*J Bangladesh Agril Univ 22(2):**166-177**, 2024* https://doi.org/10.3329/jbau.v22i2.74550

ISSN 1810-3030 (Print) 2408-8684 (Online)

Journal of Bangladesh Agricultural University

Journal home page: http://baures.bau.edu.bd/jbau

Research Article

Productivity and Profitability of Cauliflower (*Brassica oleracea* var. Botrytis L.) Based Intercropping System for *Sorjan* Bed System

Md. Mahbubur Rahman[1], Md. Alimur Rahman[1], Md. Akkas Ali[2] and Ahmed Khairul Hasan[3]✉

[1]Bangladesh Agricultural Research Institute, RARS, Rahmatpur, Barishal-8211, Bangladesh
[2]Crops and Natural Resources, Krishi Gobeshona Foundation, Dhaka, Bangladesh
[3]Department of Agronomy, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

ARTICLE INFO

Article history
Received: 26 February 2024
Accepted: 25 June 2024
Published: 30 June 2024

Keywords
Vegetables,
Intercropping systems,
Sorjan,
Profitability

Correspondence
Ahmed Khairul Hasan
✉: akhasan@bau.edu.bd

ABSTRACT

Cauliflower, scientifically known as Brassica oleracea var. botrytis L., is a highly adaptable vegetable that offers significant nutritional advantages and is cultivated to a varying extent in the Barishal region. An experiment was conducted in Banaripara Upazila, Barishal district, to inspect the selection of a suitable intercrop for cauliflower, with the goal of maximizing the usage of *Sorjan* bed space and increasing economic benefits for farmers. The study covered two consecutive years, specifically 2021-2022 and 2022-2023. The study included a combination of intercropping treatments, namely Cauliflower as sole crop (T1), Cauliflower + Red amaranth (T2), Cauliflower + coriander leaf (T3), Cauliflower + lettuce (T4), Cauliflower + radish leaf (T5) and Cauliflower + spinach (T6). A randomized complete block design with three replications was used to carry out the study, with treatment effects observed in 3×2.4 m^2 of land units. The cauliflower seeds were sown on a nursery bed at October 30th, 2021, and October 29th, 2022. Twenty days older seedlings were undertaken a hardening process for a duration of 2 days. To ensure proper growth, the cauliflower crop received nutrients including N, P, K, S, Zn, B and cow dung at rates of 120, 60, 100, 24, 3.6, 2.1 kg and 3 tons per hectare, respectively. Spanning two consecutive years, the combination of cauliflower and coriander leaf provided the highest land equivalent ratio, with values of 1.68 and 1.62, respectively. Besides, in view of BCR, cauliflower intercropped with spinach resulted the highest BCR values of 1.61 in the first year and 1.50 in the second year. Cauliflower + spinach intercropping system resulted in net returns of 217,410 and 183,950 BDT, respectively. Therefore, it can be suggested that farmers can cultivate their land with a combination of cauliflower and spinach in the interest of maximizing profitability in Sorjan bed cultivation.

Introduction

Cauliflower (*Brassica oleracea* var. botrytis L) from the *Brassicaceae* family, is a well-adapted vegetable that provides massive nutritional benefits. It is especially appreciated for its adequate quantity of antioxidants and anticarcinogenic compounds, including ascorbic acid (AA), carotenoids, and *glucosinolates*. Furthermore, cauliflower is a rich source of various vitamins and minerals (Gu et al., 2014). Cauliflower is commonly eaten up in different forms including cooked, fried, boiled, and pickled. In the fiscal year 2020-2021, cauliflower cultivation in Bangladesh recorded with a total production of 294,684.11 metric tons, covering an area of 56,029.09 acres. Specifically, the cauliflower production of Barishal division shared with 4,115 metric tons, cultivated across 1,528 acres of land (BBS, 2021). Lands of Barishal is medium low as a result the vegetables are normally grown on household area or on *Sorjan* beds. The local name of the *Sorjan* beds is "*Kandi*", which has been employed by farmers in the country for more than a hundred years to grow crops on lifted up land. The *Sorjan* system, characterized by alternating deep sinks and raised beds, is especially convenient for regions that experience both flooding and drought (Domingo and Hagerman, 1982). Including intercropping into cauliflower cultivation on *Sorjan* bed can significantly increase profitability. Willey (1979) specified that, intercropping has proven to be the most favorable practice and attract attention as the most suitable strategy for stabilizing production within different cropping systems, including multiple cropping, relay cropping, and succession cropping. Francis, 1986 also said that, small-scale subsistence farmers have

Cite This Article
Rahman, M.M., Rahman, M.A. and Ali, M.A. and Hasan, A.K. 2024. Productivity and Profitability of Cauliflower (*Brassica oleracea* var. Botrytis L.) Based Intercropping System for Sorjan Bed System. *Journal of Bangladesh Agricultural University,* 22(2):166-177. https://doi.org/10.3329/jbau.v22i2.74550

habitually clasp with intercropping as a means to mitigate risks associated with monocultures and ensure stable income and nutrition in tropical regions. Intercropping renders lots of advantages, particularly when the species involved showed distinct variations in morphology, phenology, or physiology (Andersen *et al.,* 2007). The sowing time and harvesting may be different among the crops, but they must exit side by side for a significant duration of their growth (Ofori, 1987). Intercrops can include annuals, perennials, or a combination of both (or more) species or breeds (Anil, 1998). The main objective of intercropping is to maximize productivity and enhance soil health by using the available spaces between crops as well other resources. Intercropping has been accepted as an effective strategy for sustainable agriculture (Zimmermann, 1996). Moreover, differences in the nutrient uptake among the various crops further contribute to the improved utilization of nutrients in intercropping systems (Gebru, 2015). Batista *et al*. (2016) and Silva *et al*. (2017) also stated that, enhanced crop growth and soil fertility was seen with decreasing the per unit cost of the final product is derived from the intercropping system. Riberio *et al*. (2000) further reported that intercropping does not need any extra costs. Therefore, the study was undertaken to investigate the selection of an appropriate cauliflower intercrop, maximizing the usage of *Sorjan* bed space and increase the economic benefits as well as its impact on farmers' profitability.

Materials and Methods

Feature of the Experimental location

The experiment was carried out in Banaripara Upazila, Barishal district. The study was continued for two consecutive years, namely 2021-2022 and 2022-2023. The research site is situated at a latitude of 22°46'14.90347''N, a longitude of 90°10'47.19824''E, and an elevation of 6 meters above sea level in the coastal south region. This site represents the Ganges Tidal Floodplain (AEZ-13), which is characterized by a subtropical monsoon climate and a humid environment. The soil is clayey loam in nature. The land is a medium low land that has been raised up using the *Sorjan* system for experimental purpose. The soil exposes a neutral pH, low organic matter content, and an overall low fertility level.

Table 1. Monthly average temperature and rainfall data obtained from the experimental area during the observation period (Oct., 2021- March, 2022 & Oct., 2022- March, 2023)

Months & Year	Temperature (°C)	Precipitation (mm)	Months & Year	Temperature (°C)	Precipitation (mm)
October, 2021	28.43	298	October, 2022	27.50	298
November, 2021	24.28	0.00	November, 2022	24.30	0.00
December, 2021	21.45	10.11	December, 2022	21.45	0.00
January, 2022	18.26	0.00	January, 2023	19.10	0.00
February, 202	18.2	0.00	February, 2023	22.92	0.00
March, 2022	26.64	62	March, 2023	17.80	62

* Source: Bangladesh Rice Research Institute, Regional Station, Barishal.

Experimental material, design and treatments

The study involved the usage of different leafy vegetables i.e., red amaranth (BARI Lalshak-1), coriander as leaf (BARI Dhania-1), lettuce (BARI lettuce-1), radish shank (BARI Mula-1) and spinach (BARI Palongshak-1), well-known vegetable varieties that was developed by the Bangladesh Agricultural Research Institute along with the cauliflower variety, Chamak developed by Syngenta Pvt ltd. To execute the experiment, three replications was employed with a randomized complete block design (RCBD). The main goal of the study was to determine a suitable intercrop of cauliflower for optimizing the utilization of *Sorjan* bed space and increasing the economic advantages, while also considering its influence on farmers' profitability. These treatments included: T_1= Cauliflower as sole crop, T_2= Cauliflower + Red amaranth, T_3= Cauliflower + Coriender leaf, T_4= Cauliflower + lettuce, T_5= Cauliflower + radish leaf and T_6= Cauliflower+ spinach.

Experimental techniques

The *Sorjan* beds experienced with ploughing using a high-speed rotary tiller until a fine tilth was accomplished. Then raised beds were manually established using local spades according to the designated treatments. The total land was divided into three blocks and then each block was divided into six plots resulting eighteen plots. Each plot had dimensions of 3×2.4 m^2 and comprised of four rows, accommodating five cauliflower plants per row with the recommended plant-to-plant spacing between the cauliflower plants was 60 cm. Each replication of the experiment received a different intercropping treatment. Cauliflower seeds were sown on a nursery bed on October 30th, 2021, and October 29th, 2022. When the seedlings reached twenty days of age after

germination, they were hardened for 2 days. Two seedlings were transplanted into each pit at an age of 30 days. One healthy plant was retained in each pit, while the other was cut out using a sharp knife after five days of transplanting. Additionally, other crops such as red amaranth, coriander leaf, radish leaf and spinach were directly sown in the study area, with a plant-to-plant spacing of 5 cm and three rows within the two cauliflower lines field. This was practiced immediately after removing of extra cauliflower plants from every plot, according to the recommended production technologies for these crops as outlined by BARI (2020). The soil was regularly hoed to give a fine texture starting from the following month after transplantation, facilitating the accumulation of fertilizers and irrigation. The crop received N, P, K, S, Zn, and B nutrients at rates of 120, 60, 100, 24, 3.6, and 2.1 kg per hectare respectively, in the form of Urea, Triple super phosphate (TSP), Muriate of potash (MoP), Gypsum, Zinc sulphate, and Boric acid, along with 3 tons of cow dung per hectare as recommended (FRG, 2018). During the final land preparation, half doses of organic fertilizer and full doses of all other fertilizers except N and K were evenly distributed across the plots. Remaining half of the organic fertilizer was applied in the pits just before the transplantation of cauliflower. N and K was applied in three equal splits at 15, 30 and 50 days after transplanting using ring method and irrigate the field after that. To detect and minimize the impact of major diseases and insect pests on the employed treatments, close monitoring was conducted throughout the growing period. Adequate spraying malathion 57 EC (Malathion 57%) against cauliflower cut worm, as well as the use of pheromone traps and sticky traps, were employed during the trial, resulting in no significant presence of insect pests or diseases. Harvesting of all vegetables was done manually by plucking or cutting with a sharp knife once they reached their physiological maturity and leafy vegetables were harvested by pulling them out of the soil by hand and then washing their roots to remove any soil residue.

Data collection

Data were assembled from five randomly chosen plants from each plot for each treatment.

Plant height (cm): The height of five randomly selected plant was measured and the average value was calculated for each plant.

Canopy spread (cm): It was estimated evaluating the horizontal distance from one side of the canopy to the other side. This was done by measuring the crown's diameter in two directions (e.g., north-south and east-west) and then averaged the two measurements.

Stem diameter (cm): Stem diameters of five plants during harvesting period was recorded and averaged and calculated the stem diameter.

Number of leaves per plant (Nos.): The numbers of leaves of three plants was summed from seedlings to harvesting stage and then averaged to get this.

Leaf length (cm): Ten leaves from each plant selected randomly and summing the length and averaged. The averaged value was then used as the basis of further analysis.

Leaf breadth (cm): Average breadth of leaves was obtained from randomly selected ten leaves, which breadth was counted by slide calipers and then averaged.

Days to card initiation (days): Days to curd initiation was calculated from the seed sowing of cauliflower at nursery bed.

Days to card maturity (days): It was gathered from seed sowing of cauliflower to the first harvesting date.

Curd length (cm): Five curds from each plot select with unbiasedly summing the length and averaged. The averaged value was then used as the basis of further analysis.

Curd diameter (cm): Average diameter was obtained from randomly selected ten curds, which diameter was estimated by slide calipers and then averaged.

Average curd weight (g): Five curds from each plot were randomly selected and then weighed in electrical balanced and averaged. The averaged data was then used for next analysis.

Curd yield per plot (kg): During each harvest, weight of the curds harvested from each plot was measured and recorded. When total harvesting was done, the total weights of the curds were added together, permitting for the calculation of the curd yield per plot.

Curd yield (t/ha): By multiplying plot yield to hectare and dividing by the size of the plot, it was observed.

Ascorbic acid (mg/100g):

The cauliflower sample of 100 g was sliced into small pieces and pulverized with a mortar and pestle. Distilled water was put on in 10 ml increments during grinding the sample, and the resulting liquid extract was poured off into a 100 ml volumetric flask each time. The pulp was then strained through cheesecloth, with the pulp being rinsed with several 10 ml portions of water and all filtrate and washings being collected in the volumetric

flask. Finally, the extracted solution was made up to 100 mL with distilled water. Titration was then performed repeatedly on this sample solution, and the number of moles of ascorbic acid reacting was calculated using the formula provided below (redox titration method):
Ascorbic acid + I2 → 2 I− + dehydroascorbic acid
After that, the concentration in mol L−1 of ascorbic acid in the solution was calculated gained from fruit. Then it was converted to mg/100g of ascorbic acid, in the sample of cauliflower.

Curd dry matter (%): Fresh cauliflower curd sample of 100 grams were collected from each plot, sliced, and promptly measured. Later on, the samples were kept in a well-ventilated room at ambient temperature for a duration of 2 days. Afterward, the samples were dried in a laboratory oven (memmert UN110) set at a temperature of 80 degrees Celsius for 24 hours. The dry matter content percentage was determined using the following formula (Kwach *et al.*, 2010).

Dry matter content (%) = (weight of sample (g) after drying / fresh sample weight (g)) × 100.

Yield of intercrops (t/ha): Total yield of the intercrop per plot was estimated, then converted to per hectare yield by multiplying it with ten thousand square meter and divided by the unit plot area.

Total equivalent yield (t/ha): The cauliflower equivalent yield (CEY) was calculated by the following formula:

$$\text{CEY} = \frac{\text{Intercrop yield (kg/ha)} \times \text{Price of intercrop yield (Tk/kg)}}{\text{Price of main crop (Tk/kg)}}$$

Land equivalent ratio (LER)
The Land equivalent ratio (LER) was determined as the sum of fractions of the yields of cauliflower and intercrops compared with their sole crop yields by the following formula (De Wit and Bergh, 1965):

$$\text{LER} = \frac{Yab}{Yaa} + \frac{Yba}{Ybb}$$

where, Y_{ab} is the yield of cauliflower "a" intercropped with another crop "b", Y_{aa} is the pure stand yield of cauliflower "a", Y_{ba} is the yield of crop "b" intercropped with cauliflower "a", and Y_{bb} is the pure stand yield of crop "b". Any value greater than 1.0 indicates a yield advantage for intercrop.

Benefit-cost ratio (BCR): The total cost is consisting of both fixed and operating costs. The total cost per ha was estimated to contrast on per hectare basis. By considering product yield and its selling price, the gross return is calculated. Oppositely, the net return was estimated by subtracting the cost of production from the gross return for each treatment. This method is repeated for each treatment in order to obtain the net return. The benefit cost ratio was assessed using the formula provided:

Benefit cost ratio= Gross return/ Total cost

Statistical analysis
To appraise the data analysis of variance (ANOVA) was used, performing the R statistical analysis systems 4.2.0. The average values of the plants were compared based on the applied treatments (intercropping) using the LSD test at a significance level of $P<0.05$. According to Gomez and Gomez (1984), the results of the intercropping effect were presented using two-year data. The Pearson correlation was conducted to evaluate the relationship between the traits, and the correlation matrix will exhibit the statistically significant ($P<0.05$) correlation results.

Results and Discussion

Plant height (cm)
Plant height significantly varied with the employed treatments in the both two growing seasons. The longest plant was obtained from the cauliflower intercropped with radish (60.57cm), which was statistically identical with other intercropped cauliflower plants and the shortest plant was obtained from sole cauliflower (52.36cm) in first season. Similarly, in next cropping season the highest plant height was recorded in intercropping treatment, which was intercropped with lettuce (58.14cm) and identical with other intercropped cauliflower plants. The lowest plant height was observed in sole crop (53.22cm) presented on table 2. The variance in the height of plants can be attributed to the effects of intercropping, enclosed factors like the rivalry for nutrients, light, and space. Mineral demands tend to be increased, in plantations with higher density due to an environment created and inscribed by strong competition for water, light, and nutrients within the space occupied by the plants. Accordingly, plants in denser populations involved in increased growth in differentiation to those in less crowded plantations (Scarpare and Kluge, 2001). The rise in average plant height could be associated to a reduction in the length and weight of tuberous roots of the component crops, leading to increased plant height and growth. Babar *et al*. (2021) also recorded the occurrence of the same phenomenon while doing their research on turnip intercropping with radish. Riad *et al*. (2009) while working with intercropping of cabbage stated that, the noticed increase in plant length as

planting densities rise can be ascribed to the increased competition for sunlight among plants and this phenomenon causes some plants to be shaded, leading to the elongation of their stems.

Canopy spread (cm)

The plant canopy had significantly differed with the changes in applied treatment in both seasons. The highest canopy spread was found 53.34 cm and 52.13 cm in two seasons respectively in sole cultivation of cauliflower. The lowest canopy spread was recorded 44.24 cm in first growing season and 43.29 cm during second season in treatment T_5, indicating cauliflower intercropped with radish, these are visualized in Table 2. The differences may be due to the competition for scarce resources, which was resulted from higher number of plant population in the intercropping system. James *et al*. (2022) have found that intercropped pea showed a reduction in number of nodes, a shorter growth stature, resulting in a lower canopy, and finally produced less biomass and grain compared to the pea grown as a sole crop.

Stem diameter (cm)

At the time of harvesting, the diameter of stem varies with the impact of treatments in both cultivating years. The thickest stem was observed in sole cropping 3.22 and 3.14 cm in first and second seasons respectively. The thinnest stem was obtained from the treatment T_4 (2.62cm) in first year and from treatment T_6 (2.52cm) in the next cropping year, reflected in Table 2. The sole crop flourishes in an environment ample with sunlight, nutrients, and water, utilizing these essential resources to enhance the growth and thickness of its stem. Yildrim and Guvenc (2005) also observed that, the sole cauliflower plant displayed the thickest stem diameter, which can be ascribed to its ability to fully utilize the available resources for optimal vegetative growth. The stem diameter of cauliflower plants showed remarkable improvement, also as a result of reduced competition among plants and the intake of appropriate levels of inorganic fertilizers. These fertilizers were useful to meet the specific nutritional needs of the plants, thereby promoting optimal growth and development. The same result was observed by Sharma (2016) and Metwaly (2017) on cauliflower and Doklega and Abd El-Hady (2017) on broccoli.

Table 2. Various growth parameters are influenced by the effect of intercropping

Treatments	Plant height (cm)		Canopy spread (cm)		Stem diameter (cm)		No. of leaves/ plant	
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
T_1	52.36 b	53.22 b	53.34 a	52.13 a	3.22 a	3.14 a	21.24 a	20.75 a
T_2	58.39 a	56.15 ab	49.79 b	48.95 b	3.08 b	2.97 b	19.02 b	18.60 b
T_3	59.31 a	56.58 a	48.02 b	47.06 b	2.94 c	2.83 c	17.74 bc	17.51 bc
T_4	60.31 a	58.14 a	44.27 c	43.34 c	2.62 e	2.71 cd	16.49 c	17.49 bc
T_5	60.57 a	57.32 a	44.24 c	43.29 c	2.86 c	2.61 de	17.90 bc	16.82 bc
T_6	60.00 a	55.85ab	43.54 c	42.58 c	2.72 d	2.52 e	17.10 bc	16.09 c
CV (%)	3.09	2.77	3.12	3.13	1.81	2.6	6.21	6.5
Significance	**	*	**	**	**	**	**	**
LSD	3.24	2.8	2.64	2.6	0.09	0.13	2.04	2.09

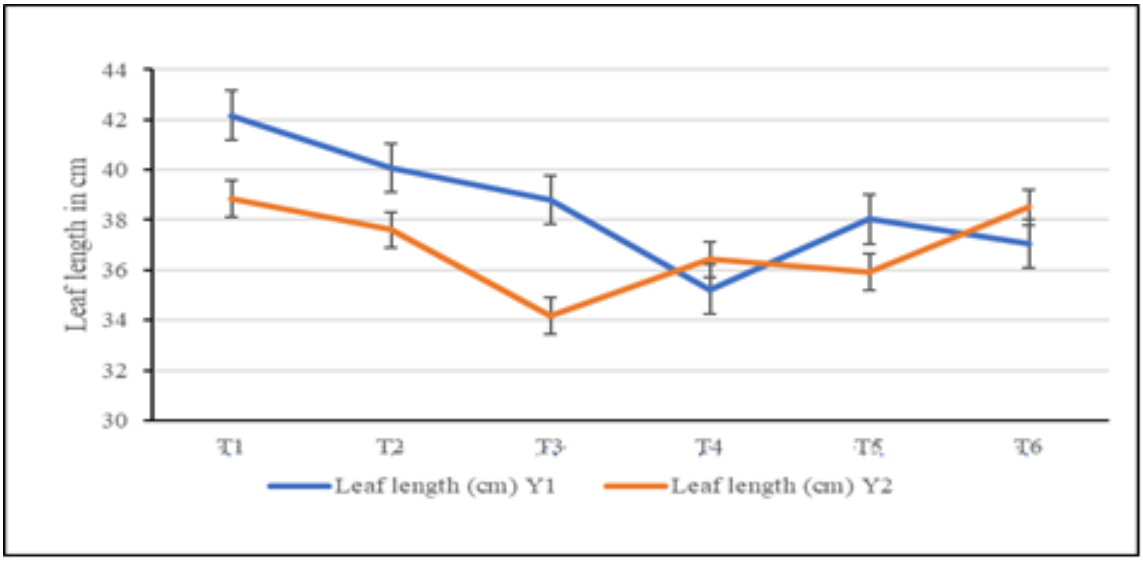
*T_1= Cauliflower as sole crop, T_2= Cauliflower + Red amaranth, T_3= Cauliflower + Coriender leaf, T_4= Cauliflower + lettuce, T_5= Cauliflower + Radish shank, T_6= Cauliflower+ spinach; Y_1= 2021-2022, Y_2= 2022-2023

Number of leaves per plant

There were remarkable variations observed in the treatments performed during each season. Sole cropping resulted the highest leaf count, with 21.24 and 20.75 leaves in two consecutive seasons. Contrarily, the lowest leaf count was recorded in treatment T4 (16.49 leaves) and treatment T_6 (16.09 leaves) over the two cropping seasons, as indicated in Table 2. The crops showed a remarkable number of leaves due to their extraordinary vigor and excellent health. This can be assigned to the fact that the crops were cultivated in an environment that circulated them with a plenty of essential resources such as nutrients, light, water, and space. Amoli (2012) documented that sole cauliflower system resulted with higher number of leaves in intercropping system. Intercropping declines the availability of various fertilizers, particularly nitrogenous fertilizer. Contra wise, in sole cropping, plants are offered the opportunity to absorb an optimal quantity of nitrogen. As a result, intaking adequate nitrogen (N) assists the optimal growth of chlorophyll, thereby increasing the rate of photosynthesis. Accordingly, the increased rate of photosynthesis leads to a higher number of leaves. Furthermore, the spacing between plants has a notable impact on the number of leaves. As in sole cropping, spacing increases than intercropping, the number of leaves per plant increases in sole crop. Bewuket *et al*. (2020) observed increase in number of leaves per plant is responsible to the availability of nitrogen and proper spacing.

Leaf length (cm)

In two consecutive seasons, a statistical difference depending on the treatments applied was observed in the length of leaves. The largest leaves, with a size of 42.17 cm and 38.86 cm, were noticed in the sole cropping method during both seasons. Alternatively, the shortest leaves were gathered from lettuce intercropped with cauliflower plants, measuring 35.23 cm in the first year and from coriander leaf intercropped with cauliflower, measuring 34.17 cm in the second season. These findings are visually placed in Figure 1. According to Amoli (2012), the length of leaves in cauliflower cultivated solely was observed to be greater than that of cauliflower cultivated with intercrops.



*T_1= Cauliflower as sole crop, T_2= Cauliflower + Red amaranth, T_3= Cauliflower + coriander leaf, T_4= Cauliflower + lettuce, T_5= Cauliflower + Radish shank, T_6= Cauliflower+ spinach; Y_1= 2021-2022, Y_2= 2022-2023

Figure 1. Effect of treatments on the leaf length of cauliflower

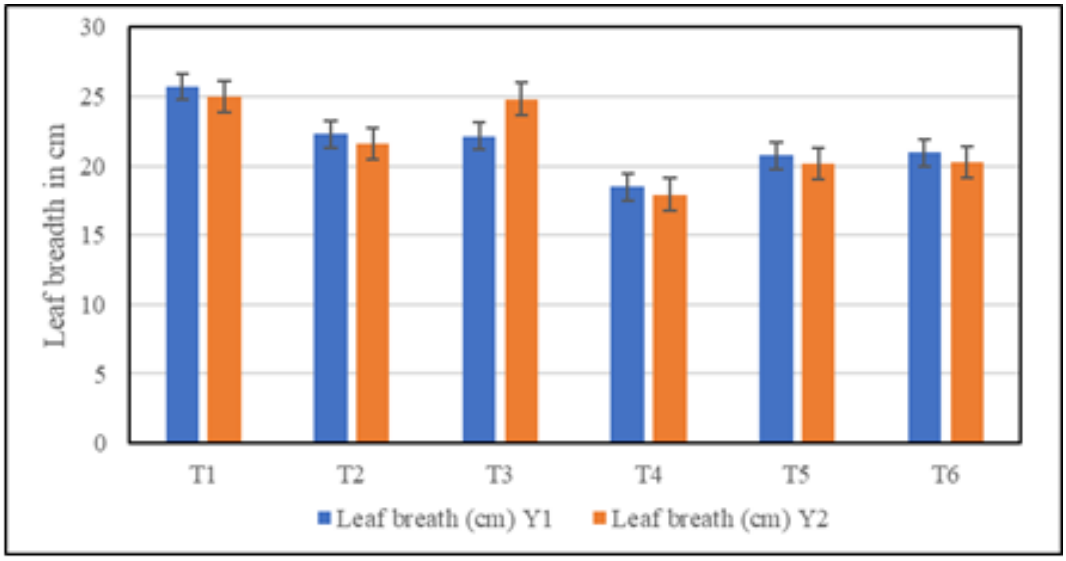
Leaf breadth (cm)

The statistical analysis revealed that there were significant variations in leaf breadth in accordance with the different treatments. In the first and second year, the leaf breadth was constantly highest in the sole cropping treatment, accounting 25.7 cm and 24.95 cm respectively and this data are distributed in Figure 2. This can be resulted from the ample availability of light, nutrients, and water in this treatment. Additionally, the leaf breadth was observed lowest, in the cauliflower + lettuce treatment, measuring 18.49 cm and 17.94 cm in the first and second growing seasons respectively. This could be accredited to the existence of necessary nutrients and other essential resources, which were adequate due to reduced competition compared to the intercropped plant. Bewuket *et al*. (2020) also found same findings with lettuce and described that wider plant spacing exhibited reduced competition for light, water, minerals, and air and produce wider leaf. Amoli (2012) recorded that the exclusive cultivation of cauliflower produces a wider leaf when compared to the intercropping system with other crops.

Days to curd initiation (days)

The duration for the initiation of curd formation demonstrated significant variations depending on the treatments implemented during both years. The longest period of time needed for curd initiation was revealed in the sole plantation, with 44.93 and 43.53 days passed after transplantation in the consecutive years. Otherwise, the shortest time duration for curd initiation was recorded in the intercropped treatments, with 40.91 and 39.82 days documented after transplantation in the first and second seasons respectively. These findings were illustrated in Table 3. As the sole crop had a lower total plant population compared to the intercropped treatments, the plants were assumed with adequate opportunities to absorb a sufficient amount of nutrients. Increased intake of nutrients, particularly nitrogen fertilizers, resulted in increased plant vegetative growth and delayed the initiation of curd formation in solely cultivated cauliflower plants compared to intercropped one. Ahmad (1995) has announced comparable results in the intercropping system of cabbage + tomato and cabbage + batishak, specifying similar outcomes. According to Vishnu (2006), an excess of nitrogen can conclude in an

excessive of vegetative growth and cause a considerable delay in the reproductive growth of plants.



*$T_{1=}$ Cauliflower as sole crop, $T_{2=}$ Cauliflower + Red amaranth, $T_{3=}$ Cauliflower + coriander leaf, $T_{4=}$ Cauliflower +lettuce, $T_{5=}$ Cauliflower + Radish shank, $T_{6=}$ Cauliflower+ spinach; Y_1= 2021-2022, Y_2= 2022-2023

Figure 2. Leaf breadth of cauliflower as influenced by treatments effect

Days to curd maturity (days)

The maturity period of curd showed remarkable variations depending on the treatments applied. Plants grown as the sole crop required the longest duration to reach physiological maturity, which amounted to 78.83 days, in the initial year. Contrarily, treatment T_4 (Cauliflower + lettuce) needed the shortest time, with only 69.50 days required for maturation. Moving on to the second year, cauliflower cultivated as the sole crop attained their maturity after largest time from their transplantation (74.01days). Rather cauliflower intercropped with lettuce needed a shorter duration of 67.42 days to produce mature curd (Table 3). The achievement of maturity in plants is dependent upon their vegetative growth. In the case of solely cropped plants, which exhibit robust growth, the procedure of reaching maturity is extended than intercropped plants. The delay in maturation of curd in single cropping may be attributed to the ample availability of nutrients, light, space and delaying in curd initiation. Vishnu (2006) stated that an excess of nitrogen intake can result in an excess of vegetative growth, leading to a significant delay in the reproductive growth of plants. Harvesting of leafy vegetables required 25 to 50 days as their genetic character. Red amaranth, coriander leaf, radish leaf and lettuce required 25, 33, 30 and 50 days respectively for harvesting.

Curd length (cm)

During 2021-22, the variation in treatments showed a distinct impact on the length of the curd. The highest curd length of 14.57 cm was found in sole plantation. Conversely, the intercropped plots derived the lowest curd length, measuring 12.99 cm (Table 3). In case of subsequent growing season, the curd length remained consistent. Increased curd length of cauliflower in sloe cultivation can be ascribed to the availability of nutrients, light, water space and also to planting density lower than intercropping system. The result is similar to the findings of Riad *et al*., (2009), who found head length and diameter were positively influenced by the N fertilizer and plant density had a negative effect on all these parameters, as higher density led to lower values of these parameters.

Curd diameter (cm)

The curd diameter showed significant differences across both cropping seasons in accordance with the treatments. The sole cropping method consistently yielded the largest curd diameter over the course of two consecutive years, measuring 20.17 cm and 19.75 cm respectively. Conversely, the smallest curd diameter was observed in treatment T_4 (Cauliflower + lettuce), measuring 17.12 cm and 17.30 cm, as indicated in Table 3. This phenomenon can be the result of less competition for essential nutrients and good micro climate prevailed in the sole cropped plot. This corelates with the research of Znidarcic *et al*. (2007), who observed a negative correlation between plant density and head diameter in cabbage cultivars and also reported that as plant density increased, the head diameter generally decreased. The decrease in curd

diameter in intercropped plants can attributed to limitation of resources as they have grown in a limited space. According to Semuli (2005), the depletion in plant spacing led to an up rise in competition for essential resources such as nutrients, light, air, and moisture and caused a decline in both the diameter and weight of cabbage heads.

Table 3. Effect of intercropping on growth and yield parameters on cauliflower

Treatments	Days to curd initiation (days)		Days to curd maturity (days)		Curd length (cm)		Curd diameter (cm)	
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
T_1	44.93 a	43.53a	74.83 a	74.01a	14.57 a	14.06	20.17 a	19.75a
T_2	42.26 b	41.74b	71.17 b	70.36b	13.62 b	13.13	18.43 b	18.03b
T_3	42.26 b	41.18bc	70.83 b	70.03b	13.27 b	12.81	18.13 bc	17.70bc
T_4	40.93 c	40.35cd	68.5 d	67.42d	13.12 b	12.67	17.12 d	17.30c
T_5	40.93 c	40.26cd	69.83 c	68.88c	13.00 b	13.53	17.72 cd	17.36c
T_6	40.91 c	39.82d	69.83 c	68.88c	12.99 b	12.52	17.87 cd	17.46c
CV (%)	1.17	1.81	0.78	0.91	2.73	6.44	1.26	1.32
Significance	**	**	**	**	**	NS	**	**
LSD	0.88	1.34	0.99	1.14	0.66	-	0.42	0.42

*T_1= Cauliflower as sole crop, T_2= Cauliflower + Red amaranth, T_3= Cauliflower + Coriender leaf, T_4= Cauliflower + lettuce, T_5= Cauliflower + Radish shank, T_6= Cauliflower+ spinach; Y_1= 2021-2022, Y_2= 2022-2023

Average curd weight (g)

The treatments implemented in both seasons had a significant impact on the average weight of individual curds. In every season, the sole cropped cauliflowers resulted the heaviest curds, weighing 1009.9 g and 999.33 g respectively. Otherwise, the intercropped treatments followed in the production of the lightest curds, weighing 799.4 g and 726.91 g in the first and second season respectively Availability of light, nutrients, water and less completion for space resulted highest curd weight in sole plantation. Yildirim and Guvenc (2005) also documented a moderately higher yield of cauliflower in the sole cauliflower system. Ananda *et al*. (2018) also reported in previous studies that the weight of the cabbage head weight was appreciably impacted by the practice of intercropping, lining up with our findings.

Curd yield per plot (kg)

The reaction of curd yield per plot to the treatments applied demonstrated a significant variation in the two following years. In terms of plot yield, the highest amount was rendered from single cropped cauliflower, with 20.20 kg in the first season and 19.99 kg in the second season. On the other hand, treatment T_6 (Cauliflower+ spinach) which included a combination of cauliflower and spinach, yielded in the lowest plot yield of 15.99 kg in the first season. In the second season, treatment T_5, which involved cauliflower and radish shank intercropping, had the lowest plot yield of 14.37 kg. The superior functions of the obtainable NPK nutrients in individually cultivated areas contribute to the encouragement of photosynthesis and the synthesis of necessary organic compounds, including carbohydrates and proteins. These components are then transported and magnified within the edible plant parts, such as the cauliflower curds, through the impact of these constituents. As a result, the productivity of cauliflower is outstandingly improved in sole cropped plot. Farahzety and Aishah (2013), demonstrated similar findings in their study on cauliflower when applying the proper dosage of fertilizer. Doklega and Abd El-Hady (2017) also found similar results on broccoli.

Curd yield (t/ha)

The curd yield per hectare was significantly influenced by the treatments applied during two successive growing seasons. In the first season, sole cropping (T_1) resulted the highest amount of curd at 26.45 t/ha, while in the second season, it produced 27.76 t/ha. Instead, the intercropped treatments, especially treatment T_5 (Cauliflower + radish shank), yielded the lowest curd yield of 22.29 t/ha in the first cropping season and 19.50 t/ha in the second cropping season (Figure 3). The curd yield per plot was found highest in the sole crop, simultaneously as a result curd yield in terms of hectare observed highest in the sole crop cultivation. Due to availability of fertilizer, especially nitrogen fertilizer, curd yield was found highest in sole cultivation. It is related to the findings of Yildirim *et al*. (2007), that has been recorded that the inorganic nitrogen fertilizers play a vital role in increasing both the yield and quality of broccoli. Intercropping treatments occurred in reduced yields due to poor supply of nitrogen fertilizer. Insufficient nitrogen can lead to a decrease in crop yield as stated by Belec *et al.* (2001).

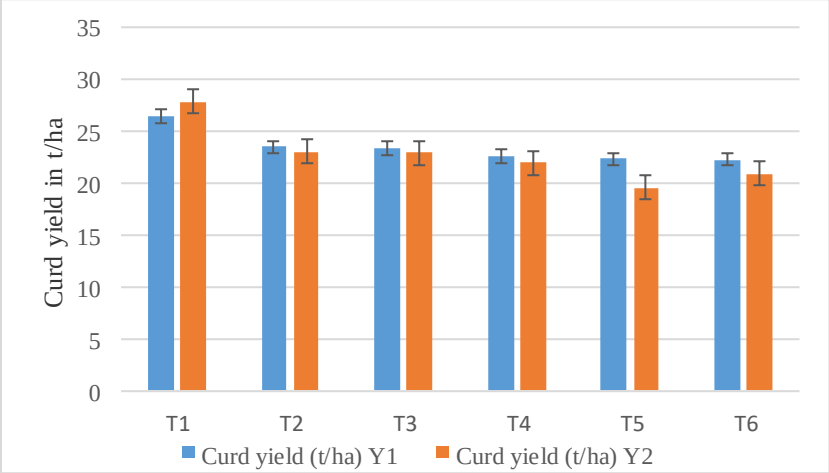
Table 4. The impact of treatments on yield and quality characteristics of cauliflower

Treatments	Average curd weight (g)		Curd yield/plot (kg)		Ascorbic acid (mg/100g)		Curd dry matter (%)	
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
T_1	1009.9 a	999.33a	20.20a	19.99a	46.04a	45.98a	9.94c	9.81b
T_2	841.6 b	831.73b	16.83 b	16.58b	43.16b	43.07b	10.21b	10.09ab
T_3	837.3 b	829.94b	16.75 b	16.50b	43.31b	43.20b	10.44a	10.31a
T_4	809.4 c	803.49bc	16.19 c	15.78bc	43.32b	43.19b	10.42a	10.28a
T_5	800.3 c	726.91c	16.00 c	14.37c	43.18b	43.08b	10.34ab	10.25a
T_6	799.4 c	793.59bc	15.99 c	15.05bc	43.09b	43.00b	10.26b	10.16a
CV (%)	1.52	6.49	1.52	7.14	2.40	1.81	0.78	1.61
Significance	**	**	**	**	*	**	**	*
LSD	23.16	96.96	0.46	2.1	0.87	0.64	0.14	0.29

*T_1= Cauliflower as sole crop, T_2= Cauliflower + Red amaranth, T_3= Cauliflower + Coriender leaf, T_4= Cauliflower + lettuce, T_5= Cauliflower + Radish shank, T_6= Cauliflower+ spinach; Y_1= 2021-2022, Y_2= 2022-2023

Ascorbic acid (mg/100g)

The alteration in treatments is significantly influenced the ascorbic acid content in curd, also known as Vitamin C. During the first and second growing seasons, the highest levels of ascorbic acid were recorded in sole cropping (T_1). The documented values for ascorbic acid content were 46.04 mg/100g and 45.98 mg/100g, respectively. Otherwise, the intercropped treatments provided the lowest values, which were relatively similar. Specifically, treatment T_6 (Cauliflower + spinach) had the lowest value of 43.09 mg/100g and 43.00 mg/100g in the two sequential seasons. These may be due to the proper light penetration to cauliflower plant throughout the growing season. According to Smirnoff and Pallanca, (1996) and Smirnoff (2002), the vitamin C content in plant tissues rises proportionally with the intensity of light in the course of the growing season. Smirnoff (2002) also stayed that,Howard *et al*. (1999), Lisiewska and Kmiecik (1996), and Jeffery *et al*. (2003) stated that, a number of factors, including genetic variations, the type of fertilizers employed, the prevailing climatic conditions, cultural techniques employed can influenced the concentration of vitamin C in fruits and vegetables.



*T_1= Cauliflower as sole crop, T_2= Cauliflower + Red amaranth, T_3= Cauliflower + Coriander leaf, T_4= Cauliflower + lettuce, T_5= Cauliflower + Radish shank, T_6= Cauliflower+ spinach
Y_1= 2021-2022, Y_2= 2022-2023

Figure 3. Yield of cauliflower curd varies with the treatments

Curd dry matter (%)

The treatments employed in both cropping seasons had a significant impact on the results. The curd of intercropped cauliflower plants displayed the highest dry matter content, and their values were relatively similar. Specifically, treatment T_3 (Cauliflower + coriander leaf) resulted with the highest dry matter content, with percentages of 10.44% and 10.31% in the

first and second cropping seasons, respectively. These findings are shown on Table 4. Sole cropping produced lowest curd dry matter and valued 9.94% and 9.81% in two consequent years. This result is similar to some researcher. In accordance with a study conducted by Yildirim *et al*. (2007), it was observed that higher levels of nitrogen (N) were related to decreased dry matter percentages in the leaves, stem, and heads of broccoli *(Brassica oleracea* L. var. *italica*) and cabbage.

Yield of intercrops (t/ha)

In the first growing season (2021-2022), the yield of red amaranth, coriander leaf, lettuce, radish shank and spinach were found 9.07, 7.32, 10.06, 12.38 and 16.11 t/ha and in the second cropping season (2022-2023) was observed 8.51, 6.76, 9.32, 11.44 and 15.75 t/ha (table 5). The potential yield of BARI Lalshak-1 (red amaranth), BARI Dhania-1 (coriander leaf), lettuce (BARI Letuce-1), BARI Mula-1 (radish shank) and BARI Plangshak-1 (Spinach) was 12, 8.5, 15, 22 and 25 t/ha (Krishi Projukti Hatboi, Handbook on Agro-technology, 2020). The potential yield of component crops in intercropping system is decreased than sole cropping as a result of the competition for light, nutrients, water, and space, leading to a reduction in their overall yield (Bhuiyan *et al*., 2021).

Total equivalent yield (t/ha)

The differences in treatments resulted in a remarkable variation in case of total equivalent yield. In the years 2021-2022 and 2022-2023, treatment T_3 (Cauliflower +coriander leaf), resulted the highest total equivalent yield. This combination produced a total yield of 35.84 and 39.75 t/ha, which were statistically similar to certain other intercropped treatments. These values are figured in Table 5. Otherwise, the lowest total equivalent yield was found from the sole cropping system, with yields of 25.89 and 28.07 t/ha in the consequent years. These results have been showed in Table 5. Tringovska *et al.* (2015) have also recorded a decline in yield obtained by lettuce when it was cultivated alongside tomatoes compared to sole cultivation.

Land equivalent ratio (LER)

Highest LER was observed in coriander intercropped with cauliflower treatment in both season and valued 1.68 and 1.62 in first and second cropping season respectively and lowest was observed in sole crop. This data were displayed on Table 5. The high efficiency of intercropping observed in this study is similar to the experimentation of Malhotra and Kumar (1995) and Baumann et al. (2001). These researchers have assigned this occurrence to the supportive usage of growth resources in vegetable production.

Table 5. Economics of cauliflower intercropping as influenced by the treatments

Treatments	Yield of intercrops (t/ha)		Total equivalent yield (t/ha)		Land equivalent ratio (LER)		Return from cauliflower (Tk/ha)	
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
T_1	0	0	25.89c	28.07c	1	1	396750	416400
T_2	9.07	8.51	27.57c	28.99c	1.58	1.54	351600	345150
T_3	7.32	6.76	35.84a	39.75a	1.68	1.62	349650	343650
T_4	10.06	9.32	33.95a	36.53ab	1.46	1.42	338100	328650
T_5	12.38	11.44	31.57ab	33.75b	1.35	1.31	334350	292500
T_6	16.11	15.75	28.57bc	28.10c	1.45	1.42	333900	312750
CV (%)	-	-	10.14	6.18	-	-	-	-
Significance	-	-	**	**	-	-	-	-
LSD	-	-	5.56	3.61	-	-	-	-

*$T_{1=}$ Cauliflower as sole crop, $T_{2=}$ Cauliflower + Red amaranth, $T_{3=}$ Cauliflower + Coriender leaf, $T_{4=}$ Cauliflower + lettuce, $T_{5=}$ Cauliflower + Radish shank, $T_{6=}$ Cauliflower+ spinach; Y_1= 2021-2022, Y_2= 2022-2023, Price of cauliflower, red amaranth, coriander, lettuce, radish shank and spinach @ 15, 12, 25, 20, 12 and 15 Tk/kg, Labor charge @ 500 Tk/day/man.

Economics of cauliflower intercropping system

The findings of the research determined that the most economically possible intercropping technique is the combination of cauliflower and spinach, nevertheless of the two seasons. The financial achievement from this particular combination amounted to Tk. 217,410 during the first growing season, with the highest BCR recorded at 1.61. In the second growing season, the net return was Tk. 183,950, with a BCR of 1.50 Table 6. The study also disclosed that while sole cauliflower had the highest yield in terms of growth and productivity, the cauliflower-spinach combination displayed the highest net return and BCR. Jani *et al*.(2014) who found maize-chickpea intercropping profitable than sole cropping as in this experiment intercropped treatment showed more profit than sole crop.

Table 6. Benefit cost ratio of cauliflower as influenced by different component crops Intercropping

Treat.	Return from intercrops (Tk/ha)		Total return (Tk/ha)		Total cost (Tk/ha)		Net return (Tk/ha)		Benefit Cost ratio	
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
T_1	0	0	396750	416400	326665	342990	70085	73410	1.21	1.21
T_2	108840	102120	460440	447270	337495	354360	122945	92910	1.36	1.26
T_3	183000	169000	532650	512650	340780	357820	191870	154830	1.56	1.43
T_4	141200	158000	479300	486650	341430	358500	137870	128150	1.40	1.36
T_5	148560	137280	482910	429780	337510	354385	145400	75395	1.43	1.21
T_6	241650	236250	575550	549000	358140	365050	217410	183950	1.61	1.50

*$T_{1=}$ Cauliflower as sole crop, $T_{2=}$ Cauliflower + Red amaranth, $T_{3=}$ Cauliflower + Coriender leaf, $T_{4=}$ Cauliflower + lettuce, $T_{5=}$ Cauliflower + Radish shank, $T_{6=}$ Cauliflower+ spinach; Y_1= 2021-2022, Y_2= 2022-2023, Price of cauliflower, red amaranth, coriander, lettuce, radish shank and spinach @ 15, 12, 25, 20, 12 and 15 Tk/kg, Labor charge @ 500 Tk/day/man.

Conclusion

Cauliflower in combination with coriander leaf showed the highest land equivalent ratio of 1.68 and 1.62 in two successive years. In terms of BCR, cauliflower cultivated with spinach produced the highest BCR of 1.61 in first year and 1.50 in second year with a net return of 217410 BDT and 183950 BDT respectively. So, it can be suggested that, for *Sorjan* bed profitability, farmers should cultivate their land with cauliflower and spinach intercropping for more income.

Acknowledgement

The authors received technical support from the Bangladesh Agricultural Research Institute during they conducted the study, for which they express their gratitude. Furthermore, the authors are gratful to the Krishi Gobeshona Foundation for providing financial support during the study period.

References

Ahmad, M.1995. Study on the performance of tomato + Batisak, Tomato + Cabbage intercropping. *Journal of Agricultural Research*, 20: 47 – 51.

Ananda, A.; Devi, A. B.; Barik, S. P.; Konthoujam, J. and Bairwa, M. K.2018. Effect of Growth, Physiological Aspects and Yield of Cabbage (*Brassica oleracea* L. cv Rareball) in Knol khol and Broad Bean Intercropping System under Imphal West Condition. *Int. J. Curr. Microbiol. App. Sci*., 7(10): 1111-1117.

Amoli, N.2012. Investigation of intercropping cauliflower and spinach in north of Iran. *Technical Journal of Engineering and Applied Sciences*, 2(6): 135 – 140.

Andersen, M. K.; Hauggaard-Nielsen, H.; Hogh-Jensen, H. and Jensen, E. S.2007. Competition for and utilisation of sulfur in sole and intercrops of pea and barley//Nutrient Cycling in Agroecosystem, 77(2):143–153.

Anil, L.; Park, J.; Phipps, R. H. and Miller, F. A.1998. Temperate intercropping of cereals for forage: a review of the potential for growth and utilization with particular reference to the UK Grass and Forage Science, 53: 301–317.

Babar, M. A.; Arif, M., Kashif, M.; Hanif, M.; Hayat, M. and Daud, M.2021. Effects of intercropping on growth and yield of radish inter cropped with turnip and spinach under clmatic conditions of quetta. *Pak. J. Biotechnol.*, 18 (3-4): 57-61. DOI http://doi.org/10.34016/pjbt.2021.18.2-3.57.

BARI (Bangladesh Agricultural Research Institute). 2020. Krishi Projukti Hatboi (Handbook on Agro-technology), 8th edition, Bangladesh Agricultural Research Institute, Gazipur.

Batista, T.M.V.; Bezerra, N.F.; Silva, I.N.; Silva, M.L.; Oliveira, E.Q. and Barros J.A.P.2016. Agronomic efficiency of the intercropping of arugula with carrot under different population combinations. *Revista Caatinga*, 29(1): 76-84.

Baumann, D.T.; Bastiaans, L. and Kropff, M.J.2001. Competition and crop performance in a leek - celery intercropping system. *Crop Science*, 41: 764-774.

BBS. 2021. Year Book of Agricultural Statistics of Bangladesh. Bangladesh Bureau of Statistics. Statistics Division. Ministry of Planning. Govt. of the People's Republic of Bangladesh. Pp-338.

Belec, C.Villeneuve, S.; Coulombe, J. and Tremblay, N.2001. Influence of nitrogen fertilization on yield, hollow stem incidence and sap nitrate concentration in broccoli. *Can. J. Plant Sci.*, 81(4):765-772. DOI: 10.4141/P00-108.

Bewuket, G. and Shewaye, H.2020. Effect of Different Rates of N and Intrarow Spacing on Growth Performance of Lettuce (*Lactuca sativa* L.) in Gurage Zone, Wolkite University, Ethiopia. Advances in Agriculture,1-6. https://doi.org/10.1155/2020/7364578.

Bhuiyan, M.M.R., Monshi, F.I., Begum, M., Tabassum, R,Hoque, Islam, S.S and Hasan, A.K.2021. Maize-Chickpea Intercropping under Diverse Tillage Systems Enhance the Productivity and Economic Returns. *World Journal of Agricultural Sciences* 17 (6): 509-520.

De Wit, C.T. and Van den Bergh, J.P. 1965. Competition between herbage plants. *Netherlands Journal of Agricultural Science,* 13: 212-221.

Doklega, S.M.A. and Abd El-Hady, M.A.2017. Impact of organic, mineral and bio-fertilization on broccoli. *J. Plant Production, Mansoura Univ.*, 8(9): 945 – 951.

Domingo, A.A. and Hagerman, H.H.1982. *Sorjan* cropping system trial in integrated wet land conditions. *Philippines J. Crop Science*, 7(3): 154-161.

Farahzety, A.M. and Aishah, H.S.2013. Effects of organic fertilizers on performance of cauliflower (*Brassica oleracea* var. Botrytis) grown under protected structure. *J. Trop. Agric. Food sci.*, 41 (1): 15-25.

FRG (Fertilizer Recommendation Guide). 2018. Fertilizer Recommendation Guide, Bangladesh Agricultural Research Council, Farmgate, Dhaka.

Francis, C.A.1986. Introduction: Distribution and importance of multiple cropping.1-39.1.0. Francis, C.A. (ed.) Multiple cropping systems.

Gebru, H.2015. A review on the comparative advantages of intercropping to mono-cropping system. *Journal of Biology, Agriculture and Healthcare*, 5(9): 1-13.

Gomez, K.A. and A.A. Gomez. (1984). *Statistical Procedure for Agricultural Research*. John Willy and Sons. New York. Pp-680.

Gu, H.; Wang, J.; Zhao, Z.; Sheng, X.; Huifang, Y. and Huang, W.2015. Characterization of the appearance, health-promoting compounds, and antioxidant capacity of the florets of the loose-curd cauliflower. *Int. J. Food Properties*, 18(2):392-402. DOI: 10.1080/10942912.2013.831445

Howard L.A; Wong, A.D.; and Perry, A.K. and Klein, B.P.1999. B-Carotene and ascorbic acid retention in fresh and processed vegetables. *J. Food Sci*., 64(5):929-936.

Jani, A. H. A. A., Hossain, M.A., Karim, M.M. and Hasan, A.K. 2014. Performance of maize-lentil/chickpea intercropping as influenced by row arrangement *Int. J. Sustain. Crop Prod.* 10: 1-7.

Jeffery, H.; Brown, A.F.; Kurilich, A.C; Keek, A.S; Matusheski, N. and Klein, B.P.2003. Variation in content of bioactive components in broccoli. Study review. *J. Food Composition Anal.*, 16:323-330.

James, A.; Lars P.K.; Robin J.P.; Christoph, S. and Martin, W.2022. Intercropping drives plant phenotypic plasticity and changes in functional trait space. Basic and Applied Ecology, 61:41-52. https://doi.org/10.1016/j.baae.2022.03.009.

Kwach, J.K.; Odhiambo, G.O.; Dida, M.M. and Gichuki, S.T.2010. Participatory consumer evaluation of twelve sweet potato varieties in Kenya. African Journal of Biotechnology, 9(11):1600-1609.

Lisiewska, Z. and Kmiecik, W.1996. Effects of level of nitrogen fertilizer, processing conditions and period of storage of frozen broccoli and cauliflower on vitamin C retention. Food Chemistry, 57(2):261-270.

Malhotra, S. and Kumar, N.1995. Performance of potato vegetables intercropping systems under dry temperate conditions of north – western Himalayas. Indian Journal of Agronomy, 40(3): 394 -397.

Metwaly, E.E. (2017). Influence of phosphorus and potassium on growth and yield of cauliflower. J. Plant Production, Mansoura Univ., 8(2): 329 – 334.

Ofori, F. and Stern W. R.1987. Cereal-legume intercropping systems. Advances in Agronomy, 41:41–90.

Riad, G.; Ahmed, A.; El-Baky, M.; Ghoname E. A. and Hegazi, A.2009. Cabbage Nutritional Quality as Influenced by Planting Density and Nitrogen Fertilization. Fruit, Vegetable and Cereal Science and Biotechnology, 3(1):68-74.

Ribeiro, G.M.; Bezerra N.F.; Lima, J.S.S.; Silva, M.L.; Barros, J.A.P. and Santos, E.C.2017. Agro-economic efficiency of the intercropping of carrot × cowpea-vegetable under diff-erent spatial arrangements and population densities. Rev Caatinga, 30(4): 847-854.

Scarpe, F.J.A. and Kluge, R.A.2001. Yield of 'nanicão' banana at different plant densities and spacing systems. Pesq Agropec Bras, 36:105-113.

Semuli, K.L.H.2005. Nitrogen requirements for cabbage (*Brassica oleracea capitata*) transplants and crop response to spacing and nitrogen top-dressing. MSc thesis, University of Pretoria. pp.57

Sharma, V. (2016). Effect of nutrient management on growth and yield of cauliflower (Brassica oleracea var botrytis) inside low cost polyhouse. Himachal J. Agric. Res., 42 (1): 88-92.

Silva, J.N.; Bezerra N.F.; Lima, J.S.S.; Rod-rigues, G.S.O.; Barros J.A.P. and Chaves, A.P.2017. Combinations of coriander and salad roc-ket cultivars in bicropping systems intercropped with carrot cultivars. Rev Caatinga, 30 (1): 125-135.

Smirnoff, N. and Pallanca J.E.1996. Ascorbate metabolism in relation to oxidative stress. Biochem. Soc. Trans., 24:472- 478.

Smirnoff N.2002. Ascorbic acid, metabolism and functions of a multifaceted molecule. Curr. Opin. Plant Biol., 3:229-235.

Tringovska, I.; Yankova, V.; Markova, D. and Mihov, M.2015. Effect of companion plants on tomato greenhouse production. Sci. Hortic.186: 31–37.

Vishnu, S. 2006. Vegetable Science and Technology in India. Kalyani Publishers, India. Pp-125.

Willey, R.W. 1979. Intercropping, its importance and research need. Part I. Competition and yield advantages. Field Crop Abstract, 32(1-10): 73-85.

Yildirim, E. and Guvenc, I.2005. Intercropping based on cauliflower: more productive, profitable and highly sustainable. European Journal of Agronomy. 22: 11-18.

Yildirim, E.; Guvenc, I.; Turan, M. and Karatas, A.2007.Effect of foliar urea application on quality, growth, mineral uptake and yield of broccoli (*Brassica oleracea* L., var. italica). Plant, Soil and Environment.53:120-128. DOI:10.5219/723.

Zimmermann, M.J.O.1996. Breeding for yield, in mixtures of common beans (*Phaseolus vulgaris* L.) and maize (Zea mays L.). Euphytica, 92: 129-134.

Znidarcic, D.; Kacjan, M.N.; Osvald, J.; Požrl, T. and Trdan, S.2007. Yield and quality of early cabbage (Brassica oleracea L. var. capitata) in response to within-row plant spacing. Acta Agriculturae Slovenica, 89:15-23. DOI:10.2478/v10014-007-0002-1.