IMPACT OF AMMONIUM SULPHATE (PAPER MAKER'S ALUM) ON SOME PHYSIOLOGICAL GROWTH CHARACTERISTICS OF LENTIL AND SOIL PARAMETERS

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Abstract: A field experiment was carried out to evaluate the effect of different levels of paper maker's alum on some soil and physiological growth parameters of lentil crop. The experiments were conducted in the research farm of the Botany Department of C.C.S.University, Meerut during Rabi season (2017-18). The effect of paper maker's alum concentrations (0.0% 0.5%, 1.0%, 1.5%) on pH and CEC value of soil, seed germination %, nodules attributing characters, plant length, fresh and dry matter production were studied. 1.5 % solution of paper maker's alum had a positive effect on soil parameters, biomass and other plant growth parameters.

Index terms - *Lens culinaris.* L, cation exchange capacity, ammonium sulphate, fertilizer.

1. INTRODUCTION

Lentil (*Lens culinaris* Medikus subsp. *culinaris*) is a diploid (2*x* = 14 chromosomes) autogamous annual legume with a haploid genome size of an estimated 4063 Mbp (Abraham Reda et al. 2015). In India, lentil is the second most important Rabi legume crop after chickpea. It is cultivated on 1.47 million hectares area with an annual production of 1.04 million tones with productivity around 705 kg/ha during 2014 (Agricultural Statistics Division, 2014-2015). It is mainly grown as rain fed crop in Uttar Pradesh, Madhya Pradesh, Chhattisgarh, Punjab, Haryana, Jharkhand, Bihar, Rajasthan, Uttarakhand, West Bengal, Jammu and Kashmir and some north eastern states (Choudhary et al. 2017). Like other leguminous crops lentil also has availability to fix the atmospheric nitrogen by the process of nitrogen fixation but due to environmental stresses or poor nutritional soils affect the nitrogen fixation capacity of the plants and reduce the crop productivity. To overcome this problem plants needs fertilizers which provide essential elements to cope with this stresses. Nitrogen and sulfur are essential nutrient elements with a remarkable effect on crop growth and productivity (Harper, 1994). The normal growth of plant highly depends on nitrogen supply. Increase in nitrogen supply can stimulate plant growth and productivity (Joel et al. 1997) by improving photosynthetic activity (Makino et al. 1992). Leguminous plant species also require a large quantity of sulfur, because of their high protein content (Padovani et al. 2007). Sulfur deficiency in legume crops not only affects yield efficiency, but also affects the quality and the nutritional value of the seeds (Sexton et al. 1998, D'Hooghe et al. 2013). Methionine (S- containing amino acid) is the most limiting essential amino acid in legume seeds (Friedman, 1996) which helps in the nitrogen fixation capacity of legume crops. Ammonium sulphate is the only fertilizer which provides essential elements: sulfur (24%-29%) and nitrogen (21%) (Hzhbryan et al. 2014) to a crop which enhances the nitrogen fixation capacity and crop productivity to increase some physiological growth characteristics like germination percentage (%), nodule attributes, plant length, podulation, fresh and dry matter production. Ammonium sulphate has the capacity to change the soil texture and pH as ammonium sulphate rapidly dissolves into its ammonium ion and sulfate components. The nature of ammonium ion is acidic that lowers the pH of soil and changes the cation exchange capacity and provides better internal environment to nutrient uptake by plants and maintains healthy nitrogen levels in the soil which in turn enhances the nitrogen fixation capacity of nodules.

A lot of research work has been done by many researchers in respect to the use of ammonium sulphate as a sulfur fertilizer or as a nitrogen fertilizer but in the present study we checked the ammonium sulphate's potential as a sulfur and nitrogen fertilizer.

I. METHOD AND MATERIAL

Geographical situation:

The Choudhary Charan Singh University campus, Meerut (U.P. India) is situated between 29^0 01N latitude and 77^0 45E longitudes at an altitude of 237 meters above sea level. The total geographical area of Meerut district is 2564 km^2. The district falls under western plain zone of Uttar Pradesh, sub-region of Upper Gangetic plain.

Material used:

Certified seeds of *Lens culinaris.* L. (Pusa vaibhav) from IARI, New Delhi and Paper maker's alum (ammonium sulphate; $(NH_4)_2SO_4$) from Fisher scientific company.

Experimental site:

The field experiment was conducted during the Rabi season in the month of November to January during 2017-2018 to evaluate the "impact of paper maker's alum on some physiological growth characteristics of lentil and soil parameters"

II. Preparation of stock solution:

Three samples of different concentrations of ammonium sulphate solution were prepared. For this 5, 10 and 15 gm of ammonium sulphate were dissolved in each of 1 liter of double distilled water.

1. 05 gm + 1000 ml distilled water (0.5%)
2. 10 gm + 1000 ml distilled water (1.0%)
3. 15 gm + 1000 ml distilled water (1.5%)

III. Experimental Details:

Four levels of ammonium sulphate as 0, 5, 10, and 15 gm/1000 ml distilled water in soil were used in this experiment, resulting in a total of 4 treatments (control, 0.5%, 1.0 %, 1.5% $(NH_4)_2.SO_4$). Four small land plots, each of 1X1 meter^2 were sprayed with each of four solution of treatments i.e. control, 0.5%, 1.0 %, 1.5% $(NH_4)_2.SO_4$.

pH: pH of soil was measured by the method as adopted by Covington (2009).

Cation exchange capacity: CEC of soil was measured by the method of Jones (1967).

Moisture content: Moisture content of the soil was measured by the method adopted by Reeb (1999).

Seed viability: The seeds were checked for their viability by using the test made by Lamarca (2014).

Seed Germination Assay ISTA (1976):

Number, weight and volume of nodules: Nodules from different five plants of each treatment including the test plant (control) were collected at morning on the same day for the determination of number, weight and volume of nodules of the lentil plants. Healthy lentils plants were uprooted carefully so as to get intact plants. The detached roots were washed in smoothly running tap water to remove the adhering soil particles from the nodule surface (if any). These were brought in laboratory without any delay. From the roots, pink colored nodules were carefully collected by the forceps. Root nodules of the five plants from each plot were counted and their numbers were recorded and weight of nodules was measured using Sartorius digital analytical balance CP124S machine. The volume of nodules was measured through the volumetric syringe.

Length, weight of plants: The whole plant at the age of full maturity was harvested from each treated plots including control. Then they were collected in the plastic tray and brought to laboratory. The whole plant length was sum up of the length of root and shoot. After measuring fresh weight of the plants using Sartorius digital analytical balance CP124S machine. They were collected separately in the paper envelope and kept in an oven at 120 ^{0}C for 30 minutes followed by complete drying at 80 ^{0}C at least for 48 hours or till they get whole drying. The dried plants were weighted again in gm.

IV.RESULT AND DISCUSSION

Table1 – Effect of ammonium sulphate on pH and cation exchange of soil.

Treatment	pH	CEC
Control	7.78	9.90
Ammonium sulphate 0.5%	7.17	9.24
Ammonium sulphate 1.0%	6.99	8.80
Ammonium sulphate 1.5%	6.90	8.58

pH of soil: Ammonium sulphate is an inorganic salt that was used as a soil fertilizer in the present experiment. It is known to contain 24% sulfur and 21% nitrogen. It is primarily used as a fertilizer for alkaline soils. Minimum pH as 6.90 of the soil was observed in case of 1.5% ammonium sulphate as compared to the control and other ammonium sulphate treated soils as 7.78, 7.17 and 6.99, respectively (Table 1). However, maximum pH of soil was observed in the control soil. Ammonium sulphate rapidly dissipates into its ammonium and sulphate components. If it remains on the soil surface, the ammonium may be susceptible to gaseous loss in alkaline conditions. To overcome this, it is advisable to incorporate the chemical to be used in the soil as soon as possible or as it is applied before irrigation events or even before a predicted rainfall. Most plants are able to utilize both ammonium and nitrate forms of nitrogen for growth. In warm soils (dry climatic soils), microbes rapidly start to convert ammonium to nitrate in the process of nitrification [$2\ NH^{4+} + 3O_2 \rightarrow 2NO^{3-} + 2H_2O + 4H^+$]. During this microbial reaction, [H^+] is released, which ultimately decrease the soil pH after repeated use. Ammonium sulphate has an acidifying effect on soil due to the nitrification process (due to ammonium ions), not from the presence of sulphate, which has a negligible effect on pH. The acid-producing potential of ammonium sulphate is greater than that of the same nitrogen application from ammonium nitrate. Similar kinds of results have also been reported earlier (Majdi et al. 1995).

Cation exchange capacity: The main ions associated with CEC in soils are the exchangeable cations: calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^+) and potassium (K^+) (Rayment & Higginson, 1992). The maximum CEC of soil was observed in the control soil (9.90) and minimum in the 1.5% ammonium sulphate (8.58) treated plots. As the concentration of ammonium sulphate solutions increases from 0.5 to 1.5%, the value of CEC decreases as 9.24, 8.80, and 8.58, respectively. It may be due to the application of ammonium-based fertilizers and the growth of legumes which cause acidification of the soil (lowering the pH) which in turn causes the loss to the base cations and reduces the CEC of soils (Goulding, 2016). Similar kinds of results have also been reported by Fenn et al. (1976).

Table 2- Effect of ammonium sulphate on seed germination percentage of *Lens culinaris*.

Treatment	Germination %		
	7 days after sowing	14 days after sowing	21days after sowing
Control	36	43	44
Ammonium sulphate 0.5%	34	42	45
Ammonium sulphate 1.0%	33	43	46
Ammonium sulphate 1.5%	30	49	49

Germination Percentage (%): Seed germination is the most critical stage in seedlings establishment and decides successful level of crop production as reported by Peralta et al. (2001). In initial analysis of the seed germination % (Table 2) it was found that germination % decreases gradually from control to 1.5% ammonium sulphate treatment in starting days of seed germination (7 d) but after that in 14 and 21 days of sowing, the decrease in germination % is held as was found higher. Similarly, 1.0% ammonium sulphate also showed better germination percentage in comparison to control and 0.5% ammonium sulphate. In starting days the decrease in germination % is held as ammonium sulphate has 21% nitrogen contents which produces ammonia and generates osmotic pressure, responsible to delay germination %. Higher germination % with 1.5% ammonium sulphate is attributed to the secondary metabolites of sulfur like as methionine that plays an important role in a variety of metabolic processes like synthesis of protein, S-adenosyl methionine, ethylene and polyamine. All of these are essential for germination of seeds as well as seedlings growth. Methionine synthase and S-adenosylmethionine synthetase are the basic components needed during switching from a dormant to a highly active metabolic state in the seed germination process (Gallardo et al., 2002) and chemical stimuli like $N0_3^-$ to break dormancy (McIntyre et al. 1996). Similar kinds of findings with explanations have also been submitted by Chien et al. (2011.) and by Dostálová et al. (2015).

Table 3- Effect of ammonium sulphate on various attributes of nodules of *Lens culinaris.*

Treatment	Number of nodules (no.)	Volume of nodules (ml)	Weight of nodules(gm)
Control	61	0.656	0.570
Ammonium sulphate 0.5%	49	0.598	0.555
Ammonium sulphate 1.0%	99	0.662	0.600
Ammonium sulphate 1.5%	111	0.694	0.650

Nodule attributes: Recorded data on number, volume and weight of nodules plant-1 were found maximum with the treatment of 1.5% ammonium sulphate (Table3). Minimum amount of ammonium sulphate suppress the nitrogenase activity of the plant which consequently suppresses the nodulation attributes. Nitrogenase enzyme activity suppresses very quickly at low concentration of ammonium sulphate (Kamberger, 1977) but otherwise increases the nodulation parameters when applied in the higher concentrations. Higher concentrations of ammonium sulphate enhance the nodulation parameters: the reason behind may be because the sulfur enhances the metabolic activity of a plant and promotes chlorophyll, amino acid, and protein synthesis. Choudhary and Das (1996) also reported the beneficial effect of sulfur by lowering the soil pH and improving the physical conditions of the soil and enhancing the nodule attributing characters. Similar results have been reported by Deo & Khandelwal (2009), Dhewal et al. (2017).

Table 4– Effect of ammonium sulphate on plant length (cm) of *Lens culinaris* .

Treatment	Root length	Shoot length	Total length
Control	16.2	43.0	60.2
Ammonium sulphate 0.5%	16.6	44.8	61.4
Ammonium sulphate 1.0%	16.6	45.0	61.6
Ammonium sulphate 1.5%	18.0	46.9	64.9

Plant length: The treatment given in the soil as ammonium sulphate sprays significantly influenced the lentil growth. The highest value of plant height (64.9 cm) was found in 1.5% ammonium sulphate a treated plot which was significantly superior to all the other treatments and as compared to the control (Table 4). The improvement in growth characters with the application of ammonium sulphate may be attributed to the higher availability of sulfur in the rhizosphere system of the plants resulting in increased uptake of nutrients used in photosynthesis and enhancing the growth attributes (Dhewal et al. 2017). Nitrogen also plays an important role in growth of plants as ammonium (NH_4^+) being the main source of available nitrogen for plant growth (Youngquist et al.1992, Hassanein, 1996). Further it is also an essential component of structural amino acid, amides, nucleotides, and nucleoproteins and to cell division, expansion and non-structural components of plant cells (Mengel & Kirkby, 1979, Farooqui et al. 2009). Their results were coincided with those of the present study i.e., plant length. Hzhbryan et al. (2014) also recorded similar kind of observations in their study.

Table 5– Effect of ammonium sulphate on number of pods plant-1 and number of seeds pods-1 in *Lens culinaris*.

Treatment	number of pods plant-1	number of seeds plant-1
Control	54	96
Ammonium sulphate 0.5%	60	105
Ammonium sulphate 1.0%	69	120
Ammonium sulphate 1.5%	80	150

Number of pods plant-1 and number of Seeds pods-1: The data regarding number of pods plant-1 and number of seeds pods-1 are presented in the Table 5. Maximum pods plant-1 (80) were obtained with the application of 1.5% ammonium sulphate solution as compared to 1.0% (69), 0.5% solutions (60) of ammonium sulphate and control (54). Maximum seeds pods-1 (150) were obtained with the application of 1.5% ammonium sulphates as compared to 1.0% (120), 0.5% solution(105) and control (96). It may be explained on account of to the fact that sulfur promotes the chlorophyll, amino acid, and protein synthesis activity (Akter et al. 2013). Contrarily, nitrogen also plays an important role in photosynthetic activity (Makino et al. 1992) and for normal growth of plants (Hassan et al. 2006). Increase in nitrogen supply can stimulate plant growth and productivity (Joel et al. 1997) by improving photosynthetic activity (Makino et al. 1992). Overall the number of pods plant^{-1} and number of seeds pod^{-1} got increased because nitrogen and sulfur both are the essential elements released from the ammonium sulphate to the soil, which help enhance the crop growth and their productivity. These results are in line with the early research work done by Sattar et al. (2011), Sharifi et al. (2012) and Anjum et al. (2017).

Table 6– Effect of ammonium sulphate (0.5%, 1.0%, and1.5%) on fresh and dry matter production and total moisture content of *Lens culinaris*.

Treatment	Total fresh weight of plant (TFW)	Total dry weight of plant (TDW)	Total moisture content of plant (TDC)
Control	8.47	2.09	6.38
Ammonium sulphate 0.5%	8.80	2.37	6.44
Ammonium sulphate 1.0%	10.14	2.61	7.40
Ammonium sulphate 1.5%	10.89	2.87	8.15

Fresh and dry matter production and total moisture content: Application of ammonium sulphate caused significant changes in fresh and dry weight along with moisture content of plants. The differences were noticed among all treatments with regard to their dry and fresh weight production and moisture content of the plants (Table 6). However, TFW, TDW, TMC of 1.5% ammonium sulphate treated plots were significantly superior to rest of the other treatments including 0% ammonium sulphate. The effects of the ammonium sulphate (1.5% solution) on the fresh and dry weight content, and total moisture contents of the plants are affected by many eco - physiological factors such as uptake of sulfur and nitrogen or other essential elements (better availability of nutrients and moisture), photosynthetic pigment content, protein contents, cell division (Hanshal et al. 2014). Hence such mechanism increases the growth of roots and shoots system which increases the fresh and dry matter contents and moisture contents of the plants. These findings are in conformity with those of Hassan et al. (2008) and Ehsan et al. (2017).

V. CONCLUSION

From the results obtained one can be concluded that significant decrease in soil pH and CEC values of soil is obtained with the application of 1.5% ammonium sulphate solution. Further, with this treatment there is also seen an enhancement in the germination %, nodules attributes as well as growth and yield attributes. Essentially true this concentration of ammonium sulphate is useful for the crop.

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