Effectiveness the source of nitrogen from NO$_3$ and NH$_4$ for *Panicum maximum* Jacq. growth in saline soil

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Abstract. The purpose of this study was to determine the source of nitrogen used by *Panicum maximum* Jacq. plants in salt soil. Experimenting pots in a greenhouse with a medium of saline soil. The 2 × 3 factorial design is used in repeated trials. The first factor is calcium sulfate (0 and 2 t ha$^{-1}$), the second factor is N fertilizer includes (a) without nitrogen = N0, (b) 60 kg N of potassium nitrate (KNO$_3$) and (c) 60 kg N of ammonium sulfate (NH$_4$SO$_4$). The parameters observed were nitrogen uptake, constant growth rate (CGR), biomass yield, crude protein content, NDF, and ADF. The interaction of calcium sulfate and nitrate fertilizer increases CGR, biomass yield, N uptake, CP, and ADF. The interaction calcium sulfate and ammonium fertilizer increase CGR, biomass yield, N uptake, CP, and ADF.

Keywords: Feed productivity, fertilizer, Guinea grass, soil fertility, turgor plant pressure.

1. Introduction

The saline soil is a soil condition caused by the accumulation of NaCl salt dissolved in the soil [1]. The main soluble salts in the soil are Na$^+$ (sodium), Ca$^{2+}$ (calcium), Mg$^{2+}$ (magnesium) and K$^+$ (potassium), and Cl$^-$ (chloride), SO$_4^{2-}$ (sulfate), HCO$_3^-$ (bicarbonate), CO$_3^{2-}$ (carbonate) and NO$_3^-$ (nitrate) [2]. The acidity (pH) of the saline soil is about 8.5 and the Na cation exchange is less than 15 %. The conductivity value of the saline soil reaches a value of 4 dS m$^{-1}$ [3].

The ability of plants to use nitrogen from the soil depends on the type of soil, environment and plant species [4]. Environmental factors that affect the growth and development of plants are nutrients. Nutrient management is essential for normal growth and crop production [5]. One of the macro nutrients needed by plants is nitrogen. N deficiency results in (i) reduced the ability of photosynthetic plants due to decreased leaf area, (ii) N leaf content decreases [6].
Nitrogen nutrients can enter the plant in the form of nitrate (NO$_3^-$) and ammonium (NH$_4^+$) and amino acids. In saline conditions, where excessive Na$^+$ and Cl concentrations are present in the complex, there will be competition with other nutrient ions such as K$^+$, NO$_3^-$, H$_2$PO$_4^-$, which will affect N uptake into root cells [7]. In the soil solution, nitrogen can be nitrate (NO$_3^-$) or in the form of ammonium (NH$_4^+$) [8]. In the plant body, nitrogen can be in the form of nitrate, ammonium and inorganic N. Information on the source of nitrogen fertilizer for grass feed applied to the saline soil is still very limited. The type of nitrogen source favored by the grass of Guinea (Panicum maximum Jacq.) in salt soils is the subject of this study.

2. Materials and methods

The experiment was carried out at the Ecology and Plant Production Laboratory of the Department of Agriculture, Faculty of Animal Husbandry and Agriculture, Diponegoro University, Indonesia from March to October 2012. The study was a pot experiment designed using a complete randomized design of 2 x 3 factorial pattern repeated three times. The first factor is calcium sulfate (0 t ha$^{-1}$ and 2 t ha$^{-1}$), the second factor is nitrogen including (a) without nitrogen = N0, (b) nitric fertilizer (KNO$_3$) of 60 kg N ha$^{-1}$, and (c) ammonium fertilizer (NH$_4$SO$_4$) of 60 kg N ha$^{-1}$.

The soil media used is saline soil taken from the North coast of Central Java. The texture of the soil includes clay with a N content of 0.08 %. The exchanged of K, Ca and Mg were for each (0.4; 1.26 and 0.5) cmol kg$^{-1}$. The acidity of soil was 7.8. The volume of pot used 8 kg. Calcium sulfate according to the treatment is mixed with the soil evenly and filled into the pot, then the pols grass Guinea is planted in pots.

Plants were given a superphosphate fertilizer of 30 kg P$_2$O$_5$ ha$^{-1}$ and KCl with a dose of 30 kg K$_2$O. At the age of 1 mo, the whole plant is pruned. Once trimmed, the plants are nitrogen fertilized according to the treatment. Plants kept up to 45 d. The parameters observed were nitrogen uptake, constant growth rate (CGR), biomass yield, crude protein content, NDF and ADF. Crude protein content measured by Kjeldahl method and fiber component based on Van Soest method [9]. ANOVA test results were followed by DMRT [10].

3. Result and discussion

3.1. Crop growth rate (CGR)

In saline soil, plant growth rates were approximately (0.36 to 5.0) of g plant d$^{-1}$ (table 1) with the highest CGR values in the N ammonium and calcium sulfate treatments. The interaction between calcium sulfate and no nitrogen application has no effect. The growth of crops affected by Ca sulfate treatment increased by 152 %.

The application of nitrogen in the form of NO$_3^-$ and NH$_4^+$ had the same effect on CGR, which increased to 72.2 % of NO$_3^-$ and 122 % in NH$_4^+$ form (table 2). In this study, the growth rate measured in the vegetative phase of the plant and the accumulation of dry matter was observed during the vegetative phase. Plant growth can be divided into three phases: germination, vegetative, and generative. Vegetative growth occurs at the time of root development, leaves and stems. Generative growth occurs in the formation of flowers and seeds.

Plant growth is influenced by genetic and environmental factors. Genetic factors affect the physiological processes of plants. Environmental factors that affect plant growth are temperature, soil moisture, and nutrition. Plants that are responsive to nutritional limitations vary between different organs and processes. The greatest effect is the growth of total crops.

The study of Orndorff et al. [11] showed that Na of 1.62 me 100 g$^{-1}$ in saline soil causes the solution to be concentrated causing the lower turgor plant pressure. Turgor pressure is associated with the opening and closing of the stomata. Gastal and Lemaire [12] reported that the growing sites and plant growth phases greatly affected the N plant content. If the N excess of soil is excessive then the N content of the plant is related to the rate of plant growth and biomass yield. Ali and Hameed [13] reported that the dose of nitrogen fertilizer resulted in increased plant growth (CGR).
Table 1. Mean square effect of calcium sulfate and nitrogen sources treatment on CGR, forage yield, N uptake, CP, NDF and ADF

| Mean square:       | CGR  | Forage | N uptake | CP    | NDF  | ADF   |
|-------------------|------|--------|----------|-------|------|-------|
| Ca sulfate        | 30.160* | 859797.555* | 59892.605* | 5.848* | 180.500* | 296.0556* |
| Nitrogen (N)      | 7.086 *   | 103940.167* | 13075.101* | 6.512* | 57.056 | 81.500* |
| Ca sulfate*N      | 0.549   | ns     | 9798.722* | 1936.022* | 0.136 | ns    |

* significant   ns: not significant
CP: crude protein,  NDF: neutral detergent fiber, ADF: acid detergent detergent fiber.

3.2. Biomass yields

Under soil conditions without calcium sulfate, nitrogen application increased biomass yield (38.55 % KNO$_3$ and 55.43 % NH$_4$SO$_4$) compared with no nitrogen. The application of calcium sulfate to the soil improves biomass yield (19.24 % NO$_3$ and 45.79 % NH$_4$) compared treatment without nitrogen. The results yield biomass of (13.8 to 42.66) t ha$^{-1}$. Assimilation, photosynthesis, and respiration greatly affect the yield of plant biomass. How cultivation, climate, environmental conditions as well as plant organs and plant life is critical to the production of plants. The vegetative phase and the generative phase also determine the production of plants [4]. Forage yield increases with increasing nitrogen dosage. Decreased cell membrane permeability can occur due to high salt content, consequently reduced water absorption and dissolved nutrients [14]. In saline soil, water absorbed by plants is small, this condition causes a narrowing of the stomatal opening which results in the reduced CO$_2$ intake. As a result, there is chloroplast damage and leads to a decrease in the net result of photosynthesis. Ammonium-treated plants show better growth than nitrate-treated plants under high salinity conditions.

Under saline conditions, NH$_4^+$ is associated with increased antioxidant enzyme activity in Spartina alterniflora Loisel. indicating that NH$_4^+$ is more advantageous than NO$_3^-$. The activity of the antioxidant enzyme is stimulated by NH$_4^+$ to limit major oxidative damage [15]. Growth and development of plants require nitrogen because nitrogen is an important part of the structure of chloroplasts and proteins. Nitrogen deficiency is readily recognizable in horticultural crops, but nitrogen excess effects on the quality of horticultural crops have not been studied [16].

Dry matter production is affected by the time of administration of nitrogen. Nitrogen giving an effect on improving NUE and ANR. The nitrogen content increases linearly with increasing dose of N being given. The highest nitrogen efficiency and optimum results have achieved a result of a dose of N of 100 kg N ha$^{-1}$ [17]. VonWiren et al., [18] reports on the preference of plant crops against one type of N source compared to other forms. The taking of N in certain form corresponds to growth-related plant needs when N enters the root surface. In addition, many plants contain large amounts of N during vegetative growth and in the generative stage. As consequence, the system responsible for transport N needs to be regulated and its activity during the availability and needs of the N plant.

3.3. Nitrogen uptake

The addition of calcium sulfate treatment (CaSO$_4$.2H$_2$O) resulted in an average increase in N uptake of 161.71 % versus no calcium sulfate (table 2). Compared with non-nitrogen treatment, the N uptake of NO$_3$ treatment was increased by 74.35 %, while the NH$_4^+$ treatment rate increased by 142.76 %. In the addition of calcium sulfate and NO$_3$-fertilizer increased N uptake of 32.53 % while calcium sulfate-NH$_4^+$ increased by 96.83 %.

Based on Rodriguez et al. [12] that the biomass of food crops and accumulation of N depends on the physiological processes within the plant. N absorption, C intake and growth rate, and the allocation of C and N in the organs and in plants have their own characteristics. The soil condition with N amount is available much then the N uptake of the plant depends on the availability and distribution of N soil and at the root. If N content is available enough then N uptake is highly dependent on the rate of plant growth.
Table 2. Crop growth rate, biomass yield, N-uptake, crude protein and fiber affect calcium sulfate and nitrogen sources.

| Treatment                     | CGR       | Biomass yield | N uptake | CP | NDF | ADF |
|-------------------------------|-----------|---------------|----------|----|-----|-----|
|                               | g plant⁻¹ d⁻¹ | t ha⁻¹        | g kg⁻¹   | % |     |     |
| No Calcium Sulfate            |           |               |          |    |     |     |
| No N                          | 0.36d     | 13.8f         | 41.37e   | 4.0d | 40.6b | 37.3d |
| NO₃⁻                         | 1.7c      | 19.12e        | 72.13de  | 5.0c | 41.3b | 44.3bc |
| NH₄⁺                         | 3.1b      | 21.45d        | 100.43cd | 6.3b | 42.6b | 42.6cd |
| Calcium Sulfate               |           |               |          |    |     |     |
| No N                          | 3.4b      | 29.26c        | 130.43c  | 5.3c | 41.6b | 45.3bc |
| NO₃⁻                         | 4.5a      | 34.89b        | 172.87b  | 6.3b | 52.0a | 49.3ab |
| NH₄⁺                         | 5.0a      | 42.66a        | 256.73a  | 7.1a | 50.0ab | 54.0a |
| Average:                      |           |               |          |    |     |     |
| No Calcium Sulfate            | 1.7a      | 18.12a        | 71.3a    | 5.1a | 41.5a | 41.4a |
| Calcium Sulfate               | 4.3b      | 35.61b        | 186.6b   | 6.2b | 47.8b | 49.5b |
| No N                          | 1.8c      | 21.53c        | 85.9c    | 4.6c | 41.1a | 41b  |
| NO₃⁻                         | 3.1b      | 27.00b        | 122.5b   | 5.6b | 46.6a | 46a  |
| NH₄⁺                         | 4.0a      | 32.06a        | 178.5a   | 6.7a | 46.3a | 48a  |

*abc* Means in the same column the same letter are not different at *P* < 0.05

3.4. Crude Protein (CP)

CP plant level is influenced by calcium sulfate and nitrogen form. The interaction between Ca sulfate and nitrogen is not significant. The average treatment of calcium sulfate increased CP by 21.5%. Application of NO₃-nitrogen form significantly (*P* < 0.05) increased CP 21.7% and NH₄⁺ significantly (*P* < 0.05) increased CP by 45.6%. This is because the soil media research is a saline soil that has a problem of soil fertility.

In addition to soil fertility, protein content is influenced by the ratio of leaf-stem, growth phase, plant defoliation and fertilization. Plant tissues contain nitrogen in the form of dissolved proteins and insoluble proteins, amino acids, amides, urea, nitrites, and ammonia. Proteins are all non-protein N and N components. Chloroplasts and cytoplasm contain 75% to 90% protein in the grass and more than 50% of these proteins function as ribulose enzymes in the phosphate. The amino acid composition of the plant protein is relatively constant and quite abundant in the plant. Experiments [16] shows that the quality of horticultural crops, including quality and taste, is directly influenced by the availability of N. Adequate nitrogen is essential for growth and development of plants to grow normally. Sufficient nitrogen in the plant is part of the protein and chloroplast structure.

Nitrogen is most needed by plants rather than other nutrients. Nitrogen is an element required for all types of plants, the chemical N forms in the soil are NO₃⁻ and NH₄⁺ [18, 8]. According to [4] the availability of soil nitrogen fluctuates due to precipitation, temperature, wind, soil type and pH. The preferred N shape depends on the adaptation of the plants to soil conditions.

Plants that adapt to low pH tend to contain ammonium, while plants adapted to higher pH and more on aerobic soil prefer nitrates. The plants experiencing difficulties in the removal of nitrogen from soil solutions, were able to grow comparable to plants growing on soils with much higher nitrogen levels. Certain plants have developed mechanisms to survive. Potentially toxic N-soil concentrations primarily derived from NH₄⁺ [8].

3.5. Neutral detergent fiber (NDF)

The interaction between calcium sulfate and nitrogen form has no significant effect on NDF plants. The effects of calcium sulfate are apparent in NDF while nitrogen fertilizer application is not
significantly different. The productivity of the plant is largely determined by nitrogen. According to leaf area, plant biomass, leaf content, leaf area index and PAR decreased due to deficiency N.

Kering et al. [19] reported that CP, TDN, and mineral content of P and Mg increased, while ADF and NDF decreased due to administration increased doses of nitrogen fertilizer. Crude protein increased by ≥ 50%, and ADF and NDF fell by 25%. Repeated (split) N applications produce low quality forages compared to N applications once but do not affect forage yields. The acidity values dependent on the equilibrium of NH₃ ions and NH₄⁺ ions, whichever is more dominant in all physiological conditions and is a determinant of Acid Detergent Fiber (ADF) [4].

The interaction between calcium sulfate and nitrogen form has no significant effect on ADF plants. The application of calcium sulfate does not decrease the plant ADF. Nitrogen fertilizers in the form of nitrates have the same effect as NH₄⁺ compared to no-nitrogen fixing. Amin [20] reported that crude fiber and crude protein are affected by nitrogen sources. Urea provides the lowest crude protein content (8 %), highest biomass (64.80 t ha⁻¹) and the lowest soluble carbohydrate (12.80 %) and fiber content (31.90 %). When the dosage of nitrogen fertilizer increases, the level of crude protein increases but the crude fiber content decreases.

4. Conclusion
Application of calcium sulfate to saline soil and NO₃ interaction-improves CGR, biomass yield, N, CP and NDF uptake. Calcium sulfate in salt soil and NH₄⁺ interaction increase CGR, biomass yield, N uptake, CP, and ADF. Guinea grass (Panicum maximum Jacq.) prefers NH₄⁺.

Acknowledgments
The author would like to thank the University of Diponegoro, Indonesia for the received research fund. We would like to thank the Faculty of Animal Husbandry and Agriculture Sciences, Diponegoro University, Semarang, Indonesia for research facilities.

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