Plant Archives Vol. 24, Special Issue (GABELS), 2024 pp.232-237 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2024.v24.SP-GABELS.035

FERTIGATION STUDIES IN BROCCOLI (*BRASSICA OLERACEA VAR. ITALICA*) CROP

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ABSTRACT

The experiment was carried out to study the effect of fertigation levels and schedules on growth and yield of broccoli (*Brassica oleracea var italica*) during the rabi season of 2021-22 involving 4 levels of fertilizer (75, 100 and 125 % RDF) along with one control (100 % RDF) through soil application and three fertigation scheduling (S_1, S_2 and S_3) with three replications. The result of study revealed that higher fertigation of broccoli with balanced nutrition; better water and nutrient utilization gave significantly higher plant growth and yield and good quality of broccoli. In general, pooled mean revealed that application of 125 % RDF with fertigation schedule S_2 -15 % NPK at transplanting to plant establishment, 1-10 DAT, 50 % NPK at curd initiation stage, 11-35 DAT and 35 % NPK at curd development stage, 36-60 DAT recorded maximum plant height at 30 DAT and 45 DAT (31.90 cm and 43.53 cm), number of leaves at 30 DAT and 45 DAT (16.64 and 19.85). Similar pattern on the TSS (11.78 %), curd yield (g) per plant (438.60 g) and curd yield (q) per hectare (q) (121.57 q) and minimum was under control (100 % RDF through soil application) treatment and schedule S_1- 10 % NPK (1-10 DAT), 40 % NPK (11-35 DAT) and 50 % NPK (36-60 DAT)

Keywords: Broccoli, Fertigation, Schedules

Introduction

Broccoli is a member of the Brassicaceae plant family, also known as the mustard family. It is packed with nutrients and vitamins and is sometimes even called a superfood. A major portion of broccoli consumption is only in the metros. When it comes to rural India, it is seldom consumed. Consumers do not purchage broccoli as they either do not know how to cook or consume it and find it unappealing if they try it. Broccoli is known as the Crown of Jewel Nutrition" as it is rich in vitamins and minerals. It is one of the most nutritious cole crops and contains vitamin A (130 times and 22 times higher than cauliflower and cabbage, respectively), thiamin, riboflavin, niacin, vitamin C and minerals like Ca, P, K and Fe (Kumar *et al.* 2013). Eating large portion may also have additional benefits, since broccoli is also a rich source of many vitamins and minerals such as vitamin A and C, carotenoides, fiber, calcium and folic acid**.** Consumption of broccoli in daily diet minimizes the incidence of various types of cancers in human beings. In India, it is mainly grown in hilly areas of Himachal Pradesh, Uttarakhand and Jammu & Kashmir, Tamilnadu and Northern plains.

Broccoli is a nutrient-demanding crop and fertilizer rates for fertilization should be based on soil nutrient tests. Broccoli requires an adequate supply of soil moisture to produce maximum yields of good quality. Earlier studies have shown that drip irrigation is the most suitable method of irrigation for vegetable crops, and it is possible to increase water use efficiency (WUE) by well scheduled irrigation programs, such as broccoli. Due to water scarcity, the available water resources should be very effectively utilized through water saving irrigation technologies. Fertigation facilitates a variety of benefits to the users like high crop productivity, quality, resource use efficiency, environmental safety, flexibility in field operations, effective weed management and successful crop cultivation in fields with undulating topography. Regular and unbalanced use of chemical fertilizers leads in the end to a decrease in the base saturation and

to acidification of soil. Hence, judicious use of fertilizers needs to be addressed. Fertigation facilities the enhanced mobility, availability and uptake of applied nutrients because of higher soil moisture content and more frequent application of fertilizers, corresponding to quantitative and timely demand by the crops. Fertigation scheduling is a critical management input to ensure optimum soil nutrients status for proper plant growth and development as well as for optimum yield and economic benefits. Therefore, it is essential to develop fertigation scheduling strategies under local climatic conditions to utilize scarce water resources efficiently and effectively. Appropriate fertigation scheduling is to increase fertilizer efficiencies by applying the balance amount of fertilizer needed to replenish the soil nutrients to desire level, saves nutrients resources and energy. Therefore, it is important to develop fertigation scheduling techniques under prevailing climatic conditions in order to utilize scare nutrients resources effectively for crop production.

Materials and Methods

Field experiment

The present investigation was carried out at Instructional farm, Dr. P.D.K.V, Akola, Maharashtra, India and Agriculture Training School, Buldhana during Rabi Season of 2021-22. Akola is situated in the subtropical. The climate of the place is semi-arid and is characterized by three distinct seasons viz., hot and dry summer from March to May, warm and rainy monsoon from June to October and mild winter from November to February and Buldhana district lie between 19°51 to 21°17 North latitudes and 76°38 to 76°40 east longitudes. It is surrounded by Satpuda mountain ranges. The climate of the district is hot and humid. In some parts of the districts *i.e.* Khamgaon, Jalgaon (Jamod) and Shegaon area the climate is very hot in summer, which reaches to 42° C in the month of May and is much cold in winter during the month of December which come down to 8°C to 10°C. Buldhana district falls in the rainfall zone between 700-800 mm per annum.

The experiment was laid out in split plot design. The first factor was different NPK fertigation levels (4) denoted by F whereas the second factor was scheduling of NPK fertigation throughout the growth period denoted by S.

Factor A – Fertigation levels: (Main Plot factor)

1. F_1: 100% RDF (100 : 50 : 50 NPK Kg ha^{-1}) – through conventional method
2. F_2: 75% RDF (75 : 37 : 37 NPK Kg ha^{-1})
3. F_3: 100% RDF (100 : 50 : 50 NPK Kg h^{-1})
4. F_4: 125% RDF (125 : 62.5 : 62.5 NPK Kg ha^{-1})

Factor B – Fertigation Schedules: 03 (Sub plot factor) – 12 splits at 5 days interval

Sr. No.	Fertigation Schedules	Transplanting to plant establishment (1-10 DAT)	Curd initiation stage (11-35 DAT)	Curd development stage (36-60 DAT)
1	Schedule-1	10% NPK	40% NPK	50%NPK
2	Schedule-2	15% NPK	50% NPK	35%NPK
3	Schedule-3	20% NPK	45%NPK	35%NPK

Four week old seedlings of broccoli cv. Palam samridhi were transplanted in second week of October in the plot size 450 m^2 in the experimental season. Transplanting was done in the early morning hours. Light irrigation was applied just after the transplanting and the gap filling was done seven days after transplanting.

Statistical Analysis

The data on various parameters collected from the experiment were statistically analysed by analysis of variance (ANOVA) for splti plot design. Critical difference was worked out at five per cent probability level when the treatment differences were found significant and the values were furnished. The treatment differences that were not significant were denoted by non- significant.

Result and Discussion

Growth parameters

The data regarding plant height of broccoli (Table 1) at 30 DAT and 45 DAT was significantly determined by the fertigation level and schedules. The data clearly indicated that, the maximum plant height of broccoli at 30 DAT and 45 DAT was found (31.90 cm and 43.53 cm), (28.83cm and 42.74cm) in the fertigation level F_4 (125 % RDF) with schedule S_2 -15 %NPK (1-10 DAT), 50 % (11-35 DAT) and (36-60 DAT) and similarly the minimum plant height (22.58 cm and 38.77 cm), (24.23cm and 39.26cm) was found

in the F_1S_1 (100 % RDF with S_1- 10 % NPK (1-10 DAT), 40 % NPK(11-35 DAT) and 50 % NPK (36-60 DAT). It may be due to complete solubility, mobilization and availability of nutrients at regular interval in required quantity due to split application of nutrients (Mal *et al.* 2005), resulting in higher nutrient uptake by plant promoting better growth and development.

The data regarding number of leaves of broccoli (Table 2) at 30 DAT and 45 DAT were significantly influenced by the fertigation level and schedules. The data clearly indicated that, the maximum number of leaves of broccoli at 30 DAT and 45 DAT were found (16.69 and 19.85), (15.46 and 17.49) in the fertigation level F_4 (125 % RDF) with schedule S_2 -15 %NPK (1-10 DAT), 50 % (11-35 DAT) and (36-60 DAT) and similarly the minimum number of leaves (10.43, 12.83) and (12.05 and 14.77) were found in the F_1S_1 (100 % RDF with S_1- 10 % NPK (1-10 DAT), 40 % NPK(11-35 DAT) and 50 % NPK (36-60 DAT). This might be due to continuous supply and consequent availability of plant nutrients at root zone at regular time and also due to availability of ample amount of macronutrients in soil applied through drip resulted in better vegetative growth and other attributing characters. Similar findings were observed by Ughade and Mahadkar (2015) and Ashwini and Binitha (2022) in bhindi.

Yield Parameters

The data recorded curd yield plant^{-1} (g) and curd yield plant^{-1} (q) (Table 3) of broccoli significantly influenced by the fertigation level. The data clearly indicated that, the maximum curd yield plant^{-1} (g) of broccoli was found (438.60 g, 121.57 g) in the fertigation level F_4 (125 % of RDF) and similarly the minimum curd per plant^{-1} (g) and curd yield ha^{-1}(q), (402.25 g, 110.26 g) was found in the F_1 (100 % RDF-through soil application). This might be due to better water utilization and uptake of nutrients and excellent soil-water and air relationship with higher oxygen concentration in the root zone. It may be due to the optimum moisture conditions in the entire root zone of the crop which reflected in better physiological activities of plants resulting into increased dry matter accumulation (Godara *et al*. 2013), Meena, Y. (2017) in cauliflower and Baby *et al*. (2022) in onion.

The data curd yield plant^{-1} (g) and curd yield plant^{-1} (q) was significantly influenced by the fertigation schedules. The data clearly indicated that, the maximum curd yield plant^{-1} (g) and curd yield ha^{-1} (q) of broccoli was found (432.27 g, 119.93 q) in the fertigation schedule S_2 -15 %NPK (1-10 DAT), 50 % (11-35 DAT) and (36-60 DAT) and similarly the minimum curd yield plant^{-1} (418.88 g, 116.50 q) was found in the fertigation schedule S_1- 10 % NPK (1-10 DAT), 40 % NPK (11-35 DAT) and 50 % NPK (36-60 DAT). This increase in yield might be due to better proportion of air- soil-water which was maintained throughout the life periods crop in drip fertigation. In case of water soluble fertilizers, the nutrients become available readily throughout the growth stage of crop, which produces optimum yield. The results were observed with Prabhakar *et al* (2013) in watermelon and Amala and Syriac (2016) in tomato, Nedunchezhiyan *et al.* (2019) in elephant foot yam.

Quality Parameters

The data regarding TSS (%) (Table 4) of broccoli significantly influenced by the fertigation level. Its pooled mean clearly indicated that, the maximum TSS (%) of broccoli was found (11.78 %) in the fertigation level F_4 (125 % of RDF) and similarly the minimum TSS (%) (8.08) was found in the F_1 (100 % RDF-through soil application). The increase in TSS content of head with increasing the fertigation levels could be attributed to the absorption of more nitrogen and phosphorus due to higher application of these nutrients which helps in photosynthates biosynthesis during growth and development of head. Subsequently during head maturity this photosynthates are converted to soluble solids content (Emongor *et al.,* 2017). These results are in accordance with Pradhan *et al*. (2019) in tomato, Singh *et al.* (2019) in tomato, Kshirsagar *et al.* (2021) in bittergourd.

The data regarding TSS (%) (Table 4) of broccoli significantly influenced by the fertigation schedules. The data clearly indicated that, the maximum TSS (%) of broccoli was found (9.79 %) in the fertigation schedule S_2 -15 % NPK (1-10 DAT), 50 % (11-35 DAT) and 35 % (36-60 DAT) and similarly the minimum TSS of broccoli (9.28 %) was found in the fertigation schedule S_1- 10 % NPK (1-10 DAT), 40 % NPK(11-35 DAT) and 50 % NPK (36-60 DAT).. High fertigation levels have favourably enhanced the chlorophyll index of leaves that resulting inincreased synthesis of carbohydrates and building of new cells resulted in high T.S.S. Similar observations are recorded by Sumathi *et al*. (2011) in cucumber, Lata *et al.* (2018) in cucumber and Reddy *et al.* (2022) in tomato.

Table 1 : Effect of fertigation levels and schedules on plant height of broccoli 30 DAT and 45 DAT

Treatments	2021-22				2021-22				Pooled			
	30 DAT				30 DAT				Pooled			
Fertigation levels	**S1**	**S2**	**S3**	**Mean**	**S1**	**S2**	**S3**	**Mean**	**S1**	**S2**	**S3**	**Mean**
F1	21.79	25.29	23.59	23.56	18.89	21.76	23.21	21.28	19.33	25.03	23.40	22.58
F2	24.77	28.58	26.84	26.73	20.50	25.11	27.44	24.35	22.63	27.85	25.14	25.20
F3	25.81	29.85	27.89	27.85	24.92	28.97	26.24	26.71	25.78	28.41	27.57	27.25
F4	31.40	34.88	32.49	32.92	28.45	33.39	30.56	30.80	29.20	34.05	32.45	31.90
Mean	25.94	29.65	27.70		23.19	27.30	26.86		24.23	28.83	27.14	
F-test	Sig	Sig	Sig		Sig	Sig	Sig		Sig	Sig	Sig	
SE(m)±	0.56	0.21	0.61		0.46	0.27	0.83		0.49	0.21	0.66	
CD at 5 %	2.00	0.66	1.31		1.63	1.83	1.64		1.73	0.66	1.30	
	45 DAT				**45 DAT**				**Pooled**			
Fertigation levels	**S1**	**S2**	**S3**	**Mean**	**S1**	**S2**	**S3**	**Mean**	**S1**	**S2**	**S3**	**Mean**
F1	36.83	42.17	40.84	39.95	31.47	39.83	38.51	36.60	35.65	41.00	39.67	38.77
F2	39.27	44.30	42.82	42.13	38.25	41.30	40.15	39.90	38.76	42.80	41.49	41.02
F3	41.13	43.89	42.17	42.39	38.94	41.41	40.50	40.29	40.04	42.65	41.33	41.34
F4	43.27	45.83	44.27	44.46	41.91	43.16	42.71	42.59	42.59	44.50	43.49	43.53
Mean	40.13	44.05	42.52		37.64	41.43	40.47		39.26	42.74	41.50	
F-test	Sig	Sig	Sig		Sig	Sig	Sig		Sig	Sig	Sig	
SE(m)±	0.72	0.33	0.88		0.71	0.32	0.90		1.02	0.52	1.32	
CD at 5 %	2.55	0.93	1.84		2.51	0.98	2.08		2.46	0.97	1.94	

Table 2 : Effect of fertigation levels and schedules on number of leaves of broccoli at 30 DAT and 45 DAT

Treatments	2021-22				2021-22				Pooled			
	30 DAT				30 DAT				Pooled			
Fertigation levels	**S1**	**S2**	**S3**	**Mean**	**S1**	**S2**	**S3**	**Mean**	**S1**	**S2**	**S3**	**Mean**
F1	9.41	12.20	10.17	10.59	8.89	11.38	10.15	10.14	9.15	11.98	10.18	10.43
F2	11.47	15.71	12.60	13.26	9.25	14.64	11.26	11.71	10.48	15.17	11.95	12.53
F3	14.20	16.61	14.77	15.19	11.42	16.15	13.63	13.73	12.80	16.38	14.20	14.46
F4	16.40	18.44	16.48	17.10	15.14	18.20	15.42	16.25	15.78	18.32	15.98	16.69
Mean	12.87	15.74	13.19		10.92	14.91	11.79		12.05	15.46	13.07	
F-test	Sig	Sig	Sig		Sig	Sig	Sig		Sig	Sig	Sig	
SE(m)±	0.75	0.36	0.96		0.54	0.31	0.74		0.25	0.32	0.59	
CD at 5 %	2.64	1.09	2.16		1.88	1.61	3.22		0.89	0.97	1.94	
	45 DAT				**45 DAT**				**Pooled**			
Fertigation levels	**S1**	**S2**	**S3**	**Mean**	**S1**	**S2**	**S3**	**Mean**	**S1**	**S2**	**S3**	**Mean**
F1	10.60	15.47	14.42	13.49	9.89	14.87	12.70	12.48	10.24	14.67	13.56	12.83
F2	12.67	17.80	15.43	15.30	12.89	15.20	14.13	14.07	12.79	15.59	14.98	14.45
F3	17.73	20.28	18.20	18.73	15.72	18.78	17.20	17.07	16.78	18.98	17.83	17.86
F4	20.80	21.20	19.60	20.53	17.56	20.17	18.30	18.82	19.28	20.75	19.54	19.85
Mean	15.45	18.68	16.91		14.01	17.25	15.71		14.77	17.49	16.47	
F-test	Sig	Sig	Sig		Sig	Sig	Sig		Sig	Sig	Sig	
SE(m)±	0.35	0.22	0.50		0.37	0.29	0.60		0.36	0.25	0.54	
CD at 5 %	1.24	0.67	1.34		1.31	0.88	1.74		1.26	0.75	1.49	

Table 3 : Effect of fertigation levels and schedules on curd yield (g) per plant and curd yield (q) per hectare of broccoli

Treatments	2021-22				2021-22				Pooled			
Curd yield (g) per plant												
Fertigation levels	**S1**	**S2**	**S3**	**Mean**	**S1**	**S2**	**S3**	**Mean**	**S1**	**S2**	**S3**	**Mean**
F1	397.85	416.77	397.72	404.11	393.01	413.08	395.04	400.38	395.43	414.92	396.38	402.25
F2	410.86	430.71	420.47	420.68	408.84	426.64	417.10	417.53	409.85	428.67	418.78	419.10
F3	437.17	442.15	435.99	438.43	432.63	441.94	434.59	436.38	434.90	442.05	435.29	437.41
F4	436.50	447.11	438.66	440.75	434.19	445.79	435.39	438.45	435.34	443.45	437.03	438.60
Mean	420.59	434.18	423.26		417.17	431.86	420.53		418.88	432.27	421.87	
F-test	**Sig**	**Sig**	**Sig**		**Sig**	**Sig**	**Sig**		**Sig**	**Sig**	**Sig**	
SE(m)±	2.80	2.55	5.01		1.49	2.23	3.93		1.33	2.15	3.75	
CD at 5 %	8.45	7.67	15.08		4.48	6.69	11.79		3.99	6.45	11.25	
Curd yield (q) per hectare												
Fertigation levels	**S1**	**S2**	**S3**	**Mean**	**S1**	**S2**	**S3**	**Mean**	**S1**	**S2**	**S3**	**Mean**
F1	110.47	115.77	110.51	112.25	105.17	114.74	109.73	109.88	108.45	113.25	109.10	110.26
F2	116.79	119.64	114.13	116.85	113.56	118.51	115.86	115.98	113.85	119.07	116.32	116.41
F3	121.11	122.85	121.43	121.79	120.17	122.94	116.72	119.94	120.80	122.93	120.91	119.35
F4	121.81	124.19	121.15	122.41	117.60	123.82	120.76	120.72	122.39	124.01	121.79	121.57
Mean	116.56	120.61	116.83		114.87	119.50	117.27		116.50	119.93	117.53	
F-test	Sig	Sig	Sig		Sig	Sig	Sig		Sig	Sig	Sig	
SE(m)±	0.77	0.70	1.39		0.41	0.61	1.09		0.37	0.59	1.04	
CD at 5 %	2.34	2.10	4.17		1.23	1.83	3.27		1.12	1.79	3.12	

Table 4 : Effect of fertigation levels and schedules on TSS (%) of broccoli

Treatments	2021-22				2021-22				Pooled			
TSS (%)												
Fertigation levels	**S1**	**S2**	**S3**	**Mean**	**S1**	**S2**	**S3**	**Mean**	**S1**	**S2**	**S3**	**Mean**
F1	7.24	9.35	8.29	8.29	7.16	8.29	8.13	7.86	7.20	8.83	8.21	8.08
F2	8.27	11.96	9.27	9.83	7.26	10.97	9.24	9.15	7.79	11.48	9.26	9.51
F3	9.53	13.16	10.94	11.21	9.50	12.11	10.92	10.99	9.52	12.13	10.94	10.86
F4	10.19	14.77	11.39	12.11	10.11	13.73	11.36	11.75	10.15	13.75	11.38	11.78
Mean	8.80	12.31	9.97		8.50	10.77	9.91		9.28	9.79	9.44	
F-test	**Sig**	**Sig**	**Sig**		**Sig**	**Sig**	**Sig**		**Sig**	**Sig**	**Sig**	
SE(m)±	0.49	0.57	1.05		0.55	0.58	1.09		0.41	0.40	0.77	
CD at 5 %	1.86	1.67	3.35		1.70	1.39	2.78		1.10	1.16	2.32	

Conclusion

From the findings of the present investigation, it may be inferred that fertigation level F4 (125 % RDF) with schedule S_2 was found superior. Growth parameters like plant height, number of leaves, stem diameters, quality parameters like TSS, dry matter content and yield parameters curd diameter, curd yield (g) per plant, curd yield (q) per hectare. Interaction effect of fertigation levels with fertigation schedules was significant for all the parameters.

Acknowledgement

First and foremost, I am grateful to the government of India for providing me Senior Research fellowship under Indian council of Agriculture Research during Ph.D.in Vegetable Science. I equally owe a special debt of gratitude to my university, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola for allowing me to attain the study.

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