International Journal of Botany Studies
www.botanyjournals.com
ISSN: 2455-541X
Received: 30-11-2021, Accepted: 16-12-2021, Published: 31-12-2021
Volume 6, Issue 6, 2021, Page No. 1521-1524

Growth and yield of cabbage as influenced by different irrigation and fertigation levels

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Abstract

An investigation was undertaken at a farmer's field of Panjappalli village, Dharmapuri district, Tamil Nadu to find out the effect of drip irrigation and fertigation in cabbage. The field experiment was carried out in Randomized Block Design with nine treatments in three replications. The treatments comprised of four irrigation levels *viz.*, 0.6 to 1.2 PE and two fertigation levels of 75 and 100 per cent of RDF. The results revealed that the treatment of Irrigation 1.0 PE + 100 % RDF through fertigation significantly recorded the maximum plant height (18.80 cm, 25.60 cm and 29.86 cm), plant spread (34.78 cm, 51.28 cm and 58.78 cm), number of non-wrapping leaves (12.20, 16.73 and 20.13) and leaf area (1193.53 cm^2, 1448.50 cm^2 and 1538.58 cm^2) at 30 DAT, 60 DAT and 90 DAT, respectively. The same treatment had recorded the highest yield attributes head diameter (16.20 cm), head length (12.40 cm), head volume (1313.60 cc), head weight (1208.66 g/plant), yield per plot (62.85 kg) and yield (49.29 t/ha).

Keywords: cabbage, drip irrigation, fertigation, NPK, RDF, pan evaporation

Introduction

Cabbage (*Brassica oleracea* L. var. *capitata*) is one of the most important cool-season vegetable crop which belongs to the family Brassicaceae. Cabbage is rich in minerals and vitamins A, B_1, B_2, and C (Hanif *et al.*, 2006) [4]. The American Cancer Society and the National Research Council have recommended increased consumption of cabbage to lower down the risk of a certain type of cancer (Birt, 1988) [2]. In India, cabbages are grown in an area of 3, 99, 000 ha with an annual production of 90, 37, 000 metric tonnes with average productivity of 22.65 t/ha (Anon., 2018) [1]. Conventional methods of irrigation and fertilization results in losses of water and nutrients through leaching, surface runoff, absorption on clay fraction and also create an adverse condition for plant growth like water logging to some extent. Nevertheless, water scarcity and the high input cost of fertilizer are other constraints in increasing the area, production and productivity of cabbage. Water and nutrients acquisition by plants and the formation of a depleted zone in the immediate vicinity of the roots are the driving forces for solute movement towards the roots. 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 (Silber *et al.*, 2003) [11]. Drip fertigation therefore is the most suitable option, which can efficiently use and save water and fertilizer in addition to increase in the area increasing productivity. Fertigation ensures better fertilizer use efficiency and reduction in leaching (Kumar and Singh, 2002) [7]. In quest of the above considerations, a comprehensive field investigation was carried out in sandy loam soil to evaluate the effect of drip irrigation and fertigation in cabbage.

Material and Methods

The experiment was conducted at a farmer's field of Panjappalli village, Dharmapuri district, Tamil Nadu. The experiment was laid out in a randomized block design with nine treatments replicated thrice. The experimental schedule for this study comprised of different levels of drip irrigation and fertigation *viz.*, T_1- Furrow irrigation + 100 % RDF as soil application (Control), T_2- Irrigation 0.6 PE + 75 % RDF through fertigation, T_3- Irrigation 0.6 PE + 100 % RDF through fertigation, T_4- Irrigation 0.8 PE + 75 % RDF through fertigation, T_5- Irrigation 0.8 PE + 100 % RDF through fertigation, T_6- Irrigation 1.0 PE + 75 % RDF through fertigation, T_7- Irrigation 1.0 PE + 100 % RDF through fertigation, T_8- Irrigation 1.2 PE + 75 % RDF through fertigation, T_9- Irrigation 1.2 PE + 100 % RDF through fertigation. The recommended dose of fertilizer is NPK @ 200: 150: 150 kg/ha respectively. The plot size for each treatment per replication was 4.05 m × 3.15 m and 25 days old seedlings were transplanted with a spacing of 60 × 45 × 45 cm under paired row system. A drip system was laid out with laterals of 16mm diameter having inline emitters with discharge rate of 4 L/hr. Irrigation water was applied daily based on pan evaporation (PE). The biometric observations were recorded on growth traits *viz.*, plant height (cm), plant spread (cm), number of non-wrapping leaves and leaf area (cm^2) at 30 DAT, 60 DAT and 90 DAT, yield attributes *viz.*, head diameter (cm), head length(cm), head volume (cc), head weight (g/plant), yield per plot (kg), yield (t/ha). Five plants were tagged and assessed on each plot for the purpose of recording data. The data were subjected to analysis of variance as per the procedure described by (Panse and Sukhatme., 1985) [10].

Results and Discussion

The results revealed that the plant height significantly varied among the different treatments at 30 DAT, 60 DAT and 90 DAT (Table 1). The plant height varied from 18.80 cm to 10.07 cm at 30 DAT, 25.60 cm to 17.66 at 60 DAT and 29.86 cm to 20.26 cm at 90 DAT. The plant height at different stages of growth was found to be higher with higher doses of fertilizers. The tallest plants were observed in T_7- Irrigation 1.0 PE + 100% RDF (200: 150: 150 kg/ha) through fertigation. On the other hand, the shortest plants were observed in T_1 – Furrow irrigation + 100% RDF as soil application (Control). An increase in plant height at Irrigation 1.0 PE + 100% RDF (200: 150: 150 kg/ha) through fertigation at different stages might be due to maximum uptake of water and nutrients resulted from better availability of sufficient quantity of major nutrients through fertigation. The enhanced plant growth might be due to the fact that nitrogen with synthesized carbohydrates was metabolized into amino acids and proteins which allowed the plants to grow fast. As nitrogen is one of the major plant nutrients required for growth consequently its uptake increases the cell number and size leading to better growth. The results are in conformity with Singh *et al*., (2006) [13].

The plant spread was influenced significantly due to various drip irrigation and fertigation levels at all crop growth stages. The plant spread was found to be the maximum in the treatment which received Irrigation 1.0 PE + 100% RDF (200: 150: 150 kg/ha) through fertigation (34.78 cm, 51.28 cm and 58.78 cm at 30 DAT, 60 DAT and 90 DAT respectively) (Table 1). The minimum plant spread in 22.20 cm, 34.46 cm and 38.46 cm was noted due to Furrow irrigation + 100% RDF as soil application (Control) at 30 DAT, 60 DAT and 90 DAT. The maximum plant spread might be attributed to increased uptake of nutrients and effective utilization of these nutrients for increase synthesis of carbohydrates, greater vegetative growth, and subsequent partitioning and translocation from leaf (source) to the head (sink). These results are in conformity with those reported by Shinde *et al*., (2006) [14]. Number of non-wrapping leaves varied significantly among the treatments (Table 2). The maximum number of leaves per plant (12.20 cm at 30 DAT, 16.73 at cm 60 DAT and 20.13 cm at 90 DAT) were recorded in the treatment T_7 which received the application of irrigation 1.0 PE + 100% RDF (200: 150: 150 kg/ha) through fertigation. The next best value (11.40 cm at 30 DAT, 15.60 cm at 60 DAT and 18.40 cm at 90 DAT) was recorded in the treatment T_9 which received the application of irrigation 1.2 PE + 100% RDF (200: 150: 150 kg/ha) through fertigation. The number of non-wrapping leaves is an important factor, because the leaves are structures bearing photosynthetic machinery and an increase in leaf number, may promote the better root development better translocation of water uptake and deposition of nutrients and increase in yield. The above results were in close agreement with the finding of Jeeva Jothi *et al*., 1993 [6]. Mitigating the water deficit to the level of pan evaporation demand through drip irrigation improved the availability of applied water through the establishment of relatively moist conditions in the root zone and also increased the availability of nutrients throughout the crop growth period. The leaf area showed significant results due to various treatments (Table 2). Application of Irrigation 1.0 PE + 100% RDF (200: 150: 150 kg/ha) through fertigation (T_7) had recorded the maximum leaf area (1193.54 cm^2 at 30 DAT, 1448.50 cm^2 at 40 DAT and 1538.58 cm^2 at 90 DAT). This was followed by the treatment T_9 irrigation 1.2 PE + 100% RDF (200: 150: 150 kg/ha) through fertigation which recorded.

The minimum leaf area of (760.30 cm^2 at 30 DAT, 950.99 cm^2 at 60 DAT and 1051.99 cm^2 at 90 DAT) cm was recorded under control (T_1). Lingaiah *et al*., (2005) [8] and Choudhury *et al*., (2004) [3] also reported similar results in cabbage. The head length and diameter of cabbage is a vital parameter that influences the head size and its market value. A large diameter of head fetches better market quality of cabbage as well as processing. The head length and diameter were influenced significantly due to different drip irrigation and fertigation levels (Table 3). Application of Irrigation 1.0 PE + 100% RDF (200: 150: 150 kg/ha) through fertigation (T_7) resulted in higher head diameter (16.20 cm) and head length (12.40 cm). This was followed by the treatment T_9- Irrigation 1.2 PE + 100% RDF (200: 150: 150 kg/ha) through fertigation. The minimum head length of 7.46 cm and head diameter of 10.20 cm was observed in the treatment T_1 (Furrow irrigation + 100% RDF as soil application). The higher values of the diameter of the head with these levels and combinations might be due to the higher uptake of nutrients. These results are in close conformity with the findings of Sharma *et al*., (2004).

The results presented in table 3 revealed that the head volume significantly varied among the treatments. The maximum head volume was observed in the treatment T_7 - irrigation 1.0 PE + 100% RDF (200: 150: 150 kg/ha) through fertigation (1313.60 cm). This was followed by the treatment T_9 - Irrigation 1.2 PE + 100% RDF (200: 150: 150 kg/ha) through fertigation (1242.20 cm). An increased head volume might be due to increase nutrient availability in the root zone leads to greater absorption of nutrients by plants which might increase the vegetative growth and more translocation of photosynthates towards head which increased head volume. These results are in accordance with those obtained from Tanpure *et al*., (2007) [15] and Hossain *et al*., (2011) [5] in cabbage. The weight of the individual head is an important parameter that ultimately decides the yield of the cabbage crop (Table 3). The treatment T_7 (Irrigation 1.0 PE + 100% RDF (200: 150: 150 kg/ha) through fertigation) significantly recorded the higher head weight (1208.66 g) than the rest of the drip irrigation and fertigation levels. Whereas minimum head weight (788.53 g) was observed in the treatment T_1 – Furrow irrigation + 100% RDF as soil application (Control). Optimum nutrition and irrigation levels might have provided better translocation of minerals and increased accumulation of photosynthates in plants thus increased head weight. These results come along with results obtained by Wange *et al*., (1995) [16] and Mohapatra *et al*., (2013) [9]. The cabbage yield per plot was influenced significantly due to different drip irrigation and fertigation levels (Table 3). Application of Irrigation 1.0 PE + 100% RDF (200: 150: 150 kg/ha) through fertigation (T_7) significantly recorded the highest cabbage yield per plot (62.85 kg) and yield (49.29 t/ha) than the rest of the treatments. The minimum yield per plot was recorded in T_1 (control). The highest yield per plot was due to the precise amount of water with fertilizer through the drip system. Yield is a complex character that involves the interaction of several intrinsic and external factors. It largely depends upon the production and mobilization of carbohydrates, uptake water, and nutrients from the soil, in addition to several environmental factors to which plants are exposed during the growing periods.

At a higher dose of drip irrigation and fertigation level, the crop might meet out its nutritional requirements at respective growth stages leads luxurious growth resulted in more interception of light and more translocation of photosynthates from source to sink which enhanced the yield. These results are in agreement with those reported by Shinde *et al*., (2006) [14].

Table 1: Effect of varying drip irrigation and fertigation levels on plant height (cm) and plant spread (cm) in cabbage

Treatments	Plant height (cm)			Plant spread (cm)		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
T_1 - Furrow irrigation + 100 % RDF as soil application (Control)	10.07	17.66	20.26	22.20	34.46	38.46
T_2 - Irrigation 0.6 PE + 75 % RDF through fertigation	11.13	19.07	21.86	24.80	37.11	41.61
T_3 - Irrigation 0.6 PE + 100 % RDF through fertigation	13.46	20.86	23.73	26.80	40.80	45.60
T_4 - Irrigation 0.8 PE + 75 % RDF through fertigation	12.26	19.53	22.13	24.90	37.90	42.40
T_5 - Irrigation 0.8 PE + 100 % RDF through fertigation	16.53	24.07	27.80	31.61	47.61	54.61
T_6 - Irrigation 1.0 PE + 75 % RDF through fertigation	15.33	22.73	26.07	29.57	44.57	51.07
T_7 - Irrigation 1.0 PE + 100 % RDF through fertigation	18.80	25.60	29.86	34.78	51.28	58.78
T_8 - Irrigation 1.2 PE + 75 % RDF through fertigation	15.07	22.13	25.33	28.60	43.60	48.80
T_9 - Irrigation 1.2 PE + 100 % RDF through fertigation	17.13	24.26	28.20	32.73	48.23	55.23
SE (d)	0.47	0.64	0.74	0.86	1.28	1.46
C.D @ 5%	0.94	1.28	1.49	1.73	2.56	2.93

Table 2: Effect of varying drip irrigation and fertigation levels on Number of non-wrapping leaves and Leaf area (cm^2) in cabbage

Treatments	Number of non-wrapping leaves			Leaf area (cm^2)		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
T_1 - Furrow irrigation + 100 % RDF as soil application (Control)	7.53	10.73	12.63	760.30	950.99	1051.99
T_2 - Irrigation 0.6 PE + 75 % RDF through fertigation	8.33	11.63	13.73	815.52	1015.27	1085.44
T_3 - Irrigation 0.6 PE + 100 % RDF through fertigation	9.26	12.76	15.16	885.00	1090.20	1165.20
T_4 - Irrigation 0.8 PE + 75 % RDF through fertigation	8.46	11.76	13.96	834.94	1034.13	1104.31
T_5 - Irrigation 0.8 PE + 100 % RDF through fertigation	11.13	15.20	18.40	1100.83	1340.51	1421.66
T_6 - Irrigation 1.0 PE + 75 % RDF through fertigation	10.20	14.00	17.13	994.10	1214.46	1289.73
T_7 - Irrigation 1.0 PE + 100 % RDF through fertigation	12.20	16.73	20.13	1193.54	1448.50	1538.58
T_8 - Irrigation 1.2 PE + 75 % RDF through fertigation	10.07	14.33	16.93	952.49	1172.47	1252.74
T_9 - Irrigation 1.2 PE + 100 % RDF through fertigation	11.40	15.60	18.40	1130.21	1370.19	1450.11
SE (d)	0.30	0.41	0.50	23.87	29.34	26.92
C.D @ 5%	0.61	0.83	1.00	47.74	50.69	53.84

Table 3: Effect of varying drip irrigation and fertigation levels on yield and yield attributes in cabbage

Treatments	Head diameter (cm)	Head length (cm)	Head volume (cc)	Head weight (g/plant)	Yield per plot (kg)	Yield (t/ha)
T_1 - Furrow irrigation + 100 % RDF as soil application (Control)	10.20	7.46	836.46	788.53	39.58	31.00
T_2 - Irrigation 0.6 PE + 75 % RDF through fertigation	11.07	8.20	909.66	849.66	42.90	33.60
T_3 - Irrigation 0.6 PE + 100 % RDF through fertigation	12.20	9.13	1002.26	932.20	47.54	37.20
T_4 - Irrigation 0.8 PE + 75 % RDF through fertigation	11.33	8.40	936.33	871.26	44.26	34.70
T_5 - Irrigation 0.8 PE + 100 % RDF through fertigation	14.86	10.93	1208.13	1118.07	57.58	45.10
T_6 - Irrigation 1.0 PE + 75 % RDF through fertigation	13.73	10.13	1126.73	1046.86	53.59	42.00
T_7 - Irrigation 1.0 PE + 100 % RDF through fertigation	16.20	12.40	1313.60	1208.66	62.85	49.29
T_8 - Irrigation 1.2 PE + 75 % RDF through fertigation	13.07	9.86	1087.07	1012.13	51.82	40.60
T_9 - Irrigation 1.2 PE + 100 % RDF through fertigation	15.20	11.46	1242.20	1152.20	59.33	46.50
SE (d)	0.40	0.31	22.98	21.15	1.57	1.23
C.D @ 5%	0.81	0.62	45.97	42.30	3.14	2.46

Conclusions
Based on this study, it can be concluded that drip irrigation 1.0 PE given equivalent to evapotranspiration is better than the furrow method of irrigation. Drip irrigation at 1.0 PE + 100 % RDF through fertigation may be efficiently utilized for getting higher yield with net saving in water and fertilizers.

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