Effect of irrigation and fertigation schedules on yield of cabbage (Brassica Oleracea var. Capitata)

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Abstract

The field experiment was conducted during 2016-2017 and 2017-2018 to investigate the effect of irrigation and fertigation schedules on yield of cabbage during the winter season at AICRP on Water Management, VNMKV, Parbhani. Drip method with alternate day irrigation was adopted for all the plots with five irrigation levels as main plot viz., 0.4 ETc (I1), 0.6 ETc (I2), 0.8 ETc (I3), 1.0 ETc (I4) and 1.2 ETc (I5). Fertigation levels were 50% (F1), 75% (F2) and 100% (F3) of recommended dose of fertilizers (120:60:60; N: P2O5:K2O kg ha⁻¹) with eight splits during crop growth period. All the treatments were replicated thrice. The treatment combination of 1.0 ETc with 125% RDF, 1.0 ETc with 100% RDF and 0.8 ETc with 100% RDF give comparable and better cabbage yields. Hence the combination treatment of drip irrigation at 0.8 ETc and fertilizer level of 100% RDF may be adopted to obtain higher yields with net saving in water and fertilizers. The economic analysis of cabbage under drip fertigation also suggests that the drip irrigation at 0.8 ETc and fertilizer level of 100% RDF is more economical and feasible as compared to all other combinations.

Keywords: Drip irrigation, Irrigation scheduling, Fertigation

Introduction

Cabbage, one of the important vegetable crops, requires comparatively more water and nutrients in precise quantity and is very sensitive to moisture and nutrient stress. Conventional methods of irrigation and fertilization results in losses of water and nutrients through leaching, surface runoff, absorption on clay fraction and also create adverse condition for plant growth like water logging to some extent. Nevertheless, water scarcity and high input cost of fertilizer are other constraints in increasing the area, production and productivity of cabbage. Drip fertigation therefore is the most suitable option, which can efficiently use and save water and fertilizer in addition to increase in the area along with increasing productivity. Research on drip irrigation conducted so far in India and abroad has shown that this method leads not only the appreciable saving of water but also returns in achieving higher crop yields as compared to surface irrigation method. Much of work has been done on growth and yield response of various vegetable crops under drip including scheduling. Most of the field studies were conducted with irrigation levels based on pan evaporation data. However, the studies on irrigation schedule based on crop coefficient and real time evapotranspiration data and fertigation scheduling are limited. Similarly, the work on vegetable crop growth simulation under various full and deficit water and fertilizer conditions are scanty. In quest of the above considerations, a comprehensive field investigation was carried out in heavy black soil to evaluate the effect of various irrigation and fertigation levels on cabbage (Brassica Oleracea var. Capitata) crop growth and yield.

Material and Methods

Two field experiments were conducted on cabbage (Brassica Oleracea var. Capitata) during two growing seasons: January through May 2017 and 2018 in a split plot randomized block design at Research Farm of All India Coordinated Research Project on Irrigation Water Management, VNMKV Parbhani. The experimental plots were 7.2 x 7.5 m size with a buffer strip of 1 m and 2 m kept between two adjacent plots and within replications, respectively. Drip method with alternate day irrigation was adopted for all the plots with five irrigation levels as main plot viz., 0.4 ETc (I1), 0.6 ETc (I2), 0.8 ETc (I3), 1.0 ETc (I4) and 1.2 ETc (I5).
Fertilization levels were 50% (F₁), 75% (F₂) and 100% (F₃) of recommended dose of fertilizers (120:60:60; N : P₂O₅ : K₂O kg ha⁻¹) with eight splits during crop growth period. All the treatments were replicated thrice.

**Irrigation scheduling**

Irrigation water was applied as per the irrigation levels at 0.4, 0.6, 0.8, 1.0 and 1.2 times ETᵢ. The daily crop water requirement for cabbage was estimated using crop coefficient and reference crop evapotranspiration. The crop evapotranspiration ETᵢ was calculated using the following equation

\[
ETᵢ = Kᵢ x ETo
\]

Where,

ETᵢ - Crop evapotranspiration [mm d⁻¹]

Kᵢ - Crop coefficient [dimensionless]

ETo - Reference crop evapotranspiration [mm d⁻¹]

The daily reference crop evapotranspiration (ETo) was estimated by using daily meteorological data collected from the meteorological observatory. The reference crop evapotranspiration was estimated using the FAO Penman-Monteith equation (Allen et al., 1998) [2]: using the following equation

\[
Eₜ = \frac{0.408 \Delta (Rᵣ - G) + \gamma \frac{900}{T+273} uₙ(vₑ - vₛ)}{\Delta + \gamma (1 + 0.34uₙ)}
\]

Where,

Eₜ - Reference evapotranspiration [mm day⁻¹]

Rᵣ - Net radiation at the crop surface [MJ m⁻² day⁻¹]

G - Soil heat flux density [MJ m⁻² day⁻¹]

T - Mean daily air temperature at 2 m height [°C]

uₙ - Wind speed at 2 m height [m s⁻¹]

vₑ - Saturation vapour pressure [KPa]

vₛ - Actual vapour pressure [KPa]

(ves-ea) - Saturation vapour pressure deficit [KPa]

Δ - Slope vapour pressure curve [KPa °C⁻¹]

γ - Psychrometric constant [KPa °C⁻¹]

**Crop coefficient**

The crop coefficient varies according to crop type, growth stages and local climatic conditions. The FAO-56 curve method was used to estimate the local value of the crop coefficient. The stage wise crop coefficients of cabbage were derived from FAO 56 and were modified as per the climatic parameters of Parbhani by following the standard procedure and guidelines suggested in Allen et al., (1998) [2].

**Fertilizer application**

For cabbage the recommended dose of fertilizers as 120:60:60 kg ha⁻¹ N, P and K was used. In fertigation water soluble graded fertilizers such as (Urea, 19:19:19) were applied in 8 splits as per the treatment. The weighted quantity of fertilizers designed for the treatments were dissolved in water by continuous stirring and the fertilizer solution was injected through venturi in the main pipeline by creating the pressure difference.

**Field data collection and analysis**

In order to study the effect of irrigation and fertigation levels on growth and yield of cabbage crop, the data on the plant and growth attributes of the cabbage crop were collected periodically during the experimental periods (2016-17 and 2017-18). The collected data was analysed further for interpretations.

After transplanting 5 plants were randomly selected from each plot and were properly labeled. The crop growth parameters were recorded from these plants approximately at 15 days interval to monitor their growth. The observations at harvest such as weight of curd and curd yield were recorded for all the plants in the plot.

**Curd yield of cabbage**

Data pertaining to yield of cabbage (q ha⁻¹) as influenced by different irrigation and fertigation levels is presented in Table 1.

**Table 1: Curd yield of cabbage (q ha⁻¹) as influenced by different irrigation and fertigation levels.**

| Treatment     | Yield (q ha⁻¹) | 2016-2017 | 2017-2018 | Pooled  |
|---------------|----------------|-----------|-----------|---------|
| Irrigation schedules |
| F₁: 0.4 ETo | 279.04 | 236.85 | 257.95 |
| F₁: 0.6 ETo | 346.80 | 296.19 | 321.49 |
| F₁: 0.8 ETo | 426.37 | 371.48 | 398.92 |
| F₁: 1.0 ETo | 438.79 | 386.65 | 412.72 |
| F₁: 1.2 ETo | 388.14 | 333.75 | 360.95 |
| SEᵢ | 4.83 | 6.29 | 5.17 |
| CD at 5% | 14.24 | 18.56 | 15.24 |
| Fertilization levels |
| F₁: 75% RDF | 331.93 | 303.16 | 327.13 |
| F₁: 100% RDF | 385.02 | 331.93 | 358.47 |
| F₁: 125% RDF | 391.37 | 339.86 | 363.61 |
| SEᵢ | 3.09 | 3.67 | 3.28 |
| CD at 5% | 9.12 | 10.83 | 9.68 |
| Interaction (IxF) |
| SEᵢ | 4.56 | 5.18 | 5.04 |
| CD at 5% | 13.45 | 15.27 | 14.88 |
| GM | 375.83 | 324.98 | 350.41 |

**Effect of irrigation schedules on curd yield**

The data furnished in Table 1 revealed that application of irrigation through drip at 1.0 ETo (I₃) recorded significantly higher curd yield (438.79, 386.65 and 412.72 q ha⁻¹) over rest of the irrigation schedules. However, it was at par with irrigation at 0.8 ETo (426.37, 371.48 and 389.92 q ha⁻¹) during 2016-2017, 2017-2018 and in pooled results. Lower yields (279.04, 236.85 and 257.95 q ha⁻¹) were noticed in 0.4 ETo (I₁) treatment during these years.

The higher yield with 1.0 ETo (I₃) and 0.8 ETo (I₂) treatments might be due to availability of sufficient water to boost the overall vegetative growth and biological efficiency of plant whereas and the lowest yield under 0.4 ETo (I₁) may be due to water stress. An increase in cabbage yield with 0.8 ETo (I₂) treatment could be attributed to the optimum moisture content near to field capacity which helped roots to absorb optimum water and nutrient to satisfy the crop needs.

The effective root zone of cabbage is reported to be 15-30 cm. Excess moisture tends to leach down the nutrients beyond the root zone. Hence treatment I₃ did not gave maximum yield of cabbage.

**Effect of fertigation levels on curd yield**

Fertigation at 125% RDF recorded significantly highest curd yields (391.37, 339.86 and 363.61 q ha⁻¹) which were at par with fertigation at 100% RDF (385.02, 331.93 and 358.47 q ha⁻¹). They were superior over fertigation at 75% RDF.
(351.09, 303.16 and 327.13 q ha\(^{-1}\)) during 2016-2017 and 2017-2018 and in pooled results, respectively. Higher yields under F\(_3\) (fertigation at 125% RDF) and F\(_2\) (fertigation at 100% RDF) may be due to higher application of nutrients, their mobilization and availability at regular interval in required quantity resulting in better yields.

**Interaction effects on curd yield of cabbage**

The data presented in Table 2, 3 and 4 shows the interaction effects of irrigation schedules and fertigation levels on curd yield of cabbage during 2016-17, 2017-18 and in pooled results. These are also depicted in Fig. 1 through 3.

Data presented in Table 1 indicated that the combination I\(_4\) F\(_3\) (drip irrigation at 1.0 ET\(_c\) with 125% RDF) was superior showing highest curd yield (456.53 q ha\(^{-1}\)) over all other combinations of treatments during 2016-2017. This was at par with I\(_4\) F\(_2\) (drip irrigation at 0.1 ET\(_c\) with 100% RDF) and I\(_3\) F\(_2\) (drip irrigation at 0.8 ET\(_c\) with 100% RDF) which showed curd yield of 448.63, and 445.13 q ha\(^{-1}\), respectively.

Similar results are also seen during 2017-18 where treatment combination of I\(_4\) F\(_3\) (irrigation at 1.0 ET\(_c\) and 125% RDF (I\(_4\) F\(_3\)) recorded significantly highest curd yield (407.62 q ha\(^{-1}\)) among all treatment combinations and was at par with I\(_4\) F\(_2\) (irrigation at 1.0 ET\(_c\) and 125% RDF) and I\(_3\) F\(_2\) (irrigation at 0.8 ET\(_c\) and 100% RDF) showing curd yield of 398.45, 395.38 q ha\(^{-1}\).

The pooled results also indicated that the combination I\(_4\) F\(_3\) is superior by recording curd yield of 432.07 q ha\(^{-1}\) over rest of the combinations and was at par with I\(_4\) F\(_2\) (423.54 q ha\(^{-1}\)) and I\(_3\) F\(_2\) (420.26 q ha\(^{-1}\)) (Fig. 4.15). The lowest curd yield of 259.97, 219.59 and 239.78 q ha\(^{-1}\) was recorded under I\(_1\) F\(_1\) during 2016-2017, 2017-2018 and in pooled results.

The higher yields in I\(_4\) F\(_3\), I\(_4\) F\(_2\) and I\(_3\) F\(_2\) combinations might be due to uniform distribution and adequate availability of nutrients and moisture in the root zone of the crop. On the other hand, the lowest yield under combination I\(_1\) F\(_1\) might be due to low uptake of nutrients by the plants under inadequate irrigation and fertigation level (drip irrigation with 40% ET\(_c\) and 75% RDF).

![Image](http://www.chemijournal.com)
Table 1: Interaction effect (IxF) on curd yield of cabbage (q ha⁻¹) during 2016-2017

| Treatment | Fertigation levels | F₁: 75% RDF | F₂: 100% RDF | F₃: 125% RDF |
|-----------|-------------------|-------------|-------------|-------------|
| Irrigation schedules | | | | |
| I₁: 0.4 ETC | 259.97 | 283.37 | 293.80 |
| I₂: 0.6 ETC | 314.43 | 362.93 | 363.03 |
| I₃: 0.8 ETC | 395.80 | 445.13 | 438.17 |
| I₄: 1.0 ETC | 411.20 | 448.63 | 456.53 |
| I₅: 1.2 ETC | 374.07 | 385.03 | 405.33 |
| SE | | 4.56 |
| CD at 5% | | 13.45 |

Table 2: Interaction effect (IxF) on curd yield of cabbage (q ha⁻¹) during 2017-2018

| Treatment | Fertigation levels | F₁: 75% RDF | F₂: 100% RDF | F₃: 125% RDF |
|-----------|-------------------|-------------|-------------|-------------|
| Irrigation schedules | | | | |
| I₁: 0.4 ETC | 219.59 | 240.71 | 250.25 |
| I₂: 0.6 ETC | 285.46 | 293.60 | 309.50 |
| I₃: 0.8 ETC | 337.45 | 395.38 | 381.60 |
| I₄: 1.0 ETC | 353.87 | 398.45 | 407.62 |
| I₅: 1.2 ETC | 319.42 | 331.51 | 350.32 |
| SE | | 5.18 |
| CD at 5% | | 15.27 |

Table 3: Interaction effect (IxF) on curd yield of cabbage (q ha⁻¹) (Pooled)

| Treatment | Fertigation levels | F₁: 75% RDF | F₂: 100% RDF | F₃: 125% RDF |
|-----------|-------------------|-------------|-------------|-------------|
| Irrigation schedules | | | | |
| I₁: 0.4 ETC | 239.78 | 262.04 | 272.02 |
| I₂: 0.6 ETC | 299.94 | 328.26 | 336.26 |
| I₃: 0.8 ETC | 366.62 | 420.26 | 409.89 |
| I₄: 1.0 ETC | 382.54 | 423.54 | 432.07 |
| I₅: 1.2 ETC | 346.75 | 358.27 | 377.82 |
| SE | | 5.04 |
| CD at 5% | | 14.88 |

Conclusion
The treatment combination of 1.0 ETC with 125% RDF, 1.0 ETC with 100% RDF and 0.8 ETC with 100% RDF give comparable and better cabbage yields. Hence the combination treatment of drip irrigation at 0.8 ETC and fertilizer level of 100% RDF may be adopted to obtain higher yields with net saving in water and fertilizers. The cost economics of cabbage under drip fertigation also suggests that the drip irrigation at 0.8 ETC and fertilizer level of 100% RDF is more economical and feasible as compared to all other combinations.

References
1. Abdul HA, Kumar S, Singh AK. Water requirement and irrigation schedule through drip in Cabbage (Brassica oleracea var. capitata). Horticulture Flora Research Spectrum 2014;3(2):166-168.
2. Allen RG, Pereira LS, Raes D, Smith M. Crop Evapotranspiration- Guidelines for Computing Crop Water Requirements-FAO Irrigation and Drainage Paper 1998;56:104-114.
3. Anonymous. Indian horticulture database, National Horticulture Board. www.nhb.gov.in 2014, 139-286.
4. Chatterjee R. Physiological Attributes of Cabbage (Brassica oleracea) as Influenced by Different Sources of Nutrients under Eastern Himalayan Region. Research Journal of Agricultural Sciences 2010;1(4):318-321.
5. Khodke UM, Patil DP. Effect of subsurface drip irrigation on moisture distribution, root growth and production of cauliflower, AICRP on Water Management, Annual Report, Marathwada Agricultural University, Parbhani-431402. India 2012.
6. Ugade SR, Ayare BL, Thorat TN, Thokal RT. Effect of irrigation and fertigation levels on yield and nutrient uptake of brinjal (Solanum melongena L.). International Journal of Agricultural Engineering 2014;7(1):74- 80.