# Growth and Yield of *Brassica oleracea* in Response to Phosphorus Fertilizer Application

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***Abstract*—** Cabbage is an important vegetable that is grown around the world because of its nutritional content and for medicinal purposes. Plant nutrients can deplete due to continuous cultivation, this necessitates the addition of fertilizer to sustain production. Therefore, the objective of this experiment was to investigate the effect of phosphorus fertilizer on the vegetative and reproductive growth of cabbage growth in the Western Cape. A two-season experiment was conducted using a complete randomized complete block design (RCBD), with four replicates. Treatments of phosphorus (Triple superphosphate) at four levels 109, 163.5, 218, and 222.5kg/ha. Data collection on the vegetative and yield was recorded and analyzed using the SPSS software. The results showed that treatment did not have a significant difference ($p>0.05$) on vegetative and yield and generally p fertilizer at 218 kg/ha increased all the measured parameters. An increase in yield during the last season of the experiment was also noted.

***Keywords*—** *Brassica oleracea*, plant nutrients, phosphorus

## I. Introduction

Cabbage (*Brassica oleracea*. L), is one of the most common vegetables grown in South Africa (SA) and its production is generally concentrated in Mpumalanga and Kwazulu-Natal [2]. In SA this leafy vegetable is typically cultivated in smallholder plots and provides dietary diversity and nutrients in poor rural communities [7]–[8]. *Brassica oleracea* is rich in minerals and vitamins such as A, B1, B2, C [14], and these characteristics are an indication of good quality [15]. According to Nikzad [9], cabbage contains phosphorus which assists in the utilization of calcium and the assimilation of carbohydrates and fats in the human body. Cabbage is adaptable to a wide range of climatic conditions, soil type and nutritional benefits [2], [5]-[6]. This vegetable crop is regarded as a heavy feeder as it requires large quantities of the macronutrients [2], [4]-[5]. Natural occurring nutrients easily get depleted over the years of cultivation this necessitates the addition of synthetic fertilizer such as phosphorus. This macro-nutrient is essential for plant growth, metabolic processes and is required plants in large quantities [5]. However, majority of research done has mainly focused on macronutrient nitrogen and its effect on the cabbage vegetative parameters and yield [4], [11]-[13]. The objective of this experiment was, therefore, to investigate the effect of phosphorus fertilizer on vegetative and reproductive growth of cabbage growth in the Western Cape.

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## II. Materials And Methods

### *A. Study Area*

The research was conducted at a Research and Teaching Farm, the Agricultural-Hub, Department of Agriculture, Wellington Campus, Cape Peninsula University of Technology, Western Cape Province. The area is located in the northern part of Wellington with the following coordinate (S33$^o$ 37' E19$^o$ 37'), with the Mediterranean climate (with hot dry summers and wet cold winters). The area receives an annual rainfall of 585 mm and approximately one-third falls between March and August. Prior to transplanting the field was tilled and plots were prepared accordingly. After transplanting uniform irrigation was supplied and the supply of irrigation water was uniform throughout the growing season. Cultivation practices such as weeding was done manually when necessary. Nitrogen and potassium fertilizer was applied and kept constant. The initial soil results indicated that the field was a loam soil with a pH of 4.6, P 23 and K 178 mg/kg and the second year analysis pH was 4.6, P 32 and K 93.9 mg/kg [10].

### *B. Experimental Layout and treatment application*

The trial was conducted during the summer season 2019-2020. The experimental design for each year was laid in a complete randomized complete block design (RCBD), with four replicates. Each unit plot measured 3.5m x 1m, 1m between plots and plant spacing of 60cm. The treatments consisted of four rates of phosphorus (Triple superphosphate 20%): 109(T1), 163.5 (T2), 218 (T3) and 222.5 (T4) kg/ha.

### *C. Data collection*

Data collection on plant height, number of leaves and leaf width, leaf length were recorded over a period of two weeks interval during the growth period of 2019 and 2020, data

collection commenced four weeks after transplanting. The total yield was recorded at harvest for both seasons.

*D. Statistical analysis*

Analysis of variance ANOVA at 95% confidence limit and comparison of means was carried out on vegetative growth and yield. Analysis of data of the plant data collected using IBM SPSS software (2020). Means separation was done using Fisher`s Least Significant Difference (LSD).

## III. Results And Discussion

### *A. Effect of Phosphorus Fertilize Treatment on Vegetative Growth and Yield of Brassica oleracea.*

TABLE I: Influence of Fertilizer Treatment on Vegetative Growth and Yield of Cabbage 2019

| Treatment | Number of leaves | Plant height (cm) | Leaf length (cm) | Leaf width (cm) | Yield (kg/ha) |
|---|---|---|---|---|---|
| T1 | 13.13[a] | 20.62[a] | 15.73[a] | 13.38[a] | 1.53[a] |
| T2 | 12.71[a] | 21.03[a] | 15.72[a] | 14.07[a] | 1.96[a] |
| T3 | 12.42[a] | 21.13[a] | 13.29[a] | 12.35[a] | 2.01[a] |
| T4 | 13.13[a] | 21.89[a] | 16.38[a] | 13.98[a] | 2.20[a] |
| LSD | NS | NS | NS | NS | NS |

Means in the same column with the same superscript are not significantly different (P>0.05). LSD= Least significant difference; NS= Not Significant; T1= P 0%, T2= P 50%, T3= 75%, T4= 100%.

Phosphorus (P) fertilizer treatment had no significant ($p>0.05$) effect on vegetative growth and yield as shown in (Table I & II). This could be due to that only P was varied in the study and the other two significant macronutrients nitrogen and potassium we kept constant. However, the application of phosphorus fertilizer at 222.5 kg/ha (T3) in the year 2019 increased plant height, leaf length, leaf width and yield by 6, 4, 4, and 44% compared to the control. These findings were in contrast with those of [16] who reported that phosphorus significantly increased vegetative growth, yield and also improved soil P content. Soil results from this study showed an increase in P content before the second season of planting which increased from 23 to 32mg/kg. The ideal soil pH that is suitable to cultivate cabbage ranges from 5.5 to 6.5 and initial soil analysis results for this field experiment was 4.6 and might have restricted phosphorus availability to plants. These observations are in line with those of [1], as the results showed that in acidic soils phosphorus is fixed by aluminium and iron.

TABLE II: Influence of Fertilizer Treatment on Vegetative Growth and Yield of Cabbage 2020

| Treatment | Number of leaves | Plant height (cm) | Leaf length (cm) | Leaf width (cm) | Yield (kg/ha) |
|---|---|---|---|---|---|
| T1 | 16.03[a] | 17.01[a] | 15.79[a] | 15.62[a] | 5.02[a] |
| T2 | 15.64[a] | 16.93[a] | 15.13[a] | 14.95[a] | 5.82[a] |
| T3 | 16.45[a] | 18.89[a] | 17.58[a] | 16.84[a] | 5.86[a] |
| T4 | 15.00[a] | 16.48[a] | 15.35[a] | 14.94[a] | 5.97[a] |
| LSD | NS | NS | NS | NS | NS |

Means in the same column with the same superscript are not significantly different (P>0.05). LSD= Least significant difference; NS= Not Significant; T1= P 0%, T2= P 50%, T3= 75%, T4= 100%

Similar results were obtained during the year 2020, phosphorus fertilizer treatment had no significant effect ($p>0.05$) on all measured vegetative parameters. An increase in yield during the second season harvest of cabbage was observed even though not significant. The highest yield of 5.97kg/ha was obtained during the second year of planting compared to 2.20kg/ha on the first year.

### *B. Effect of treatment on vegetative growth measured at different dates.*

The different dates of data collection had a significant difference in the vegetative parameters measured for the two growing seasons (Table III & IV). This is due to the general growth pattern of plants that affects the vegetative parameters measured and increases as the season progresses. The date in which parameters were measured had a significant ($p<0.05$) effect on all vegetative parameters measured for both seasons. These findings are in agreement with those of [5], who reported an increase in plant height and number of leaves per plant at six week after transplanting. Reference [3], stated that different vegetables differ in their ability to uptake phosphorus which eventually affects the general growth of the crop.

TABLE III: Influence of Time on Data Collected on Vegetative Growth During the Year 2019.

| Period | Number of leaves | Plant height (cm) | Leaf length (cm) | Leaf width (cm) |
|---|---|---|---|---|
| t1 | 8.75[c] | 14.68[b] | 8.26[c] | 7.48[c] |
| t2 | 13.39[b] | 24.06[a] | 17.73[b] | 14.14[b] |
| t3 | 16.41[a] | 24.83[a] | 19.85[a] | 18.71[a] |
| LSD | 3.02 | 9.38 | 2.12 | 4.57 |

Means in the same column with the same superscript are not significantly different (P>0.05). LSD= Least significant difference; t1= First date of data collection, t2= Second date of data collection, t3= Third date of data collection.

TABLE IV: INFLUENCE OF TIME ON DATA COLLECTED ON VEGETATIVE GROWTH DURING THE YEAR 2020.

| Period | Number of leaves | Plant height (cm) | Leaf length (cm) | Leaf width (cm) |
|---|---|---|---|---|
| t1 | $11.28^{c}$ | $11.89^{c}$ | $10.71^{b}$ | $9.67^{b}$ |
| t2 | $15.74^{b}$ | $20.77^{a}$ | $18.47^{a}$ | $18.27^{a}$ |
| t3 | $20.32^{a}$ | $19.33^{b}$ | $18.71^{a}$ | $18.83^{a}$ |
| LSD | 4.46 | 1.44 | 0.24 | 0.65 |

Means in the same column with the same superscript are not significantly different (P>0.05). LSD= Least significant difference; t1= First date of data collection, t2= Second date of data collection, t3= Third date of data collection.

## IV. CONCLUSION AND RECOMMENDATIONS

The availability of phosphorus (P) to plants can be restricted due to a number of factors such as crop type and soil condition such as the soil pH. The findings from the field experiment indicated that P did not affect growth parameters measured, however, an increase in yield was observed in the second year of the experiment. Research on macronutrients has mainly focused on nitrogen which influences vegetative growth and formation of stems and the findings from the study indicated that P had no significant effect on parameters measured. So further research on fertilizer combination is essential, including potassium and other macronutrients to provide the recommended fertilizer ratio that will improve production of cabbage in Western Cape, Wineland region.

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