# Studies on the Effects of Potassium Ion on *Nostoc Muscorum*[1]

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## ABSTRACT

In the present study the effect of potassium on *Nostoc muscorum* has been analyzed in terms of total growth, total carbohydrate, proteins and amino acids using 1 mg/l to 10 mg/l concentrations of potassium. All the growth and physiological parameters increases regularly upto 1 mg/l and after this level, these rapidly decreases up to 10 mg/l. High levels of $K^+$ have not affect the total dissolved solids and electrical conductivity. Heterocyst frequency calculated after growth period of 18 days. Heterocyst frequency and enzyme activities of *N. muscorum* regularly increases under all the concentrations of $K^+$.

**Keywords:** *Potassium, Growth Parameters, Heterocyst Frequency, Nostoc muscorum*

## INTRODUCTION

Potassium is one of sixteen essential nutrients required for plant growth and reproduction. It is classified as a macronutrient and chemical symbol for potassium is "K." It is taken up by plants in its ionic form ($K^+$). Elemental potassium (K) is not found in pure state in nature because of its high reactivity. All naturally occurring potassium contained in the soil originated from the disintegration and decomposition of potash-feldspars and micas. Much of the natural potassium occurring in soils is not available to plants and crops; therefore, soils containing relatively large amounts of total potassium usually respond to potassium fertilization.

Potassium is essential in nearly all processes needed to sustain plant growth and reproduction. It acts as a chemical traffic policeman, root booster, stalk strengthener, food former, sugar and starch transporter, protein builder, breathing regulator and as a disease retarder. Potassium is an essential element for the development of chlorophyll. It plays an important role in photosynthesis, i.e., converting carbon-dioxide and hydrogen into sugars, for translocation of sugars and in starch formation. It improves the health and vigour of the plant, enabling it to withstand adverse climatic conditions. It increases the crop resistance to certain diseases. Potash plays a key role in production of quality vegetables. Potassium is an enzyme activator and increases the plumpness and boldness of grains and seeds. It improves the water balance, promotes metabolism and increases the production of carbohydrates. Although potassium is not an integral part of any major plant component, it does play a key role in a vast array of physiological processes from protein synthesis (Leigh and Jones, 1984; Walker *et al.,* 1998) to maintenance of plant water balance (Hsiao and Lauchli, 1986). Potassium is known to activate at least 60 enzymes involved in plant growth, including many that are essential for photosynthesis and respiration (Evans and Sorger, 1966) and it also plays a vital role in starch synthesis (Nitsos and Evans, 1969) and many other processes (Marschner, 1995). It has been shown that high levels of potassium prevented inhibition of photosynthesis under dehydration stress. According to Iyer et.al. (2015), the shape of *Coelastrella oocystiformis* and *Chlorolobion braunii* plays a role in their ability to absorb potassium at various concentrations.

## MATERIAL AND METHODS

Study was done in two stages. At first stage, *Nostoc muscorum* was grown and maintained as unialgal, clonal and axenic cultures in nitrogen-free Allen and Arnon's culture medium (1955) at 1800 lux and 28± 2°C. At second stage, stock solution of potassium chloride was prepared and it was then diluted with sterile distilled water to get concentrations ranging between 0.1 to 10 mg/l. Experiments were carried out

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in triplicate in 125 × 25mm test tubes with a total volume of 15ml (medium plus toxicant). Controls were maintained. The readings were recorded after a growth period of 18 days.

Growth was measured by taking optical density of chlorophyll pigments at 630, 645 and 665nm by UV-VIS spectrophotometer Systronics-117. Total carbohydrate content was estimated by acid hydrolysis Anthrone reaction method (Plummer, 1979). Total protein content was estimated by Lowry's method (Lowry et al. 1951). Total content of amino acid was estimated by Ninhydrin method (Mahadevan A. and Sridhar R. 1982). Heterocyst frequency of exponentially growing cultures was determined after the growth period of 18 days by calculating an average of 5 fields under microscope. Percentage heterocyst frequency as represented indicates number of heterocyst per 100 vegetative cells.

## RESULTS AND DISCUSSION

Growth experiments were designed using various concentrations of potassium ranging from 0.1 mg/l to 10 mg/l. The test organisms cultured in K-free medium upto five to six generations. Effect of various concentrations on growth patterns of test alga has been observed. Statistical data obtained included standard error of mean, coefficient of variance and coefficient of deviation at 5% and 1% level of significance.

All the growth and physiological parameters increases regularly upto 1 mg/l and after this level, these rapidly decreases up to 10 mg/l (Tables-1 & Fig 1). So, above 1 mg/l $K^+$ concentration, the inhibition level regularly increases with *Nostoc muscorum.* Heterocyst frequency of *N. muscorum* regularly increases under all the concentrations of $K^+$ indicating that it can fix nitrogen also under supra-optimal conditions of $K^+$.

pH of culture supernatant increases upto 0.6 mg/l only and after this level, all tested culture media becoming more acidic with the increasing $K^+$ concentrations. This indicates tolerating power of *N. muscorum* towards high levels of $K^+$ is directly proportional to pH (Table 1).

| Concentration (mg/l) | Total growth (mg/l) | Total carbohydrate (mg/l) | Total protein (mg/l) | Total Amino Acids (mg/l) | pH | TDS (ppt) | EC (µS/cm) | HF (%) |
|---|---|---|---|---|---|---|---|---|
| **Control** | 0.009 | 0.033 | 0.018 | 0.007 | 7.42 | 0.86 | 1.75 | 4.83 |
| **0.1** | 0.078 | 0.079 | 0.053 | 0.013 | 7.41 | 1.07 | 2.14 | 4.86 |
| **0.2** | 0.093 | 0.095 | 0.082 | 0.027 | 7.43 | 1.09 | 2.18 | 4.93 |
| **0.3** | 0.167 | 0.141 | 0.089 | 0.029 | 7.39 | 1.14 | 2.29 | 5.28 |
| **0.4** | 0.205 | 0.169 | 0.138 | 0.051 | 7.40 | 1.18 | 2.36 | 5.61 |
| **0.5** | 0.362 | 0.237 | 0.151 | 0.067 | 7.43 | 1.15 | 2.30 | 5.79 |
| **0.6** | 0.489 | 0.383 | 0.189 | 0.077 | 7.45 | 1.25 | 2.51 | 5.91 |
| **0.7** | 0.557 | 0.389 | 0.192 | 0.079 | 7.43 | 1.29 | 2.58 | 6.42 |
| **0.8** | 0.593 | 0.418 | 0.203 | 0.088 | 7.42 | 1.35 | 2.71 | 6.81 |
| **0.9** | 0.628 | 0.478 | 0.225 | 0.095 | 7.39 | 1.37 | 2.74 | 7.31 |
| **1.0** | 0.652 | 0.481 | 0.257 | 0.099 | 7.40 | 1.37 | 2.74 | 7.52 |
| **5.0** | 0.343 | 0.403 | 0.173 | 0.026 | 7.29 | 1.58 | 3.16 | 7.93 |
| **10.0** | 0.256 | 0.286 | 0.143 | 0.011 | 7.13 | 1.67 | 3.34 | 8.08 |
| $SEM^{+-}$ | **0.0046** | **0.0038** | **0.0046** | **0.0007** | **0.0980** | **0.0170** | **0.0367** | **0.0917** |
| CD (5%) | **0.0134** | **0.0109** | **0.0133** | **0.0020** | **0.2848** | **0.0493** | **0.1068** | **0.2665** |
| CD (1%) | **0.0181** | **0.0148** | **0.0180** | **0.0028** | **0.3849** | **0.0666** | **0.1443** | **0.3603** |
| CV | **2.34** | **2.35** | **3.29** | **2.37** | **2.30** | **2.35** | **2.52** | **2.54** |

(TDS- Total Dissolved Solids; EC-Electrical Conductivity; HF-Heterocyst Frequency)

**Table 1. Effects of various concentrations of $K^+$ on various growth parameters of *Nostoc muscorum*:**

Total Dissolved Solids (TDS) and Electrical Conductivity (EC) regularly increase with the increasing $K^+$ concentrations (Table 1). So, the high levels of $K^+$ have not affected the T.D.S. and Electrical Conductivity also.

Potassium ($K^+$) is an essential macronutrient for the growth of most organisms. In bacteria, potassium plays an important role in the maintenance of intracellular pH (Booth, 1985) and cell turgor. The role of $K^+$ in general protein synthesis has been investigated. More specifically, the peptidyl transferase reaction during protein synthesis was found to be $K^+$-dependent (Monro, 1967; Maden and Monro, 1968).

Major interest was to study potassium in optimal and supra-optimal concentrations. It was a uniform observation tested with its concentrations ranging from 0.1 to 10 mg/l showed growth promotion as well as all parameters studied like chlorophyll a, carbohydrate, protein, amino acid levels increased proportionately without exhibition of any symptom of inhibition in their qualities. So the productivity definitely increased. We know that all metals not reduce or inhibit the enzyme activity on mild scale metal concentration. Although changes in enzyme activity are not associated with visible sign of toxicity but the enzyme activity parameter are most sensitive in evaluation of metal inhibition/toxicity stress of cyanobacterial system.

All data obtained do not indicate any symptom of toxicity caused by presence of potassium ions into the medium. This is possible because involvement of potassium in many vital processes at major levels. So, it is probable that $K^+$ uptake and utilization by the cyanobacteria was very fast and symptoms and effects of potassium excess/toxicity could not be much more pronounced.

Further analysis of variance, ANOVA**,** of various growth parameters studied were performed at 5% and 1% level of significance of total growth, total carbohydrate, total proteins, total amino acids and heterocyst frequency which indicate highly significant values (Tables 2).

In the present study, controls were potassium-starved cultures. When $K^+$ concentrations were increased gradually, an increase in total chlorophyll a, carbohydrate, proteins and amino acids seen proving role of $K^+$ as macro-nutrient (Fig.1). As discussed earlier, $K^+$ is required for many vital processes and same is presented by present investigation. At 0.9 mg/l concentration, the growth promotory activity is highest. Same is seen for the macromolecular contents and heterocyst frequency (Table 1).

| SOV | Total Growth | | | Total carbohydrate | | | Total protein | | | Total amino acids | | | Heterocyst frequency | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | DF | SS | MSS | DF | SS | MSS | DF | SS | MSS | DF | SS | MSS | DF | SS | MSS |
| **Conc.** | 12 | 1.83 | 0.152272* | 12 | 0.92 | 0.076412* | 12 | 1.60 | 0.133034* | 12 | 0.04 | 0.0035* | 12 | 50.54 | **4.211865*** |
| **Error** | 26 | 0.00 | 0.000064 | 26 | 0.00 | 0.000042 | 26 | 0.00 | 0.000067 | 26 | 0.00 | 0.000001 | 26 | 0.66 | **0.025221** |
| **Total** | **38** | | | **38** | | | **38** | | | **38** | | | **38** | | |

(*Significant)

Table 2. ANOVA for studied different parameters on *Nostoc muscorum* under the influence of $K^+$

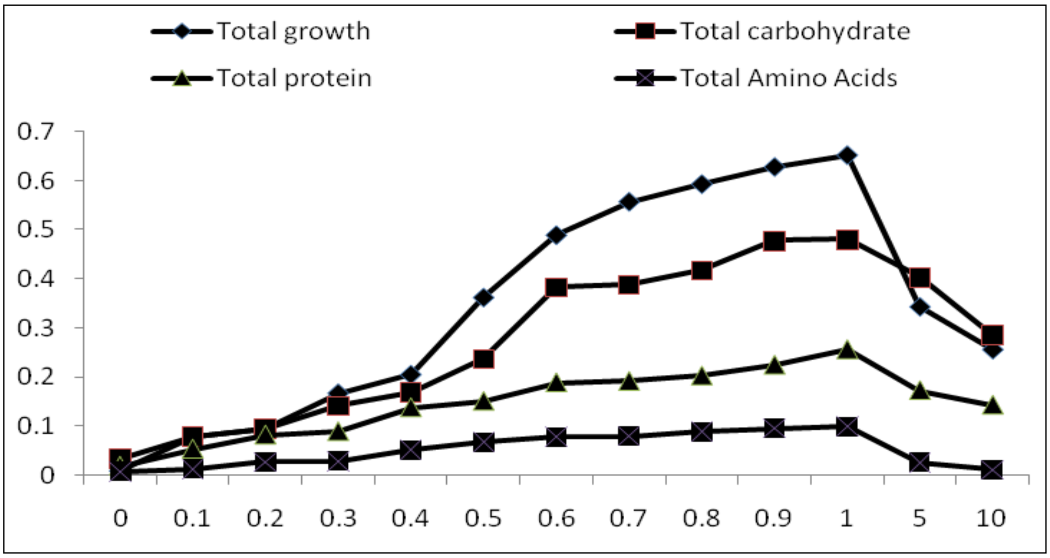


**Figure 1. Effects of various concentrations of $K^+$ on different growth parameters of *Nostoc muscorum*.**

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