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GROWTH PERFORMANCE OF CAULIFLOWER UNDER SHORT-DURATION VEGETABLE INTERCROPPING

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ABSTRACT

The study was conducted at the Vegetable Experimental Farm, Division of Vegetable Science and Floriculture, SKUAST-Jammu, Chatha to evaluate the effects of intercropping systems on the growth parameters of different sole and intercrops. A Randomized Complete Block Design (RCBD) with three replications and fifteen treatments was used for the experiment. The sole crop treatments included cauliflower (T_1), knol-khol (T_2), spinach beet (T_3), swiss chard (T_4), lettuce (T_5), fenugreek (T_6), coriander (T_7) and radish (T_8). The intercropping treatments consisted of cauliflower combined with knol-khol (T_9), spinach beet (T_{10}), Swiss chard (T_{11}), lettuce (T_{12}), fenugreek (T_{13}), coriander (T_{14}) and radish (T_{15}). The sole crop, cauliflower exhibited the highest growth parameters, including plant height (43.55 cm), number of leaves (23.95), curd compactness (71.18) and the shortest time to marketable curd maturity (101.66 days) compared to intercropped treatments. Within the intercropping systems, cauliflower combined with spinach beet and swiss chard resulted in the longest leaf length (20.85 cm and 21.51 cm, respectively) compared to monocropping, though it recorded the lowest leaf width and leaf area index. Lettuce in intercropping treatments showed a higher number of non-wrapper leaves (8.24) than in its sole crop form. The fastest marketable maturity was achieved with cauliflower intercropped with fenugreek followed by coriander, spinach beet and Swiss chard. Therefore in conclusion the intercropping of cauliflower with leafy vegetables such as coriander and fenugreek proved to be more beneficial than growing cauliflower alone.

Key words : Cauliflower, Intercropping, Marketable maturity, Monocropping, Curd compactness.

Introduction

The rapid growth of population and industrialization worldwide has led to a steady decline in cultivable land, creating pressure on existing arable areas to meet increasing food demands. This challenge is particularly pronounced in developing regions like Asia and Africa, where farmers often operate on small landholdings (Awal *et al.*, 2006). One possible solution to this issue is to maximize productivity per unit area of available land or expanding the area of land under production, which seems shrinking day by day. To ensure sustainable food production, adopting efficient vegetable-based cropping systems that optimize both natural and artificial resources is essential. Intercropping has emerged as a beneficial practice, allowing for the optimal use of land, water, nutrients and solar energy leading to higher productivity compared to monocropping (Yildirim and Guvenc, 2005). This system involves cultivating two or more crops simultaneously in a defined spatial arrangement to enhance yield per unit area. Several factors influence the success of intercropping including plant density, sowing and harvesting schedules, crop maturity periods, species compatibility and socio-economic conditions of the region. The effectiveness of intercropping is often measured using the land equivalent ratio (LER), which evaluates land productivity in such systems (Aziz *et al.*, 2015). Cauliflower being a widely spaced vegetable crop, is well-suited for intercropping. As a long-duration, nutrient-demanding winter season crop, cauliflower requires frequent intercultural operations throughout its growth cycle. However, during its early stages, its leaf area remains insufficient to capture most of the incoming solar radiation. Additionally, due to its wide spacing the area between rows remains underutilized for an extended period leading to inefficient land use. A practical approach to addressing this issue is intercropping cauliflower with short-duration, fast-growing crops such as fenugreek, coriander, lettuce, swiss chard, spinach beet, knol-khol and radish. This strategy not only optimizes space and sunlight utilization but also enhances overall productivity and profitability per unit area. Therefore, the present study aims to assess efficient land and resource utilization by evaluating different vegetable-based intercropping systems where cauliflower intercropped with short-duration crops including fenugreek, coriander, lettuce, swiss chard, spinach beet, knol-khol and radish, to determine the most suitable cropping combinations for maximizing growth performance.

Material and Methods

A field experiment was carried out during the Rabi season of 2021–2022 at the Vegetable Experimental Farm, Division of Vegetable Science and Floriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology (SKUAST), Jammu. The trial was laid out in a Randomized Complete Block Design (RCBD) with three replications and fifteen treatments in total. Of these, eight treatments involved sole cropping are T_1 - Cauliflower, T_2 - Knol-khol, T_3 - Spinach beet, T_4 - Swiss chard, T_5 - Lettuce, T_6 - Fenugreek, T_7 – Coriander and T_8 - Radish. The remaining seven treatments consisted of intercropping systems are T_9 (Cauliflower + Knol-khol), T_{10} (Cauliflower + Spinach beet), T_{11} (Cauliflower + Swiss chard), T_{12} (Cauliflower + Lettuce), T_{13} (Cauliflower + Fenugreek), T_{14} (Cauliflower + Coriander) and T_{15} (Cauliflower + Radish).

The crop varieties used were Snowball-16 for Cauliflower, G-40 for Knol-khol, Jammu Spinach beet-07 for Spinach beet, Jammu Swiss chard-01 for Swiss chard, Chinese Yellow for Lettuce, Jammu Fenugreek-07 for Fenugreek, Jammu Coriander-07 for Coriander and CR-45 for Radish. Seedlings of cauliflower, knol-khol and lettuce were raised on raised nursery beds sown on 6th September 2021, following the Package of Practices for Vegetable Crops (2020). Transplanting of cauliflower was done at a spacing of 60 cm × 60 cm and intercrops were sown between rows on 9th October 2021 at a spacing of 20 cm.

All cultural practices were carried out as per the SKUAST-recommended guidelines. Each plot received well-decomposed farmyard manure (FYM) at 25 t/ha before planting along with the recommended fertilizer dose for cauliflower (120 kg N, 60 kg P_2O_5) and 60 kg K_2O per hectare. The well-rotted FYM, full doses of phosphorus and potassium and one-third of the nitrogen were applied as a basal dose. The remaining nitrogen was top-dressed in two equal splits at 30 and 45 days after transplanting of cauliflower. Intercultural operations were performed accordingly.

The growth duration of the main crop (cauliflower) served as the basis for harvesting both sole and intercropped treatments. In intercropping setups, companion crops were harvested before the cauliflower canopy expanded. Under sole cropping, cauliflower was harvested alongside one crop of lettuce and two successive harvests of radish and knol-khol. For leafy vegetables two cuttings were taken during the crop cycle.

Results and Discussion

Cauliflower as sole and in intercropping

The present study showed the maximum growth parameters in respect of plant height (43.55 cm) and number of leaves (23.95) in sole crop of cauliflower as compared to intercropping treatments. This can be attributed to the lack of competition for sunlight, space, nutrients and moisture in the sole cultivation of the crop. This result is in consistent with the findings of Kumar *et al.* (2022) and Nandekar *et al.* (1995) where the growth parameters are higher in sole crop as in comparison to intercropping.

However, the intercropping of cauliflower with intercrops like fenugreek and coriander was at par with the main crop cauliflower. This might be due the reason that only two cuts were harvested from fenugreek and coriander, which prevented all kinds of competition between the main and intercrops for soil nutrients. Moreover, these two crops are early maturing and short duration. Splitstoesser (1990) reported that early-maturing crops would not interfere with the growth of the late-maturing ones. Similar findings in cauliflower-based intercropping by Yildirim and Guvenc (2005), Varghese *et al.* (1990), who reported that intercropping did not much affect some growth characteristics of main crop. But intercrops like radish and knol-khol had significantly affected all the growth parameters of cauliflower (main crop). The reason might be due to the fact that the crops, belonging to similar families, grown side by side have similar type of plant canopy and nutrient requirement. Intercropping of such crops resulted in poor growth and development of both the crops (Varughese *et al.*, 2019) and Ashwini *et al.* (2017) also reported antagonistic effect of knol-khol intercropped on cabbage through the secretion of allelochemicals by root exudates as they tend

Table 1 : Growth response of cauliflower as sole crop and as influenced by intercropping.

Notation(s)	Treatment (s)	Plant height (cm)	No. of leaves per plant	Days to marketable curd formation	Curd compactness
	A) Sole crop				
T_1	Cauliflower	43.55	23.95	101.66	71.18
	B) Inter crops				
T_9	Cauliflower + Knol-khol	39.14	19.75	112.66	46.06
T_{10}	Cauliflower + Spinach beet	41.76	22.10	108.00	56.15
T_{11}	Cauliflower + Swiss chard	42.23	22.29	109.00	58.23
T_{12}	Cauliflower + Lettuce	40.42	21.45	111.66	65.66
T_{13}	Cauliflower + Fenugreek	43.21	23.47	104.33	69.31
T_{14}	Cauliflower + Coriander	43.12	23.25	106.00	67.21
T_{15}	Cauliflower + Radish	39.10	19.23	113.00	45.33
SEm (±)		0.78	0.35	1.54	0.97
C.D (5%)		2.40	1.07	4.72	2.97

Table 2 : Leaf length, leaf width, leaf area index and plant frame of spinach beet and swiss chard as sole crop and as influenced by intercropping.

Notation(s)	Treatment (s)	Leaf length (cm)	Leaf width (cm)	LAI	Plant frame (cm^2)
	A) Sole crop				
T_3	Spinach beet	18.10	5.56	6.11	847.87
T_4	Swiss chard	19.00	6.45	8.30	795.32
	B) Inter crops				
T_{10}	Cauliflower + Spinach beet	20.85	4.33	5.89	721.00
T_{11}	Cauliflower + Swiss chard	21.51	5.28	6.39	675.40

to be from the same botanical family might have resulted in lower growth parameters. A similar result was reported by Jha *et al.* (2002), Barik *et al.* (1996) and Choudhary *et al.* (2014).

Minimum days to marketable curd formation determine the earliness of the crop. The data revealed that the sole crop of cauliflower took the minimum days (101.66) for marketable curd formation, which was statistically at par with intercrops like fenugreek and coriander as compared to other treatments under study. This might be due to less competition and efficient utilization of sunlight, space, nutrients and other resources in the sole crop. However, in various intercropping treatments, the days to marketable maturity increased, since no additional fertilizer was provided and all the crops compete for limited resources. But leafy crops like coriander and fenugreek with less nutrient demand, rosetted growth, shallow roots, sparse leaf canopy and harvested early, did not interfere with the growth of the main crop. Splitstoesser (1990) also reported that the early-maturing crops would not interfere with the growth of the late-maturing crop like cauliflower.

Intercrops as sole and in intercropping

The perusal of data about the different growth parameter suggested that leaf length of intercrops like spinach beet and swiss chard was recorded maximum in intercropping (20.85 cm and 21.51 cm) as compared to monocrop, whereas minimum values of leaf width and leaf area index was recorded. This might be due to the competition for light and space with main crop. Being a quick and erect growing nature of these intercrops, they tend to produce leaves of much higher length compromising leaf width and leaf area index than grown as sole crop. Similar results were also reported by Muoneke *et al.* (2012). Choudhary *et al.* (2014) and Fawusi (1985) where maximum LAI was

Table 3 : Plant frame of fenugreek and coriander as sole crop and as influenced by intercropping.

Notation(s)	Treatment (s)	Plant Frame (cm^2)
	A) Sole crop	
T_6	Fenugreek	275.33
T_7	Coriander	245.73
	B) Inter crops	
T_{13}	Cauliflower + Fenugreek	246.26
T_{14}	Cauliflower+ Coriander	214.50

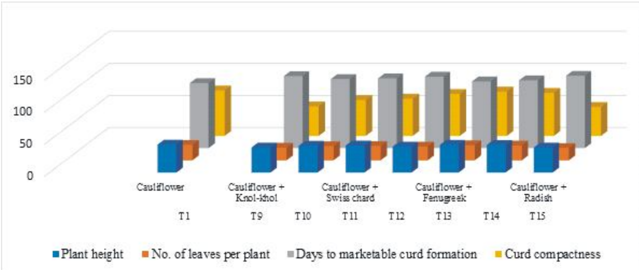

Fig. 1 : Growth response of cauliflower as sole crop and as influenced by intercropping.

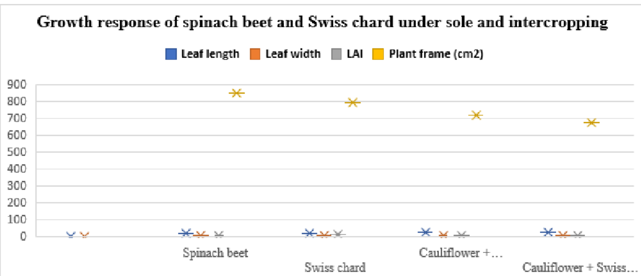

Fig. 2 : Leaf length, leaf width, leaf area index and plant frame of spinach beet and swiss chard as sole crop and as influenced by intercropping.

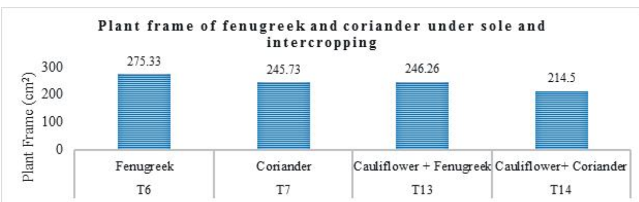

Fig. 3 : Plant frame of fenugreek and coriander as sole crop and as influenced by intercropping.

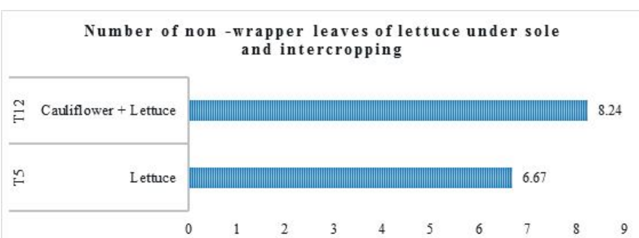

Fig. 4 : Number of non-wrapper leaves of lettuce as sole crop and as influenced by intercropping.

recorded in sole crop than in intercropping. Similarly, the plant frame of fenugreek, coriander, spinach beet and swiss chard was also recorded higher in sole crops i.e 275.33 cm², 245.73 cm², 847.87 cm² and 795.32 cm² respectively. This might be due to more space available to these crops for their growth as a sole was responsible to increase the circumference and spread of the plant. Same findings were also reported by Chattopadhyay *et al*. (2008). However, the findings of Agrawal *et al*. (2010) are in contrary to the present findings where they recorded more plant frame in intercropping system than sole crop.

Table 4 : Number of non-wrapper leaves of lettuce as sole crop and as influenced by intercropping.

Notation(s)	Treatment (s)	Number of non - wrapper leaves
	A) Sole crop	
T_5	Lettuce	6.67
	B) Inter crops	
T_{12}	Cauliflower + Lettuce	8.24

Table 5 : Number of leaves, root length and root girth of radish as sole crop and as influenced by intercropping.

Notation(s)	Treatment (s)	No of leaves	Root length (cm)	Root girth (cm)
	A) Sole crop			
T_8	Radish	13.53	26.32	12.30
	B) Inter crops			
T_{15}	Cauliflower + Radish	11.16	24.16	11.00

Table 6 : Days to marketable harvest of intercrops as sole crop and as influenced by intercropping.

Notation(s)	Treatment (s)	Days to marketable harvest
	A) Sole crop	
T_2	Knol-khol (G-40)	44.33
T_3	Spinach beet (Jammu Spinach beet- 07)	43.99
T_4	Swiss chard (Jammu Swiss chard- 01)	42.33
T_5	Lettuce (Chinese Yellow)	47.66
T_6	Fenugreek (Jammu Fenugreek- 07)	45.66
T_7	Coriander (Jammu Coriander- 07)	46.00
T_8	Radish (CR-45)	56.33
	B) Inter crops	
T_9	Cauliflower + Knol-khol	52.33
T_{10}	Cauliflower + Spinach beet	48.66
T_{11}	Cauliflower + Swiss chard	47.00
T_{12}	Cauliflower + Lettuce	60.00
T_{13}	Cauliflower+ Fenugreek	47.00
T_{14}	Cauliflower + Coriander	48.33
T_{15}	Cauliflower + Radish	66.00
SEm (±)		0.83
C.D (5%)		2.44

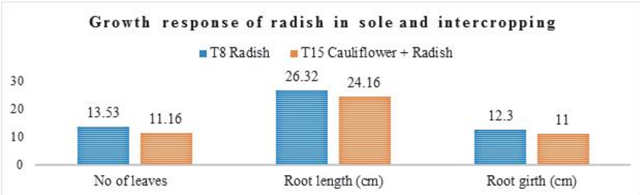

Fig. 5 : Number of leaves, root length and root girth of radish as sole crop and as influenced by intercropping.

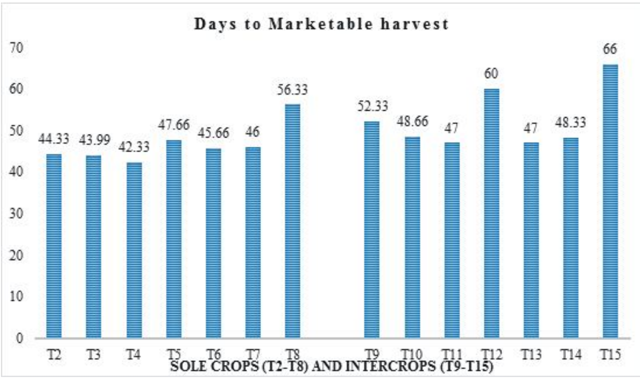

Fig. 6 : Days to marketable harvest of intercrops as sole crop and as influenced by intercropping.

Number of non-wrapper leaves of lettuce was recorded maximum in intercropping treatment (8.24) than in sole crop. The increase in number of non-wrapper leaves in intercropping system might be due to the reason that two crops of dissimilar nature compete for moisture, sunlight and nutrient that negatively affect the marketable maturity of each crop. Therefore it produced small headed lettuce with more number of non-wrapper leaves. Guvenc and Yildirim (2006) also reported more number of non-wrapper leaves . However, the sole crop of radish showed more number of leaves as compared to intercropping system. Similar result have been reported by Kumar *et al.* (2018) and Nandekar *et al.* (1995) in french radish - coriander and potato based intercropping. Marketable harvest of intercrops took more number of days, which ranged from 1.34 to 12.34 days in various intercropping, as compared to their sole crops. Among the various intercropping treatments, the earliest treatment to achieve marketable maturity was cauliflower intercropped with fenugreek followed by coriander, spinach beet and swiss chard. It resulted so because most of the leafy vegetables are fast growing and does not require more room for their growth therefore they neither compete for moisture and nutrients as compared to other intercrops such as radish and knol-khol.

Conclusion

This study's findings highlight the advantages of intercropping systems in maximizing land use and enhancing crop yield. Although the exclusive cultivation of cauliflower showed enhanced growth metrics, including plant height, leaf count, curd compactness and reduced duration to marketable curd maturity, specific intercropping arrangements also yielded favorable outcomes. Intercropping cauliflower with fenugreek and coriander not only preserved similar growth metrics but also promoted earlier marketable maturity relative to alternative intercrops. This can be ascribed to the brief growth period, limited nutrient competition and effective resource utilization by these green crops. In contrast, intercropping with radish and knol-khol adversely affected cauliflower's growth, perhaps due to competition for analogous resources and possible allelopathic interactions, given both crops are from the same botanical family. The study indicated that intercropping influenced the growth characteristics of secondary crops, with changes noted in leaf length, leaf area index and plant structure across various combinations. Spinach beet and Swiss chard exhibited enhanced leaf length but diminished leaf breadth and leaf area index when intercropped, signifying a competitive reaction to constraints in light and space. This research demonstrates that strategically chosen intercropping combinations, such as cauliflower with leafy vegetables such as fenugreek, coriander, spinach beet and swisschard can improve land equivalent ratios and provide a sustainable method for vegetable production. These findings support the implementation of strategic intercropping systems to enhance land productivity, optimize resource utilization and increase economic returns for farmers, especially in areas with constrained arable land.

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