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Effect Of Different Hybrids*Spacing*Fertilizer Doses On Vegetative And Yield Characters Along With Correlation Among The Characters In Broccoli (Brassica Oleracea Var. Italica L.)

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ABSTRACT

The study was carried out to examine the effect of different hybrids*spacing*fertilizer doses on vegetative and yield characters along with correlation among the characters in broccoli (Brassica oleracea var. italica L.) at Department of Horticulture, Eternal University, Baru Sahib, Sirmaur (Himachal Pradesh). The experiment was laid out in Factorial Randomized Block Design with three replications. The experiments comprised of three hybrids (Saki, Diana, Besty), three levels of spacing (60 × 30 cm, 60 × 45 cm and 60 × 60 cm) and three different fertilizer doses (75% RDF, 100% RDF, 125% RDF). Results revealed that maximum plant height (67.80 cm, 70.40 cm, 69.10 cm) was recorded from treatment combination $H_3S_1F_3$, highest curd yield/m^2 (4.77 kg, 5.22 kg, 4.99 kg) was produced under $H_2S_1F_3$ and $H_2S_3F_3$ found maximum number of leaves per plant (19.73, 26.07, 22.90). Whereas, treatment combination $H_3S_3F_3$ recorded maximum plant spread (91.13 cm, 95.10 cm, 93.12 cm), maximum leaf area (487.96 cm^2, 497.04 cm^2, 492.50 cm^2), stem girth (8.77 cm, 13.03 cm, 10.90 cm) and stem diameter (4.96 cm, 5.37 cm, 5.16 cm) in both the years and pooled analysis. Correlation studies revealed that different characters were highly significant at 1% and 5% level of significance. Hence treatment combination $H_2S_1F_3$ must be recommended to the farmers.

Keywords: *Broccoli, Fertilizer, Hybrid, Interaction, Spacing, Vegetative, Yield*

1. INTRODUCTION

Broccoli (Brassica oleracea var. italica L.) is a significant crop of exotic vegetables that is both highly nutritious and profitable (Tejaswini et al. 2018). It is a member of the cole group with the chromosomal number (2n=18) and is a member of the cruciferae family. One of the most widely consumed frozen vegetables, it is a high quality vegetable (Kumar et al. 2021). Area under cultivation of cauliflower and broccoli is about 1.12 million hectare in the world with annual production of about 20.88 million tonnes (Anonymous, 2015). In India cauliflower and broccoli are grown over an area of 369 thousand ha with annual production 6745 thousand tonnes (Anonymous, 2015). In India it is generally grown in hilly areas of Himachal Pradesh, Uttar Pradesh, Jammu and Kashmir, Nilgiri Hills and Northern plains (Abhijithnaik et al. 2022). It is known for its better taste, flavour, high nutritive and medicinal value. In the world market, about 40% is marketed as fresh and remaining

60% as frozen. It is used as curries, pie and casserole, boiled, stir fried, steamed, pickles, soups and also eaten as a salad and cooked as a single or mixed vegetable with potato (Thamburaj and Singh, 2001). Many of the anticancer benefits of broccoli are lost when it is cooked for more than ten minutes (Jeffery, 2005). Broccoli is an important food for health because it has antioxidant qualities and a lot of "sulphoraphane," which can help prevent heart disease and reduce the risk of cancer (Kumar et al. 2021). Broccoli has a lot of vitamins and minerals per 100 g of edible portion including calcium (103 mg), phosphorous (78 mg), potassium (382 mg), iron (1.10 mg) and sodium (15 mg) in addition to significant amounts of vitamin A (2500 I.U.), vitamin C (113 mg) and carbohydrates (5.90 g) (Rana, 2008). Additionally, it includes niacin, thiamine and riboflavin. Among cole crops, broccoli has the highest amount of protein (3.60 g) (Roni et al. 2014). This crop has gained popularity in the few years due to increased awareness of its better nutritional values and influx of tourists in the country, as a result of which area under broccoli is increasing every year (Kaur and Rampal, 2024).

Number of superior broccoli varieties are released by different universities and ICAR Institutes so, there is a need to make farmer aware about the best hybrids, suitable spacing and fertilizer doses in Sirmaur area, so that growers of the district get benefited. Another important elements in raising crop output in order to improve broccoli growth, production and quality (Tejaswini et al. 2018).

2. MATERIALS AND METHODS

The field experiment was conducted at Department of Horticulture, Dr. Khem Singh Gill Akal College of Agriculture, Eternal University, Baru Sahib, Sirmaur, Himachal Pradesh during the two consecutive years 2023-2024 and 2024-2025. There were three different hybrids viz., (Saki, Diana, Besty), three levels of spacing (60 × 30 cm, 60 × 45 cm, 60 × 60 cm) and three different fertilizer doses (75% RDF, 100% RDF, 125% RDF). The experiment was laid out in Factorial Randomized Block Design with replicated thrice. The plot size was 1.8m × 1.8m. There were 27 treatment combinations. The details are mentioned in table 2.1.

Table 2.1. Details of the treatment combinations

Treatment Code	Treatment combinations	Treatment details
T_1	H1S1F1	Saki + 60 × 30 cm + 75 % RDF
T_2	H1S1F2	Saki + 60 × 30 cm + 100 % RDF
T_3	H1S1F3	Saki + 60 × 30 cm + 125 % RDF
T_4	H1S2F1	Saki + 60 × 45 cm + 75 % RDF
T_5	H1S2F2	Saki + 60 × 45 cm + 100 % RDF
T_6	H1S2F3	Saki + 60 × 45 cm + 125 % RDF
T_7	H1S3F1	Saki + 60 × 60 cm + 75 % RDF
T_8	H1S3F2	Saki + 60 × 60 cm + 100 % RDF
T_9	H1S3F3	Saki + 60 × 60 cm + 125 % RDF
T_{10}	H2S1F1	Diana + 60 × 30 cm + 75 % RDF
T11	H2S1F2	Diana + 60 × 30 cm + 100 % RDF
T12	H2S1F3	Diana + 60 × 30 cm + 125 % RDF
T13	H2S2F1	Diana + 60 × 45 cm + 75 % RDF
T14	H2S2F2	Diana + 60 × 45 cm + 100 % RDF
T15	H2S2F3	Diana + 60 × 45 cm + 125 % RDF
T16	H2S3F1	Diana + 60 × 60 cm + 75 % RDF
T17	H2S3F2	Diana + 60 × 60 cm + 100 % RDF

T18	H2S3F3	Diana + 60 × 60 cm + 125 % RDF
T19	H3S1F1	Besty + 60 × 30 cm + 75 % RDF
T20	H3S1F2	Besty + 60 × 30 cm + 100 % RDF
T21	H3S1F3	Besty + 60 × 30 cm + 125 % RDF
T22	H3S2F1	Besty + 60 × 45 cm + 75 % RDF
T_{23}	H3S2F2	Besty + 60 × 45 cm + 100 % RDF
T_{24}	H3S2F3	Besty + 60 × 45 cm + 125 % RDF
T_{25}	H3S3F1	Besty + 60 × 60 cm + 75 % RDF
T_{26}	H3S3F2	Besty + 60 × 60 cm + 100 % RDF
T_{27}	H3S3F3	Besty + 60 × 60 cm + 125 % RDF

Statistical Analysis

Analysis of variance and means comparison from each treatment combination by using general linear model. Mean values were compared using DMRT at a significance level 0.05.

It was worked out in different observations using SPSS version 20.00.

3. RESULTS AND DISCUSSION

3.1 Effect of hybrid × spacing × fertilizer doses on vegetative and yield characters

The result revealed that during 2023 plant height, plant spread, number of leaves per plant, leaf area, stem girth and stem diameter were significant whereas curd yield/m^2 was non significant. Whereas in 2024 and pooled data, all vegetative characters responded significantly as the value of p was less than 0.05.

Table 3.1. Hybrid * Spacing * Fertilizer

Hybrid * Spacing * Fertilizer				2023	2024	Pooled
Dependent Variable	H	S	F	Mean	Mean	Mean
Plant height	H_1	S_1	F_1	53.00	62.00	57.50
			F_2	53.87	64.80	59.33
			F_3	54.71	65.67	60.19
		S_2	F_1	61.07	69.47	65.27
			F_2	53.80	62.47	58.13
			F_3	60.20	63.40	61.80
		S_3	F_1	52.71	55.33	54.02
			F_2	57.67	60.67	59.17
			F_3	58.67	61.67	60.17
	H_2	S_1	F_1	47.40	50.40	48.90
			F_2	53.27	56.27	54.77

			F_3	58.82	56.47	57.65
		S_2	F_1	58.27	49.70	53.98
			F_2	41.60	50.70	46.15
			F_3	52.40	52.50	52.45
		S_3	F_1	41.03	45.80	43.42
			F_2	41.47	46.90	44.18
			F_3	47.33	46.67	47.00
	H_3	S_1	F_1	59.87	62.87	61.37
			F_2	62.40	67.73	65.07
			F_3	67.80	70.40	69.10
		S_2	F_1	59.27	62.27	60.77
			F_2	59.40	62.80	61.10
			F_3	64.47	67.47	65.97
		S_3	F_1	55.20	58.80	57.00
			F_2	57.80	60.90	59.35
			F_3	59.20	62.70	60.95
Plant spread	H_1	S_1	F_1	66.63	63.53	65.08
			F_2	57.90	66.40	62.15
			F_3	66.77	62.17	64.47
		S_2	F_1	63.87	63.83	63.85
			F_2	67.63	70.60	69.12
			F_3	64.83	67.50	66.17
		S_3	F_1	68.33	71.60	69.97
			F_2	71.57	74.80	73.18
			F_3	61.37	71.50	66.43
	H_2	S_1	F_1	60.67	63.70	62.18
			F_2	69.47	72.40	70.93
			F_3	62.20	65.60	63.90
		S_2	F_1	63.50	66.20	64.85
			F_2	72.33	75.30	73.82
			F_3	70.80	73.40	72.10

		S_3	F_1	74.13	77.30	75.72
			F_2	77.37	64.70	71.03
			F_3	76.07	76.70	76.38
	H_3	S_1	F_1	78.20	69.70	73.95
			F_2	64.53	73.93	69.23
			F_3	67.17	76.27	71.72
		S_2	F_1	71.00	74.70	72.85
			F_2	77.77	77.70	77.73
			F_3	78.77	76.80	77.78
		S_3	F_1	78.30	82.77	80.53
			F_2	75.38	83.40	79.39
			F_3	91.13	95.10	93.12
Number of leaves per plant	H_1	S_1	F_1	18.54	19.87	19.20
			F_2	18.60	21.50	20.05
			F_3	17.40	23.40	20.40
		S_2	F_1	17.63	22.67	20.15
			F_2	19.53	22.74	21.13
			F_3	19.46	22.94	21.20
		S_3	F_1	16.80	22.80	19.80
			F_2	19.01	24.74	21.88
			F_3	18.60	21.94	20.27
	H_2	S_1	F_1	17.70	25.40	21.55
			F_2	18.93	21.94	20.44
			F_3	19.00	23.43	21.22
		S_2	F_1	19.13	22.14	20.64
			F_2	18.20	22.20	20.20
			F_3	18.67	21.34	20.00
		S_3	F_1	19.27	22.28	20.77
			F_2	19.53	22.54	21.04
			F_3	19.73	26.07	22.90
	H_3	S_1	F_1	16.87	19.87	18.37

			F_2	16.27	19.27	17.77
			F_3	15.93	19.28	17.61
		S_2	F_1	16.33	18.34	17.34
			F_2	16.53	19.54	18.04
			F_3	17.40	20.40	18.90
		S_3	F_1	17.20	20.20	18.70
			F_2	17.40	20.40	18.90
			F_3	18.40	20.74	19.57
Leaf area	H_1	S_1	F_1	355.72	386.05	370.89
			F_2	357.71	367.71	362.71
			F_3	362.57	418.91	390.74
		S_2	F_1	423.80	391.71	407.76
			F_2	432.42	420.40	426.41
			F_3	436.90	450.13	443.52
		S_3	F_1	423.07	434.63	428.85
			F_2	473.45	488.44	480.95
			F_3	417.62	473.13	445.38
	H_2	S_1	F_1	364.78	428.34	396.56
			F_2	413.12	447.59	430.35
			F_3	394.25	438.05	416.15
		S_2	F_1	418.21	479.19	448.70
			F_2	405.72	445.97	425.84
			F_3	445.46	465.51	455.48
		S_3	F_1	417.20	476.45	446.83
			F_2	425.72	474.58	450.15
			F_3	419.82	449.05	434.44
	H_3	S_1	F_1	377.91	454.39	416.15
			F_2	421.39	441.33	431.36
			F_3	434.54	477.77	456.15
		S_2	F_1	441.09	456.65	448.87
			F_2	404.84	453.96	429.40

			F_3	409.54	462.71	436.12
		S_3	F_1	416.65	466.57	441.61
			F_2	424.40	443.34	433.87
			F_3	487.96	497.04	492.50
Stem girth	H_1	S_1	F_1	6.93	9.06	8.00
			F_2	7.48	9.75	8.61
			F_3	7.67	10.00	8.83
		S_2	F_1	7.08	8.76	7.92
			F_2	7.23	9.61	8.42
			F_3	7.24	9.65	8.45
		S_3	F_1	7.51	9.43	8.47
			F_2	7.48	12.04	9.76
			F_3	8.42	12.90	10.66
	H_2	S_1	F_1	6.84	10.23	8.54
			F_2	8.27	11.41	9.84
			F_3	6.77	10.61	8.69
		S_2	F_1	7.40	11.06	9.23
			F_2	7.50	11.57	9.53
			F_3	7.45	10.64	9.04
		S_3	F_1	7.75	11.06	9.40
			F_2	7.88	11.43	9.66
			F_3	8.65	12.47	10.56
	H_3	S_1	F_1	7.87	12.47	10.17
			F_2	7.24	10.93	9.09
			F_3	8.33	12.66	10.50
		S_2	F_1	8.37	11.20	9.78
			F_2	8.13	12.33	10.23
			F_3	8.03	12.30	10.16
		S_3	F_1	8.38	12.13	10.26
			F_2	8.57	12.32	10.45
			F_3	8.77	13.03	10.90

Stem diameter	H_1	S_1	F_1	4.42	3.83	4.13
			F_2	4.36	4.85	4.60
			F_3	4.77	4.92	4.84
		S_2	F_1	4.18	4.27	4.23
			F_2	4.42	4.50	4.46
			F_3	4.74	4.65	4.70
		S_3	F_1	4.36	5.11	4.73
			F_2	4.45	4.94	4.69
			F_3	4.58	5.24	4.91
	H_2	S_1	F_1	4.26	4.37	4.32
			F_2	4.39	4.02	4.20
			F_3	4.03	4.97	4.50
		S_2	F_1	4.50	4.36	4.43
			F_2	4.46	5.02	4.74
			F_3	4.39	4.93	4.66
		S_3	F_1	4.60	5.06	4.83
			F_2	4.65	5.01	4.83
			F_3	4.70	4.93	4.82
	H_3	S_1	F_1	4.73	4.90	4.81
			F_2	4.50	4.60	4.55
			F_3	4.43	4.61	4.52
		S_2	F_1	3.94	4.82	4.38
			F_2	4.06	4.74	4.40
			F_3	4.72	5.09	4.91
		S_3	F_1	4.90	4.98	4.94
			F_2	4.78	5.30	5.04
			F_3	4.96	5.37	5.16
Curd yield/m^2	H_1	S_1	F_1	1.34	2.36	1.85
			F_2	1.71	2.85	2.28
			F_3	4.07	4.30	4.19
		S_2	F_1	2.16	2.91	2.54

			F_2	2.63	3.27	2.95
			F_3	4.28	4.41	4.34
		S_3	F_1	1.48	2.02	1.75
			F_2	2.05	2.70	2.37
			F_3	3.91	4.25	4.08
	H_2	S_1	F_1	2.19	2.84	2.51
			F_2	2.63	3.17	2.90
			F_3	4.77	5.22	4.99
		S_2	F_1	2.63	3.28	2.96
			F_2	2.53	3.38	2.96
			F_3	3.20	3.33	3.27
		S_3	F_1	1.87	2.31	2.09
			F_2	2.46	3.08	2.77
			F_3	4.37	4.81	4.59
	H_3	S_1	F_1	1.32	1.96	1.64
			F_2	1.82	2.15	1.99
			F_3	2.68	3.02	2.85
		S_2	F_1	1.53	2.16	1.85
			F_2	1.49	2.24	1.87
			F_3	1.96	2.70	2.33
		S_3	F_1	1.08	1.83	1.46
			F_2	1.29	2.14	1.71
			F_3	1.89	2.96	2.42

*H_1-Saki, H_2-Diana, H_3-Besty

S_1-60 × 30 cm, S_2-60 × 45 cm, S_3-60 × 60 cm

F_1-75 % RDF, F_2-100 % RDF, F_3-125 % RDF

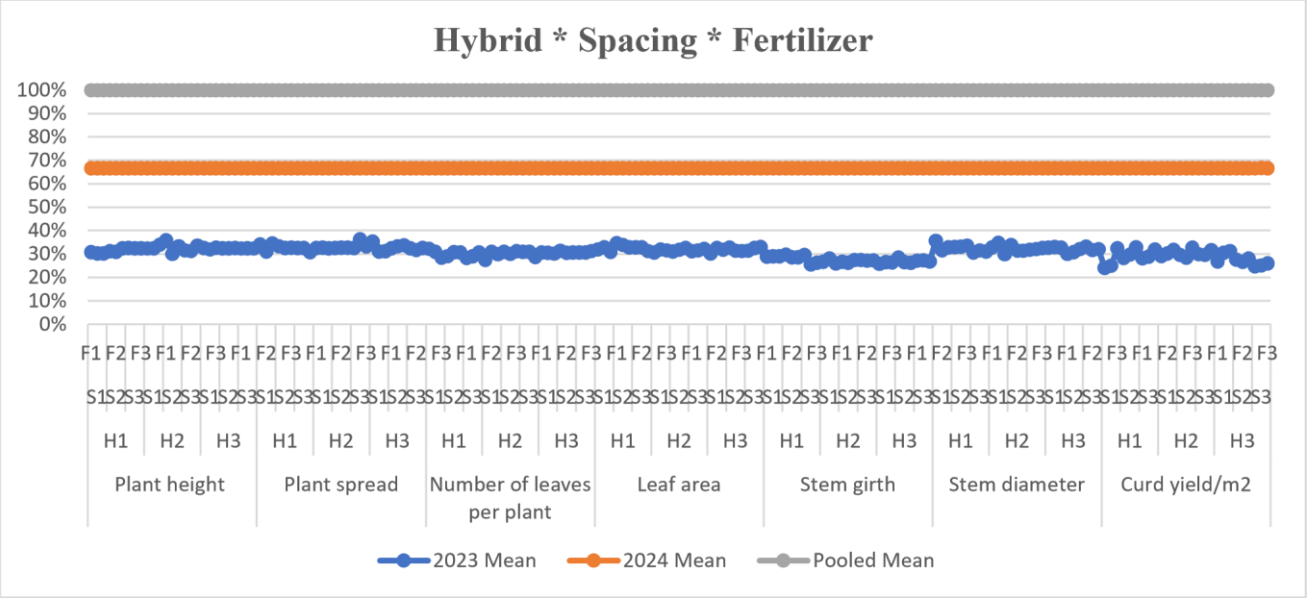


Table 3.2. Tests of between subjects

Source	Dependent Variable	2023		2024		Pooled	
		F Cal	P Value	F Cal	P Value	F Cal	P Value
Hybrid * Spacing * Fertilizer	Plant height	3.384	.003	3.309	.004	3.924	.001
	Plant spread	5.022	.000	9.401	.000	8.606	.000
	Number of leaves per plant	3.946	.001	11.308	.000	5.534	.000
	Leaf area	4.593	.000	10.404	.000	11.210	.000
	Stem girth	7.447	.000	6.453	.000	9.489	.000
	Stem diameter	3.159	.005	11.765	.000	6.802	.000
	Curd yield/m^2	1.320	.255	4.339	.000	4.614	.000

Maximum value of plant height (67.80 cm, 70.40 cm, 69.10 cm) was recorded from $H_3S_1F_3$.The variation in diverse genotypes could be because of their diverse genetic makeup and expression in particular environmental conditions and when plants are spaced closer together, there may be competition for light and nutrients.

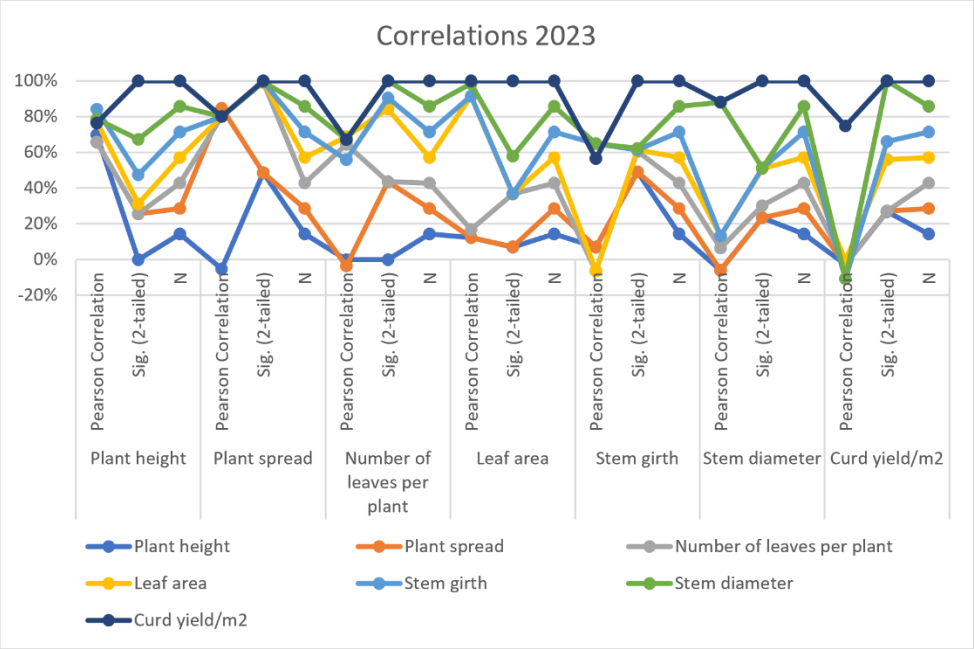
As a result, plants often grow taller to compete for light, leading to increased plant height. Additionally, more terminal growth could occur in such conditions as plants try to optimize their vertical growth along with greater amount of nutrient availability to the plant by the fertilizer level F_3. Similar findings were reported by Prasad et al. 2009 in Chinese cabbage, Saikia et al. 2010, Haque et al. 2015 in cabbage, Thakur et al. 2016, Abhijithnaik et al. 2022 and Kande et al. 2024 in broccoli. Highest curd yield/m^2 (4.77 kg, 5.22 kg, 4.99 kg) was produced under $H_2S_1F_3$. This might be due to the availability of suitable gene and are interacting with suitable environmental condition. Closer spacing might have led to a higher weight of curds per unit area, which can result in a higher total yield even if individual curds are smaller along with availability of more nutrients. Higher fertilizer level was might have led to the highest curd yield/m^2. Similar results have also been observed by Kumar and Rawat (2002) in cabbage, Dragan et al. 2007 in broccoli, Hossain et al. 2011, Bhangre et al. 2011, Bika et al. 2018, Thapa and Rai (2012), Singh et al. 2014, Thakur et al. 2016 and Rahman et al. 2022 in cauliflower. $H_2S_3F_3$ found maximum number of leaves per plant (19.73, 26.07,

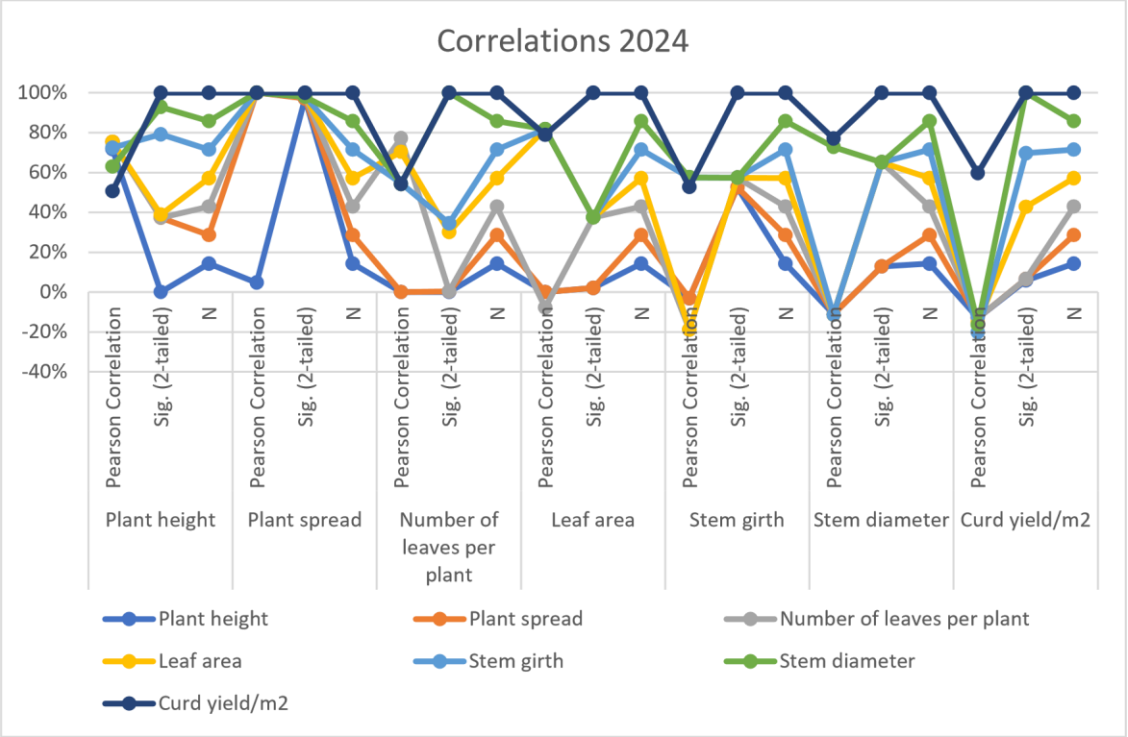
22.90). Whereas, treatment combination $H_3S_3F_3$ recorded maximum plant spread (91.13 cm, 95.10 cm, 93.12 cm), maximum leaf area (487.96 cm^2, 497.04 cm^2, 492.50 cm^2), stem girth (8.77 cm, 13.03 cm, 10.90 cm) and stem diameter (4.96 cm, 5.37 cm, 5.16 cm). This may be due to the availability of suitable genes along with more access to light and nutrients, which could

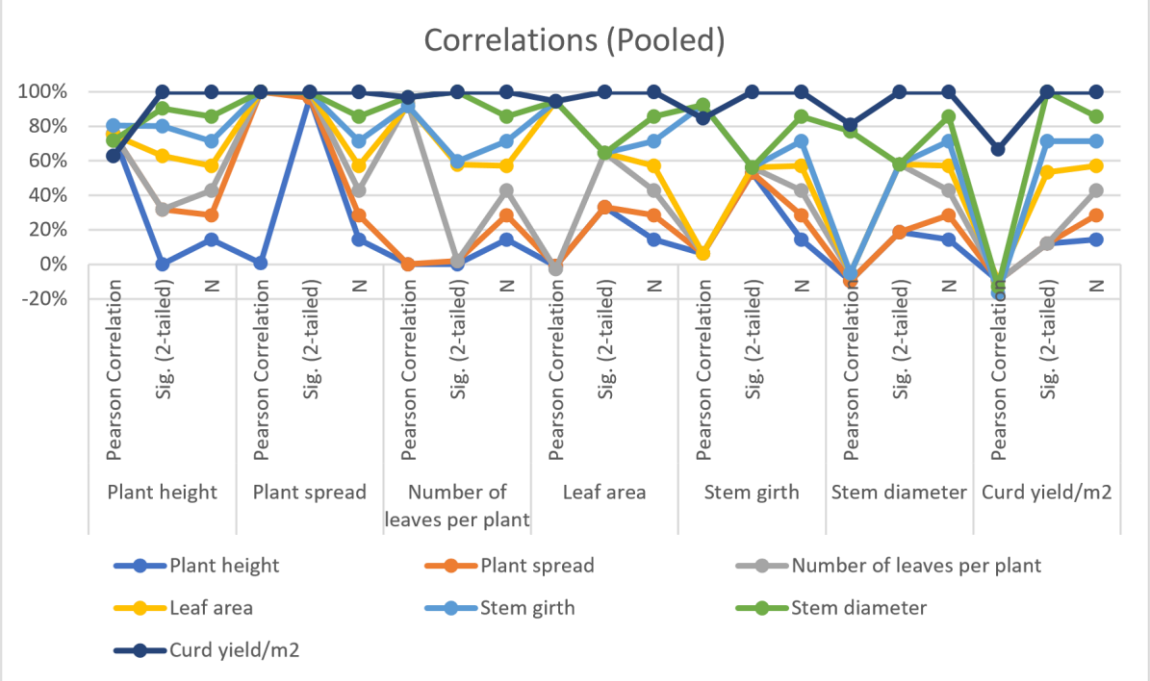
have led to better growth condition and each plant has more space to spread its roots and capture sunlight, reducing competition with neighbouring plants along with higher doses of fertilizer could have enhanced the vegetative growth due to the fact that fertilizer helps in better growth of plants. Similar results were obtained by Gonzalez (1980), Bobade (2001) in cabbage, Nieuwhof (1961), Kelley (2007) in broccoli, Neethu et al. 2015, Bika et al. 2018, Prashanthi et al. 2022, Kaur and Rampal (2024).

3.2 Correlation among the different parameters

In the year of 2023, result revealed that plant height was positively correlated with plant height, leaf area, stem girth and negatively correlated with plant spread, number of leaves per plant, stem diameter and curd yield/m^2. In 2024, plant height was positively correlated with plant height, plant spread and negatively correlated with number of leaves per plant, leaf area, stem girth, stem diameter and curd yield/m^2. In pooled data, plant height was positively correlated with plant height, plant spread, stem girth and negatively correlated with number of leaves per plant, leaf area, stem diameter and curd yield/m^2. Plant height was highly significant to number of leaves per plant at the 1 % level of significance in both the years and pooled data. In both the years and pooled data, plant spread was positively correlated with plant spread, leaf area, stem girth, stem diameter and negatively correlated with number of leaves per plant and curd yield/m^2. In 2023 plant spread was highly significant to leaf area, stem girth, stem diameter and curd yield/m^2. Whereas, in 2024 plant spread was highly significant to number of leaves per plant, leaf area, stem girth and stem diameter. In pooled data, plant spread was highly significant to leaf area, stem girth, stem diameter and curd yield/m^2. In 2023, number of leaves per plant were positively correlated with number of leaves per plant, leaf area, stem diameter, curd yield/m^2 and negatively correlated with stem girth and highly significant to plant height and curd yield/m^2. In 2024, number of leaves per plant were positively correlated with number of leaves per plant, curd yield/m^2 and negatively correlated with leaf area, stem girth, stem diameter and highly significant to plant height, plant spread and curd yield/m^2. In pooled data, number of leaves per plant were positively correlated with number of leaves per plant, stem diameter, curd yield/m^2 and negatively correlated with leaf area, stem girth and highly significant to plant height and curd yield/m^2. Leaf area was positively correlated with all the vegetative parameters and highly significant to plant spread and stem girth during 2023. In 2024, leaf area was positively correlated with leaf area, stem girth, stem diameter and negatively correlated with curd yield/m^2. In pooled data, leaf area was positively correlated with leaf area, stem girth, stem diameter and curd yield/m^2. In 2024 and pooled data, leaf area was highly significant to plant spread, stem girth and stem diameter. Stem girth was positively correlated with stem girth, stem diameter and negatively correlated with curd yield/m^2 and highly significant to plant spread, leaf area and stem diameter in both the years and pooled data. In 2023, 2024 and pooled analysis, stem diameter was positively correlated with stem diameter and curd yield/m^2. In 2023 stem diameter was highly significant to plant spread and stem girth. Whereas in 2024 and pooled data, stem diameter was highly significant to plant spread, leaf area and stem girth. Curd yield/m^2 was positively correlated with curd yield/m^2 in both the years and pooled data. This was highly significant to plant spread and number of leaves per plant in 2023 and pooled data. Whereas in 2024 curd yield/m^2 was highly significant to number of leaves per plant.







4. CONCLUSION

Interaction among different hybrids, spacing and fertilizer levels results revealed that maximum plant height was observed from treatment combination $H_3S_1F_3$, highest curd yield/m^2 was produced from $H_2S_1F_3$ and $H_2S_3F_3$ found maximum number of leaves per plant. Whereas, treatment combination $H_3S_3F_3$ recorded maximum plant spread, leaf area, stem girth and stem diameter during both the years and pooled analysis. Hence treatment combination $H_2S_1F_3$ must be recommended to the farmers.

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