

Effects of Nitrogen Application Levels on Leaf Yield and Nutrient Uptake of *Moringa oleifera* under Mowing Condition

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Abstract. Taking Indian *Moringa oleifera* as the object, using pot experiment, setting different nitrogen application levels under the mowing conditions, the most appropriate nitrogen fertilizer application was determined by analysing the effects of different nitrogen application levels on the dry matter and uptake of nitrogen, phosphorus and kalium. The results showed that after mowing five times, when the application rates of phosphorus and kalium and are both 250mg kg⁻¹, the yield of *Moringa oleifera* leaves increased significantly with the increase of nitrogen application rate. The highest yield was 595.67 g /tree when the nitrogen application rate is 300 mg kg⁻¹. It is favorable for dry matter accumulation of *Moringa oleifera*, especially leaf dry matter when the nitrogen application rate is 300mg N / kg, and increases its absorption of phosphorus and potassium. Therefore, in the present experiment condition, when the dosage of nitrogen, phosphorus and potassium in the cultivation of *Moringa oleifera* is 300 mg kg⁻¹, 250 mg kg⁻¹,250 mg kg⁻¹ respectively, it was beneficial to improve the yield and nutrient uptake of *Moringa oleifera*.

Introduction

Moringa oleifera, a perennial deciduous woody vegetable and oil plant, rich in nutrients, is a medicinal and edible plant, known as the "magic tree" and "mother's best friend"[1-2]。 At present, the research on *Moringa oleifera* at home and abroad mainly focuses on the development and utilization of medicinal value and active ingredients. However, the research on cultivation and management of *Moringa oleifera* is insufficient, leading to the lack of scientific and efficient cultivation and management techniques of *Moringa* plantation.[3-6] Therefore, how to improve the yield and nutrient content of *Moringa oleifera* through effective field cultivation and management measures has become an urgent problem to be solved in production. Fertilization is one of the important contents of field cultivation and management measures, and it is an important part of scientific and reasonable planting of *Moringa oleifera*. However, due to that less research has been done on this area at present, it is difficult to determine the scientific and efficient rational fertilization formula according to its growth situation.

Studies have shown that when the *Moringa* seedlings lack of nitrogen, the symptoms appear the most obviously. The initial lack of nitrogen will make the plant light yellow and short, the leaves small and weak growth, which will not appear if kalium is insufficient. Among them, the differences of net height of seedling and stem growth are significant when the nitrogen is insufficient. Therefore, nitrogen is the major element which determines the elongation and stem thickening of *Moringa oleifera*, while the effect of kalium deficiency on leaf number of *Moringa oleifera* is not obvious.

The results showed that nitrogen, phosphorus, kalium and calcium deficiency had a certain effect on the growth of *Moringa oleifera* in seedling stage, but the influence degrees were different, with the greatest impact of nitrogen deficiency[7-8]. The above research is carried out under the condition that the leaves of *Moringa* are not mowed, but in the actual production, leaves are the

mainly useful parts, which need to be mowed continuously. Therefore, the effect of different nitrogen fertilizer levels on the growth of *Moringa oleifera* and the nutrient uptake of nitrogen, phosphorus and potassium under the mowing condition was studied by single factor experiment. Also, the requirement of nitrogen utilization of *Moringa oleifera* was studied in order to provide the theoretical basis for determining the suitable nitrogen fertilizer amount and establishing reasonable fertilization formula of *Moringa oleifera*.

Experimental Material

Experimental Crop: *Moringa oleifera*, whose seedlings were provided by the Vegetable Research Institute, Tropical Crops Genetic Resources Institute, Chinese Academy of Tropical Agricultural Sciences. The average seedling height before planting was 14.00cm, stem 2.30mm.

Experimental Substrate : The latosol and coir pith were mixed at the volume ratio of 2:1. The pH value of cultivation substrate was 4.98. The content of organic matter was 8.74 g / kg, available nitrogen 118.37 mg / kg, available phosphorus 7.32 mg / kg, and rapidly available potassium 90.83 mg / kg.

Experimental Fertilizer: urea (N 46%), calcium magnesium phosphate (P₂O₅ 12.5%), potassium chloride (containing 60% K₂O).

Experimental Pot: the upper diameter was 30cm, the lower diameter was 24cm and the height was 34cm. The substrate was 10kg / pot.

Experimental Method

We took single-factor experiment, and the nitrogen level was the factor. The soil nitrogen content were 100 mg N/kg, 200 mg N/kg, 100 mg N/kg. The soil P₂O₅ and K₂O content were both 250 mg/kg, which were set as control groups with non-fertilization, were recorded as N₁, N₂, N₃, CK. The fertilizer was applied 6 times, once every two weeks in the form of water and fertilizer. In this study, there were four treatment groups, including three different experimental groups and a blank control group. Each tree is a repeat, with 15 trees in an experimental group. The experiment was conducted from August 2016 to November 2016 at the fifth teams greenhouse test base in Tropical Crops Genetic Resources Institute, Chinese Academy of Tropical Agricultural Sciences. They were planted, transplanted seedlings, and fertilized according to the treatment. They were watered and the agriculture chemical were sprayed regularly to guarantee the the normal growth of plants. The trees were fertilized once every two weeks at 6 times according to the test plan. The *Moringa oleifera*s were mowed when their overall growth height reached to stubble height standards (100m). We weighed and recorded the biomass of each fresh weight under mowing, drying and pulverizing, to be tested. The samples were pulverized and digested with H₂SO₄-H₂O₂. The N was measured through indigo phenol blue colorimetric method. The P was measured through Mo-Sb colorimetric method and the K was measured through flame spectrophotometry method[9].

Data Calculation and Processing

The test data were processed and analysed by Excel 2007 and SPSS 13.0 software.

Result and Analysis

Effects of Nitrogen Application on Leaf Yield

As shown in Table 1, compared with CK, the application of nitrogen fertilizer under mowing conditions can significantly improve the yield of *Moringa oleifera*. The leaves fertilized by nitrogen output from the first time mowing to the fifth are respectively 2.67 times, 1.44 times, 2.84 times, 2.37 times, 3.11 times of CK, raising the total yield to 144.64%. Comparing the different nitrogen application levels, we could know that with the increase of mowing times, the effect of nitrogen application on the yield of *Moringa oleifera* was more obvious. At the fifth mowing, the leaf yield of *Moringa oleifera* showed significant difference with the nitrogen application level. In summary, the results showed that N₃ had the highest treatment rate of 595.67g / tree. It could be seen that when the level of phosphorus and potassium were consistent, the yield of *Moringa oleifera* increased significantly with the increase of nitrogen application rate, and the highest yield was 300 mg N / kg in this experiment.

Table 1 Effects of nitrogen application on leaf yield (g/tree)

Times	Experimental Treatment			
	CK	N1	N2	N3
1st	5.12±0.07c	17.52±0.70a	8.23±0.60b	15.27±1.52a
2nd	46.53±3.08b	54.51±2.24b	70.04±2.27a	76.04±2.08a
3rd	28.06±2.62c	71.27±4.27b	79.07±5.59ab	88.23±2.61a
4th	61.97±1.65c	118.76±4.91b	163.79±6.78a	158.96±1.11a
5th	59.08±1.42d	103.64±1.88c	190.77±8.48b	257.18±6.36a
Total	200.74±7.41d	365.70±9.51c	511.91±2.42b	595.67±5.98a

(Note: The values in the table represent the mean ± standard error, and the difference between the lowercase letters of the peer is significant ($P \leq 0.05$). The multiple comparison used Duncan's new differential method. Hereinafter inclusive.)

The Influence on the Dry Matter Accumulation of *Moringa Oleifera*

The application of nitrogen fertilizer can significantly increase the dry matter accumulation of *Moringa oleifera* according to the analysis of the dry matter of different parts.(table 2). The average increase of dry matter of whole *Moringa oleifera* was 90.35%. The dry matter of leaf, root, stem and other parts also increased significantly. Further analysis showed that the dry matter quality of the leaves increased significantly with the increase of nitrogen application rate, while the root showed the opposite trend, that is, the dry matter accumulation decreased significantly with the increase of nitrogen application rate. N1, N3 treatments showed that the dry matter of stem was not significantly different and were both higher than N2 treatment, which may be due to when low nitrogen stress was soil of 100mg N / kg, *Moringa oleifera* roots grew rapidly, resulting in mass dry matter accumulation.300 mg N / kg soil nitrogen application rate can promote the growth of leaves rapidly, thereby increasing leaf yield. Therefore, the nitrogen application level of 100mg N / kg or 300mg N / kg can promote the accumulation of dry matter of *Moringa oleifera*, especially 300mg N / kg is more conducive to leaf dry matter accumulation.

Table 2 Effect of nitrogen application on dry matter accumulation of *Moringa oleifera*

Parts	Experimental Treatment			
	CK	N1	N2	N3
Leaf	34.18±1.00d	60.96±1.58c	80.78±0.81b	90.02±0.80a
Root	13.25±0.65c	34.87±0.97a	15.54±0.59b	12.08±0.48c
Stem	22.14±0.63c	37.18±1.30a	30.70±0.82b	35.13±0.47a
Plant	69.57±1.80c	133.02±1.57a	127.02±1.01b	137.23±0.76a

Effect on Nutrient Uptake of *Moringa oleifera*

The results in Tab.3 showed that the application of nitrogen fertilizer in the mowing condition could significantly improve the absorption of nitrogen, phosphorus and kalium in *Moringa oleifera*, which were 2.41 times, 2.42 times and 1.52 times of CK treatment respectively. In terms of nitrogen uptake, the nitrogen uptake of *Moringa oleifera* increased significantly with the increase of nitrogen application rate, and the N uptake was the highest in N3 treatment, which was 94.55% and 56.85% higher than N1 treatment and N2 treatment respectively. With the increase of nitrogen application rate of *Moringa oleifera*, The phosphorus uptake increased first and then decreased, and the highest nitrogen uptake was N2 treatment. It showed no significant difference between N2 and N3 treatments about kalium, which were significantly higher than those of N1 treatment. It can be seen that the increase of nitrogen application is beneficial to the uptake of nitrogen and potassium for *Moringa oleifera*.

Table 3 Effect of nitrogen application on nutrient uptake of *Moringa oleifera*

Nutrition	Experimental Treatment			
	CK	N1	N2	N3
N	0.912±0.013d	1.574±0.011c	1.952±0.016b	3.062±0.055a
P	0.240±0.006c	0.517±0.012b	0.689±0.021a	0.539±0.010b
K	2.768±0.040c	3.999±0.056b	4.348±0.040a	4.301±0.026a

Discussion and Conclusion

Studies have found that on the condition that the application of phosphorus and kalium fertilizer did not change, the application of nitrogen fertilizer can significantly promote the growth of plant leaves and accumulation of dry matter of *Moringa oleifera* [7,10]. The experiment also showed that when the amount of phosphorus and kalium fertilizer used were the same, different concentrations of nitrogen treatment had different effects on the *Moringa oleifera*.

The application of nitrogen had significant effects on the growth of *Moringa oleifera*, and when the application of nitrogen was 300mg kg⁻¹, the yield of the leaves, the quality of dry matter and the growth of *Moringa oleifera* were all the best. In addition, the effect of nitrogen on different parts of *Moringa oleifera* was also different, which was shown by the dry matter accumulation of different parts of *Moringa oleifera*. In this experiment, the dry matter accumulation of leaves was highest at nitrogen application level of 300 mg N / kg soil, while the dry matter accumulation of roots was the highest at 100 mg N / kg soil.

In the process of growth of *Moringa oleifera*, fertilization is one of the most important links. Through the scientific fertilization management, can ensure the adequate supply of *Moringa* nutrient, while the growth of *Moringa oleifera* trees, flowering and results have a positive effect, increase seed yield and improve its quality [7-8,11]. According to the results of this experiment, the nitrogen has significant facilitation to the growth and nutrient uptake of *Moringa oleifera* under the mowing conditions. When the amount of nitrogen application was 100-300mg kg⁻¹, and the amounts of phosphorus and kalium were 250mg kg⁻¹, the yield of leaves and the dry matter accumulation of *Moringa oleifera* was increased greatly. When the amount of nitrogen application was 300mg kg⁻¹, the uptake of nitrogen and kalium by *Moringa oleifera* was the highest. This experiment only studied the effect of nitrogen on the growth and nutrient uptake of *Moringa oleifera*. In order to provide a really complete scientific and reasonable fertilization plan for the processing of *Moringa oleifera*, the effects of combined application of nitrogen, phosphorous and kalium or other factors still need further studies.

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