{-1}while lowest (11) numbers of nodules were obtained in the control. This was because that Fe and Mo are integral part of nitrogenase enzyme which plays an important role in nodulation and symbiotic N_2 fixation. Similar investigation was also observed by Chakraborty

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(2009) who found that foliar application of Mo respond well in increasing nodules number lentil. Iron and molybdenum significantly enhanced nodules number in legumes crops (Brkics *et al.,* 2004).

Number of active nodules plant^{-1}

Data of active nodules plant^{-1} showed in Table-3 indicated that Fe and Mo significantly enhanced number of active nodules in lentil. Results declared that maximum number of active nodules (27) in lentil was obtained in the plots treated with foliar application of iron @ 1.0 kg ha^{-1} and molybdenum @ 0.10 kg ha^{-1} while lowest (9.00) numbers of active nodules in lentil were obtained in control. These results are an agreement with Tantawy *et al.* (2013) reported that Fe and Mo significantly enhanced active nodules number in broad bean. Similarly Bhuiyan *et al* (2008) stated that increased in active root nodules number in cowpea was because of molybdenum application.

Table-3. Effect of iron and molybdenum on quality parameters of lentil.

Treatments	Total N uptake (kg ha^{-1})	Protein content (%)	Total No of nodules plant^{-1}	No of active nodules plant^{-1}	No of non active nodules plant^{-1}
Control	60.28 g	25.85 f	11 h	9 f	2
Fe 0.5 Fe kg ha^{-1}	67.63 f	26.70 e	17 g	13 e	4
Fe 1.0 Fe kg ha^{-1}	71.19 e	26.83 de	19 f	15 d	4
Mo 0.05 kg ha^{-1}	71.99 de	27.00 cd	21 e	17 d	4
Mo 0.10 kg ha^{-1}	72.62 cd	27.14 bc	23 d	19 c	4
Fe 0.5 kg ha^{-1} + Mo 0.05 kg ha^{-1}	73.29 bcd	26.66 e	*25 d*	21 c	4
Fe 0.5 kg ha^{-1} + Mo 0.10 kg ha^{-1}	73.86 bc	26.73 e	27 c	24 b	3
Fe 1.0 kg ha^{-1} + Mo 0.05 kg ha^{-1}	74.36 b	27.31 b	29 b	26 a	3
Fe 1.0 kg ha^{-1} + Mo 0.10 kg ha^{-1}	90.40 a	28.03 a	32 a	27 a	5
LSD (0.05)	**1.3706**	**0.1779**	**1.5082**	**1.7861**	**NS**

Means with similar alphabets in columns and rows are not significantly different from one another at $p<0.05$ using LSD.
NS= Non significant

CONCLUSIONS

Micronutrients play a vital role in the growth and yield of legumes crops, it is therefore proved from our investigations that foliar application of iron and molybdenum significantly improved yield and nodulation of lentil. Grain yield, plant biomass, total nitrogen uptake kg ha^{-1}, one thousand seed weight (g), harvest index, protein content, nodulation and nodules activity were significantly enhanced by the combined application of Fe @ 1.0 and Mo @ 0.10 kg ha^{-1}. Much more experiments are required on micronutrients especially on iron and molybdenum for improving growth, yield, and seed quality and root nodulation of legumes crops.

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