

ROLE OF PLANT SPACING AND SOWING ORIENTATION IN CABBAGE GROWTH AND HEAD FORMATION

Muhammad Bilal^{1*}, Hafiz Muhammad Bilal², Irfan Ahmad³

¹Faculty of Agriculture, Gomal University, Dera Ismail Khan 29050, Khyber Pakhtunkhwa, Pakistan

²Water Management Research Farm, Renala Khurd, Okara, Punjab, Pakistan

³Department of Soil Sciences, Faculty of Agriculture, Gomal University Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan

*Corresponding Author E-mail: bilalkhanento@gmail.com

Abstract

A field experimentation was piloted at Lasbela University, Balochistan, Pakistan, to evaluate the influence of different plant spacings and sowing orientations on the growth and yield performance of cabbage (*Brassica oleracea* var. *capitata*). The study included six treatment combinations involving three plant spacings (45×45, 60×45, 60×60 cm) and two sowing orientations (north-south and east-west). Data were recorded on plant tallness (at 30, 60 days after transplanting and at maturity), leaves, leaf area, stem diameter, head initiation (days), diameter & weight, marketable & unmarketable yield. Results showed that wider spacing, particularly the 60×60 cm configuration combined with north-south orientation (S3O1), significantly enhanced the growth of cabbage plants. This treatment also delayed head initiation slightly but produced significantly larger and heavier heads. Consequently, it resulted in the maximum marketable yield (29.0 Mg ha⁻¹) and the lowermost unmarketable yield (2.5 t ha⁻¹). The improved performance under wider spacing and favorable orientation is attributed to reduced interplant competition and better resource utilization. These results provide useful recommendations for farmers in Balochistan and similar agro-ecological zones aiming for efficient cabbage cultivation.

Article History

Received:
September 30, 2024

Revised:
October 14, 2024

Accepted:
November 08, 2024

Available Online:
December 31, 2024

Keywords: “Plant Spacing”, “Sowing Orientation”, “Cabbage”, “Marketable Yield”, “Aridity”.

Scientific

INTRODUCTION

Cabbage is a globally noteworthy vegetable, cherished for its dietary content and economic connotation. Its cultivation stresses careful contemplation of agronomic practices, predominantly plant spacing and sowing orientation, which are pivotal in defining growth dynamics, head formation and overall yield (Ullah A).

Plant spacing unswervingly impacts the microenvironment of cabbage crops affecting factors i.e., light interception, air circulation and nutrient availability (Abed MY,). Optimum spacing guarantees adequate resources for every plant encouraging robust growth and head development (Hinsermu M,). Contrariwise, improper spacing can lead to competition for resources, resulting in suboptimal growth and increased susceptibility to pests and diseases (Shrestha S,).

Recent researches have emphasized the implication of appropriate plant spacing. For instance, Jat et al. (Jat R,) observed that a spacing of 45 x 45 cm yielded the tallest plants, leaves count and head weight plant¹ in Chinese cabbage under the Prayagraj agro-climatic conditions. A study in East Medinipur testified that wider spacing (60 x 60 cm) resulted in taller plants and higher

individual head weights, attributed to reduced intra-plant competition (Gogoi S).

The interplay between plant spacing and sowing orientation significantly impacts cabbage growth parameters. For example, closer spacing increases plant density, potentially leading to higher yields per unit area but may compromise individual head size and quality due to intensified competition (Devi P) (Bangoria UV,). Conversely, wider spacing may enhance individual plant performance but reduce overall yield per hectare. Balancing these factors is crucial for optimizing both yield and quality (Verma S,) (Joraboevich SA.).

Proper orientation can enhance light interception, leading to improved photosynthetic efficiency and, consequently, better growth and yield (Narwariya BS,). Sowing orientation, or the arrangement of plants in the field, affects light distribution and air flow, which are critical for photosynthesis and disease prevention (Anushruti SK,). While specific studies on cabbage are limited, general agronomic principles suggest that orientation aligned with prevailing sunlight can optimize growth conditions (Bhandari SR,) (Gelaye Y,).

Understanding the role of plant spacing and sowing orientation is vital for enhancing cabbage production. These agronomic practices influence key growth parameters and yield outcomes.

Materials and Methods

The study was piloted at Lasbela University of Agriculture, Water and Marine Sciences (LUAWMS), Uthal, Balochistan, Pakistan. The site is situated at 25.8° N and 66.6° E with an altitude of approximately 50 meters. The region falls under an arid-semi-arid climate, described by hot summers, mild winters and low annual rainfall, with sandy loam soils and moderate fertility.

The Experiment

The trial was laid out during the Rabi season using a thrice replicated RCB. The treatments consisted of combinations of plant spacing and sowing orientation as follows:

- **Plant Spacing:**
 - S1: 45 × 45 cm
 - S2: 60 × 45 cm
 - S3: 60 × 60 cm
- **Sowing Orientation:**
 - O1: North-South rows
 - O2: East-West rows

Crop Husbandry

The cabbage variety used in the study was a commonly grown hybrid, selected for its adaptability to regional conditions and uniform head formation. Healthy seedlings were raised in a nursery and transplanted to the main field at 25 days after sowing. Land was thoroughly prepared using plowing and leveling techniques to ensure uniform seedbed conditions.

Each experimental plot measured 3 m × 3 m. Plants were transplanted according to the assigned spacing and orientation, ensuring consistent planting depth and row arrangement.

Fertilizer and Irrigation Management

Recommended doses of fertilizers were applied uniformly @ 120:80:60 kg ha⁻¹ NPK to all plots. Half of the N and the full dose of P&K were applied at transplanting, while the outstanding N was applied in two identical splits at 30 and 45 days after transplanting. Irrigation was provided at weekly intervals or as required, depending on weather and soil moisture conditions, using a furrow irrigation method.

Weed and Pest Management

Manual weeding was carried out twice during the crop growth period. Pest and disease management practices were followed as per local recommendations,

with the use of integrated pest management (IPM) techniques to curtail chemical applications.

Data Collection

Growth and yield parameters were recorded at different growth stages and at harvest. Five plants were arbitrarily designated from each plot for measurement and average values were computed.

Statistical Analysis

The collected numbers were evaluated using Statistix 8.1 software. Analysis of variance (ANOVA) was performed to determine the significance of treatment effects. Where F-values were significant, Tukey's HSD test was used to differentiate the means at a 5% level of significance.

Results and Discussion

Plant Height

The results of plant height indicated a progressive increase across all treatments over time. Notably, the treatment with the widest spacing and optimal sowing orientation (S3O1) consistently exhibited the tallest plants at each growth stage. This suggests that reduced intra-specific competition for resources i.e. light, nutrients and water in wider spacing facilitates enhanced vegetative growth

(Devi P). These findings align with previous research indicating that wider spacing can lead to increased plant height due to better resource availability (Rani KS,).

Number of Leaves and Leaf Area

The leaves count and area are precarious indicators of photosynthetic capacity and overall plant vigor. Treatments with broader spacing (S3O1 and S3O2) validated a higher leaves count and larger leaf area compared to nearer spacing treatments. This can be attributed to reduced competition, allowing plants to develop more expansive foliage (Gogoi S) (Verma S,). Similar observations have been reported in studies where increased spacing resulted in enhanced leaf development (Swe KM,).

Stem Diameter

An important structural trait the stem diameter supports the plant and its developing head. The broadest spacing treatment (S3O1) produced plants with pointedly thicker stems. This may be due to the ample space allowing for better nutrient uptake and allocation towards stem development (Jat R,). These results are consistent with findings that wider spacing can lead to increased stem girth due to improved resource availability (Sarkar P,).

Days to Head Initiation

The beginning of head creation is a critical stage in cabbage development. Treatments with closer spacing (S1O1 and S1O2) demonstrated earlier head origination compared to wider spacing treatments. This could be due to amplified competition in closer spacing encouraging earlier reproductive development (Qiao Y,). However, while earlier head initiation was observed, it did not necessarily translate to higher yields, highlighting the complex interplay between growth dynamics and yield outcomes (Rani KS,).

Head Diameter & Weight

Head diameter and weight are primary determinants of cabbage marketability. The widest spacing treatment (S3O1) resulted in the largest head diameter and heaviest heads. This can be ascribed to the reduced rivalry, allowing plants to allocate more resources towards head development (Narwariya BS,). These outcomes are in agreement with previous studies that have testified increased head size and weight with wider spacing (Sarkar P,).

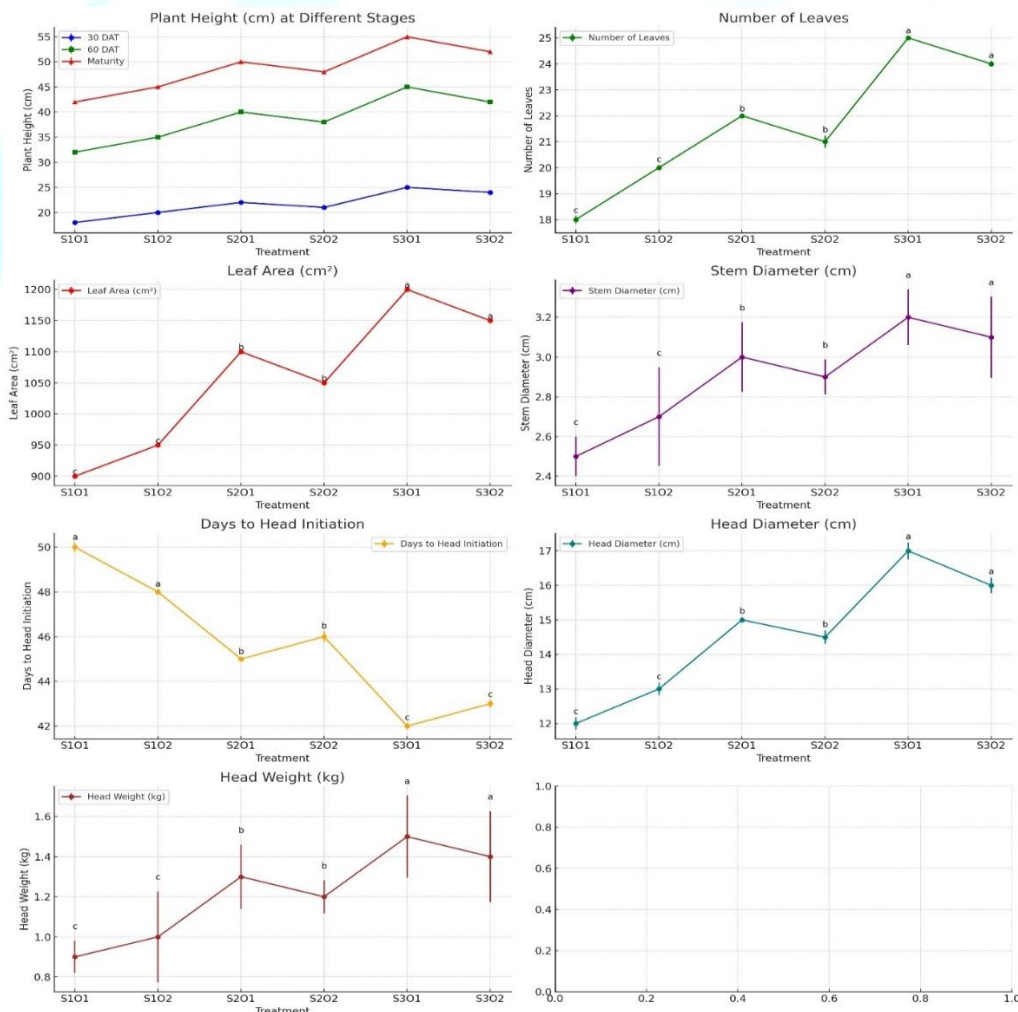


Figure 1. Effect of sowing geometry on plant height (cm) of cabbage at 30, 60 days after transplanting and at maturity, number of leaves per cabbage plant, leaf area (cm²) of cabbage, stem diameter (cm) of cabbage, days to head initiation in cabbage, head diameter (cm) of cabbage and head weight (g) of cabbage.

Marketable and Unmarketable Yield

Marketable yield was highest in the widest spacing treatment (S3O1), while

unmarketable yield was lowest in the same treatment. This suggests that optimal spacing not only enhances overall yield but also improves the quality of the produce. The reduction in unmarketable yield may be due to better air circulation and reduced disease incidence in wider spacing (Ghiffar HM,). These results are supported by studies indicating that appropriate plant spacing can lead to higher marketable yields and reduced losses (Jat R,) (Devi P) (Bhandari SR,) (Gelaye Y.).

Table 1. Effect of different sowing geometries on marketable and unmarketable yield of cabbage (t ha⁻¹)

<i>Treatment</i>	<i>Marketable yield (t ha⁻¹)</i>	<i>Unmarketable yield (t ha⁻¹)</i>
<i>S1O1</i>	22.5 ± 0.41c	3.5 ± 0.29a
<i>S1O2</i>	23.0 ± 0.37c	3.2 ± 0.25a
<i>S2O1</i>	26.0 ± 0.39b	2.8 ± 0.19b
<i>S2O2</i>	25.5 ± 0.48b	3.0 ± 0.13b
<i>S3O1</i>	29.0 ± 0.25a	2.5 ± 0.12c
<i>S3O2</i>	28.5 ± 0.43a	2.6 ± 0.15c

CONCLUSION

The study demonstrates that plant spacing and sowing orientation significantly influence cabbage growth and yield parameters. Wider spacing, particularly the S3O1 treatment, consistently outperformed other treatments across various metrics, including plant height, leaf development, stem diameter, head size and marketable yield. These findings underscore the importance of optimizing planting

geometry to enhance cabbage productivity and quality.

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