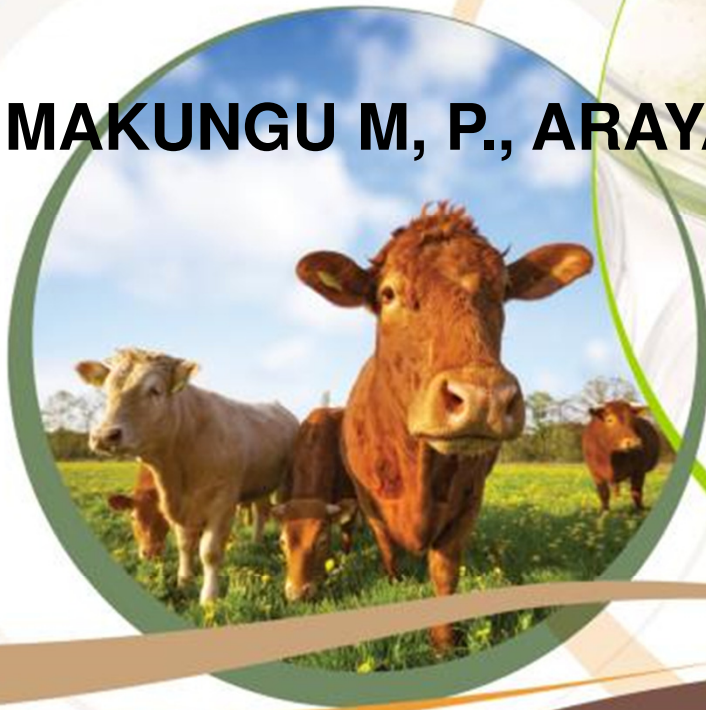


Response of physiological and biomass production of baby spinach (*Spinacia oleracea* L.) leafy vegetable to nitrogen, phosphorus and potassium nutrition

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Introduction

- Baby spinach (*Spinacia Oleracea* L.)
- Belongs to the family Amaranthaceae
- Annual cool season crop
- Green leafy vegetable predominantly eaten raw
- Leaves are small, not longer than 6cm
- Sweet tender, smoother than semi-savoy spinach

Justification of the study

- Baby spinach is a relatively new crop in South Africa, and the demand for baby spinach exceeds supply
- Farmers are predominantly cultivating normal spinach
- Data on the recommended rates of major nutrients such as N, P and K and combination NPK are not readily available in South Africa

Objectives of the study

- The effect of different N, P and K applications on the growth and development of baby spinach
- To investigate the interactive effect of combined NPK nutrition on the growth and development of the plants

Experimental site

- The trial was conducted at the Agricultural Research Council, Vegetable and Ornamental Plant Institute
- 25 Km North of central Pretoria
- GPS coordinates 25°59" S; 28°35"E
- The farm covers 4000 ha, of which only 650 ha is under irrigation



Experimental design and treatment details

- Three parallel trials for N, P and K and interactive trials were arranged in RCBD
- 5 treatments, replicated 4 times
- Sub plots were 2x2 m in size
- 3 rows with 10 plants each
- Inter-row spacing of 20cm, intra- row spacing of 10cm

Experimental design and treatment details

- Cv. Ohio cultivar seeds were planted in seedling trays filled with media from Hygromix
- Germinated after 5 days
- Transplanted done in two weeks
- Nitrogen and phosphorus treatments consisted of 0; 45 kg/ha; 75kg/ha; 105 kg/ha 120kg/haN/P
- Potassium treatments consisted of 0; 63 kg/ha; 85kg/ha; 127 kg/ha; 148 kg/ha

Treatment combinations trials

- After parallel N, P and K trials, the combined NPK trial was conducted, consisting of 5 treatments
- Combined NPK: 0; 30: 30: 45; 45:45:63 kg/ha; 60:60:78 kg/h and 75:75:93 kg/ha arranged in a RDCD replicated three times

Experimental design and treatment details

- Lime ammonium nitrate (28% N kg/ha) was supplied as the N fertiliser source
- Phosphorus was supplied in the form of super phosphate (83% P kg/ha)
- Potassium was supplied in the form of potassium chloride (50% K kg/ha)

Parameters recorded

- Data plants were sampled at 35 days after planting (DAP)
- Parameters recorded were biomass production (fresh mass, dry mass, root length, fresh root mass, dry root mass)
- Chlorophyll content
- Stomatal conductance above
- Stomatal conductance below

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- Leaf area index (LAI)
- Leaf protein percentage
- Total leaf nitrogen/phosphorus/potassium
- Leaf nitrate

Statistical analysis

- Treatment sums of squares were partitioned into linear and quadratic polynomial contrast using SAS version 14.1

Biomass production parameters of baby spinach in response to Nitrogen nutrition

Applied N (Kg/ha)	Fresh mass(g) per plant	Dry matter (g) per plant	Root length (cm)	Fresh root mass (g) per plant	Dry root mass (g) per plant	Leaf protein (K) %	Total leaf K %	Leaf nitrate %	Leaf protein in %
0	12.43d	2.33c	14.50b	1.84a	0.460a	1.34b	1.34b	0.02b	8.3b
45	37.62ab	5.43b	16.00b	0.54a	0.150a	4.01a	4.01a	0.04b	25.0a
75	45.81a	10.29a	21.50a	0.47a	0.115a	4.26a	4.31a	0.23b	26.6a
105	27.89bc	10.20a	20.50a	0.92a	0.315a	4.22a	4.34a	0.57b	26.3a
120	21.49cd	8.91a	15.00b	0.37a	0.090a	4.22a	4.54a	1.33a	26.5a

Summary

- The application of different nitrogen levels did not have any significant effect on root mass.
- Nitrogen applied linearly increased the percentage protein content to 4.26% of baby spinach as compared to control. The significant increases varied with the applications of 0 to 45 kg/ha
- Percentage leaf nitrogen of baby spinach showed a significant increase at 45 kg/ha
- Where high nitrogen treatment was applied at 120 kg/ha, a significant percentage increased in the nitrate content level of 1.33% was observed
- All treatments linearly increased the percentage leaf protein contents compared to the control

Physiological parameters of baby spinach in response to N nutrition

Applied P (Kg/ha)	Chlorophyll Content	Stomatal conductance (Upper) mmol/m ² /s	Stomatal conductance (Lower) mmol/m ² /s	Leaf Area Index
0	151.08c	815.0b	743.73b	2.90b
45	338.38a	907.2a	819.48a	3.58a
75	437.78a	1197.7a	781.93a	3.78a
105	370.85a	937.59a	866.30a	4.08a
120	233.50b	865.3b	921.70a	4.25a
Sign	Q	Q	Q	Q

Nitrogen treatments ranging 0 to 45 kg/ha quadratically improved -chlorophyll content, -Upper lower stomatal conductance and as well as leaf area

Biomass production parameters of baby spinach in response to **Phosphorus** nutrition

Applied P (Kg/ha)	Fresh mass(g) per plant	Dry matter (g) per plant	Root length (cm)	Fresh root mass (g) per plant	Dry root mass (g) per plant	Leaf protein (P) %	Total leaf P %	Leaf nitrate %
0	3.54b	0.23a	7.75a	0.21a	0.09a	0.53b	2.13b	0.02a
45	5.69b	0.15b	5.50a	0.24a	0.11a	0.97a	3.42ab	0.06a
75	13.04a	2.69a	10.25a	0.23a	0.11a	0.95a	4.25a	0.09a
105	12.94a	1.21b	8.25a	0.25a	0.06a	0.95a	4.22a	0.09a
120	13.83a	1.24b	9.75a	0.42a	0.08a	1.13a	4.32a	0.14a
Sign	Q	Q	NS	NS	NS	Q	Q	Ns

Physiological parameters of baby spinach in P nutrition

Applied P (Kg/ha)	Chlorophyll Content	Stomatal conductance (Upper) mmol/m ² /s	Stomatal conductance (Lower) mmol/m ² /s	Leaf Area Index
0	62.78c	59.53c	65.00b	80.4b
45	69.00b	72.05a	71.70a	9.40b
75	171.35a	114.40a	64.93a	21.18a
105	90.45b	61.50a	42.23b	17.37a
120	95.28b	39.78a	53.40b	17.87a
Sign. Level	0.0001	0.0001	0.0001	0.0001

- All phosphorus treatments significantly increased the chlorophyll content of baby spinach, from 0 to 171.37 nm
- Adaxial stomatal conductance was not influenced by different rates of phosphorus application
- However, applying phosphorus at 45 kg/ha significantly influenced the abaxial stomatal conductance by 71.70 mmol/m²/s

Biomass production parameters of baby spinach in response to potassium nutrition

Applied K (Kg/ha)	Fresh mass(g) per plant	Dry matter (g) per plant	Root length (cm)	Fresh root mass (g) per plant	Dry root mass (g) per plant	Leaf protein (K) %	Total leaf K %	Leaf nitrate %
0	1.25a	0.27a	8.00a	0.59a	0.26a	0.26a	1.74b	0.03a
63	1.13a	0.26a	5.25a	0.37a	0.06a	0.36a	2.30a	0.08a
85	3.69a	0.99a	9.50a	0.97a	0.16a	0.31a	2.32a	0.09a
127	1.32a	0.24a	6.25a	0.43a	0.06a	0.15a	1.79b	0.49a
148	1.65a	0.33a	6.00a	0.46a	0.07a	0.20a	1.83b	0.04a
Response	Ns	Ns	Ns	Ns	Ns	Ns	0.05	Ns

Physiological parameters of baby spinach in response to potassium nutrition

Applied potassium (kg/ha)	Chlorophyll content (nm)	Stomatal conductance – adaxial (upper) mmol/m ² /s	Stomatal conductance – abaxial (lower) mmol/m ² /s	Leaf area index
0	80.05a	32.25a	36.93a	0.91b
63	66.30a	42.00a	38.00a	1.31a
85	81.73a	39.55a	39.28a	1.02a
127	48.28a	43.03a	41.38a	1.02a
148	53.78a	48.47a	47.43a	0.74b
Response	Ns	Ns	Ns	Q

The application of potassium caused a quadratic response in the leaf area index of baby spinach at 63 kg/ha

Biomass production parameters of baby spinach in response to combined NPK nutrition

- The combination of NPK significantly increased fresh and dry mass compared to control, stomatal conductance (upper and lower)
- No significant differences in leaf area were observed following applications of combined NPK nutrition
- None of the combined treatments improved root length, fresh root mass and dry root mass

Conclusions

- Growth and development of baby spinach was significantly improved by the fertilisers applied as well as fertiliser rates
- Adequate application of nitrogen and phosphorus fertiliser at 45 kg/ha improves plant growth parameters significantly, leading to quadratic effect on yield, dry matter, chlorophyll content and leaf area
- Potassium did not exhibit any significant effect
- Combined NPK fertilisers applied at a rate of 45:45:60 kg/ha had a significant effect on the yield as well as dry matter of baby spinach

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